Prepared for:
Nevada Division of Environmental Protection
Las Vegas, NV

Prepared by:
AECOM
Camarillo, CA
December 2016

Surface Water Investigation Plan

NERT Remedial Investigation – Downgradient Study Area
Nevada Environmental Response Trust Site
Henderson, Nevada

Final

Surface Water Investigation Plan

NERT Remedial Investigation – Downgradient Study Area

Nevada Environmental Response Trust Site
Henderson, Nevada

Final

Surface Water Investigation Plan, Revision 0

Nevada Environmental Response Trust
Remedial Investigation – Downgradient Study Area, 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.

Sally W. Bilodeau (signature) 12/27/2016

Sally W. Bilodeau, CEM
NERT RI, Downgradient Study Area Project Manager
Date

Certified Environmental Manager
AECOM
CEM Certificate Number: 1953
CEM Expiration Date: September 30, 2017

The following individuals provided input to this document:

Kristen Durocher
Harry Van Den Berg, PE, CEM
Carmen Caceres-Schnell, PG, CEM
Ryan McCarthy
C. Steve Howe
Michael Flack

Contents

List of Appendices

List of Tables

List of Figures

List of Acronyms

AMPAC	American Pacific Corporation
cfs	cubic feet per second
CSM	conceptual site model
Downgradient Study Area	NERT RI Downgradient Study Area
DQO	data quality objective
EB	equipment blank
EPA	United States Environmental Protection Agency
FB	field blank
FD	field duplicate
FGD	Field Guidance Document
gpm	gallons per minute
HASP	Health and Safety Plan
ID	identification number
IDW	investigation-derived waste
JHA	job hazard analysis
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LVW	Las Vegas Wash
LVWCC	Las Vegas Wash Coordination Committee
µg/L	micrograms per liter
MS/MSD	matrix spike/matrix spike duplicate
NDEP	Nevada Division of Environmental Protection
NERT	Nevada Environmental Response Trust
NERT On-Site Study Area	on-site portion of the NERT RI Downgradient Study Area
±	plus or minus
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RI	Remedial Investigation
RM	river mile
SM	Standard Method
SNWA	Southern Nevada Water Authority

SOPs	standard operating procedures
SWIP	Surface Water Investigation Plan
USGS	United States Geological Survey

1.0 Introduction

This Surface Water Investigation Plan (SWIP) describes the locations, procedures, and methods for a comprehensive set of stream stage measurements, surface water sampling, and analyses of the Las Vegas Wash (LVW), supporting the Nevada Environmental Response Trust (NERT) Remedial Investigation (RI) Downgradient Study Area in Henderson, Nevada (herein referred to as the Downgradient Study Area or Project) (**Figure 1**). This SWIP was developed at the direction of the Nevada Division of Environmental Protection (NDEP) and describes the procedures and methods for establishing transects, installing surface water level staff gages, and collecting and analyzing surface water samples from locations along the transects. In addition, up to 20 surface water grab samples will be collected from various locations along the LVW and analyzed for the target constituents. The surface water sample locations (those along the transects and the grab locations) were established based on the results of the May 2016 surface water sampling program (AECOM, 2016a), during which 21 surface water grab samples were collected at historical locations previously sampled by Southern Nevada Water Authority (SNWA). Additionally, during the May 2016 sampling event, three seeps were sampled. Two of the seeps were sampled previously by Kerr McGee in 2000. The third seep sampled is the “original” seep identified by SNWA in the spring of 1999.

The objective of the investigation of the Downgradient Study Area is to identify downgradient and cross-gradient subsurface pathways through which perchlorate-impacted groundwater is entering the LVW (**Figure 1**). While quarterly sampling has been conducted at a limited number of surface water locations in the past few years, a coordinated effort to quantify perchlorate concentrations relative to flow and location in the LVW has not been undertaken. As part of the planning phase for this investigation in the Downgradient Study Area, sampling of these historical surface water sample locations was conducted in May 2016 to assess current surface water conditions in the LVW. The surface water and seep sampling locations sampled in May 2016 are shown on **Figure 2**. Determination of the seasonal patterns of perchlorate concentrations is not the intent of the one-time sampling events described in this SWIP. Although the concentrations in the LVW may vary significantly with time, both diurnally (from wastewater reclamation discharge) and seasonally (due to sporadic rain events, evapotranspiration, etc.), the sampling design described in this SWIP is intended to provide indication as to which reaches in the LVW are currently receiving significant perchlorate from groundwater or seep discharges. This in turn will assist in focusing additional investigations of perchlorate pathways in groundwater within the Downgradient Study Area. Note that, as discussed in Section 7 of this SWIP, the United States Geological Survey (USGS) is currently working under a contract with NDEP to conduct long-term water quality sampling and analysis on the LVW, which will provide more insights on the spatial and temporal concentration variations of perchlorate in the LVW in the future. However, most of the data from the USGS study will not be available in time for incorporation in the NERT RI.

While effort has been made to establish sample locations in areas with easy and safe access to the LVW, the primary objectives of the sampling proposed in this SWIP are to refine the conceptual site model (CSM) through identification of perchlorate discharge locations to the LVW, and provide the information to quantify perchlorate fluxes along different reaches of the LVW. Extensive onshore riparian zone restoration has occurred, making it difficult to access all of the locations on foot. As needed, boats will be used to access the majority of sampling locations in the LVW; sample locations in the seep areas and the wastewater discharge streams will be accessed on foot. While no accessibility problems are anticipated, should any occur due to safety concerns or physical limitations, AECOM will evaluate options to collect the required data in consultation with NDEP.

The activities in this SWIP will be conducted in conformance with the Quality Assurance Project Plan (QAPP) (AECOM, 2016b) and the site-specific Health and Safety Plan (HASP) (AECOM, 2016c) developed by AECOM. Modifications to the HASP that specifically address on-water safety are also provided as **Appendix A** to this SWIP. As needed, Job Hazard Analyses (JHAs) will be prepared during the pre-field and field efforts to cover any additional concerns with working on or near the water.

Data collected under this SWIP will be reported in a technical memorandum which will in turn be used by NERT during the preparation of the RI Report.

1.1 Surface Water Sampling Plan Organization

This document includes the following sections:

- Section 1.0 provides an introduction, including the overall objectives and organization of the SWIP.
- Section 2.0 presents a CSM of the LVW.
- Section 3.0 discusses the data quality objectives (DQOs) for the sampling and analyses.
- Section 4.0 describes the sampling and testing objectives for the SWIP and describes the sampling types, locations, and frequency along with pre-field and field activities to be conducted.
- Section 5.0 details the sampling procedures and equipment to be used during the investigation.
- Section 6.0 describes sample designations, sample handling, and analytical methods to be conducted as part of the investigation.
- Section 7.0 presents a brief description of an optional field task, co-ordinating with the USGS seepage study.
- Section 8.0 describes the schedule and report preparation that will document the results of this assessment.
- Section 9.0 provides references to sources of information used in the preparation of this SWIP.

1.2 Definitions and Key Terms

The following terms are used throughout the SWIP and are defined here for consistency.

Groundwater discharge: approximate location where groundwater is entering the surface, either on land or under water. The groundwater may or may not contain perchlorate.

Groundwater flux: measurement of the amount of groundwater discharging per unit of time (for example, gallons per minute [gpm] or cubic feet per second [cfs]).

Perchlorate discharge: approximate location where groundwater containing perchlorate is discharging to the surface, either on land or under water.

Perchlorate flux: the amount of perchlorate transported in water per unit of time (e.g., pounds per day).

Potential discharge: a location where discharge may be occurring, but there is still uncertainty

Seep: an area of slow discharge of groundwater on land or into a body of water.

Spring: a discrete place where groundwater actively discharges on land or into a body of water. In contrast to seeps, springs often create small rivulets on the ground surface, and may be visible underwater as sand boils or areas of reduced cloudiness.

Sump: a manmade collection structure used to manage surface runoff water.

2.0 Conceptual Site Model

Before development of the Las Vegas area, the LVW was a natural stream in southern Nevada that flowed year-round. In the past decades, the LVW has experienced large increases in water flow due to increases in wastewater discharge related to development in the Las Vegas Valley, providing the LVW with a relatively steady year-round water flow. The increased flow rates combined with flooding during major storm events cause erosion of the LVW channel. Erosion control weirs have been constructed, and are continuing to be constructed, to slow down the water velocities through major portions of the LVW. Groundwater infiltrating into the LVW via seeps and springs is known to be contaminated with dissolved chemicals related to industrial operations in the Las Vegas Valley, including perchlorate, chlorate, and chromium. The paths by which the contaminated groundwater enters the LVW and introduce contamination to the surface waters are not well understood. The following section provides a description of the CSM of the LVW and known and suspected inputs.

2.1 Regional Hydrology and Water Usage

The headwaters of the LVW are located in the northern part of the Las Vegas Valley near Fossil Ridge in the Las Vegas Range. The LVW flows to the southwest around Gass Peak then turns to the southeast flowing toward Tule Springs Ranch and North Las Vegas. Tule Springs was one of the larger springs in the valley (Rafferty, 1984). LVW then runs south-southeast along the eastern edge of the valley before turning east toward its exit from the valley near the City of Henderson, joining with the Colorado River in Lake Mead approximately 5 miles to the northeast. As the point of discharge from the valley, the LVW picks up flow from all other intermittent and perennial streams draining the basin, including Las Vegas Creek which drains another area of significant historical spring discharge (Las Vegas Springs and Big Springs).

In the early 1900s, the water demands of the growing population in the area began to overwhelm the natural rate of groundwater recharge, and a number of large, flowing artesian wells were drilled in the valley floor (Pavelko et al, 1999). Flow from those wells represented a significant increase in groundwater discharge within the basin, causing increased surface water flows and water-level declines in aquifers. As a result, water levels in parts of the valley dropped by as much as 300 feet and resulted in land subsidence due to compaction of aquifer materials.

Following the construction of the Hoover Dam on the Colorado River, Lake Mead began to supply water to the Las Vegas Valley and today represents approximately 90 percent (%) of the water supply (Las Vegas Valley Water District, 2016). The streamflow characteristics of the LVW have changed considerably through the years as natural contributions from large springs have dried up and treated wastewater discharge from the growing population has increased (**Figure 3**).

Figure 4 presents a map and schematic representation of the LVW across the Downgradient Study Area, including known major inflow and outflows by river mile (RM) as measured from the historic high water level mark on Lake Mead. **Figure 4** shows the location and average flow (based on up to 10 years of discharge data; 2006–2015), where available, for USGS water level gages in the general study area, including gages on the LVW, one on Duck Creek, and the C-1 Channel.

The USGS has operated a long-term stream gaging station downstream of Las Vegas since 1958 (LVW at Pabco Road near Henderson, Nevada; gage 09419700) (**Figure 4**). From 1958 through 1967, the average annual flow at the Pabco Road station was 21.8 cfs. The rate of flow grew steadily through much of the period of record at Pabco Road (**Figure 3**) and has stabilized at approximately 300 cfs since 2005 (average annual flow of 296 cfs from 2006 to 2015).

The USGS also operates a long-term gaging station near the point of exit for the LVW from the valley (above Three Kids Wash; gage 09419753) (**Figure 4**). Between 2006 and 2015, the average annual flow at the downstream station was 302 cfs, or only 6 cfs (2.0%) higher than at the Pabco Road gaging station. While that apparent increase is within the uncertainty of streamflow measurements (generally accepted to be within plus or minus (±) 5% of true streamflow), some additional flow inputs have been observed over the 2.5-mile distance between the two stations. Those inputs, including stormflow and groundwater discharge (springs and seepage areas), are balanced to some degree by losses to evapotranspiration (**Figure 4**).

2.2 Anthropogenic Sources of Discharge to the LVW

Discharges from the four major wastewater treatment plants in the valley represent the vast majority of flow in the LVW (Clark County Water Reclamation District, City of Las Vegas Water Pollution and Control Facility, City of Henderson Water Reclamation Facilities, and City of North Las Vegas Water Reclamation Facility). Outfalls from groundwater treatment plants (NERT, American Pacific Corporation [AMPAC], and TIMET) join the channel conveying treated wastewater from the City of Henderson, entering LVW above Pabco Weir (indicated as combined treated wastewater inflow on **Figure 4**). The remaining flow in the LVW comes from Duck Creek and the C-1 channel, as well as non-point sources including urban and stormwater runoff and shallow groundwater discharge. It is expected that portions of LVW are below the groundwater table and, therefore, receive groundwater discharge. Other parts of LVW are above the groundwater, which cause infiltration (loss) of the surface water. This condition is dynamic and changes depending on a wide variety of variables including, but not limited to, increases in flow rates from the wastewater treatment plants due to increased land development, diurnal fluctuations in wastewater flows, and seasonal fluctuations of the groundwater table.

The treatment plants contribute a relatively steady daily supply of water to the LVW throughout the year. The outfalls discharge continuously but at a predictably cyclic rate. That cycling causes a diurnal flow pattern similar to a tidal pattern, with daily high and daily low flows. Unless disrupted by rain storm events, daily high flows are on the order of 100% higher than the daily low. However, the constant daily discharge represents the vast majority of flow in LVW, and the natural, seasonal variability in streamflow has largely been eliminated. On average, streamflow tends to be somewhat higher from October through March (290 to 340 cfs) and lower from April through September (260 to 310 cfs) (USGS, 2016).

Along with the general increase in background flow in LVW through the years, there has also been an increase in the magnitude of stormwater runoff draining into the LVW. Fifty years ago, the annual peak flow at Pabco Road was on the order of 300 cfs (median value of 280 cfs from 1957 to 1967), or similar to the current average annual flow (298 cfs). More recently, annual peak flows are on the order of 4,500 cfs (median value of 4,350 cfs from 2005 to 2015) (USGS, 2016).

In an effort to protect the channel from the erosive forces of higher flows, a series of erosion control structures (weirs) have been constructed to slow the water velocities in the LVW. Where erosional forces have been allowed to run their course, the stream channel within the Downgradient Study Area is generally 40 feet or less in width. Near some of the weirs, the width increases to 300 feet or more.

The channel materials consist of loose, unconsolidated sediments that have been shifted and sorted by the energy of the flowing water. Most of the underlying material is alluvium that consists of both fine-grained materials (silts and clays) and courser materials (sands and gravels). As the water carries those deposits downstream, sand and gravel are deposited in areas with higher velocity, providing a more solid streambed. Where streamflow slows down in natural pools and behind some of the weir structures, silts and clays are deposited, creating a soft bottom. The Horse Springs Formation is present in the southern streambank east of Calico Ridge Weir, and the Thumb Formation is present on the northern and southern streambanks between the Lower Narrows and Three Kids Weirs.

2.3 Known Sources of Perchlorate

The former Kerr McGee/Tronox site (NERT On-Site Study Area) (**Figure 1**) 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, this area continued to be used for industrial activities, including production of perchlorate, boron, and manganese compounds. Former industrial and waste management activities conducted at the NERT On-Site Study Area, as well as those conducted at adjacent properties, resulted in contamination of environmental media, including soil, groundwater, and surface water. Since 1979, the NERT On-Site Study Area has been the subject of numerous investigations and removal actions. Soil removal actions were conducted in 2010 and 2011 from the NERT On-Site Study Area to minimize potential health risks from impacted soil. Additional soil removal was performed in 2013 when the eastern end of the Beta Ditch was excavated. The soil removal activities and post-removal conditions are described in detail in the Revised Interim Soil Removal Action Completion Report (ENVIRON International Corporation, 2012). On-site and Off-site groundwater removal actions include the installation of the groundwater extraction-and-treatment system, designed to capture and treat perchlorate and hexavalent chromium in shallow groundwater.

In the spring of 1999, SNWA hydrologists discovered a seep ("the original seep") discharging to the LVW at approximately 400 gpm. The location of the sump collecting water from the original seep is shown on **Figure 2** as location KM-S. Perchlorate concentrations in the seep exceeded 100,000 micrograms per liter (µg/L) in 1999. The results of the seep samples indicated that a significant mass flux of perchlorate was entering the LVW; Kerr McGee subsequently implemented a capture system at the seep in November 1999 to reduce the migration of perchlorate to the LVW (ENSR International 2005). The operation of the Seep Capture System has contained and treated a substantial mass of perchlorate that otherwise would have entered the LVW. To support the Downgradient Study Area investigation, surface water samples were collected from several locations in and near the LVW in May 2016. As part of that sampling program, a sample was collected from the sump immediately downgradient of the seep discovered by SNWA in 1999 (labelled KM-S in **Figure 2**). The capture system that was subsequently implemented has significantly reduced both the perchlorate concentration and volume of groundwater discharging at the location. The 2016 sample had a perchlorate concentration of 85 µg/L, three orders of magnitude lower than samples collected in 1999. The seep is currently reported to be active only seasonally, with the small volume of flow terminating a short distance downstream in a topographic low where it seeps back into the ground and/or is evaporated into the air upgradient of its historic confluence with LVW. The seep was active during the May 2016 sampling, with discharge through the sump visible (AECOM, 2016a).

2.4 Perchlorate Patterns and Suspected Discharges

In an effort to locate additional potential inputs of perchlorate to the LVW, Kerr McGee conducted a groundwater seep sample field program in the LVW (**Figure 5**). Samples were collected from additional seep locations in April 2000 by Kerr McGee before the installation of the weirs, which caused some of the seeps to be submerged below the water surface of the LVW. **Table 1** is a list of existing and proposed weirs in and near the Downgradient Study Area, and includes the year the weir was completed. Concentrations of perchlorate reported in the 2000 sampling were up to 57,000 µg/L (location KM-70; approximately RM 6). The perchlorate concentrations in the seeps from the 2000 seep sampling were highest near the original seep discovered by SNWA; upstream concentrations were either non-detect or very low (31 µg/L at KM-58; near the Duck Creek confluence). Downstream seep concentrations dropped from KM-70 with distance downstream to KM-53 (321 µg/L; approximately RM 5), but increased at KM-91 (2,100 µg/L; approximately RM 4.7). Concentrations in the seeps again decreased with distance downstream from KM-91 to KM-66 where the concentration was 460 µg/L. The concentration of perchlorate then increased at KM-67 to 2,100 µg/L. No samples were collected downstream of KM-67 during this sampling event.

During the May 2016 sampling program, an attempt was made to locate the seeps from the 2000 sampling event. Seeps that were successfully located, accessible, and flowing were subsequently sampled. It is surmised that weir construction, onshore riparian zone restoration, flooding and vegetative growth during intervening years, and the ongoing regional drought conditions may have affected the occurrence and, if present, the flow from the previously identified seeps. Because the installation of the weirs likely changed the seep locations, attempts were made to relocate the seeps and, if possible, sample them. Of the 18 historic seep locations, only three (KM-45, KM-67 and KM-71) could be located in the field. All other historic seeps may have been buried by weir and bank construction, submerged by the expanded stream channel and associated sediments, temporarily dried up under the ongoing drought conditions, or obscured by dense vegetation. Of the three located seeps, two (KM-67 and KM-71) were sampled. KM-45 was identified as a pit located near the Pabco Road Weir. The pit was dry and, therefore, not sampled. The concentrations of perchlorate in the two sampled seeps were lower in 2016 than in 2000. At KM-71, the concentration in 2016 (1.4 J µg/L) was substantially lower than in 2000 (3,400 µg/L). In 2000, KM-71 was located downgradient of the proposed location of the Sunrise Mountain Weir. The seep was located in 2016 immediately upstream of this location in a backwater channel. At KM-67, located near the Three Kids Weir, the concentration (1,500 µg/L) in 2016 was slightly lower than in 2000 (2,100 µg/L). Construction of Three Kids Weir was completed in July 2015. A riprap weir referred to as “Demonstration Weir” was constructed near this location in 1999. The Demonstration Weir was relocated and rebuilt in 2007 and was eventually dismantled in 2013 and replaced by the Three Kids Weir (Las Vegas Wash Coordination Committee [LVWCC]), 2016). Although a weir was in place in this location during both the 2000 and 2016 sampling events, it is not clear to what extent, if any, each weir affected the stream flow and sample results during the 2000 and 2016 sampling events.

The results of the seep sampling conducted by Kerr McGee in 2000 and by AECOM in May 2016, indicate that there may be perchlorate discharge to the LVW, particularly in the area near Three Kids Weir. During the May 2016 sampling event, in addition to the three seep samples, surface water grab samples were collected from 14 locations in the LVW and six locations in tributary or side streams. These locations ranged from the upstream portion of the Downgradient Study Area (LW7.2) downstream to LW3.1, located out of the Study Area. The perchlorate concentrations from these samples are provided in **Figure 6**. While the daily flows may have influenced the concentration of perchlorate (i.e., the daily higher flows may dilute perchlorate in the LVW), there appears to be reaches along the LVW where perchlorate concentrations show an increase. The first increase in perchlorate concentrations appears near the NERT RI Off-Site Study Area and the Pabco Road Weir. Several potential sources, including the TIMET and City of Henderson wastewater outfalls, any uncaptured groundwater relating to the Kerr McGee seep, and potential inputs near seep KM-71 may be present. Concentrations increase again near the Proposed Historic Lateral Weir Expansion, where the C-1 channel enters the LVW. While the 2000 seep data (**Figure 5**) do not show a potential seep point source, concentrations in the surface water from May 2016 are slightly higher in this reach (19 to 23 µg/L) than upstream (8.3 µg/L), but are similar to that near Pabco Road Weir (15 to 17 µg/L in the LVW channel). Downstream of Lower Narrows Weir, concentrations increase to 44 µg/L, and remain high through the rest of the sampled reach of the LVW (51 µg/L at the most downstream location). The seep KM-67 may account for some of the increase in perchlorate concentrations from the Three Kids Weir and downstream. However, upstream near Lower Narrows Weir, the only other potential source measured is the seep KM-91 (2,100 µg/L in 2000). This seep (KM-91) could not be located in May 2016.

2.5 Surface Water Data Gaps

The reaches where perchlorate is entering the LVW can be grossly defined, but additional data are required to direct a subsurface investigation that will identify more specific loci of perchlorate discharge. The gaps include:

- Is there residual perchlorate discharge not being captured by the seep well field that is entering the LVW?
- If so, what are the approximate locations and fluxes of those inputs and the contribution of each location to the perchlorate flux discharging to Lake Mead?
- Of the almost 20 seeps sampled by Kerr McGee in 2000 that were investigated in May 2016, only three were located. Where might the other seeps, if still active, be discharging?
- Are these seeps contributing perchlorate to the LVW?
- To what extent do the daily fluctuations in the flow in the LVW, due to waste water discharges, impact the concentrations of perchlorate?
- What is the variability in perchlorate concentrations across each cross-section? Are potential points of groundwater discharge located near the south bank, mid-channel, or near the north bank of the LVW?
- Are there other, unknown, sources of perchlorate to the LVW?

3.0 Data Quality Objectives

In this section, the United States Environmental Protection Agency (EPA) DQO process is followed to assist with systematic planning for the proposed environmental sampling program described in this SWIP (EPA 2006) with the overall objective of addressing the surface water data gaps identified in Section 2.5. The DQO process is EPA's recommended planning process when environmental data are used to select between two alternatives or derive an estimate of contamination (EPA 2001). The DQO process is used to develop performance and acceptance criteria that clarify study objectives, and to define the appropriate type of data and specific tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. Performance criteria apply to new data collected for the Project, while acceptance criteria apply to existing data proposed for inclusion in the Project.

After performance criteria have been developed, the QAPP describes in comprehensive detail the necessary quality assurance (QA), quality control (QC), and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria (AECOM, 2016b). The QAPP for the proposed sampling at the Downgradient Study Area is a separate document adapted from the existing QAPP for the NERT RI and is consistent with EPA guidance.

The DQO process as described in EPA guidance involves the following seven steps:

1. Define the problem.
2. Identify the goal of the study.
3. Identify information needed for the study.
4. Define the boundaries of the study.
5. Develop the analytic approach.
6. Specify the performance or acceptance criteria.
7. Develop the plan for obtaining data.

The field work described in this SWIP include two distinct data collection efforts, each intended to provide information to fill the data gaps identified in Section 2.5. The DQO process for each of these is provided below. The two data collection efforts include a transect-based surface water sampling event and a grab sampling event. The transect-based sampling will include installation of staff gages, if not present, at each of the transect locations to provide an indication of the water level and flow through that area, and sampling discreet samples across the LVW. The grab sampling includes sampling 4 days at multiple locations along the LVW and in some side channels during periods of specific flow.

A summary of steps 1 through 6 is provided in the following sub-sections for each of the two primary activities covered in the SWIP. Those two activities will both help refine knowledge of where perchlorate is entering the LVW. Transect sampling and installation of water level gages (Section 3.1) will also help evaluate for variability in perchlorate concentrations across each cross section and identify potential locations of seepage. The collection of grab samples (Section 3.2) will help evaluate the impact of daily flow variations on perchlorate concentrations and whether or not those concentrations remain relatively consistent over a period of several days. The sampling plan details for step 7 are described in Sections 4.0 through 6.0 of this SWIP.

3.1 Water Level Staff Gages and Transect Sampling

3.1.1 Define the Problem

As discussed in Section 2.4, perchlorate discharge to the LVW is currently not well understood. While capture and treatment of perchlorate-contaminated water by Kerr McGee (currently operated by NERT) and others have substantially reduced the flux of perchlorate to the LVW, other, more diffuse sources of perchlorate to the LVW are present, likely through groundwater discharge within the reaches along the LVW within the Downgradient Study Area. Surface water grab sampling data collected in May 2016 (AECOM, 2016a) have shown that concentrations of perchlorate increase with distance downstream. Specifically, concentrations appear to increase downstream of the seeps near Pabco Road and the Historic Lateral Weir, at a location between LW4.95 (upstream of Calico Weir) and LWC4.6 (downstream of Lower Narrows Weir), and downstream of Three Kids Weir (AECOM, 2016a).

The complex geology and hydrology described in the CSM (Section 2.0), together with the construction of weir structures, confound locating perchlorate discharge points. While some perchlorate may be entering the LVW upstream of the Downgradient Study Area, ongoing sampling efforts have shown those contributions are relatively insignificant. To control perchlorate flux to the LVW, the sources of perchlorate discharge must be located and, ultimately, addressed. These sources are likely contaminated groundwater discharging as seeps or springs that may be entering via overland flow or, more likely, discharge in the LVW directly under the water surface. The points of discharge may be on the southern bank, mid-channel, or near the northern bank of the LVW.

Surface water gaging and transect sampling data are needed that represent the current nature and distribution of target constituents, including perchlorate and chlorate, in the LVW within the limits of the Downgradient Study Area. Those data will help evaluate for variations in concentration across each cross section. The surface water transect sampling will also include total dissolved solids, chloride, and bromide analyses to evaluate if differences in the concentrations of these analytes can be used in identifying areas of potential groundwater flux to the LVW, as not all groundwater discharge contributes perchlorate to the LVW and these fluxes of groundwater need to be accounted for in any future perchlorate flux calculations and modeling.

Potential groundwater and perchlorate discharges may be near the northern or southern banks or closer to the middle of the LVW. To help refine understanding of the perchlorate discharge, transect sampling in the LVW will be conducted at target locations near the northern bank, the southern bank, and mid-channel. Collecting data from a transect across the LVW will provide information to the cross-sectional differences in perchlorate concentrations, as well as a better average concentration at that point in the flow path of the LVW. The transect sampling will occur at locations where perchlorate discharge may be occurring, as determined by past sampling events, and will include a sampling transect in the upstream reaches of the Downgradient Study Area to refine the upstream and off-site inputs to the Downgradient Study Area. The transect locations will include a surface water level gage, either a USGS gage that will provide water level as well as volumetric flow, or a water level gage that will indicate water level only. The differences in water level at the staff gages will be used in relationship to the USGS gages, where volumetric flow as a function of water level has been calibrated, to estimate differences in flow at each transect.

3.1.2 Identify the Goals of the Water Level Gaging and Transect Sampling

Principal Study Questions:

- Which reaches along the LVW are primary contributors of perchlorate flux within the LVW?
- Are the concentrations of the target constituents different along cross-sections from the northern to southern bank along the length of the LVW in the Downgradient Study Area?
- Can data generated by sampling along the transects refine the locations of potential seep areas (where perchlorate discharge is occurring) near the northern bank, southern bank, or mid-channel?

The program will provide data to supplement the existing database of perchlorate and chlorate concentrations in the LVW. Specifically, the field data will be collected to:

- Provide additional data to refine the reaches in the LVW of potential discharge of perchlorate to the LVW;
- Provide data to help direct the subsurface investigation to track potential loci of groundwater discharge, regardless of perchlorate concentration, to the LVW: and
- Collect data on other constituents (chlorate, chloride, bromide and total dissolved solids) that may further the understanding of the relationship, if significant, between groundwater and surface water chemistry.

All samples will be analyzed for perchlorate, chlorate, chloride, bromide, and total dissolved solids. These analytes have been analyzed previously in groundwater and/or surface water, and new data will be used to establish current patterns of concentrations. Chloride, bromide, and total dissolved solids data are used primarily to help identify changes in the surface water quality, indicating potential areas of groundwater discharge. Analytical methods are provided in **Table 2**.

While chromium and hexavalent chromium have been analyzed previously, including in the May 2016 sampling program, review of the hexavalent chromium data indicated that this constituent was seldom detected (one detection out of samples collected from 24 surface water locations in May 2016) and dissolved chromium concentrations in the LVW channel were all low (i.e., less than 1.4 µg/L) or non-detect. Both hexavalent chromium and dissolved chromium were present in the seep KM-67, located near Three Kids Weir. Chromium and hexavalent chromium were not detected in the other seeps. Chromium was detected at low concentrations (2.2 and 2.1 µg/L in the sample and duplicate, respectively) in sample LWC6.3_1, and was detected but at laboratory-estimated (J-flag) concentrations in other the LVW grab samples. Because perchlorate and chlorate concentrations in the KM-67 seep sample were elevated by one to two orders of magnitude compared to adjacent samples in the LVW, both perchlorate and chlorate can be used as tracers for this seep water. This SWIP, therefore, does not include additional analyses of dissolved chromium and hexavalent chromium.

3.1.3 Identify the Information Inputs

Information required to answer the study questions will include existing field data and data to be obtained from the planned sampling event.

Existing data were collected by SNWA, NDEP, Kerr McGee, and others. Samples had been collected from the target locations, but often not during the same sampling event. Newly collected data, collected from 21 historic surface water and three seep locations during a single event, were obtained in May 2016. These data were used in conjunction with the historical data to provide a more refined understanding of the perchlorate, chlorate, and chromium (including hexavalent chromium) concentrations in the LVW. Based on these data, it was determined that perchlorate and chromium concentrations have generally decreased over time. Concentrations had some variation throughout the reach of the LVW sampled, with higher concentrations indicating potential perchlorate discharge near Lower Narrows Weir and Three Kids Weir (**Figure 6**).

The USGS has two permanent stream gages in the LVW in the Downgradient Study Area. Stream gages are installed near Pabco Road (USGS 09419700; approximately RM 6) and at Three Kids Wash (USGS 09419753; approximately RM 3.5). USGS has recently (September 2016) installed three additional temporary stream gages in the Downgradient Study Area that will be monitored for five years. These gages are located upstream of Duck Creek Confluence Weir (approximately RM 6.85), upstream of Bostick Weir (approximately RM 5.1), and upstream of Homestead Weir (approximately RM 4.3). These locations are provided in **Figure 7**.

The transect sampling data to be collected as part of this SWIP will be evaluated both along the LVW and across the LVW. The transect data will be averaged to provide a more robust indication of perchlorate concentration in each transect and will provide a perchlorate concentration trend from upstream to downstream along the LVW. If there are differences in perchlorate concentration from bank to bank, these differences may provide insight into a location of potential discharge. The water level gages, to be installed at the transects where no USGS gage is present, will provide qualitative information on the flows at each of the transects.

3.1.4 Define the Study Area Boundaries

Step 4 of the DQO process is to define the boundaries of the study area, which in this case are the general boundaries of the Downgradient Study Area as shown on **Figure 1**. However, specifically for the purposes of this SWIP, the boundaries are expanded in the downstream direction and include the stretch of the LVW between approximately RM 7.2 (upstream) to RM 3.1 (downstream).

Surface water samples will be collected from 10 transect locations along the LVW, extending from Duck Creek Confluence Weir (approximately RM 6.8) downstream to just upstream of the Three Kids Wash gage. The most upstream transect has been located at Duck Creek Confluence Weir to provide co-ordination with the locations of the new USGS gages (**Figure 7**). Samples will be collected from the LVW across the transects indicated in **Figure 7** from approximately four locations along each transect (i.e., near the southern bank, northern bank, and approximately two samples near mid-channel). The number of samples across the transects will be determined based on the cross-section data collected during the staff gage installation. Transect samples will be collected near-bottom to help capture seep discharge, if present. The water depth during the May 2016 grab sampling event was generally less than 1.5 feet. Of the 21 locations, only four locations were greater than 3 feet in depth (surface water depths were 5 feet at LWC4.6, 3.5 feet at LW5.3, 7.5 feet at LWC6.1_1, and 5 feet at LWC6.3_1). At sampling locations where water is over 3 feet deep, two samples will be collected at each location. For the transect locations, a sample will be collected from near bottom and from approximately one-third of the total depth. These transects, with the exception of a transect co-located with the new USGS gages at Duck Creek Confluence Weir and Homestead Weir, will include temporary surface water level staff gages to help account for the influence of flows on the constituent concentrations. The transects and surface water staff gage locations are shown on **Figure 7** and listed in **Table 3**. A map (Plate 1) showing the locations of these relative to other components of the surface water program is provided in **Appendix C**. Locations downstream of RM 3.7 are outside of the boundaries of the Downgradient Study Area but are included to provide concentration data for the downstream reach of the LVW beyond the areas of suspected perchlorate discharges.

3.1.5 Develop the Analytic Approach

Step 5 of the process involves designing the approach to answer the questions and achieve the goals. QA/QC is considered during the design process.

Samples will be collected during the “daily lower flow” along the transects. For purposes of this sampling event, “daily lower flow” is defined from the daily minimum flow (occurring at Pabco Road Gage at approximately 0830 to 0930 during weekdays) to the daily average flows (occurring at approximately 1300 to 1400 daily). The flows are off-set by approximately 2 hours from Pabco Road to Three Kids Wash (**Figure 6**) (USGS, 2016). The timing of these flows was established by evaluating data from September 2016 and October through December of 2015. See Section 3.2.5 for details. The goal of this program is not to target the potential impact in concentrations from daily flow fluctuations, but to provide data during relatively consistent flows. The time of each sample will be compared to flows from the nearest USGS gage (**Figure 7**) and temporary staff gages to allow qualification of any apparently anomalous high or low concentrations. All samples will be analyzed for perchlorate, chlorate, chloride, bromide, and total dissolved solids. Methods are provided in **Table 2**.

The transect sampling data to be collected as part of this SWIP will be evaluated both along the LVW and across the LVW. Looking at the concentrations of perchlorate from upstream to downstream, the transect samples will provide more information about the average perchlorate concentration at locations along the LVW by providing more than one data point from the channel. Looking from bank to bank, there may be differences in perchlorate concentration, which could inform the program as to the discharge point of perchlorate, or a preferential path in the LVW. In other words, are discharges of perchlorate closer to the northern or southern bank? Is perchlorate well-mixed in the LVW, or are there channels, specifically in areas where the LVW shows multiple channels, where perchlorate concentrations are different? The timing of the transect sampling will be closely coordinated within each transect and between the transects. This will provide samples across each transect that are collected during similar flows. The gages, to be installed at the transects where no USGS gage is present, will provide qualitative information on the flows at each of the transects. These data will be used to help interpret the relative concentrations of perchlorate between transects, as well as within each transect.

Project reporting limits are provided in the QAPP (AECOM, 2016b). QA/QC samples will be analyzed with the surface water samples for each analytical method, as defined in the QAPP and as described below in Section 6.8. QA/QC samples will include field duplicates (FDs), field blanks (FBs), laboratory duplicates, laboratory control and matrix control spikes, and equipment blanks (EBs). Data verification and validation protocols are detailed in the QAPP and described below in Section 6.9.

3.1.6 Specify Performance or Acceptance Criteria

Step 6 of the process outlines the performance and acceptance criteria for the study. Major sources of uncertainty are identified and the measures taken to minimize the impacts of these uncertainties are defined. Uncertainty is always present in the measurement and interpretation of environmental data. In this case, the focus is on collecting and interpreting data to better characterize the nature and extent of contamination including identification of potential sources (i.e., contaminated groundwater discharge).

In the absence of defined decision tolerance limits, the sampling design should still strive to identify possible sources of error and minimize them, to the extent practical. The most significant type of error that may be encountered includes that of field sampling. Both random and systematic errors can be introduced during the physical collection of the sample, sample handling, sample analysis, and data handling.

Errors introduced through these steps will be controlled by preparing and following standard operating procedures (SOPs) (**Appendix B**), and establishing appropriate controls for data quality. These controls apply to field procedures (e.g., adherence to SOPs, field equipment calibration, and FDs), laboratory analytical errors (e.g., calibration standard, internal standard, surrogate recoveries, and laboratory control samples [LCS]), and data validation. The QAPP (AECOM, 2016b) provides further detail on error control procedures, both in the field and in the laboratory, and details the target detection limits for the analytes.

Sampling design error is the result of the inherent variability of the sampled population over space and time, the sample collection design, and the number of samples available upon which to base the decision. Because it is impossible to sample every inch of the LVW, there is always a possibility that some feature of the natural variability is missed. Sampling design error can increase the chance for misrepresenting the natural variability by random error (imprecision) or systematic error (bias) in sampling.

Because the number of samples controls how well the sampled population (i.e., LVW surface water) is characterized, use of the DQO process requires that the variability of data be understood to evaluate the trade-off between uncertainty (confidence limit) and sampling intensity. This investigation is meant to characterize the physical and chemical qualities of the LVW using a small but robust data set of the LVW surface water. This data set has a characteristic natural variability that will be represented by this data set if all other sources of variability are minimized. By reducing the errors associated with sample collection handling, analyses, and reporting with the strict adherence and use of standardized and documented procedures, as well as the noting of deviations from these procedures, the induced variability of the data set is minimized and the data set is a better representation of the surface water.

3.1.7 Develop the Plan for Collecting Data

Step 7 is detailed in Sections 4.0 through 6.0.

3.2 Surface Water Grab Sampling

3.2.1 Define the Problem

The characterization of perchlorate concentrations in the LVW has been ongoing for several decades. Surface water in the LVW has been sampled from various locations on a routine basis by the SNWA in accordance with the Las Vegas Wash Coordination Committee's (LVWCC's) Las Vegas Wash Comprehensive Adaptive Management Plan (LVWCC 2000). Overall, perchlorate concentrations in the LVW have generally decreased over time. However, the surface water grab sampling data collected in May 2016 (AECOM 2016a) have shown that concentrations of perchlorate increase with distance downstream. Specifically, concentrations appear to increase near Pabco Road, which may be due to seeps located near Pabco Road (KM-71, KM-70 and KM-45; **Figure 5**) that have been documented to contain high concentrations of perchlorate. These seeps contained 3,400 µg/L (KM-71) to 57,000 (KM-70) µg/L perchlorate during the 2000 seep sampling event. Perchlorate concentrations also increase at a location between LW4.95 (upstream of Calico Weir; 15 µg/L) and LWC4.6 (downstream of Lower Narrows Weir; 44 µg/L), and downstream of Three Kids Weir (LW3.4; 52 µg/L) (**Figure 6**). Surface water samples were collected from 21 surface water and three seep locations in the LVW and tributaries in May 2016 (**Figure 2**). The concentrations of perchlorate generally match the existing CSM, confirming increases in perchlorate concentrations observed in previous sampling near Pabco Road (i.e., LW6.05; 17 µg/L) and Three Kids Weir (LW3.4; 52 µg/L). However, there are locations where increases or decreases appear which may or may not be artifacts of the daily flow regime or stream channel dynamics (**Figure 8**).

Surface water sampling data are needed that represent the current nature and distribution of target constituents, including perchlorate, chlorate, chloride, bromide, and total dissolved solids in the LVW within the limits of the Downgradient Study Area by minimizing fluctuations of the unknown variable of flow between datasets. To accomplish this goal, it is necessary to minimize the influence of flow by sampling the LVW "synoptically" at low and high daily flows. Bounds of variation in concentration can be determined by repeated sampling.

3.2.2 Identify the Goals of the Surface Water Grab Sampling

<u>Principal Study Questions:</u>

- What are the current flow-independent nature and concentration distribution of the target constituents in the LVW?
- Can groundwater and perchlorate discharge to the LVW be identified when flows are removed as a variable?
- How much difference does flow make in concentration?
- Can concentrations be adjusted for flow to obtain better baseline concentrations?
- What are the average concentrations of target constituents at minimum and maximum flows?

The program will provide data to supplement the existing database of perchlorate, chlorate, chloride, bromide, and total dissolved solids concentrations in the LVW. Chloride, bromide, and total dissolved solids data are used primarily to help identify changes in the surface water quality, indicating potential areas of groundwater discharge. Specifically, the field data will be collected to:

- Further assess the concentrations of perchlorate, chlorate, chloride, bromide, and total dissolved solids present in the LVW upstream, near, and downstream of the suspected loci of perchlorate-contaminated groundwater discharges to the LVW with flow reasonably controlled as a variable;
- Provide data that can augment existing data and provide a unique set of data by collecting synoptic samples from the LVW at low and high flows; and
- Provide data to help track potential loci of perchlorate-contaminated groundwater discharges to the LVW, independent of flow.

All samples will be analyzed for perchlorate, chlorate, chloride, bromide, and total dissolved solids. These analytes have been analyzed previously in groundwater and/or surface water, and new data are required to establish current patterns of concentration. As discussed in Section 3.1.2, chromium and hexavalent chromium, sampled in the May 2016 grab sampling event, will not be analyzed. Analytical methods are provided in **Table 2**.

3.2.3 Identify the Information Inputs

Information required to answer the study questions will include existing field data and data to be obtained from the planned sampling event.

As discussed in Section 3.1.3, based on historical data and recent data obtained during May 2016 (AECOM, 2016a), it was determined that perchlorate and chromium concentrations have generally decreased over time. Concentrations had some variation throughout the reach of the LVW sampled, with higher concentrations indicating potential discharge near Pabco Road, Lower Narrows Weir, and Three Kids Weir (**Figure 6**).

As indicated above, USGS has two permanent stream gages in the LVW in the Downgradient Study Area. Stream gages are installed near Pabco Road (USGS 09419700; approximately RM 6) and at Three Kids Wash (USGS 09419753; approximately RM 3.5) and three additional temporary stream gages in the Downgradient Study Area that will be monitored for 5 years. These gages are located upstream of Duck Creek Confluence Weir (approximately RM 6.85), upstream of Bostick Weir (approximately RM 5.1), and upstream of Homestead Weir (approximately RM 4.3) (**Figure 7**). USGS installed these gages in September 2016.

3.2.4 Define the Study Area Boundaries

Step 4 of the DQO process is to define the boundaries of the Study Area. The boundary of the Downgradient Study Area for the RI is shown on **Figure 1** and includes an approximately 3.5-mile stretch of the LVW.

Surface water samples will be collected from 19 locations along the LVW and tributaries, extending from approximately RM 7.2 downstream to RM 3.4. The surface water sample locations are shown on **Figure 9** and listed in **Table 4**. During the SWIP field program, samples may be added following discussion with NDEP. For instance, if the seep KM-45 has standing water, NDEP will be consulted and a sample may be added. Similarly, if the KM-S seep/sump area appears to be flowing from the sump, a sample may be collected following discussion with NDEP. AECOM will monitor for the presence of water in pit KM-45 during each mobilization of the upcoming field program. If the seep is actively flowing, NDEP will be contacted and a sample will be collected. KM-45 will be monitored during each mobilization, but no more than one sample per mobilization will be collected. This SWIP is focused on the area adjoining the LVW along the reach roughly between just upstream of Upper Narrows Weir and to just downstream of the Rainbow Gardens Weir as shown on **Figure 9**.

3.2.5 Develop the Analytic Approach

Step 5 of the process involves designing the approach to answer the questions and achieve the goals. QA/QC is considered during the design process.

Grab samples will be collected twice a day for 4 consecutive days. Sampling will be synoptic at all locations, to occur during low and high flows. At five grab sampling locations nearest the USGS gages (LW3.4, GLW4.4, LW4.95, LW6.05 and LW7.2), samples will be collected during mid-phase flows, approximately 4 hours after the low flow sampling. For purposes of this grab sampling event, the daily low flow (“daily minimum flow”) is defined as the lower 10th percentile of daily flows. For high flows, the 90th percentile of daily flow had been proposed as the sampling target but has been relaxed to the 50th percentile to allow the field teams to work in safe conditions during daylight hours (the 90th percentile of daily flow occurs from approximately 0000 to 0400). Should an event (e.g., storm or other substantial rainfall event) occur that causes an increase in flows outside of the “normal” pattern (as described below), sampling will be postponed for a minimum of 48 hours to allow stabilization of the LVW hydrology.

To evaluate timing at the two primary USGS gaging stations (LVW at Pabco Road and LVW above Three Kids Wash), streamflow data recorded on a 15-minute frequency by the USGS were downloaded and processed for the month of September 2016 (USGS, 2016). The data were evaluated for the average timing of low-flow and high-flow target (below 10th percentile and above 50th percentile, respectively) and variation of that timing. At the Pabco Road gage, streamflow was typically at or below the 10th percentile (188 cfs during September 2016) from 0800 to 1030. Streamflow at the station was typically at or above the 50th percentile (309 cfs) from 1315 to 0315 of the following day. Streamflow at the high-flow target at Pabco Road gage was, therefore, 121 cfs (64%) higher in September than at the low-flow target. At the Three Kids gage, streamflow was typically at or below the 10th percentile (188 cfs) from 0945 to 1300, and typically at or above the 50th percentile (300 cfs) from 1500 to 0515. Streamflow at the high-flow target at the Three Kids gaging station was 112 cfs (60%) higher in September than at the low-flow target.

The timing of low-flow and high-flow targets was also investigated for the fall months of 2015 (October, November, and December) to determine if there is a seasonal variation that might impact upcoming sampling times. Note that the times for October 2015 through November 7, 2015, (dates that were included in 2015 daylight savings time) that are discussed herein have been adjusted for the end of daylight savings time since the SWIP sampling will occur after the end of daylight savings (Sunday, November 6, 2016). Because wastewater discharge is the primary source of water in the LVW, the daily streamflow pattern is expected to adjust to the time change along with the schedule shift of the resident population.

In comparison to September 2016, streamflow at the Pabco Road gaging station was within the target flow ranges approximately 15 minutes later (1 reading interval of the 15-minute frequency data) during the fall months of 2015. The timing was delayed somewhat longer during December 2015 (15 to 60 minutes, or 1 to 4 reading intervals).

At the Three Kids gaging station, streamflow entered the target flow ranges approximately 60 minutes later (45 to 75 minutes, or 3 to 5 reading intervals), but exited the range at a similar time (within 0 to 30 minutes, or ± 2 reading intervals). Streamflow entered the target flow ranges later during the Fall of 2015 and remained there for a shorter period of time. Because both the timing and duration changed, that variation is attributed to alterations in one or more of the upstream control structures between December 2015 and September 2016. Similar to the Pabco Road gage, the December timing was also delayed at the Three Kids gage (by approximately 30 minutes in comparison to the October and November timing).

In comparison to the September 2016 analysis, data from the Fall of 2015 indicate that the timing of flows at the Pabco Road and Three Kids gaging stations is likely to be similar during October and November, but may be shifted out slightly during December. The change in timing and duration observed at the Three Kids gage during the Fall of 2015 is likely due to changes in streamflow dynamics rather than a seasonal change.

On any given day, the actual timing of the statistical flow targets varied by as much as 90 minutes in September 2016. Streamflow sometimes falls back below the 50th percentile during portions of the afternoon and evening. Typically that drop is on the order of 20 cfs, with flow remaining approximately 50% higher than the 10th percentile flow. Streamflow data will be monitored throughout the sampling event and incorporated into the planning of sampling times. Additionally, stream stage data are now available from three new USGS stations in the study area (below Duck Creek confluence, above Bostic Weir, and above Homestead Weir). Data from those stations will help plan the timing of samples at intervening grab sample locations, and refine streamflow estimates at the time of sampling.

Sunrise and sunset in Las Vegas in late October occur at approximately 0700 and 1800, respectively. After the time change in early November, sunrise and sunset in November and December occur at approximately 0630 and 1630, respectively. Teams will work around the timing of sunset, which may fall within the upper range of flows (above approximately the 50th percentile) (“daily high end flows”).

The goal of this program is to assess the potential impact in concentrations from daily flow fluctuations, and to provide data from the daily minimum and high-end flows on consecutive days to determine a bounded average concentration for which flow has been controlled as a variable. Given the small gain in flow between the two USGS stations recording streamflow in the Downgradient Study Area and the predictable daily cycle of flow variation observed throughout this section of LVW, relatively accurate estimates of streamflow can be made at each sampling location using data reported by the USGS at their long-term and short-terms stations in the study area and the short-term stations that will be established by AECOM. The time of each sample will be compared to flows from the nearest USGS gage (**Figure 7**) to allow qualification of any apparently anomalous high or low concentrations. Two long-term USGS gages on the LVW will be used (LVW at Pabco Road [USGS 09419700; approximately RM 6] and LVW above Three Kids Wash [USGS 09419753; approximately RM 3.7]) and three additional temporary (5-year) stream gages in the Downgradient Study Area will be used (upstream of Duck Creek Confluence Weir [approximately RM 6.85]; upstream of Bostick Weir {approximately RM 5.1]; and upstream of Homestead Weir [approximately RM 4.3]). Those stations have been reporting data on stream stage starting in September 2016. Data from those USGS stations will be augmented by stream stage data collected at the nine staff gage installation locations for transect sampling (**Figure 7**). All samples will be analyzed for perchlorate, chlorate, chloride, bromide, and total dissolved solids. Methods are provided in **Table 2**.

Seasonal differences in perchlorate concentrations are not being quantified as part of the SWIP. Data will be available from May 2016 and the SWIP (likely sampling to occur in the early winter of 2016) from several locations in the LVW. Furthermore, seasonal trends, as needed, can be determined qualitatively from the existing SNWA or NDEP database of water quality measurements.

Analytical detection limits and reporting limits are provided in the QAPP (AECOM, 2016b). QA/QC samples will be analyzed with the surface water samples for each analytical method, as defined in the QAPP and as described below in Section 6.8. QA/QC samples will include FDs, FBs, laboratory duplicates, laboratory control and matrix control spikes, and EBs. Data verification and validation protocols are detailed in the QAPP and described below in Section 6.9.

3.2.6 Specify Performance or Acceptance Criteria

Step 6 of the process outlines the performance and acceptance criteria for the investigation. Major sources of uncertainty are identified and the measures taken to minimize the impacts of these uncertainties are defined. Uncertainty is always present in the measurement and interpretation of environmental data. In this case, the focus is on collecting and interpreting data to better characterize the nature and extent of contamination including identification of potential sources (i.e., contaminated groundwater discharge).

In the absence of defined decision tolerance limits, the sampling design should still strive to identify possible sources of error and minimize them, to the extent practical. The most significant type of error that may be encountered is from field sampling. Both random and systematic errors can be introduced during the physical collection of the sample, sample handling, sample analysis, and data handling.

Errors introduced through these steps will be controlled by preparing and following SOPs (**Appendix B**), and establishing appropriate controls for data quality. These controls apply to field procedures (e.g., adherence to SOPs [**Appendix B**], field equipment calibration, and FDs), laboratory analytical errors (e.g., calibration standard, internal standard, surrogate recoveries, and LCS), and data validation. The QAPP (AECOM, 2016b) provides further detail on error control procedures, both in the field and in the laboratory, and details the target detection limits for the analytes.

Sampling design error is the result of the inherent variability of the sampled population over space and time, the sample collection design, and the number of samples available upon which to base the decision. Because it is impossible to sample every inch of the LVW, there is always a possibility that some feature of the natural variability is missed. Sampling design error can increase the chance for misrepresenting the natural variability by random error (imprecision) or systematic error (bias) in sampling.

Because the number of samples controls how well the sampled population (i.e., LVW surface water) is characterized, use of the DQO process requires that the variability of data be understood to evaluate the trade-off between uncertainty (confidence limit) and sampling intensity. This investigation is meant to characterize the physical and chemical qualities of the LVW using a small but robust data set of the LVW surface water. This data set has a characteristic natural variability that will be represented by this data set if all other sources of variability are minimized. By reducing the errors associated with sample collection handling, analyses, and reporting with the strict adherence and use of standardized and documented procedures, as well as the noting of deviations from these procedures, the induced variability of the data set is minimized and the data set is a better representation of the surface water.

3.2.7 Develop the Plan for Collecting Data

Step 7 is detailed in Sections 4.0 through 6.0.

4.0 Sampling and Testing Objectives and Locations

Sampling objectives for surface water are discussed in the following subsections. In addition, the number and types of investigation locations (i.e., surface water sampling locations) are described in these subsections.

4.1 Surface Water Objectives

4.1.1 Staff Gage Installation

Flows in the LVW vary substantially on a daily basis due to discharge of treated water from several wastewater facilities located upstream of the Downgradient Study Area. The wastewater in these daily discharges is assumed to be virtually free of perchlorate and, therefore, will dilute perchlorate concentrations during periods of higher flow. While five USGS water level gages (**Figure 7**) will be used to calculate flow in various section of the LVW, there is a substantial time lag between them. At the two gages with the longest record of data (Pabco Road gage and Three Kids Wash gage), the time lag is approximately 2 hours.

To help determine water levels at locations throughout the Downgradient Study Area, additional water level staff gages will be installed at nine locations in the LVW (**Figure 7**). The staff gages, marked in 0.01-foot increments, will be secured in the channel at a location that is near enough to allow accurate readings from the stream banks and deep enough to cover the range of streamflow variation. A recording pressure transducer will be installed at the staff gage locations to allow the collection of high-frequency data. The installation will be similar to installations by the USGS but modified as appropriate given the temporary nature of the installations (see SOP in **Appendix B**). Instead of daylighting in an instrument shelter, the transducer will be accessed through a secured PVC standpipe. These locations fill in spatial gaps from the USGS gages and will help provide a continuum of measurements. Flows (as cfs) will not be quantified in these staff gages, but can be grossly estimated using water level data at the locations and flow measurements at the long-term USGS stations at Pabco Road and above the Three Kids Wash. At each of the gages, transects will be established (see below). The water depth will be measured along the transects to provide a cross-section depth profile at each transect. These cross sections will be used primarily to identify sampling locations along the transects, but can also be used to provide a qualitative estimate of flow at each location.

4.1.2 Transect Sampling

Several seeps and springs were previously identified along the LVW, but the locations of these seeps may have been altered or they may have been eliminated during the construction of the flood control weirs. Not all seeps contain water with detectable concentrations of perchlorate. At locations where perchlorate discharges are suspected, transect sampling will be conducted to provide an average perchlorate concentration within the transect and to help determine if discharges are occurring on the northern bank, the southern bank, or within the channel of the LVW.

4.1.3 Grab Sampling

Previously, surface water grab samples from the LVW were collected by the SNWA at many locations along the LVW including those proposed in this SWIP. Some grab locations proposed in this SWIP have not been sampled, and, based on available data, flows have not been controlled (i.e., sampling during a specific time window of flow) during a robust sampling effort. Grab sampling with flows controlled will be conducted to obtain a current snapshot assessment of perchlorate concentrations in the LVW, to determine if loci of groundwater discharge can be determined, and to determine if loci of perchlorate in groundwater can be determined.

4.2 Sampling Activities

4.2.1 Staff Gage Installation and Transect Sampling of Surface Water

Staff gages will be installed at nine locations in the LVW, and transects will be established at each of these gages as well as at USGS gages located at Duck Creek Confluence Weir and above Homestead Weir (**Figure 7**). These locations were selected both to help refine areas where perchlorate discharge may be entering the LVW and to fill some gaps in the knowledge of flows in the LVW (i.e., fill spatial gaps between USGS stations). At each location, a staff gage will be installed and a cross-sectional diagram of water depth and bottom contour will be developed using a metered pole by wading across the LVW and recording water depth at intervals to be determined in the field, based on the field conditions at each transect.

During the gage installation and transect sampling event, approximately 40 surface water locations will be sampled. A list of the surface water transect locations are presented in **Table 3**. The locations along the transects will include the northern bank, southern bank, and approximately two locations near mid-channel. The transect locations and the staff gage locations are shown on **Figure 7**. Surface water samples will be analyzed for the following constituents:

- Perchlorate (EPA Method 314.0);
- Chlorate (EPA Method 300.1);
- Chloride (EPA Method 300.0);
- Bromide (EPA Method 300.0); and
- Total dissolved solids (Standard Method [SM] 2540C).

Water sampling activities for the NERT RI include field-filtering water samples analyzed for perchlorate using the sterile filtration method described in NDEP guidance document (2010); however, the NERT RI QAPP may be modified to indicate that sterile filtration is no longer required for the NERT site groundwater monitoring program. As directed by NDEP, field-filtering of water samples for perchlorate analysis is not required (NDEP, 2015). Details of the analytical program are listed in **Table 2**. Surface water sampling activities are described in Section 5.5.

4.2.2 Grab Sampling of Surface Water

During the grab sampling event, 19 surface water locations will be sampled. Samples will be collected from daily minimum flow and daily high-end flow, and will be collected over 4 consecutive days. A list of the surface water locations is presented in **Table 4**. The surface water grab sample locations are shown on **Figure 9**. Surface water samples will be analyzed for the following constituents:

- Perchlorate (EPA Method 314.0);
- Chlorate (EPA Method 300.1);
- Chloride (EPA Method 300.0;
- Bromide (EPA Method 300.0); and
- Total dissolved solids (SM 2540C).

Water sampling activities for the NERT RI include field-filtering water samples analyzed for perchlorate using the sterile filtration method described in NDEP guidance document (2010); however, the NERT RI QAPP may be modified to indicate that sterile filtration is no longer required for the NERT site groundwater monitoring program. As directed by NDEP, field-filtering of water samples for perchlorate analysis is not required. Details of the analytical program are listed in **Table 2**. Surface water sampling activities are described in Section 5.5.

4.2.3 Pre-field Activities

A site-specific HASP has been developed for the Downgradient Study Area (AECOM 2016c). As needed, this HASP has been augmented by task-specific safety documentation, such as the On Water Safety (**Appendix A**). Because sampling may occur after sunset, locations deemed unsafe for any reason may not be sampled. Working on-water or near-water in low-light conditions can be dangerous. In addition to the unstable footing in the channel or on weirs, water depth cannot be discerned in low-light conditions. The low light can exacerbate the potential hazards already in place. The LVW is also known to host a large homeless encampment and may draw illicit activities from other parties. A JHA will be prepared prior to the field investigation and will outline the specific hazards associated with sampling in low-light conditions on the LVW. The JHA will be circulated to NDEP and will be included in the health and safety appendix of the technical memorandum. The JHA is designed to augment the site-wide HASP (AECOM, 2016c) with information on hazards specific to a task. Teams have the authority to stop work should they deem conditions suspicious or unsafe. All members of the sampling teams will be in contact with each other and with the task lead during the sampling event. As each team finishes work, they will indicate so to the Task Manager and other teams, and assist, as needed, teams still working.

The existing NERT RI QAPP has been adapted to include the proposed Downgradient Study Area investigations, including the proposed surface water sampling described in this SWIP as well as groundwater and subsurface investigations (AECOM, 2016b).

4.2.4 Field Activities

The program design is outlined in Section 3.1.5 and Section 3.2.5, Step 5 of the DQO process. Because the surface water samples do not require filtration, samples will be collected primarily using a direct immersion of sampling bottles. Surface water samples from transects and from grab locations may be collected in the LVW and tributaries using a peristaltic or comparable pump with dedicated tubing as field condition warrant. The sampling methods to be used in the SWIP grab sampling program will be consistent with SNWA sample collection methods, with the exception of the option to use a pump to collect samples. SNWA collects samples from near shore along the bank or mid-channel using direct immersion of bottles. Grab samples collected under this SWIP may be collected from near shore (e.g., the tributary/seep samples identified with "LWC"), when possible and from mid-channel with the use of a boat. Grab samples will be collected from mid-depth to represent the mixed system. Transect samples will be collected from the noted location across the LVW (i.e., near bank or mid-channel). Transect samples will be collected near-bottom to help capture seep discharge, if present. If the water is over 3 feet deep at grab and transect sampling locations, two samples will be collected at each location. For the transect locations, a sample will be collected from near bottom and from approximately one-third of total depth. For the grab locations, samples will be collected from approximately one-third and two-thirds of total depth. Samplers will conduct in-field measurements of pH, electrical conductivity, dissolved oxygen, turbidity, and temperature at surface water locations. An appropriate water quality meter, calibrated as recommended by the manufacturer, will be used.

Non-dedicated sampling and monitoring equipment that is exposed to environmental contaminants will be decontaminated prior to first use and between uses. At a minimum, decontamination procedures will include scrubbing the equipment with a brush or sponge in a solution of Alconox™ detergent (or equivalent) in potable water, followed by two rinses in distilled or deionized water. Instruments requiring calibration will be calibrated prior to first use and once per day following initial calibration, or the manufacturer's specifications. If necessary, instruments may be re-calibrated to confirm readings.

Sampling procedures and equipment are described in greater detail in Section 5.0.

5.0 Sampling Procedures and Equipment

Sampling or other data collection equipment and associated procedures are described in the following sections. Sampling equipment will generally include direct immersion of sample bottles, but may also include pumps with dedicated tubing as need to obtain samples from the depths required. Sampling methods and materials are generally based on the EPA publication Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846) (EPA 1997). SOPs for surface water sampling and staff gage installation are provided in **Appendix B**.

5.1 Documentation Procedures

Records that may be generated during field work include field logs, photographic logs, sample chain-of-custody records, equipment inspection/calibration records, and others, as necessary. Units of measure for any field measurements and/or analyses will be clearly identified on the field forms and in notes and logs as necessary. The QA/QC Officer, or other appropriate person designated by the AECOM Project Manager, will review the field data to evaluate the completeness of the field records.

5.1.1 Field Notes

Field logbooks will provide the means of recording data collection activities at the time they take place. The logbooks will be bound field survey notebooks assigned to field personnel, but they will be stored with the project files in a centralized document repository at an AECOM office location when not in use. Activities will be described in as much detail as possible such that the activity being described can be reconstructed without reliance on memory. Entries will be made in language that is objective, factual, and free of personal opinions or terminology that might later prove unclear or ambiguous.

The cover of each logbook will be identified by the project name, project-specific document number, and the time period which the logbook describes (beginning and end dates). The title page of each logbook will have contact information for the AECOM Project Manager. At the beginning of each entry, the date, start time, weather, names of all team members present, level of personal protective equipment (PPE) being used, and the signature of the person making the entry will be entered. Names and affiliations of visitors to the Downgradient Study Area and the purpose of their visit will be recorded.

Entries will be made in ink, signed, and dated; no erasures will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark, initialed, and dated by the user. Whenever a sample is collected or a field water quality measurement is made, it shall be recorded. Photographs taken will be identified by number, and a description of the photograph will be provided. Equipment used to conduct water quality measurements will be identified including serial number, and any calibration conducted will be recorded.

5.1.2 Photographs

Digital photographs will be taken if necessary to supplement and verify information entered into field logbooks. For each photograph taken, the following will be recorded in the field logbook:

- Date, time, and location;
- Number and brief description of the photograph; and
- Direction in which the photograph was taken, if relevant.

If a group of photographs is taken during a task, general notes will be sufficient, as long as the information outlined above can be inferred from the notes provided.

5.2 Instrument Calibration Procedures

Instruments requiring calibration include water quality meters (e.g., pH, dissolved oxygen, specific conductivity, and turbidity meters). Equipment that can be field calibrated will be calibrated at least once per day prior to beginning sampling activities, with calibration results documented in the field logbook. Equipment that must be calibrated in a laboratory setting will be used only if a current calibration certificate is available (for example, a calibration certificate is provided with a piece of rental monitoring equipment). Calibration procedures will be consistent with manufacturer instruction manuals for each instrument. Calibration and maintenance procedures for field equipment are detailed in the QAPP (AECOM, 2016b).

5.3 Equipment Cleaning Procedures

Non-dedicated sampling and monitoring equipment that is exposed to environmental contaminants will be thoroughly decontaminated prior to first use and between uses. At a minimum, decontamination procedures will include scrubbing the equipment with a brush or sponge in a solution of Alconox™ detergent (or equivalent) in potable water, followed by two rinses in distilled or deionized water.

Equipment that is new from the factory must be wrapped in plastic as it is being transported to the Downgradient Study Area. If equipment is not wrapped in plastic during transport, it must be decontaminated prior to use.

Instructions and guidance for decontamination of sampling equipment is included in each SOP that pertains to sampling or testing of environmental media. SOPs/Field Guidance Documents[1] (FGDs) are provided in the QAPP (AECOM, 2016b); surface water sampling and staff gage installation SOPs are provided in **Appendix B**.

5.4 Investigation-Derived Waste Management

In general, investigation-derived waste (IDW) associated with the collection of surface water samples will consist mainly of purged surface water, used PPE (disposable nitrile gloves) and household trash such as used paper towels, etc. The liquid IDW (i.e., surface water from purging) will be temporarily placed into a polyethylene tank or bucket and returned to the LVW upon completion of sampling at each location. The remaining IDW will be double-bagged in plastic trash bags and will be disposed as municipal trash. The SOP/FGD for IDW management is provided in the QAPP (AECOM, 2016b).

5.5 Field Procedure

All activities must comply with the HASP (AECOM, 2016c), AECOM's On-Water Safety procedures (**Appendix A**), and task-specific JHAs to be developed for the field activities described in this SWIP. Samplers need to take care to ensure skin does not contact the water. Appropriate PPE, as described in the HASP, will be used.

5.5.1 Staff Gage Installation

Nine of the ten transect locations will also require the installation of equipment for monitoring stream stage (**Figure 7**). Data collected at those stations will be used to predict the diurnal fluctuation of streamflow, so samples can be timed to the localized daily low and high flow cycles. A detailed description of staff gage installation is in the SOP (**Appendix B**). During the installation, appropriate PPE will be used to minimize contact with water and to protect against injury from the use of hand tools.

At the staff gage stations, the streambed will be probed for locations allowing a fencepost to be driven into the alluvium. A stilling well will be attached to the secured fencepost consisting of a section of polyvinyl chloride

---

[1] SOPs refer to procedural documents developed by AECOM for this program. FGDs are procedural documents already provided for this program by ENVIRON International Corporation.

(PVC) pipe that is open to the surface water at the bottom and sides (slots or series of spaced holes). The top of the stilling well will be outfitted with a lockable top for security. A staff gage will also be attached to the fencepost/stilling well allowing for manual readings of changes in stream height. Within the stilling well, a recording pressure transducer will be installed. The transducer will be programmed to record pressure at a high frequency (i.e., once every 5 minutes). Depending upon instrument selection, automated readings from the transducers may need to be corrected for barometric pressure fluctuations before they can be calibrated using the manual staff gage readings. If barometric correction is required, one or more recording barometers will be installed nearby and programmed to record at the same frequency as the pressure transducers. Data from the transducers will be downloaded using the manufacturer’s software and processed at appropriate junctures. Before removing and after replacing the transducer, a manual reading should be recorded at the time of an automated reading (every 5 minutes on the hour). After downloading, care should be taken to make sure the transducer comes to rest at its prescribed depth within the stilling well.

5.5.2 Water Sampling

For this sampling event, surface water samples will primarily be collected using direct immersion of sampling bottles in the LVW. Direct immersion, as described in the SOPs (**Appendix B**) can be a desirable method when filtration and preservation are not required and conditions (i.e., depth) are amenable. Where conditions are not amenable to direct immersion due to water depth or access concerns, samples will be collected using a peristaltic pump (or comparable pump) and disposable tubing. These methods are included in the SOPs (**Appendix B**). Grab samples will be collected from approximately mid-stream and mid-depth. Transect samples will be collected from the designated location along the transect across the LVW and will be collected near-bottom (i.e., as close to the bottom as possible without disturbing substrate). At grab and transect sampling locations, if the water is over 3 feet deep, two samples will be collected at each location. For the transect locations, a sample will be collected from near bottom and from approximately one-third of total depth. For the grab locations, samples will be collected from approximately one-third and two-thirds of total depth.

To collect a sample by dipping the sample bottle into the LVW, the Sampler will carefully wade into the LVW, so that the Sampler is facing upstream. Samples must be collected so that the Sampler is not standing upstream of the bottle. The Sampler must then slowly lower the capped bottle into the water with the mouth of the bottle pointed toward upstream, until the lower lip of the opening is submerged to approximately mid-depth. The cap is then removed and the water fills the bottle very gradually, avoiding creating turbulence (which could add sediment to the sample and possibly bias the analytical results). When the water level in the bottle has stabilized, the Sampler must slowly rotate the bottle upright and fill it completely before capping the bottle while still submerged and then must affix the label. The Sampler must then fill out the label and record the sample on the chain-of-custody form.

Samples may be collected using a pump and tubing. When this method is used, the tubing will be purged with three volumes of water prior to sample collection. Tubing will be held at the desire sampling depth (mid-depth in the water column for grab sampling and near-bottom for transect sampling) by affixing the end of the tubing to a weighted line or pole. Prior to and during sample collection, care shall be taken to prevent the tubing from coming into contact with sediments.

6.0 Sample Designation, Handling and Analysis

In general, field sampling personnel and subcontracted analytical laboratories will handle samples in a manner to maximize data quality. Samples will be collected, handled, and stored in such a manner that they are representative of their original condition and chemical composition. Identification of samples and maintenance of custody are important elements that will be utilized to ensure samples represent surface water conditions in the locations sampled. All samples will be properly identified and maintained under chain-of-custody protocol to protect sample integrity. The following sections discuss the sample handling and custody requirements in detail. It should be noted that this information is also provided in the QAPP (AECOM, 2016b) where appropriate, and is included in this SWIP for ease of use by field staff during the investigation.

6.1 Sample Identification

To maintain consistency, a sample identification convention has been developed and will be followed throughout the implementation of the SWIP. The sample identification numbers (IDs) will be entered onto the sample labels, field forms, chain-of-custody forms, logbooks, and other records documenting sampling activities. To maintain consistency with previous sampling programs, the location IDs for re-visited locations are the approximate RM prefaced by “LW” for samples within the LVW. New grab sample locations are prefaced with “GLW” to differentiate from sample locations previously sampled by SNWA. The transect locations are identified as the RM of the transect prefaced by “T”. RMs were determined relative to existing LW locations and are only approximate.

The identification system for Downgradient Study Area Investigation primary field samples from a surface location consists of the surface water location number (usually as RM) followed by the sample date in YYYYMMDD format. The depth of each sample will be identified at the end of the sample identification by “-X”, where X equals the measured sample depth in feet (within approximately 1/10th of a foot) from the water surface at the time of sampling. For example, a surface water sample collected from location LW5.7 on October 6, 2016 at 0.8 feet depth from the water surface, will be identified as LW5.7-20161006-0.8.

At the transect locations, the transect name (e.g., T5.3) will be followed by a letter designation (A, B, C, etc.) which will identify its location along the transect. Station “A” will be the southern bank, “B” will be the next station north, etc. For example, a surface water sample collected from the southern bank of T5.3 on October 6, 2016 at a depth of 1.5, will be identified as T5.3A-20161006-1.5.

6.1.1 Field QA/QC Sample Identification Numbers

Field QA/QC samples and procedures are discussed in Section 6.8. The field QC sample codes that may be applied include:

- EB for Equipment Blanks,
- FB for Field Blanks, and
- FD for Field Duplicates.

Field QA/QC sample codes will be appended to the end of the primary sample ID that is represented by the field QA/QC sample.

An EB should be named for the sample collected immediately prior to the collection of the EB.

The FB represents a group of samples: a batch of 20 for the FB. Thus, the FB should be named after the first sample of the batch.

The FD represents the primary sample that is being duplicated, thus the FD should be named after the corresponding primary sample.

For example, the first surface water sample collected is LW5.7-1-20161006-0.8. The sample is to be analyzed for total dissolved solids, and a duplicate sample is collected. An EB is collected immediately following the collection of the surface water sample (after decontamination of sampling equipment). The associated field QA/QC samples will be identified as:

- LW5.7-20161006-0.8-EB (Equipment Blank),
- LW5.7-20161006-0.8-FB (Field Blank), and
- LW5.7-20161006-0.8-FD (Field Duplicate).

Field QA/QC samples and the frequencies of collection are summarized in Section 6.8 of this SWIP and detailed in the QAPP (AECOM, 2016b).

6.2 Sample Labels

A sample label will be affixed to all sample containers sent to the analytical laboratory. Field personnel will complete an identification label for each sample with the following information written in waterproof, permanent ink:

- Client name (“NDEP”) and project number;
- Sample location;
- Unique sample identifier;
- Date and time for sample collected;
- Filtering performed, if any;
- Preservative used, if any;
- Name or initials of Sampler; and
- Analyses or analysis code requested.

The use of pre-printed sample labels is preferred to reduce sample misidentification problems due to transcription errors. Sample labels must be completed and affixed to the sample container in the field at the time of sample collection.

If errors are made on a sample label, corrections will be made by drawing a single line through the error and recording the correct information. All corrections will be dated and initialed.

6.3 Containers, Preservation, and Hold Time

The analytical methods, type of sample containers to be used for each sample type and analysis, preservation requirements for all samples, and holding times are provided in the QAPP (AECOM, 2016b).

Each lot of preservative and sampling containers will be certified as contaminant-free by the provider and/or the laboratory. The laboratories will maintain certification documentation in their files. Preserved samples will be clearly identified on the sample label and chain-of-custody form. If samples requiring preservation are not preserved, field records will clearly specify the reason for the discrepancy.

Surface water sample containers will be refrigerated or placed in a cooler with ice to chill and maintain a sample temperature of 4 degrees (± 2 degrees) Celsius.

6.4 Sample Handling and Transport

Proper sample handling techniques are used to ensure the integrity and security of the samples. Field parameters will be measured prior to sample collection in the field by the sampling crew and recorded in the field logbook and field data sheets. Samples for laboratory analysis will be transferred immediately to appropriate laboratory-supplied containers in accordance with the following sample handling protocols:

- The Sampler will don clean gloves before touching any sample containers, and take care to avoid direct contact with the sample.
- Samples will be quickly observed for color, appearance, and composition and recorded as necessary.
- The sample container will be labeled before or immediately after sampling in accordance with Section 6.2 of this SWIP.
- Sample containers will be placed in Ziploc™-type plastic bags. The samples will be placed in an ice chest and cooled to 4 degrees (± 2 degrees) Celsius for transport to the laboratory.
- All sample lids will stay with the original containers and will not be mixed.
- Sample bottles will be wrapped in bubble wrap as necessary to minimize the potential for breakage or damage during shipment.
- The chain-of-custody form will be placed in a separate plastic bag and taped to the cooler lid or placed inside of the cooler. A custody seal will be affixed to the cooler.

The Samplers are responsible for proper handling practices until receipt at the laboratory, or by the courier, at which time the Laboratory Project Manager assumes responsibility of the samples through analysis and ultimately to the appropriate disposal of samples. Sample handling procedures specific to the laboratory are described in the individual laboratory QA Manuals provided in the QAPP (AECOM, 2016b).

6.5 Sample Custody

Standard sample custody procedures will be used to maintain and document sample integrity during collection, transportation, storage, and analysis. Custody documents must be written in waterproof, permanent ink. Documents will be corrected by drawing one line through the incorrect entry, entering the correct information, and initialing and dating the correction. The AECOM Project Manager is responsible for proper custody practices so that possession and handling of individual samples can be traced from the time of collection until receipt at the laboratory, or by the courier. The Laboratory Project Manager is responsible for establishing and implementing a control system for the samples in their possession that allows tracing from receipt of samples to disposal.

The chain-of-custody form provides an accurate written record that traces the possession of individual samples from the time of collection in the field until they are accepted at the analytical laboratory. The chain-of-custody form also documents the samples collected and the analyses requested. The Sampler will record the following information on the chain-of-custody forms:

- Client and project number;
- Name or initials and signature of Sampler;
- Name of destination analytical laboratory;
- Name and phone number of Project Manager and Deputy Project Manager in case of questions;
- Unique sample identifier for each sample;
- Data and time of collection for each sample;
- Number and type of containers included for each sample;

- Analysis or analyses requested for each sample;
- Preservatives used, if any, for each sample;
- Sample matrix for each sample;
- Signatures of all persons having custody of the samples;
- Dates and times of transfers of custody;
- Shipping company identification number, if applicable; and
- Any other pertinent notes, comments, or remarks.

Unused lines on the form will be crossed out and initialed.

A sample is considered to be under the control of, and in the custody of, the responsible person if the samples are in their physical possession, locked or sealed in a tamper-proof container, or stored in a secure area.

The person who collects the sample is the initial custodian of the sample. Any transfers are documented on the chain-of-custody form by the individuals relinquishing and receiving the sample, along with their signature, and the date and time of transfer. This transfer must continue until the custody is released to a commercial carrier (i.e., FedEx), or the laboratory (either at the laboratory or to a laboratory-employed courier). If relinquished to a commercial carrier, the carrier assumes custody through their shipping receipt. A copy of the shipping receipt should be attached to the chain-of-custody form as a permanent part of the custody control. If the sample is relinquished to a laboratory courier, the courier will then need to relinquish the sample to the stationary laboratory upon arrival. Once the sample has arrived at the stationary laboratory, it must be entered into the sample custody control system of the laboratory. If the sample is further transported to a subcontracted laboratory, the laboratory will produce an internal chain-of-custody form that will be available upon request. Chain-of-custody forms will be maintained in the digital project file by AECOM and at the analytical laboratory.

To discourage tampering during transport, a custody seal will be placed on each cooler after the samples are packed. These consist of a security tape or label with the date and initial of the sampler or person currently in possession of the sample. Receiving personnel at the laboratory will note on the cooler receipt form whether or not the custody seals are intact.

6.6 Shipping Procedures

If shipping samples using a commercial courier is necessary, each container sent will have a separate chain-of-custody form. Samples collected during the investigation will be identified as environmental samples. Samples will be packed in the same manner as when being transported from the sampler to the laboratory, with the following changes:

- Dry ice is not allowed to be used to chill samples requiring commercial shipment. Frozen water (ice) will be used to chill samples.
- Extra packing material will be used to fill the coolers in order to limit movement within the container.
- Ice should be contained in zip-closure bags, and the cooler should be lined with plastic as described below.
- Coolers containing ice and/or liquid samples should be lined with a plastic bag (such as a contractor garbage bag) to limit the potential for leaks in the event of ice bags leaking or sample container breakage. All necessary precautions must be taken to prevent any liquids leaking from sample coolers while in transit.
- Coolers will be closed and taped shut. If the cooler has a drain, it too will be closed and taped shut to prevent leaks.

- A minimum of two custody seals will be affixed to the front and side openings of the cooler so that the cooler cannot be opened without breaking a seal. The seals will be covered with wide clear tape so that the seals do not accidentally break in transit.
- Non-perishable samples collected on the weekend may be held for more than 3 days if there is no threat of exceeding hold times. If the samples require being chilled and maintained at a cool temperature (4 degrees [± 2 degrees] Celsius), they will be stored under refrigeration and shipped the following workday.

6.7 Field Measurement and Laboratory Analytical Methods

Field measurement methods and laboratory analytical methods will be utilized to analyze samples during implementation of the SWIP.

6.7.1 Field Measurement Methods

Samplers will conduct in-field measurements for depth of water; dissolved oxygen, pH, conductivity, turbidity, and temperature of the surface water at each location. For field parameter measurements, an appropriate water quality meter, calibrated as recommended by the manufacturer, will be used. Meter calibrations and field measurements will be recorded on the appropriate field forms and/or in the field logbook.

6.7.2 Laboratory Analytical Methods

The Project will involve the analysis of surface water samples for the target chemicals and physical parameters (e.g., total dissolved solids) listed in **Table 2**. The laboratory analytical methods that will be used to analyze samples are summarized in the QAPP (AECOM 2016b) and listed in **Table 2**. Additional information about each analytical method and sampling requirements such as containers, preservation, and hold times is provided in the QAPP. Analytical methods and laboratory QA/QC procedures are further detailed in the QAPP.

6.8 Field QA/QC Procedures

Field QA/QC samples that will be collected during the proposed investigation include FDs and EBs. The description and purpose of these samples are discussed in this section. In addition, matrix spike/matrix spike duplicate (MS/MSD) samples and LCS/laboratory control sample duplicate (LCSD) procedures are used as laboratory control measures. While not defined as field QA/QC samples, they may require additional sample volume as described in Section 6.8.3.

6.8.1 Equipment Blanks

EB samples are used to assess the effectiveness of decontamination procedures. EB samples are obtained by filling decontaminated sampling equipment with reagent-grade deionized water, sampling this water, and submitting the sample for analysis. Alternatively, deionized water can be poured over or through the decontaminated sampling equipment and then collected and submitted for analysis. EBs will be collected at a frequency of one in every 20 samples and will be analyzed for the same suite of parameters as the primary sample to assess the effectiveness of decontamination procedures.

6.8.2 Field Duplicates

The FD is a replicate sample collected as close as possible to the same time that the primary sample is collected and from the same location, depth, or source, and is used to document analytical precision. FD samples will be labeled and packaged in accordance with the identification scheme provided in Section 6.1.1. FD samples will have “FD” appended to the sample ID. FDs will be collected at a frequency of one in every 10 primary samples and will be analyzed for the same suite of parameters as the primary sample. The relative percent difference between the FD sample and the primary sample will be evaluated to assess the homogeneity of the sample matrix and to assess the reproducibility of laboratory and field sample collection techniques.

6.8.3 Matrix Spike/Matrix Spike Duplicates and Laboratory Control Samples/Laboratory Control Sample Duplicates

The MS/MSD is an LCS on which additional QA/QC analyses are performed to assess the effect of matrix interference on the analytical results. MS/MSD procedures will be performed on field samples at a frequency of one per 20 samples. Field samples to be used for MS/MSD analyses must be collected with a double sample volume. Similarly, LCS/LCSDs provide controls during laboratory analysis and may also require additional sample volume to be collected in the field.

6.9 Data Validation

Data generated from sampling activities will undergo two levels of review. For these samples, laboratory deliverables equivalent to EPA Level IV will be provided. Approximately 90% of the data will be validated to NDEP Stage-2b and approximately 10% of data will be validated to NDEP Stage-4. Additional details regarding data validation are provided in the QAPP (AECOM, 2016b).

7.0 Coordination with USGS Seepage Study

USGS is currently working under a contract with NDEP to conduct water quality sampling and analysis on the LVW. The three gages recently installed are part of that contract (**Appendix C**). In addition, USGS will conduct seepage studies on the LVW. These seepage studies include taking measurements of temperature and specific conductance at approximately 12 sites (**Figure 10**) in the LVW. In addition, the northern edge of the LVW will be evaluated for additional seeps. The study will occur two times within 1 year over a 2-year period, during late winter and late summer/early fall (periods of low evapotranspiration and low precipitation). USGS will coordinate with Clark County Water Reclamation to, within practical reason, limit and maintain the wastewater discharge at a low discharge with constant flow. Currently, USGS is planning these events to occur:

- Early December 2016,
- Late May 2017,
- Late November 2017, and
- Late May 2018.

The USGS data from the seepage study are intended to identify reaches where groundwater is discharging to the LVW, by measuring increases in flow and changes in temperature and specific conductance.

AECOM will collect surface water grab samples for the analytes of interest during the December 2016 USGS seepage study. One data goal of the SWIP is to limit the influence of flow/discharge on perchlorate concentrations measured throughout the Downgradient Study Area. Because USGS is planning with Clark County Water Reclamation to hold flows for 1 day only during each study period, the other tasks planned in the SWIP cannot be conducted in full during a seepage study.

During the USGS seepage study, AECOM will collect grab samples from the same 19 locations presented in **Table 4** and shown on **Figure 10**. Additional data from these locations, when flows are being held constant, will help identify reaches where perchlorate may be entering the LVW.

8.0 Schedule and Reporting

It is anticipated that the activities described in this SWIP will begin in December 2016 after the SWIP has been approved, as applicable, by NDEP, EPA, and NERT. Staff gage installation will take approximately 5 days to complete. Transect sampling will take approximately 5 days to complete. Surface water grab sampling will take 4 days to complete.

The water samples will be analyzed by TestAmerica at their laboratory in Irvine, California, under standard turnaround time of 10 business days. Once the final laboratory results have been transmitted to AECOM, data validation will be performed, which is estimated to take 4 weeks.

Dependent upon the results, maps showing the perchlorate, chlorate, chloride, bromide, the ratio of chloride/bromide, and total dissolved solids concentrations will be prepared to depict the current surface water conditions and analyte concentrations in the LVW. Figures depicting concentrations of all analytes with distance along the LVW (i.e., by RM) will be prepared. Summary tables of the laboratory data will also be prepared.

A technical memorandum will be prepared that will summarize the results of this surface water investigation. The technical memorandum will include a brief description of field methods used and will present the summary tables of analytical results and the maps. The technical memorandum will also include copies of the field data sheets, the final laboratory report and data validation summary report.

A draft of the technical memorandum will be issued within approximately 3 weeks of completion of data validation, for review by NDEP, NERT and EPA. Upon receipt of review comments, which will be consolidated by NDEP into one comment table, the technical memorandum will be finalized and distributed to NDEP, NERT, EPA, and other stakeholders. This technical memorandum will be further evaluated by NERT, and the associated data will be incorporated into the RI report.

A summary of the SWIP task schedule is provided below.

Task	Approximate Schedule
Staff Gage Installation Activities	1 week following field mobilization
Transect Sampling Activities	1 week following staff gage installation activities
Surface Water Sampling Activities	1 week following completion of transect sampling activities
Laboratory Analytical Report	2 weeks following completion of surface water sampling activities
Data Validation	4 weeks from receipt of final laboratory analytical reports
Coordination with USGS Seepage Study	First USGS seepage study is currently scheduled on December 8, 2016.
Draft Technical Memorandum	3 weeks from data validation

9.0 References

AECOM. 2016a. Surface Water and Seep Sampling Technical Memorandum. NERT Remedial Investigation – Downgradient Study Area. Nevada Environmental Response Trust Site, Henderson, Nevada. Final. November, 2016.

AECOM. 2016b. Quality Assurance Project Plan. NERT Remedial Investigation – Downgradient Study Area. Nevada Environmental Response Trust Site, Henderson, Nevada. Final. March, 2016.

AECOM. 2016c. Health and Safety Plan. NERT Remedial Investigation – Downgradient Study Area. Nevada Environmental Response Trust Site, Henderson, Nevada. Final. February 11, 2016.

ENSR International. 2005. Conceptual Site Model, Kerr-McGee Facility, Henderson, Nevada. February.

ENVIRON International Corporation. 2012. Revised Interim Soil Removal Action Completion Report, Nevada Environmental Response Trust Site, Henderson, Nevada, August 2010 – November 2011. January. Revised September 28. NDEP approved December 17, 2012.

Las Vegas Wash Coordination Committee (LVWCC). 2000. Las Vegas Wash Comprehensive Adaptive Management Plan. Las Vegas Wash Project Coordination Team, Southern Nevada Water Authority, Las Vegas, Nevada.

LVWCC. 2016. https://www.lvwash.org/html/being_done_stabilization_demonstrationweir.html

Las Vegas Valley Water District, 2016. 2016 Water Quality Report

Nevada Division of Environmental Protection (NDEP). 2010. Email from Sara Rairick, Lab Certification Officer, Nevada Division of Environmental Protection, re: Sterile Filtration Required for Perchlorate Sampling. July 9.

NDEP. 2015. Email from James Dotchin, Chief Bureau of Industrial Site Cleanup, Nevada Division of Environmental Protection, re: Sterile Filtration Not Required for NERT Regional Groundwater RI Perchlorate Samples, November 18.

Pavelko, M., D. Wood, D, and R. Laczniak, 1999. Las Vegas Nevada, Gambling with Water in the Desert. U.S. Geological Survey. 16 p.

Rafferty, K.A. 1984. Cultural Resources Overview of the Las Vegas Valley. Bureau of Land Management contribution to the Study of Cultural Resources Technical Report No. 13.

United States Environmental Protection Agency (EPA). 1997. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846). Office of Solid Waste, Washington, DC 20460. June.

EPA. 2001. EPA Requirements for Quality Assurance Project Plans (QA/R-5). March.

EPA. 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4). February.

United States Geological Survey (USGS). 2016. Flow data obtained from http://maps.waterdata.usgs.gov/mapper/index.html

Tables

Table 1 Existing and Proposed Weirs In and Near the Downgradient Study Area
NERT Remedial Investigation, Downgradient Study Area, Henderson, Nevada

Weir	Approximate Location (RM)	Year Completed
Duck Creek Confluence Weir	6.85	2013
Upper Narrows Weir	6.65	2013
Sunrise Mountain Weir	6.35	Proposed
Pabco Weir	6.05	2000
Historic Lateral Weir	5.4	2000
Historic Lateral Weir Expansion	5.25	Proposed
Bostick Weir	4.95	2003
Calico Ridge Weir	4.7	2004
Lower Narrows Weir	4.4	2011
Homstead Weir	4.1	2011
Demonstration Weir	near 3.6[1]	1999
Three Kids Weir	3.6	2015
Rainbow Gardens Weir	3.3	2004
Powerline Crossing Weir	3.2	2006
Fire Station Weir	2.9	2000

Notes:
RM = River Mile
Locations of existing and proposed weirs provided on Figure 2.
[1] Demonstration Weir was moved in 2007 and ultimately replaced with Three Kids Weir.

Sources:

Las Vegas Wash Coordination Committee.
https://www.lvwash.org/html/being_done_stabilization_bed.html

Table 2 Analytical Plan for Surface Water Samples

NERT Remedial Investigation, Downgradient Study Area, Henderson, Nevada

Analytes	Matrix	Analytical Method	Analytical Laboratory
Perchlorate	Water	EPA Method 314.0 (1)	TestAmerica (Irvine, California)
Chlorate	Water	EPA Method 300.1	TestAmerica (Irvine, California)
Chloride	Water	EPA Method 300.0	TestAmerica (Irvine, California)
Bromide	Water	EPA Method 300.0	TestAmerica (Irvine, California)
Total Dissolved Solids	Water	SM 2540C	TestAmerica (Irvine, California)

Notes:

EPA = United States Environmental Protection Agency

SM = Standard Method

All groundwater and surface water samples will be analyzed for the constituents listed above.

(1) For this NERT RI Downgradient Study Area, field-filtering of surface water samples for perchlorate analysis is not required (NDEP, 2015).

Sources:

NDEP. 2015. Email from James Dotchin, Chief Bureau of Industrial Site Cleanup, Nevada Division of Environmental Protection, re: Sterile Filtration Not Required for NERT Regional Groundwater RI Perchlorate Samples, November 18.

Table 3 List of Surface Water Staff Gage and Transect Locations Proposed for Sampling
NERT Remedial Investigation, Downgradient Study Area
Henderson, Nevada

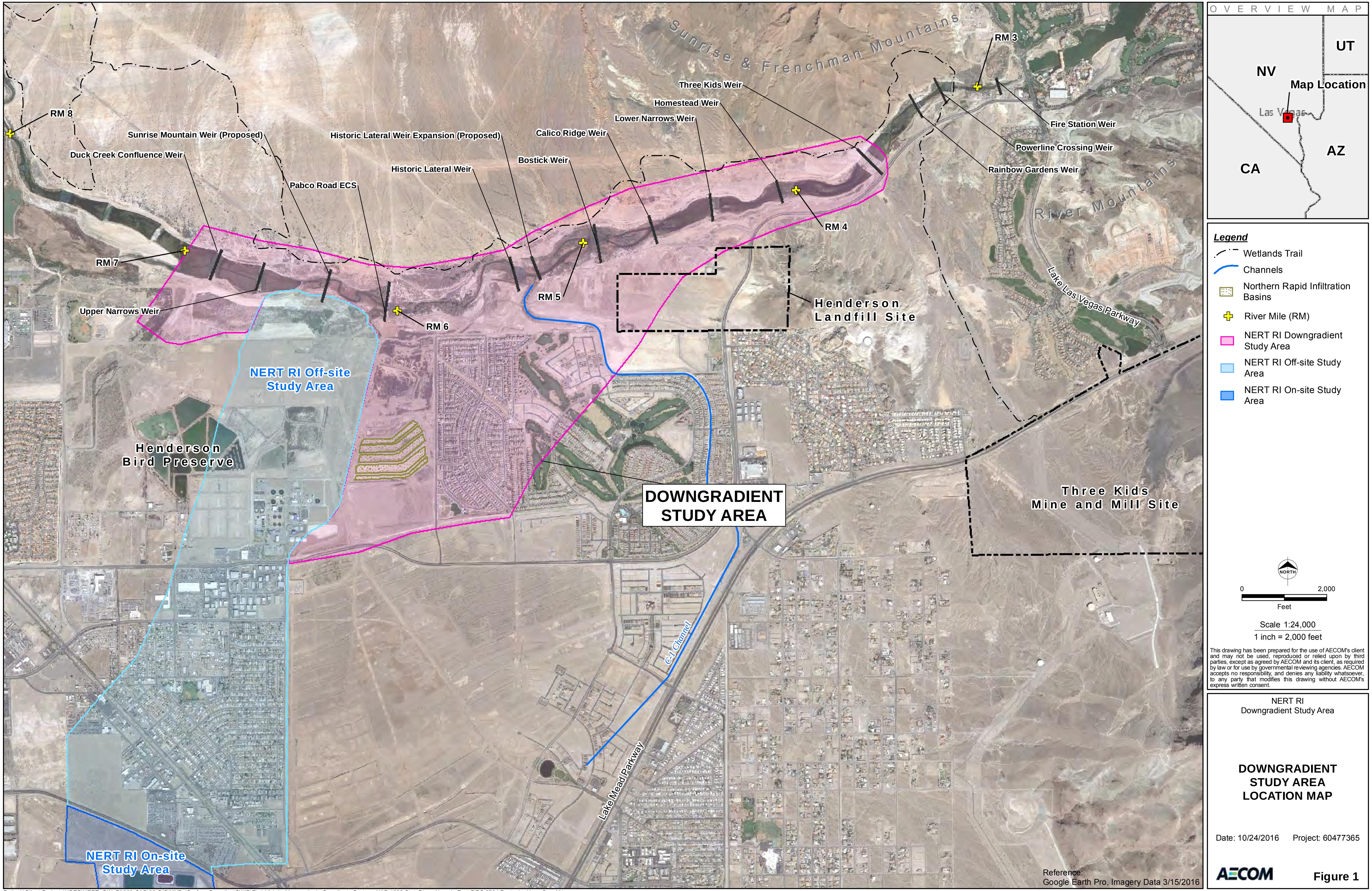
Transect Identification	Location	Rationale for Location
T3.6	Mid-way between Three Kids Weir and Rainbow Gardens Weir	Evaluate water quality downstream of groundwater inputs near Three Kids Weir
T3.75	Immediately downstream of Three Kids Weir	Check for potential groundwater inputs along Three Kids Weir upstream of KM67 (2100 parts per billion of perchlorate)
T3.8	Immediately upstream of Three Kids Weir	Evaluate water quality entering Three Kids Weir
T4.2	Upstream of Homestead Weir	Downgradient of western edge of Henderson Landfill Site near new USGS staff gage/seepage study
T4.6	Downstream of Lower Narrows Weir	Downgradient of middle portions of Henderson Landfill Site in region of observed perchlorate gain
T4.65	Upstream of Lower Narrows Weirs	Downgradient of middle portions of Henderson Landfill Site in region of observed perchlorate gain
T4.75	Downstream of Calico Ridge Weir	Downgradient of western edge of Henderson Landfill Site in region of potential perchlorate gain
T5.3	Downstream of Historic Lateral Weir Expansion	Mid-point between Pabco Road and Calico Ridge Weir
T6	Upstream of Pabco Road Weir	Downstream of Groundwater inputs from NERT Off-Site Study Area and Henderson wastewater treatment plants
T6.35	Downstream of Proposed Sunrise Mountain Weir	Downgradient of NERT Off-Site Study area near mapped location of KM71 seep (3,400 parts per billion)
T6.8	Upstream of Duck Creek Confluence Weir	Upper end of the Downgradient Study at new USGS Gage (09419698)

Table 4 List of Surface Water Grab Locations Proposed for Sampling
NERT Remedial Investigation, Downgradient Study Area
Henderson, Nevada

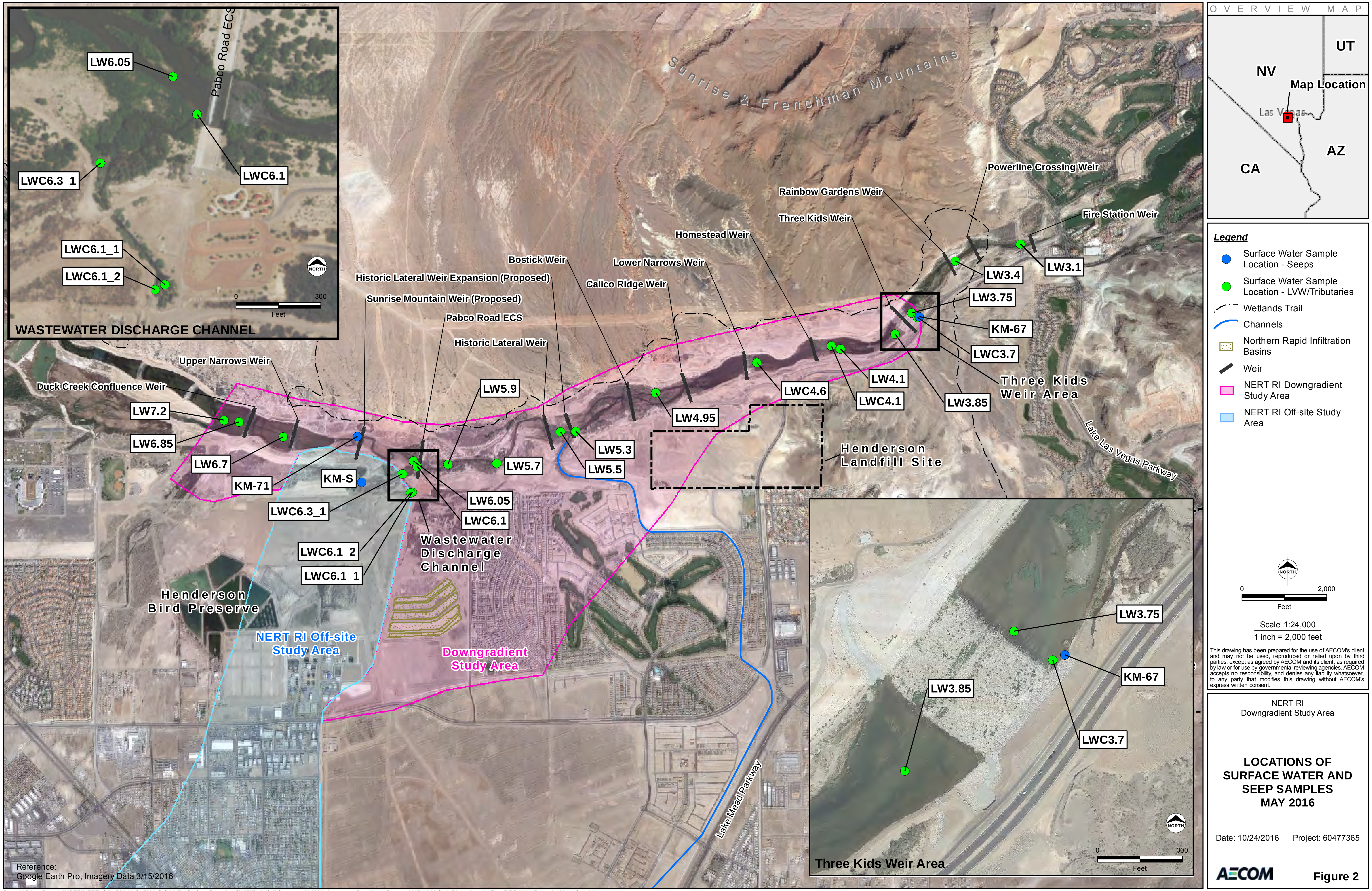
Surface Water Location Sample Identification	Location	Rationale for Grab Location
LW3.4	Downstream of Downgradient Study Area	Concentrations of perchlorate are high; verify concentrations
LWC3.7	Downstream of Three Kids Weir on south bank	Check for potential groundwater inputs along Three Kids Weir upstream of KM67
LW3.75	Downstream of Three Kids Weir	Evaluate water quality passing through main channel of Three Kids Weir
GLW3.78	Along south shore of Three Kids Weir in cobbles	Check for potential groundwater inputs along Three Kids Weir upstream of KM67
LW3.85	Upstream of Demonstration Replacement Weir	Evaluate water quality entering Three Kids Weir
LW4.1	Downstream of Homestead Weir	Downgradient of western edge of Henderson Landfill Site near new USGS staff gage/seepage study
GLW4.4	Immediately upstream of Homestead Weir	Downgradient of middle portions of Henderson Landfill Site in region of observed perchlorate gain
GLW4.85	Downstream of Calico Ridge Weir	Downgradient of eastern edge of Henderson Landfill Site in region of potential perchlorate gain
GLW4.9	Immediately Upstream of Calico Ridge Weir	Downgradient of eastern edge of Henderson Landfill Site in region of potential perchlorate gain
LW4.95	Between Calico Ridge Weir and Bostick Weir	Evaluate water quality in the Las Vegas Wash upgradient of Henderson Landfill Site
LW5.3	Downstream Historic Lateral Weir Expansion	Evaluate water quality in the Las Vegas Wash upgradient of Henderson Landfill Site
LW5.9	Downstream of Pabco Weir	Evaluate water quality in the Las Vegas Wash downstream of Wastewater Tributary and any additional groundwater inputs near Pabco Road
LW6.05	Near Pabco Weir	Evaluate water quality in the Las Vegas Wash upstream of Wastewater Tributary
LWC6.1_1	Wastewater Tributary Upstream of Pabco Road	Verify observed gain in perchlorate downstream of outfall
LWC6.1_2	Wastewater Tributary Upstream of Pabco Road	Significant inflow to the Las Vegas Wash from outfall
GLWC6.1_3	In Wastewater Tributary Downstream of TIMET and COH Outfalls	Determine combined wastestream perchlorate concentrations in wastestream prior to NERT outfall
GLWC6.1_4	In Wastewater Tributary Downstream of NERT Outfall	Evaluate water quality below known inputs to wastewater tributary
LW6.7	Downstream of Duck Creek Confluence Weir	Upstream inputs to the Las Vegas Wash
LW7.2	Upstream of Duck Creek Confluence Weir	Upstream inputs to the Las Vegas Wash

Notes:
Samples beginning with "LW" are historic locations that were sampled in May 2016.
Samples beginning with "GLW" are new grab locations.

Figures



Path: J:\Client-Projects\NDEP\NERT_GW_RI\900-CAD\00-GIS\MXDs\Surface Sampling\SWIP\Fig1 Vicinity Map.mxd | Coordinate System: NAD 1983 StatePlane Nevada East FIPS 2701 Feet | User: ScopM1



NERT RI
Downgradient Study Area

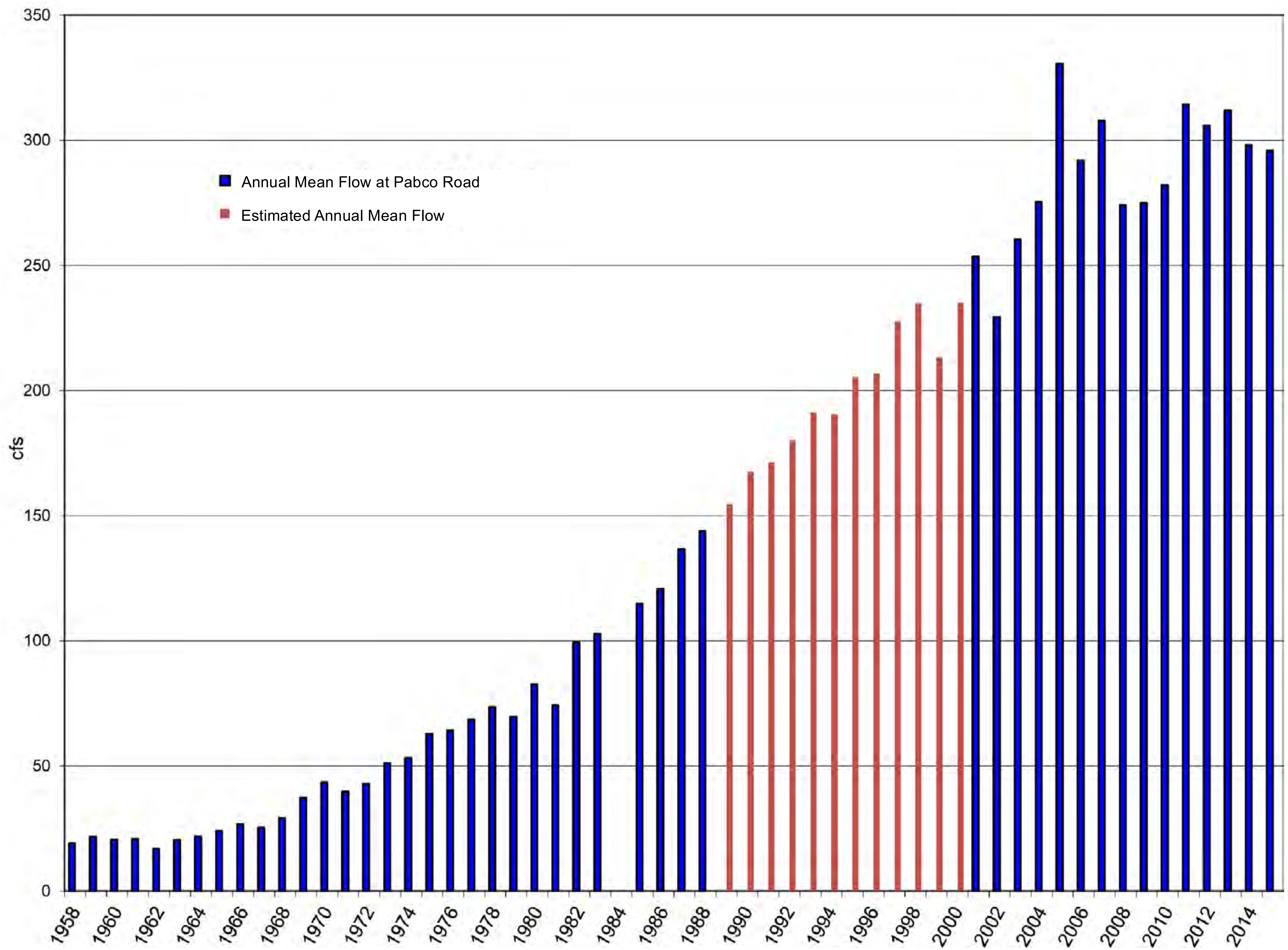
LOCATIONS OF SURFACE WATER AND SEEP SAMPLES MAY 2016

Date: 10/24/2016 Project: 60477365

AECOM

Figure 2

Path: J:\Client-Projects\NDEP\NERT_GW_RI\900-CAD\00-GIS\MXDs\Surface Sampling\SWIP\Fig2_SW Samples_20160711.mxd | Coordinate System: NAD 1983 StatePlane Nevada East FIPS 2701 Feet | User: ScopM1



OVERVIEW MAP

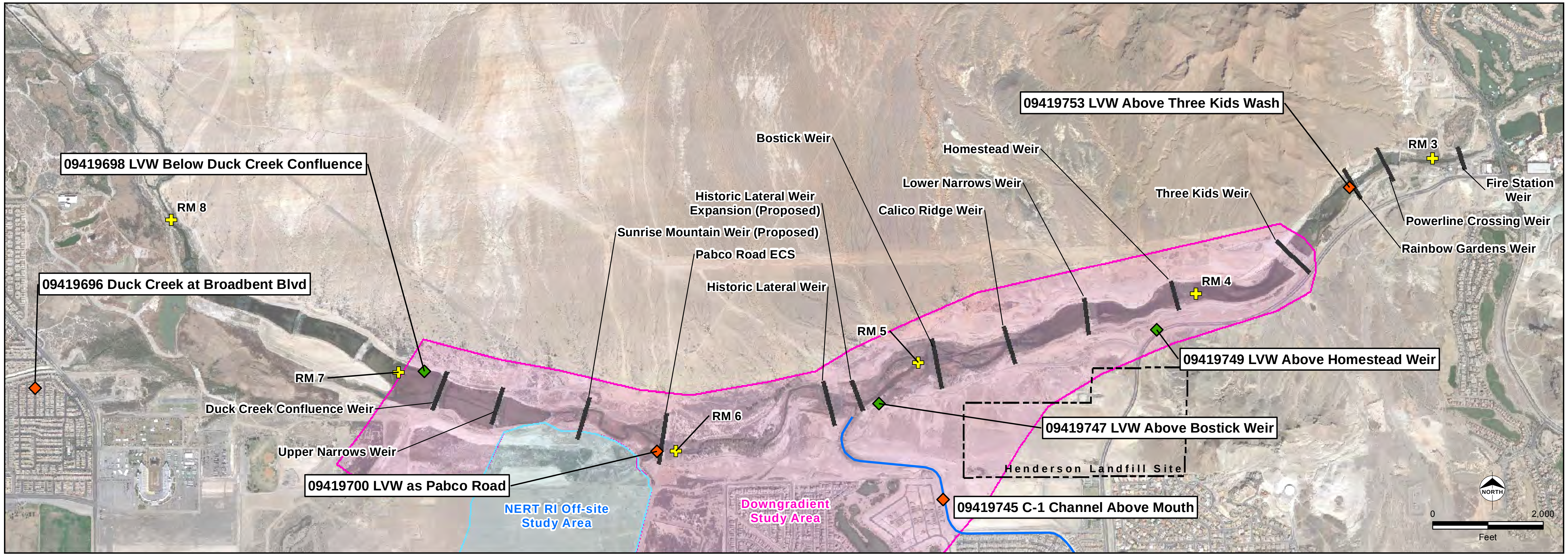
NERT RI
Downgradient Study Area

Annual Aveage Flow in the Las Vegas Wash at Pabco Road

Date: 10/24/2016 Project: 60477365

AECOM

Figure 3

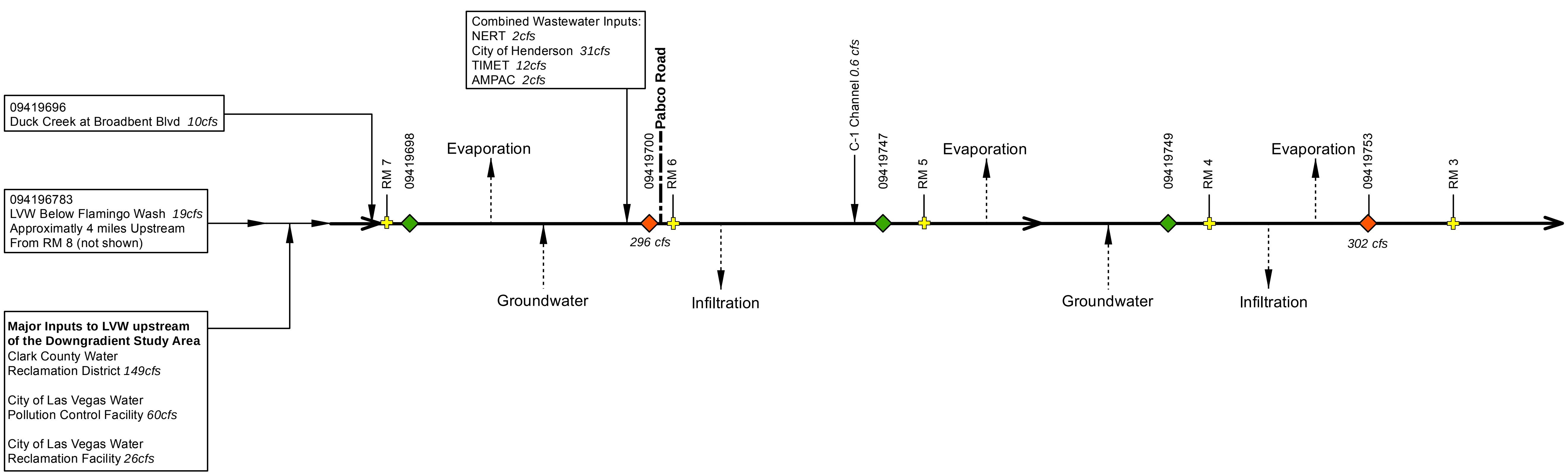


Legend

- Approximate Location of Temporary USGS Stream Gage (Installed September 2016)
- Approximate Location of Permanent USGS Stream Gage
- River Mile (RM)
- Channels
- Weir
- NERT RI Downgradient Study Area
- NERT RI Off-site Study Area
- Non Point Source / Influence

LVW = Las Vegas Wash

cfs = Cubic Feet per Second



NERT RI
Downgradient Study Area

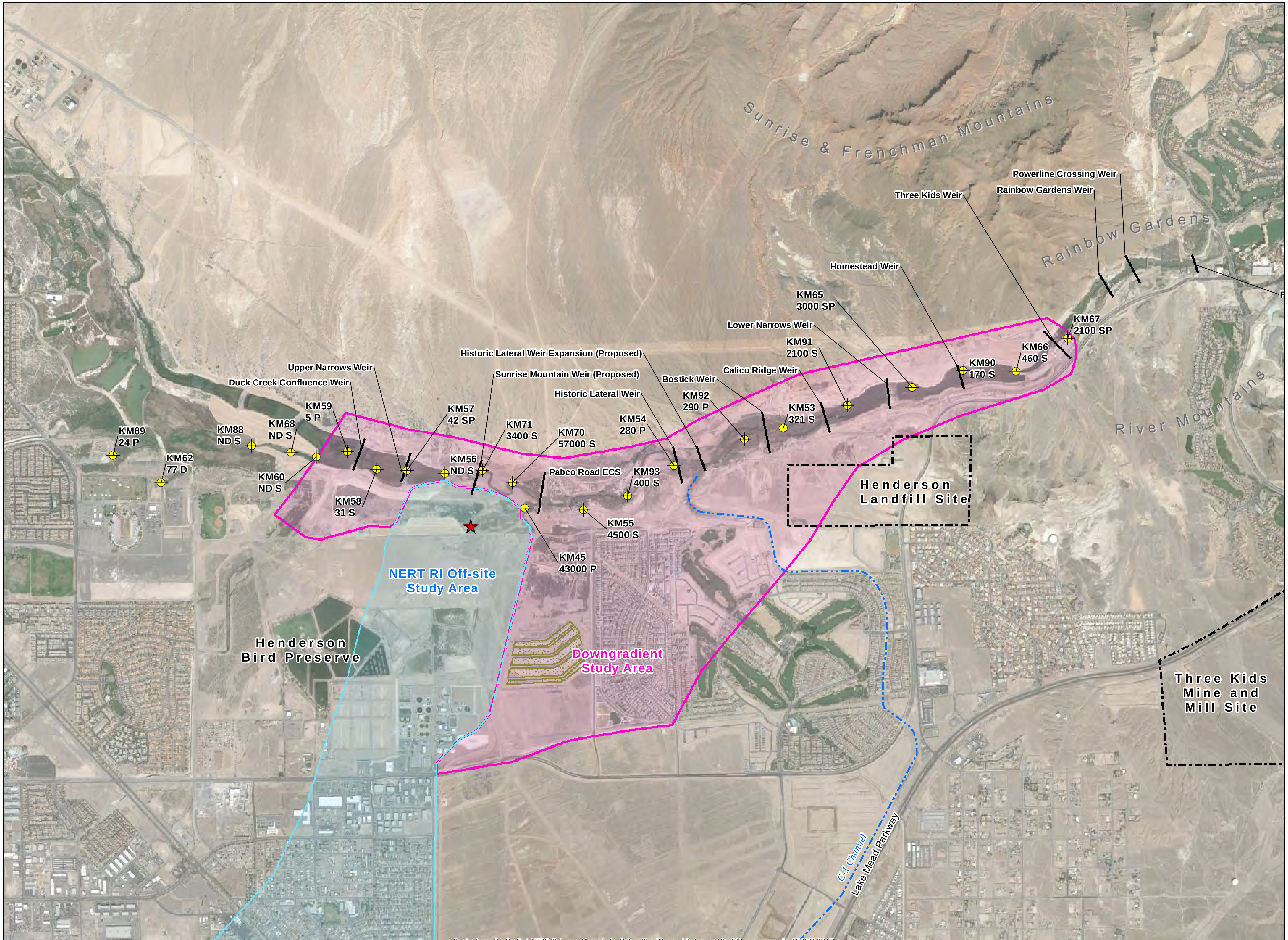
Conceptual Surface Water Model
Las Vegas Wash

Date: 10/24/2016 Project: 60477365

AECOM

Figure 4

Path: J:\Client-Projects\NDEP\NERT_GW_RI\900-CAD\00-GIS\MXDs\Surface Sampling\SWIP\CSM.mxd | Coordinate System: NAD 1983 StatePlane Nevada East FIPS 2701 Feet | User: ScopM1



Legend

- Original Seep Location
- 2000 Seep Locations
- Channels
- Weir
- Evaporation Basin

KM66 Location ID
460 S Perchlorate Result in microgram per liter (µg/l)

Category Chart
P = Pit
S = Seep
Sp = Spring
D = Drain

NORTH

0 2,000
Feet
Scale 1:24,000
1 inch = 2,000 feet

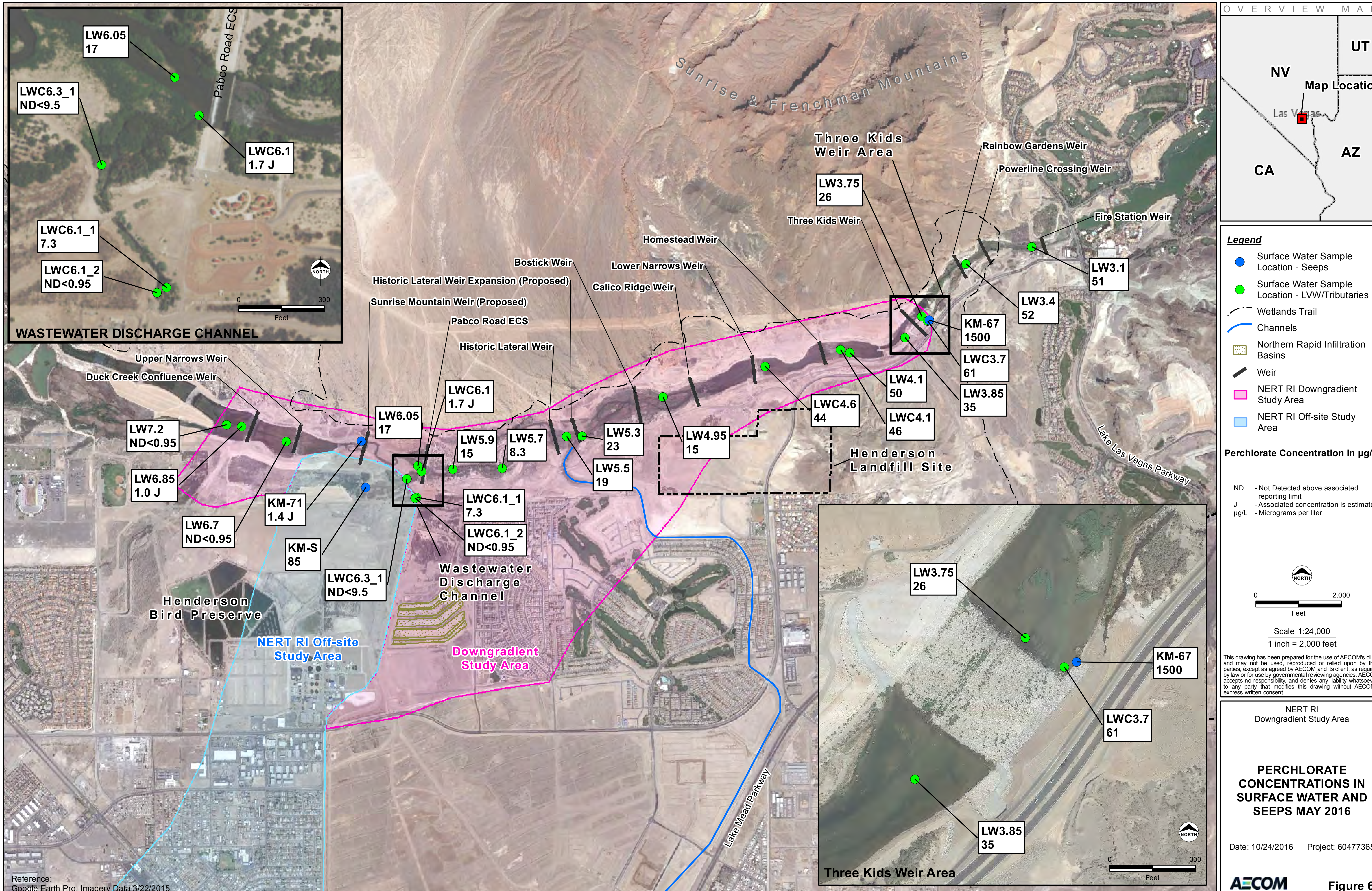
NERT RI
Downgradient Study Area

SEEP AND SURFACE WATER SAMPLING CONDUCTED BY KERR MCGEE IN 2000

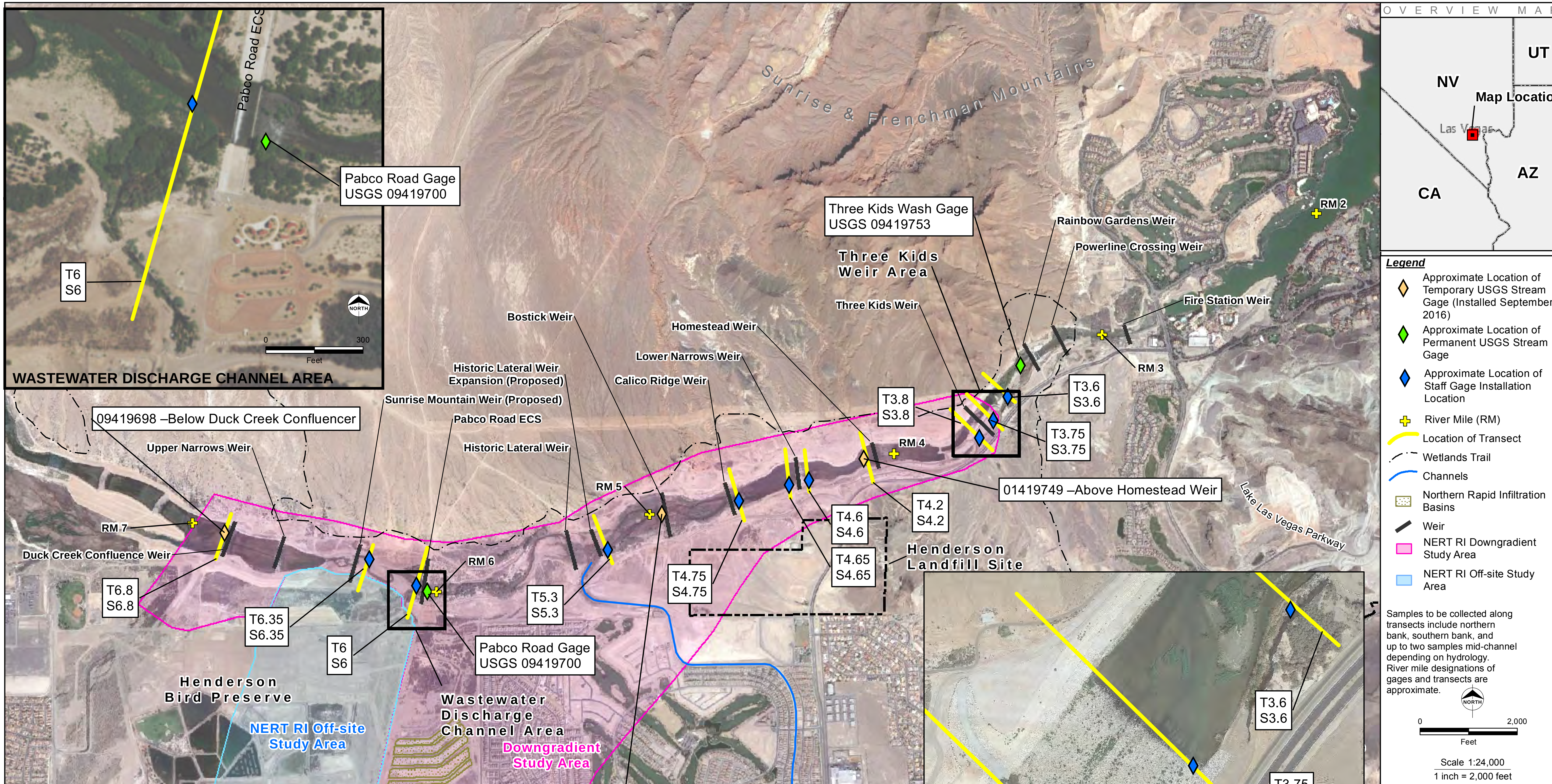
Date: 10/24/2016 Project: 60477365

AECOM

Figure 5



Path: J:\Client-Projects\NDEP\NERT_GW_RI\900-CAD\00-GIS\MXDs\Surface Sampling\SWIP\SW Perchlorate.mxd | Coordinate System: NAD 1983 StatePlane Nevada East FIPS 2701 Feet | User: ScopM1



NERT RI
Downgradient Study Area

TRANSECTS AND STAFF GAGE LOCATIONS

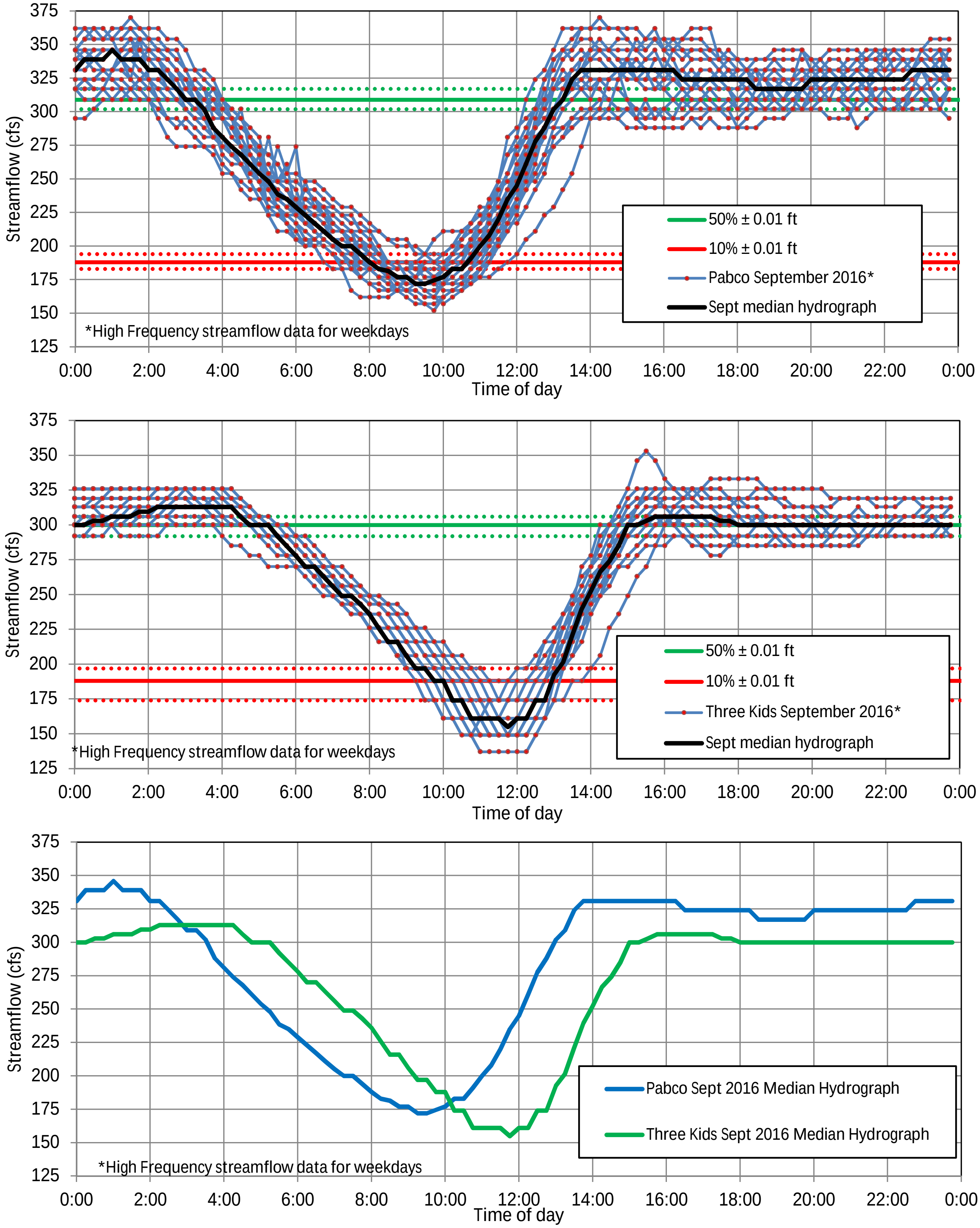
Date: 10/24/2016 Project: 60477365

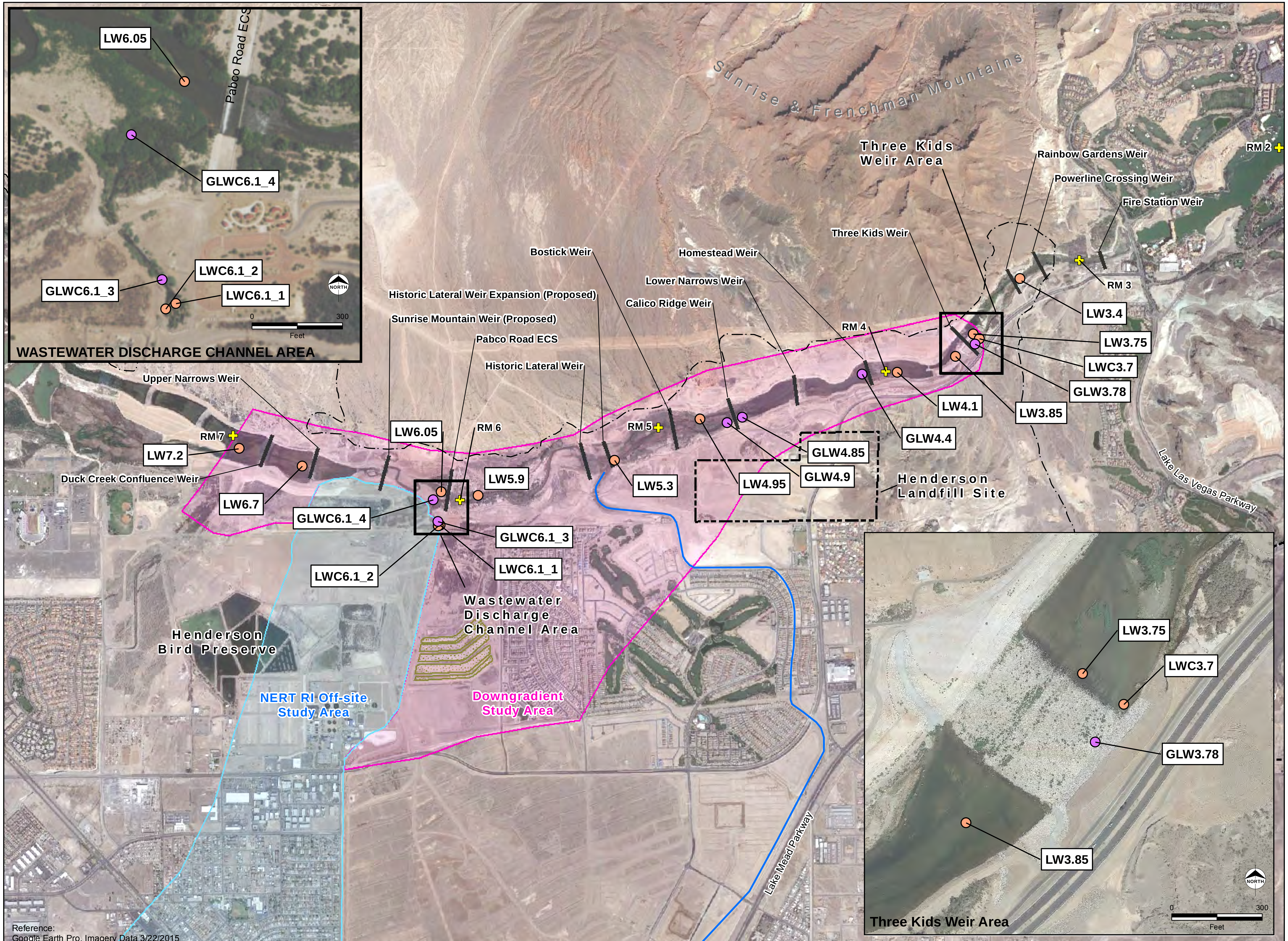
AECOM

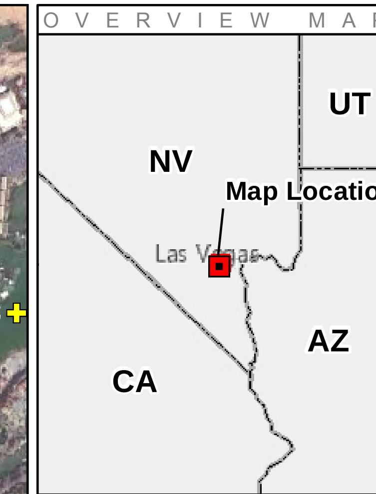
Figure 7

Path: J:\Client-Projects\NDEP\NERT_GW_RI\900-CAD\00-GIS\MXDs\Surface Sampling\SWIP\Gage-Transects.mxd | Coordinate System: NAD 1983 StatePlane Nevada East FIPS 2701 Feet | User: ScopM1

Figure 8. Example Flow Pattern at Pabco Road Gage and Three Kids Wash Gage







Legend

- Proposed Surface Water Sample - Existing Location
- Proposed Surface Water Sample - New Location
- Wetlands Trail
- Channels
- River Mile (RM)
- Northern Rapid Infiltration Basins
- Weir
- NERT RI Downgradient Study Area
- NERT RI Off-site Study Area

NORTH

0 2,000

Feet

Scale 1:24,000

1 inch = 2,000 feet

NERT RI
Downgradient Study Area

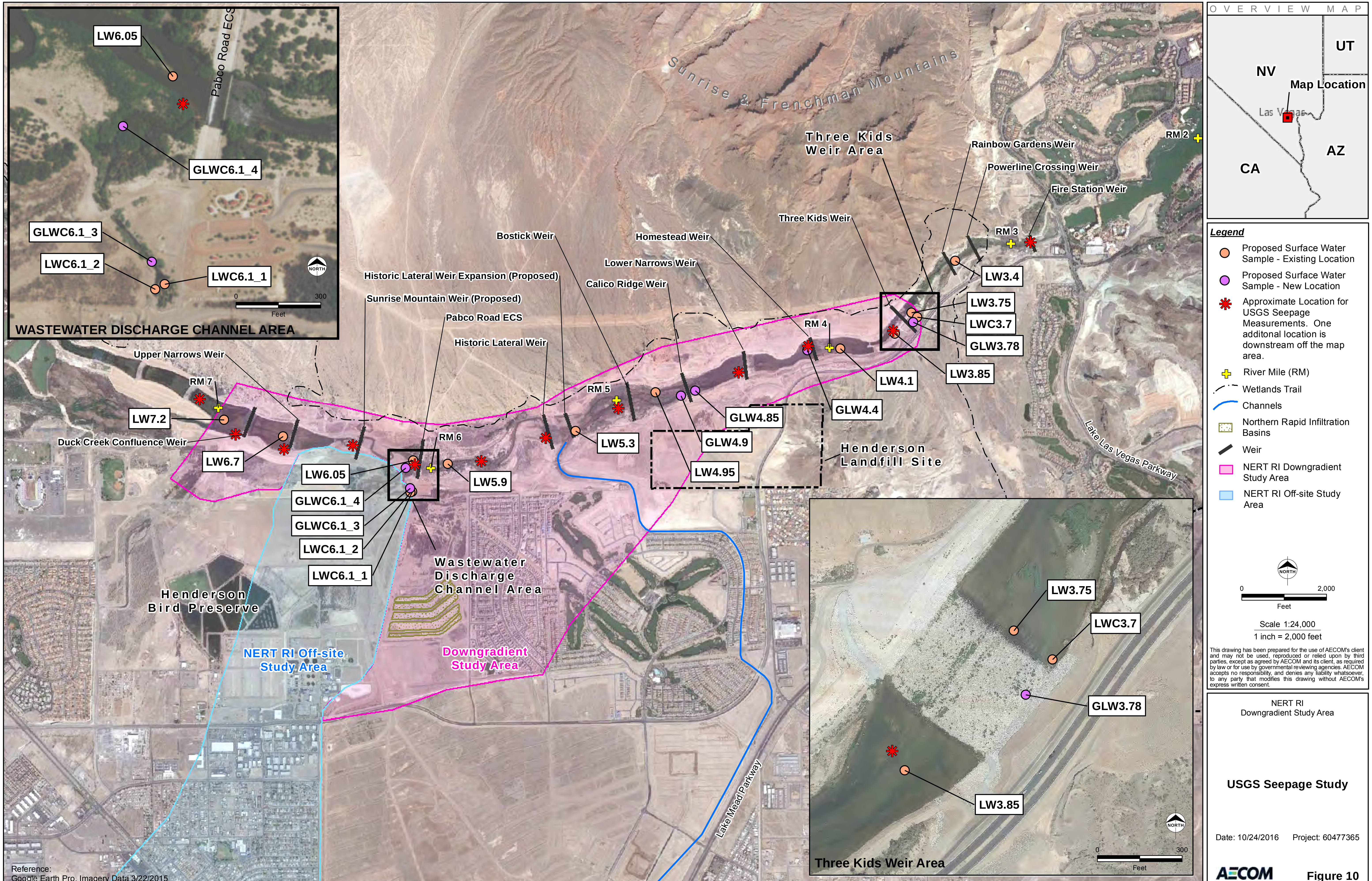
Grab Sampling Locations

Date: 10/24/2016 Project: 60477365

AECOM

Figure 9

Path: J:\Client-Projects\NDEP\NERT_GW_RI\900-CAD\00-GIS\MXDs\Surface Sampling\SWIP\Grab_Samples.mxd | Coordinate System: NAD 1983 StatePlane Nevada East FIPS 2701 Feet | User: ScopM1



Path: J:\Client-Projects\NDEP\NERT_GW_RI\900-CAD\00-GIS\MXDs\Surface Sampling\SWIP\usgs Seepage.mxd | Coordinate System: NAD 1983 StatePlane Nevada East FIPS 2701 Feet | User: ScopM1

Appendix A

On-Water Safety

Working on Water

1.1 Working on Water

Surface water samples are being collected from the Las Vegas Wash by boat (jon boat or canoe) and by wading.

1.1.1 Wading from Shore

If it is necessary to wade into the river, site workers will be required to wear hip waders, or knee high boots, depending on the specific conditions at hand. Because of the increased chance of a slip or fall while wading, it is necessary that all site workers exercise additional care and caution while performing such sampling activities. Site workers are cautioned not to wade into water that are more than knee high in depth, or where the employee cannot visibly see the stream bottom. All water work must be conducted via the buddy system. NO site worker will be permitted to work on or near the water alone. An appropriate personal flotation device (PFD) must be worn at all times when working in or near the water's edge.

1.1.2 Use of Jon Boat or Canoe

A jon boat or canoe may be used in areas of the project site where the water depth limits the practicality of wading. When working from a jon boat or other similar boat, the following precautions will be adhered to:

- Make sure that the right boat is chosen for the work. Evaluate the conditions at the work location and the waterways you must cross to reach that location. Select a boat that is appropriate for the most hazardous waterway. Small, flat bottom boats tend to be unstable and are easily capsized. In addition they often have little freeboard (i.e., distance between the actual water line and the top of the boat's side shell) making them prone to swamping, particularly in rough water.
- The on board sampling team should be comfortable about working on the water (i.e., minimally, each occupant should know how to swim) and should have experience in handling the type of boat that is chosen for the work.
- Do not load the boat beyond its safe loading capacity (SLC), typically found on a label or plate mounted near the stern of the boat. Don't forget to include the weight of equipment brought on board.
- If there is no capacity label, use the following formula to determine the SLC: # People = (length of boat x width) ÷15
- Be aware that the SLC is determined for calm conditions and should be reduced if rough water is anticipated.
- Once on board, distribute the load (people and equipment) evenly and secure all equipment to prevent it from shifting.
- While on the boat, Coast Guard approved Type III or Type V PFDs must be worn at all times by all occupants. PFDs will also be worn while transferring from boat to boat, boat to shore, or during portage.
- Boats longer than 16 feet must also be equipped with at least one Coast Guard approved Type IV throwable PFD.
- No less than two people shall be in the boat during sampling activities. In addition, an on-shore observer should maintain visual contact with the sampling team at all times. The on shore observer must be equipped with communications equipment to contact either the client or emergency responders directly in the event that an emergency situation occurs (e.g., man overboard).
- If work is to be done away from shore or the use of an observer is simply not feasible, the boat or the occupants must be equipped with emergency communications equipment.

- All sampling should be conducted from a seated or otherwise stable position. Do not stand in the boat.
- Samples shall be collected from the bow or stern of the boat (not over the side) to ensure stability.

1.1.3 General Boat Safety

This project presents unique hazards to the sampling team when compared to land-based investigation programs. No effort has been made to incorporate all applicable USCG regulations; however, some selected excerpts from USCG regulations have been included to provide general guidance. The boat operator is ultimately responsible for having knowledge of, and complying with, all USCG and any other applicable marine regulations. The Site Saftey Officer (SSO) for the project will verify that the boat captain (i.e., the AECOM team lead) adheres to USCG requirements.

1.1.3.1 Boat Inspection

Before being placed in service, boats will be inspected by the boat captain and in consultation with the SSO and determined to be in safe operating condition. The boat captain also must verify that all required safety gear is aboard before use. A pre-use inspection of the watercraft also must be performed by the boat captain before each daily use. A daily inspection sheet is provided below.

The boat captain must provide written documentation of the initial boat inspection and the daily inspections to the SSO. These inspections will be documented on standard inspection forms used by the boating contractor.

Watercraft determined to be in unsafe condition shall be taken out of service and its use prohibited until unsafe conditions have been corrected.

1.1.3.2 Boat Registration

All watercraft must meet USCG or state watercraft registration and numbering requirements. The USCG requires that all motorized watercraft be numbered in the state of principal use. A valid certificate showing the numbers issued to the watercraft is required to be on board the watercraft whenever the watercraft is in use. Watercraft registration numbers are required to be painted or permanently attached to each side of the forward half of the watercraft. Watercraft registration must be updated as the governing laws require.

1.1.3.3 Boat Capacity

Support watercraft shall not be loaded (passengers and gear) beyond the weight capacity printed on the USCG information plate attached to the stern. If there is no capacity label, use the following formula to determine the safe loading capacity:

- # People = (length of boat x width) ÷15

Support watercraft shall have sufficient room, freeboard, and stability to safely carry the cargo and number of passengers allowed, with consideration given to the weather and water conditions in which the water craft will be operated. Once on board, distribute the load (people and equipment) evenly and secure all equipment to prevent shifting.

1.1.3.4 Personal Flotation Devices

Site workers working over or near water, where the danger of drowning exists, shall wear a USCG-approved PFD. When selecting the appropriate type and style of PFD, the type of activity being conducted and the required mobility of the user must be considered because some activities may require a PFD which is less restrictive.

Site workers will be required to wear a USCG-approved Type III or Type V PFD work vest when working on the boat. Prior to and after each use, each PFD shall be inspected for defects that would alter their strength or buoyancy. Defective units shall be discarded and suitably replaced.

In situations where the water temperature has fallen below 50˚F, a USCG-approved Mustang flotation suit shall be worn in place of the Type III or Type V PFD work vest.

1.1.3.5 Float Plan

Prior to leaving shore, a plan of the day's activities, including time and place of departure, anticipated return time, and list of employees working on the project, will be filed with the PM. In the event the boat crew does not check in at the designated time stated on the float plan, the PM will be responsible for implementing the emergency procedures outlined in the float plan. A Float Plan Form is provided below.

1.1.3.6 Emergency Equipment

All site personnel conducting activities on all boat(s) are to be informed of the locations of all safety equipment on the boat, including communication with the shore (i.e., VHF radio or cellular phone) and emergency contact list, first-aid kit, fire extinguishers, and throw-ring, as applicable to the specific boat being used. Additionally, each site worker shall be provided written instructions in "Abandon ship/boat" and "person overboard" procedures during their marine safety briefing and verbally prior to the first departure of the work day by the boat captain.

1.1.4 Portage

When using a boat in the Las Vegas Wash, the vessel will need to be carried (portaged) over or around a series of erosion control weirs. These weirs are generally rocky with varying amounts and types of vegetation, depending on the age of the weir. The Pabco Road Weir is a concrete structure that will require circumventing.

When portaging the boat or canoe, field team members should remove heavy items from the boat and carry them separately. The boat should be emptied enough to allow for ease of transport of the vessel across or around the weirs. Dragging the boat may be required at times.

Daily Float Plan

Name of vessel's operator:	
Telephone Number:	
Name of Vessel:	
Registration No.:	
Description of Vessel: Type: Make: Color of Hull/Trim Most distinguishing identifiable feature:	

Rafts/Dinghies: Number: __ Size: __ Color: __

Radio/Communication Type:

Number of persons onboard:

Name:	Age:	Address & Telephone:

Engine Type:___________ H.P.:_______ Normal Fuel Supply (days):_______

Survival equipment on board: (check as appropriate)

☐ Life Jackets	☐ Flares	☐ Smoke Signals
☐ Medical Kit	☐ EPIRB	☐ Paddles
☐ Anchor	☐ Loran/GPS	☐ Life Ring

Trip:

Date & Time of Departure:	
Departure From:	Departure To:

Expected to arrive by:____________ In no case later than:_____________

Date & Time of Arrival:	Boat Lead Signature at Arrival:

Boat Safety Checklist

Keep this page with your boat, ready for inspection. By using this checklist, or one fine-tuned by yourself, you'll be sure that everything is on board and in good working order. Your passengers will appreciate knowing you're concerned about boating safety.

- [ ] Float plan--let a friend or relative know when you're leaving, where you're going, when you expect to return, what to do if you don't, and a description of your boat
- [ ] Registration certificate or documentation
- [ ] Personal Flotation Devices (wearable and throw able)--USCG approved, good condition, readily accessible, assigned and fitted
- [ ] Fire Extinguishers--right number, size, and class for boat; charged, not corroded, nozzle clear, bracketed, readily accessible
- [ ] Visual Distress Signals--current dates on flares, proper number, batteries good if lights or EPIRB
- [ ] Anchors and Line--adequate anchor for bottom, adequate line for water depth
- [ ] Bilge device --bilge pump operable, alternative bailing device available
- [ ] Watch or clock--operable
- [ ] Bright flashlight or searchlight
- [ ] Navigation lights --tested and operable, spare bulbs
- [ ] Batteries--fully charged, encased in plastic boxes or terminals covered, securely fastened down
- [ ] Sound-producing device--horn, whistle appropriate for boat
- [ ] Alternate propulsion--paddle or oar
- [ ] First Aid Kit
- [ ] Tools, spare outboard prop and lock nut
- [ ] Compass
- [ ] Sunscreen
- [ ] Weather Radio

Appendix B

Standard Operating Procedures

Project Standard Operating Procedure
NERT RI - Downgradient Study Area

Water-Level Monitoring with Pressure Transducers in a Surface-Water Feature

Procedure Number: NERT-FI-02

Revision No.: 1

Revision Date: October 2016

Prepared by

C. Steve Howe

Reviewed by:

Date: November 3, 2016

Chad Roper, PhD. CEM #2428, Analytical Task Lead

Date: October 25, 2016

Kristen Durocher, Surface Water Task Manager

Contents

1.0 Scope and applicability

1.1 This project Standard Operating Procedure (SOP) defines the operating procedures for the collection of water samples and in-situ water property data associated with the Nevada Environmental Response Trust (NERT) Remedial Investigation (RI) for the Downgradient Study Area. This SOP addresses the installation of the transducer, proper field data-collection methods, and programming/downloading concerns.

1.2 Water-level data will be collected at a series of locations along the Las Vegas Wash to help evaluate the timing of water-quality samples relative to the predictable pattern of diurnal streamflow fluctuation.

1.3 It is expected that Solinst Levelogger Edge units will be installed in stilling wells along with staff gages for manual observation of water levels. The Levelogger Edge is a recording pressure transducer that records absolute pressure readings. In order to compensate for changes in atmospheric pressure, one or more Solinst Barologgers will also be deployed.

1.4 The information contained in this SOP in not intended to be a substitute for equipment user manuals. Consult the manufacturer's manual for a complete guide to the proper use of the Levelogger and associated software (Solinst, 2015).

1.5 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Analytical Task Lead and the Surface Water Task Manager and communicated to NDEP. Deviations from this SOP will be documented in the field records.

2.0 Health and safety considerations

2.1 The health and safety considerations for the work associated with this SOP, including physical, chemical, and biological hazards are addressed in the site-specific Health and Safety Plan (HASP) (AECOM, 2016). The major health and safety considerations for the work associated with water quality data collections are the near and on-water safety aspects of the program.

2.2 Daily safety briefs are to be conducted at the start of each working day before any work commences. These daily briefs are to be facilitated by the Site Safety Officer (SSO) or his/her designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

3.0 Interferences

3.1 Water-level data may be compromised unless care is taken to ensure all equipment (stilling well, staff gage, and transducer) are installed to maintain a constant position relative to the streambed.

3.2 The pressure transducer will be installed with direct read cables to allow the downloading of data without removal from the stilling well.

3.3 Care must be taken to avoid disturbing water flow/stage during manual readings of the staff gage as those measurements will be used to correlate water pressure data from the transducer to stream stage on the staff gage.

3.4 Changes to the stream channel may take place over time due to sedimentation/erosion. Changes to flow dynamics may also occur due to the blockage of flow by debris. When such changes are noted, the condition needs to be recorded in field notes along with observations of stream stage both before and after corrective actions are taken to return the channel and flow dynamics back to their original configuration

4.0 Equipment and materials

The following equipment list contains materials which may be needed in carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, pending field conditions.

- Solinst Levelogger Edge F15 with direct-read cables;
- Solinst Barologger;
- Solinst communications cable;
- Computer (laptop, tablet, etc.) loaded with Levelogger Software Version 4.0 and having correct port for levelogger communications cable;
- 5- to 6-foot-long steel fenceposts;
- 5-foot sections of rebar;
- Section of 2-inch-diameter Schedule 40 polyvinyl chloride (PVC) to be cut into appropriate lengths in the field;
- PVC joints and glue for constructing the stilling well;
- Staff gage (0.00 to 3.33 feet in 0.01-foot increments);
- Drill and drill bits to ventilate PVC stilling well to allow equilibration with stream, and to drill holes for security padlock;
- 2-inch-diameter PVC cap for bottom to prevent loss of transducer, drilled to allow equilibration;
- long shackle padlock (keyed or combination);
- Screws to secure staff gage to fenceposts;
- Stainless steel eyebolts and associated washers and nuts;
- Post driver, 3-pound sledgehammer, shovel, and pickaxe; and
- PVC saw.

5.0 Procedures

5.1 Site Selection

The general location of stream stations (stilling wells and flow measurement transects) along the Las Vegas Wash will be determined ahead of time based upon site characteristics (inflow from tributary streams, observed or inferred locations of groundwater discharge to the stream, locations of United States Geological Survey stations, and locations of other site features such as weirs). The specific location will be determined in the field based upon physical setting. The depth of water at the stilling well should be 2 or more feet to allow proper submergence of the transducer under all anticipated flow regimes.

5.2 Stilling Well Installation

Probe the streambed near the selected transect with a section of rebar to determine a location that will allow the fencepost to be vertically advanced several feet into the alluvium, After advancing the fencepost into the streambed, drive the rebar into the alluvium within the fencepost slot. The rebar should penetrate deeper than the fencepost, helping to further secure the installation. Attach the fencepost to the rebar using several stainless steel ring clamps. Attach the staff gage to the fencepost so that it is facing the nearby bank to allow reading from the shoreline.

The stilling well will be constructed in a manner similar to that shown in Figure1 (Freeman et al, 2005).

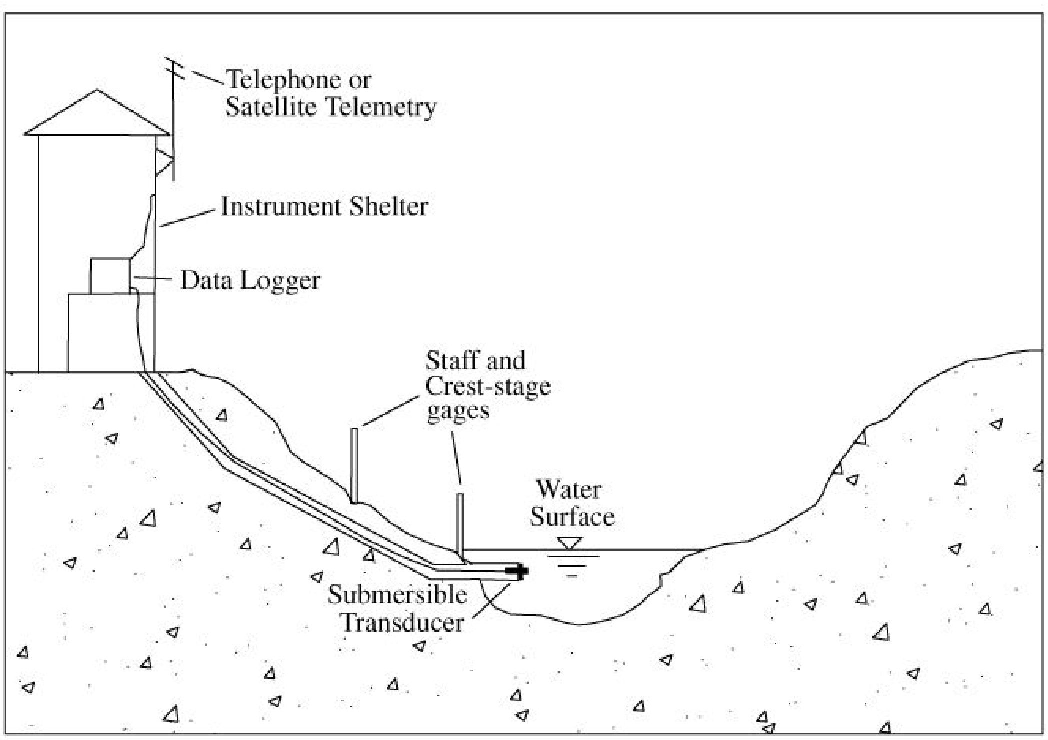


Figure 1. Staff Gage and Stilling Well Schematic.

It will be secured to the fencepost, running parallel to the streambed towards the bank, and then angling up towards the surface.

Near the surface the stilling well will be installed within a shallow, covered trench, daylighting with a short riser. Cut and layout the component pieces of the stilling well prior to installation before gluing. Drill a series of quarter-inch holes in the portions of the stilling well that will be submerged. Using a shovel and pickaxe, dig a shallow trench that will conceal the stilling well on the bank. Install the transducer (Section 5.3) before securing the stilling well. Secure first to the fencepost, then lay the assembly in the trench and backfill.

The top of the stilling well will be comprised of a cap drilled through the top for ventilation and an eye-bolt, and through the side for the shackle of the padlock. After attaching the eyebolt on the inside of the cap (for securing the connection on the direct read cable), pressure fit the cap to the top of the stilling well and drill two parallel holes through the cap and pipe for installation of the lock.

5.3 Transducer Installation and Programming

If there is sufficient depth, the Levelogger should be hung within the stilling well approximately 3.5 feet below the average water level of the wash. If the water depth is shallower than 3.5 feet, place the transducer/stilling well near the streambed. Install the transducer such that the sensor location is secured and open to the water. Attach the direct read cable to the eyebolt on the cap.

The Barologger should be installed in the general vicinity of the project in a location that is protected from direct sunlight. If there is ready access, a nearby building or shed would be ideal provided it is well ventilated. The Barologger should hang vertically in a location that would protect it from any tampering. A backup Barologger should also be installed at a second location. Program and install the Barologgers prior to programming and installing the Leveloggers.

Due to the magnitude of daily streamflow fluctuation within the Las Vegas Wash in the study area, Leveloggers and Barologgers should be programmed to record pressure at a 5-minute frequency. Follow the programming directions provided by the manufacturer (Solinst, 2015). Program the units for a delayed start so they all record on the same 5-minute schedule.

When installing a programmed Levelogger, allow the unit to record at least one pressure reading before recording a manual staff gage reading. Manual readings, which are used to calibrate the automated readings, need to be taken at the same time as a 5-minute frequency Levelogger reading.

5.4 Water Depth Profiling

Following the installation of water-level monitoring equipment, take readings to generate cross-sectional profiles of the streambed at each transect location. Water depth readings will be recorded from a metered pole while wading across the LVW. Measurement intervals will be determined in the field, based on the field conditions at each transect. While recording profile data, the staff gage will be periodically checked to allow for correction of flow/stage variation.

5.5 Monitoring and Downloading

The transducers (Leveloggers and Barologgers) should be downloaded at a regular frequency (to be determined). Before removing a Levelogger for downloading, record a manual stage reading to the nearest hundredth of a foot from the staff gage. Remove the cap and Levelogger, and download the data from the transducer following directions provided by the manufacturer. Save the data to a designated location on the computer hard drive, and save a backup file to a thumb drive. The file name should reference both the specific location and date of download, such as “LVW_3_030116” for Las Vegas Wash Station 3 on March 1, 2016.

Reprogram the transducer, replace the direct read assembly, and lock the riser cap. When a minimum of one pressure reading has occurred, record a manual reading of the staff gage. It is important to record stream stage before and after the download in case there has been a shift in the stilling well or transducer cable. After the last Levelogger has been downloaded and reprogrammed, download and reprogram the Barologgers.

6.0 Quality assurance / quality control

6.1 Entries in the field logbook will be checked by the observers to verify that the information is correct.

6.2 It is the responsibility of the Field Task Manager (FTM) or designee to spot check adherence to the procedural requirements of this SOP and to review the associated documentation for accuracy and completeness.

6.3 The FTM will be responsible for ensuring that instruments are properly functioning. The FTM (with assistance from field personnel) will be responsible for inspecting and accepting field supplies and consumables and providing replacements as necessary.

7.0 Data and records management

Field records will be generated and maintained as outlined in the SWIP. The SWIP addresses all aspects of collection including data and sample types, station locations, and chronology of events.

Deviations to the procedures detailed in the SOP must be recorded in the field logbook and communicated to the Surface Water Task Manager and the Analytical Task Lead as soon as practicable, but no later than the end of the work day.

8.0 Personnel qualifications and training

The individuals executing these procedures must have read, and be familiar with, the requirements of this SOP and the corresponding SWIP. Water level data collection is a relatively simple procedure requiring minimal training. However, inexperienced personnel performing these activities will be initially be supervised by the FTM or designee.

9.0 References

AECOM. 2016. Health and Safety Plan NERT Remedial Investigation – Downgradient Study Area. February 11.

Freeman, L.A., Carpenter, M.C., Rosenberry, D.O., Rousseau, J.P., Unger, R. and McLean, J.S. 2005. Use of Submersible Pressure Transducers in Water-Resources Investigations, U.S. Geological Survey Techniques of Water Resources Investigations, Book 8. Chap A3, 57p.

Solinst. 2015. User Guide: Levelogger Series – Software Version 4.1.2.

10.0 Revision history

Revision	Date	Changes
0	August 2016	Not applicable
1	October 2016	Stilling well design

Project Standard Operating Procedure
NERT RI - Downgradient Study Area

Water Quality Data Collection and Surface Water Sampling

Procedure Number: NERT-FI-01

Revision No.: 0

Revision Date: January 2016

Prepared by

Dion Lewis

Reviewed by:

Chad Roper, PhD CEM#2428, Analytical Task Lead

Date: November 3, 2016

Kristen Durocher, Surface Water Task Manager

Date: October 31,2016

Contents

1.0 Scope and applicability

1.1 This project Standard Operating Procedure (SOP) defines the operating procedures for the collection of surface water samples and *in-situ* water property data associated with the Nevada Environmental Response Trust (NERT) Remedial Investigation (RI) for the Downgradient Study Area. In-situ water property data (temperature, conductivity, dissolved oxygen, turbidity), hereafter referred to as water quality (WQ) data, are collected using multiparameter sensors from a boat or other sampling platform during field activities. Water samples are collected either directly, by immersing and filling sampling containers, or with the aid of a peristaltic (or other equivalent) water pump.

1.2 Samples will be collected for chemical, microbiological, and physical analyses. Analytes for a particular program are specified in the Quality Assurance Project Plan (QAPP).

1.3 It is fully expected that the procedures outlined in this SOP will be followed. Procedural modifications may be warranted depending upon field conditions or limitations imposed by the procedure. Substantive modification to this SOP will be approved in advance by the Analytical Task Lead and the Surface Water Task Manager and communicated to Nevada Division of Environmental Protection (NDEP). Deviations from this SOP will be documented in the field records.

2.0 Health and safety considerations

2.1 The health and safety considerations for the work associated with this SOP, including physical, chemical, and biological hazards are addressed in most recent update of the site specific Health and Safety Plan (HASP) (AECOM, 2016), AECOM's On-Water Safety protocol (see **Appendix A of Surface Water Investigation Plan [SWIP]**) and applicable Job Hazard Analyses. The major health and safety considerations for the work associated with WQ data collections are the near and on-water safety aspects of the program.

2.2 Daily safety briefs are to be conducted at the start of each working day before any work commences. These daily briefs are to be facilitated by the Site Safety Officer (SSO) or his/her designee to discuss the day's events and any potential health risk areas covering every aspect of the work to be completed. Weather conditions are often part of these discussions. As detailed in the HASP, everyone on the field team has the authority to stop work if an unsafe condition is perceived until the conditions are fully remedied to the satisfaction of the SSO.

3.0 Interferences

3.1 Cross-contaminations of samples may result if sample handling equipment is inadequately or improperly decontaminated.

3.2 Contamination of samples may result if samples are exposed to certain environmental conditions. Exposure to potential sources of contamination (e.g., exhaust fumes) will be minimized.

3.3 Care must be taken to avoid disturbing the river bed sediment during sampling. Re-suspended bed sediments may contaminate the surface water samples and artificially bias the analytical results.

3.4 Inappropriate sampling equipment, such as that manufactured from non-inert plastics, may contaminate samples. Using Teflon, polymer, or stainless steel sampling equipment will minimize contamination during sample collection activities.

3.5 For samples collected with a pump, purging of the tubing and pump system with a minimum of three volumes of site water prior to sample collection will ensure a representative sample.

3.6 For samples collected by direct immersion, care should be taken to sample upstream of the boat or the sampling personnel so that any contamination from the boat or personal protective equipment (PPE) on the personnel does not affect the sample.

3.7 Ensuring that the in-situ sensors are maintained and calibrated properly and that samples are preserved in accordance with the specified laboratory method will help reduce interference risks related to these sample and data collection efforts.

4.0 Equipment and materials

The following equipment list contains materials which may be needed in carrying out the procedures contained in this SOP. Not all equipment listed below may be necessary for a specific activity. Additional equipment may be required, depending on the field conditions encountered:

- Peristaltic water pump, variable speed, capable of approximately (~) 5 liters per minute (L/minute) discharge;
- 12-volt battery (as needed);
- CFLEX or equivalent polymer tubing (typical configuration requires 1.2-inch outside diameter; a 25-foot length will meet all project sampling (depth) requirements;
- Voss Technologies 0.45-micron inline metals filter (or equivalent);
- Sample containers as specified in the SWIP and QAPP;
- Multiparameter instrument package that includes temperature, pH, dissolved oxygen (DO), and turbidity (YSI sonde or equivalent);
- Connective (serial) cabling;
- Weight-bearing line/cable;
- Field computer (if applicable);
- Project-specific field log book;
- Chemical-free wipes;
- Disinfectant wipes;
- Approved plans, including target sampling locations;
- Insulated coolers with ice;
- Field notebook, pen, standardized forms (as needed);
- Chain-of-custody forms and seals;
- Multiparameter WQ sensor operating manual;

- Replacement batteries (12 volt and others as specified by equipment manufacturers);
- GPS;
- Safety gear (work vests, HASP-specified PPE);
- Nitrile gloves;
- Gauntlet gloves;
- Storage bags (plastic, sealable bags preferred) ;
- Boat (jon boat, canoe, or similar) with all applicable safety equipment (anchor, etc.); and
- Insulated Storage cooler.
- Tap Water
- Deionized Water

5.0 Procedures

5.1 In-situ Sensor Testing/Calibration

Make sure sensor/probes are clean and free of visible defects (housing cracks, etc.). Check the DO sensor for excessive wear and ensure that no air bubbles exist beneath the sensor membrane.

Instrument calibration is to be accomplished following the instrument manual. Ensure that all sensors are immersed in the calibration solutions for this activity. An instrument-specific calibration cup is standard equipment available for this purpose. Readings should be stable for ~30 seconds before accepting each calibration point. Sensors should be returned to the manufacturer if they are not operating within specified accuracy and precision limits.

5.2 Water Pump/Tubing Set-up

Connect the pump to a 12-volt battery. The water pumps and associated tubing used on this investigation should be dedicated to the project and rinsed with tap water before and after each (daily) use. Project tubing should be new at the project start, and rinsed thoroughly with deionized water. The tubing should be sealed in a storage bag when not in use; open tube ends should also be covered and protected when not in use, including between stations. Between-station rinsing is not generally required but flushing the system with site water at each sampling location is to be performed. The number of minutes required to purge the pump and tubing will be calculated as follows:

$$(((\pi r^2 \times l)/10)/f) \times 3 = \text{minutes to purge the pump}$$

Where:
π = 3.14 (rounded)
r = half the inner diameter of the tubing (centimeters)
l = length of tubing used on station (meters)
f = flow rate of the pump (L/minute)

5.3 Field Data and Sample Collections

5.3.1 Navigate to sampling stations outlined in the project sampling plan using the GPS unit.

5.3.2 Estimate and record the depth of the water. Water depth may be recorded using a weighted line with 0.1-foot increments marked.

5.3.3 At each station, the instruments should be lowered to the depth of interest and allowed to stabilize. If a profile is desired, then the instruments should be lowered to the near bottom and slowly raised between data collection points. Avoid contacting the river bed sediments, if possible. Data may be recorded electronically or entered into field logbooks. Water collections are typically made after the WQ data are collected.

Profile collection from a boat: At the station of interest, the datasonde should be lowered through the water column until it is near bottom as determined by the weighted line. If the operator “feels” the bottom with the weight, the instrument should be raised and data collection delayed to allow any resuspended sediment to dissipate as determined by monitoring real-time turbidity readings. Based on the water depth provided by the datasonde, field technicians will determine the water column structure and define the desired depths for data and sample collection. The datasonde should be allowed to equilibrate at bottom depth for at least 1 minute (or until readings for all parameters stabilized) before beginning profiling.

Profile collection from wading or shore point: At the station of interest, the field team should lower the datasonde through the water column until the probes and tubing inlet are completely submerged and at least 3 inches below the water surface. If the instrument package makes contact with the bottom profiling should be delayed for 5 minutes to allow for any suspended sediments to dissipate as confirmed by monitoring real-time turbidity readings. The datasonde should be allowed to equilibrate at sample depth for at least 1 minute (or until readings for all parameters stabilized) before beginning profiling.

5.3.4 In areas that require pumped collections (i.e., deep water or sampled from the boat) or for parameters that require filtration (i.e., total and hexavalent chromium), flush the tubing with water collected at the depth of interest. Given the small (typically quarter-inch) tube diameter, flushing will be complete for a 25-foot tube well within 10 seconds with a flow rate of ~5 L/min or better (Section 5.2).

When the purge is complete, wearing nitrile gloves, fill each sample container while avoiding contact between the sampling tube and the bottle. Bottles that contain preservatives should not be overfilled.

5.3.5 In areas and for parameters that allow direct/grab sampling, storage containers may be used to collect the sample unless they contain preservatives (e.g., nitric acid). Put on clean nitrile gloves and gauntlets, select an empty storage container, immerse below the water surface, uncap and allow the bottle to fill. Note: submerging the bottle before uncapping avoids collection of the surface film. Cap the container tightly, and remove from the water. Place the capped container in a bag and on ice in an insulated cooler.

5.3.6 If a parameter has a pre-preserved storage container, use a clean (laboratory-provided) unpreserved bottle and collect the sample in the same way. Gently pour the water sample into the storage bottle containing the preservative, avoid overfilling, cap tightly, seal in a storage bag, and place on ice in a cooler.

5.3.7 Samples will be placed in insulated coolers and stored on ice (refer to the QAPP for containerization and storage specifications) until shipment or transfer to the laboratory.

5.3.8 All discrete water samples should be collected and stored/transferred to laboratories according to the procedures described in Field Guidance Documents for Packaging and Shipping.

6.0 Quality assurance / quality control

It is the responsibility of the Field Team Leader (FTL) to check the calibration information, to spot check instrument operations, and to check the documentation accuracy of all field staff.

Quality control (QC) samples may include equipment blanks and field and laboratory duplicates.

6.1 Equipment blanks

Equipment blanks will be collected at the frequency specified in the QAPP, and from each set of sampling gear (e.g., tubing, tubing outfitted with a filter, and bottle sampler with tubing, etc.), after the sampling gear is decontaminated.

Equipment blanks may be collected if required by the SWIP for pumped samples by flushing the collection tube with deionized water and filling a set of containers with deionized water that has been pumped through the system.

If required, bottle blanks may be used to evaluate potential contamination associated with the direct grab sampling technique. In this case, bottles may be filled directly with deionized water, capped, bagged, and stored on ice for transfer to the laboratory.

6.2 Field and laboratory duplicates

Field and laboratory duplicates will be collected at the frequency specified in the SWIP. In the case of field duplicates, each container will be filled in parallel: First, one bottle will be filled one-quarter full, then the corresponding replicate will be filled one-quarter full, and the sequence should be repeated until both bottles are ready to cap.

If multiple bottles are required for evaluating laboratory accuracy and precision, then the same parallel filling approach will apply.

7.0 Data and records management

Calibration records will be recorded in the field log. Field records will be generated and maintained as outlined in the SWIP. The SWIP addresses all aspects of collection including data and sample types, station locations, and chronology of events.

Deviations to the procedures detailed in the SOP must be recorded in the field logbook and communicated to the Surface Water Task Manager and the Analytical Task Lead as soon as practicable, but no later than the end of the work day.

8.0 Personnel qualifications and training

The individuals executing these procedures must have read, and be familiar with, the requirements of this SOP and the corresponding SWIP. WQ data and water sample collections are relatively simple procedures requiring minimal training. However, initial instrument calibrations and sample/data collections should be supervised by the FTL.

9.0 References

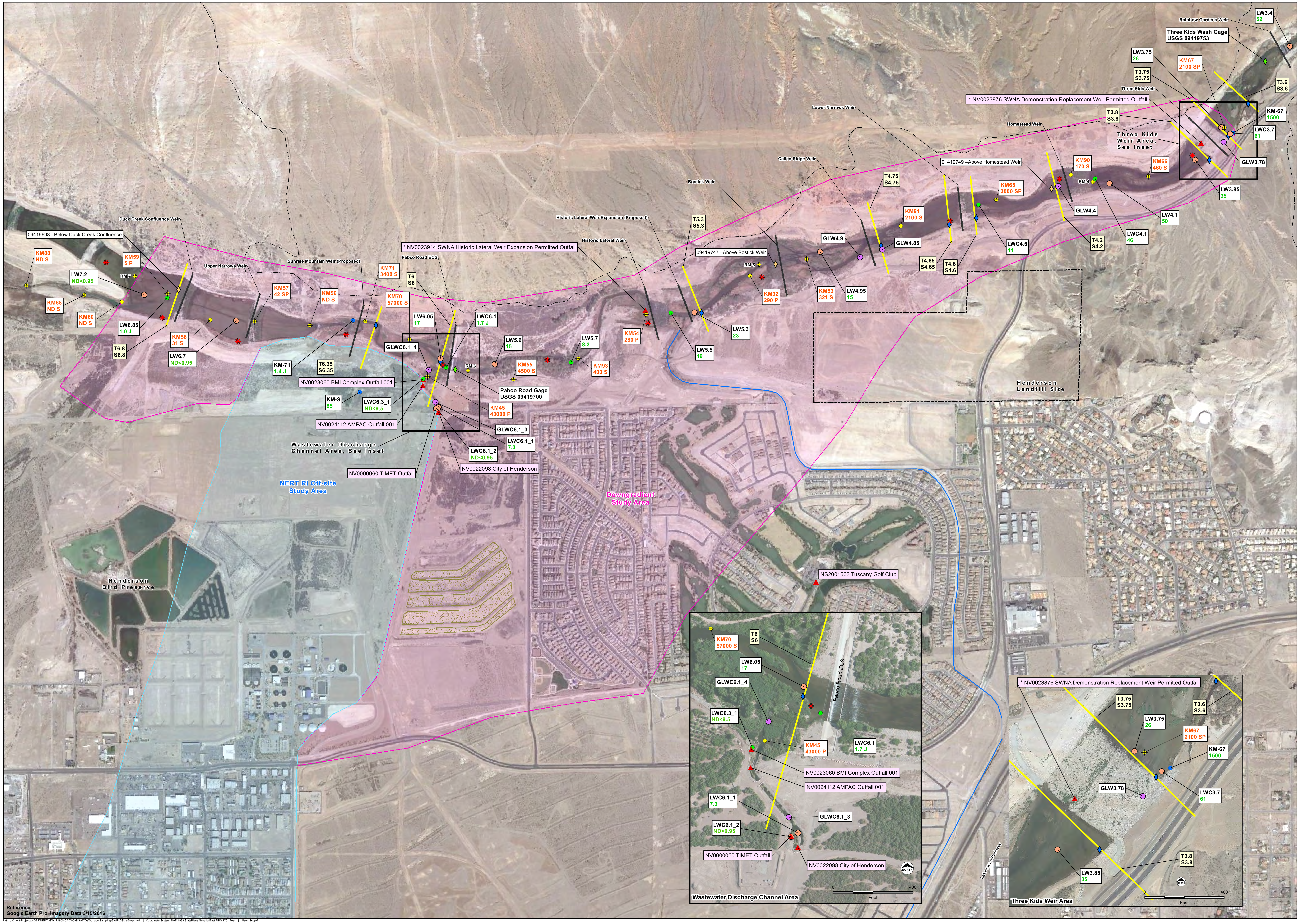
AECOM. 2016. Health and Safety Plan, NERT Remedial Investigation – Downgradient Study Area. February 11.

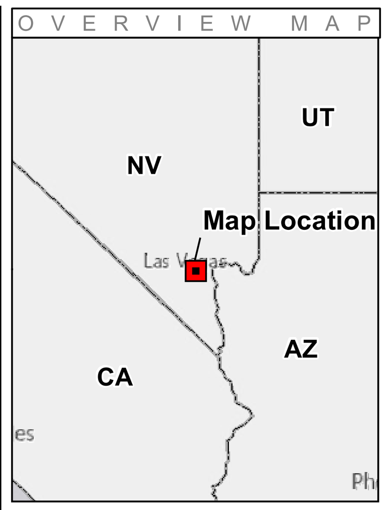
10.0 Revision history

Revision	Date	Changes
0	January 2016	Not applicable
1	November 2016	Review and update to reflect SWIP

Appendix C

Plate 1: Surface Water Program Overview





Legend

- New Temporary USGS Stream Gage
- Permanent USGS Stream Gage
- Staff Gage Installation Location
- Location of Transect Sampling
- Surface Water Sample Location - LVW/Tributaries - May 2016
- Surface Water Sample Location - Seeps - May 2016
- River Mile (RM)
- Wetlands Trail
- Channels
- Northern Rapid Infiltration Basins
- Weir
- NERT RI Downgradient Study Area
- NERT RI Off-site Study Area
- Approximate Location for USGS Seepage Measurements. One additonal location is downstream off the map area.
- Estimated Points of Permitted Discharge
- Proposed Surface Water Sample - Existing Location
- Proposed Surface Water Sample - New Location
- 2000 Seep Sample Locations

Category Chart
P = Pit
S = Seep
Sp = Spring
D = Drain

Perchlorate Concentrations (May 2016) are shown in green and 2000 seep sampling are shown in orange in micrograms per liter (µg/L)

ND - Not Detected above associated reporting limit
J - Associated concentration is estimate
µg/L - Micrograms per liter

Note:

* These outfalls are for monitoring the dewatering activities associated with construction of the weirs. As such, they are temporary structures and only active during times of construction.

NORTH
0 1,200
Feet
Scale 1:7,200
1 inch = 600 feet

NERT RI
Downgradient Study Area

SURFACE WATER PROGRAM OVERVIEW

Date: 10/24/2016 Project: 60477365

AECOM

Plate 1