February 28, 2014

Mr. Weiquan Dong, PE
Bureau of Corrective Actions, Special Projects Branch
Nevada Division of Environmental Protection
2030 E. Flamingo Rd., Suite 230
Las Vegas, Nevada 89119

Re: Semi-Annual Remedial Performance Report for Chromium and Perchlorate, July-December 2013; Nevada Environmental Response Trust Site, Henderson, Nevada (NDEP Facility ID #H-000539)

Dear Mr. Dong:

On behalf of the Nevada Environmental Response Trust ("NERT" or the "Trust"), ENVIRON International Corporation (ENVIRON) has prepared the enclosed *Semi-Annual Remedial Performance Report for Chromium and Perchlorate, July-December 2013* for the NERT site, dated February 28, 2014.

Please contact John Pekala at (602) 734-7710 if you have any comments or questions concerning this report.

Sincerely,

John M. Pekala, PG
Senior Manager
Nevada CEM #2347, expires 9/20/2014

Allan J. DeLorme, PE
Principal

Attachment

cc: BMI Compliance Coordinator, NDEP, BCA, Las Vegas
NDEP c/o Brian Giroux, McGinley and Associates, Reno

ec: James Dotchin, NDEP
Greg Lovato, NDEP
Stephen Tyahla, USEPA
Nevada Environmental Response Trust
Tanya O'Neill, Foley & Lardner LLP
Joe McGinley, McGinley and Associates
Jeff Gibson, AMPAC
Mark Paris, BMI
Lee Farris, Landwell
Ranajit Sahu, BMI
Joe Kelly, Montrose
Paul Sundberg, Montrose
Curt Richards, Olin
Davis Share, Olin
Chuck Elmendorf, Stauffer
Nick Pogoncheff, Stauffer
George Crouse, Syngenta
David Hadzinsky, TIMET
Richard Truax, GEI Consultants
Kirk Stowers, Broadbent & Associates
Victoria Tyson, Tyson Contracting
Enoe Marcum, WAPA

Semi-Annual Remedial Performance Report for Chromium and Perchlorate

Nevada Environmental Response Trust Site; Henderson, Nevada
July – December 2013

Prepared for:
Nevada Environmental Response Trust

Prepared by:
ENVIRON International Corporation
Emeryville, California

Date:
February 28, 2014

Project Number:
21-34800H

ENVIRON

Semi-Annual Remedial Performance Report for Chromium and Perchlorate

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

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

Office of the Nevada Environmental Response Trust

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

not individually, but solely as President

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

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

Title: Solely as President and not individually

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

Date: 2/28/14

Semi-Annual Remedial Performance Report for Chromium and Perchlorate

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

Responsible Certified Environmental Manager (CEM) for this project

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

February 28, 2014

John M. Pekala, PG
Senior Manager

Date

Certified Environmental Manager
ENVIRON International Corporation
CEM Certificate Number: 2347
CEM Expiration Date: September 20, 2014

The following individuals provided input to this document:

John M. Pekala, PG
Allan J. DeLorme, PE
Christopher J. Ritchie, PE
Christopher M. Stubbs, PhD, PE
Alka Singhal, PhD
Kate Logan, MPA
Lisa Ackerman Taylor, MESM
Craig J. Knox
Elysha Anderson, PE
Ruben So

Contents

List of Tables

List of Figures

List of Plates

List of Appendices

List of Attachments

Acronyms and Abbreviations

AMPAC	American Pacific Corporation
AWF	Athens Road Well Field
bgs	below ground surface
BMI	Black Mountain Industrial
CD	compact disc
COH	City of Henderson
DVSR	Data Validation Summary Report
EDD	Electronic Data Deliverable
Envirogen	Envirogen Technologies, Inc.
ENVIRON	ENVIRON International Corporation
FBR	fluidized bed reactors
ft	feet/foot
gpm	gallons per minute
GWETS	Groundwater Extraction and Treatment System
GWTP	Groundwater Treatment Plant
ITRC	Interstate Technology & Regulatory Council
IWF	Interceptor Well Field
kWh	kilowatt hours
lbs	pounds
lbs/day	pounds per day
mg/L	milligrams per liter
Northgate	Northgate Environmental Management, Inc.
NDEP	Nevada Division of Environmental Protection
OSSM	Olin Chlor-Alkali/Stauffer/Syngenta/Montrose
Qal	Quaternary alluvium
RI/FS	Remedial Investigation and Feasibility Study
RIB	Rapid Infiltration Basin
Site	Nevada Environmental Response Trust Site
SWF	Seep Well Field
TDS	total dissolved solids

TestAmerica	TestAmerica Laboratories, Inc.
Tronox	Tronox LLC
Trust	Nevada Environmental Response Trust
TSS	total suspended solids
UMCf	Upper Muddy Creek Formation
USEPA	United States Environmental Protection Agency
Veolia	Veolia Water North America
WBZ	water-bearing zones
WRF	Water Reclamation Facility
yr	year

1 Introduction

In accordance with the Interim Consent Agreement between the Nevada Environmental Response Trust (the Trust) and the Nevada Division of Environmental Protection (NDEP), ENVIRON International Corporation (ENVIRON) submits this performance report to NDEP on behalf of the Trust for the Nevada Environmental Response Trust Site (the Site). The Site comprises approximately 346[1] acres located within the Black Mountain Industrial (BMI) Complex in unincorporated Clark County and is surrounded by the City of Henderson, Nevada.

Tronox LLC (Tronox) formerly owned and operated the Site. In conjunction with the settlement of Tronox's bankruptcy proceeding, the Trust took title to the Site and the groundwater extraction and treatment system (GWETS).[2] The effective date of the property transfer to the Trust and the Interim Consent Agreement between the Trust and NDEP was February 14, 2011. The Tronox facility remains on a portion of the Site leased from the Trust in order to continue manufacturing operations.

Veolia Water North America (Veolia)[3] operated the GWETS system on behalf of Tronox beginning in 2003 and, after the Trust took title to the Site, continued to serve as the GWETS operator through the beginning of the current reporting period. As of July 24, 2013, Envirogen Technologies, Inc. (Envirogen) took over GWETS operation and maintenance duties on behalf of the Trust. Additionally, a new analytical laboratory, TestAmerica Laboratories, Inc. (TestAmerica), has acted as the Site's primary analytical testing laboratory since April 1, 2013. Prior to April 1, 2013, Eaton Analytical[4] served as the Site's primary analytical testing laboratory.

This report is a mid-period report for chromium and perchlorate, covering the period July 2013 through December 2013, and summarizes performance data for both the chromium and perchlorate removal programs based on sampling performed during this period. A detailed evaluation and presentation of data will be described in the Annual Remedial Performance Report for Chromium and Perchlorate (the "Annual Performance Report") due to the NDEP in August 2014. Specifically, this report describes:

- Regional groundwater conditions based on July through December 2013 groundwater levels;
- The hexavalent chromium remediation system (consisting of the on-site Interceptor Well Field [IWF], the off-site Athens Road Well Field [AWF],[5] and the related treatment systems) and its performance in carrying out the extraction and treatment of chromium;

[1] Prior to the sale of Parcels A and B in December 2013 to TRECO, LLC, the Site comprised approximately 410 acres.

[2] Herein "GWETS" will be used to refer to the entirety of all systems and components of the groundwater extraction and treatment systems owned by the Trust, both on-site and off-site, including extraction well fields, treatment facilities, and groundwater conveyance systems.

[3] Formerly known as US Filter Operating Services.

[4] Formerly known as MWH Laboratories.

[5] Although Athens Road has been renamed Galleria Drive, the Athens Road designation has been retained for the well field to maintain consistency with past reports.

- The perchlorate remediation system (consisting of the on-site IWF, the off-site AWF, the off-site Seep Well Field [SWF], the off-site seep capture sump, and related treatment systems) and its performance in carrying out the extraction and treatment of perchlorate;
- The distribution of total dissolved solids (TDS) concentrations at the Site;
- The evaluation of performance metrics to be used during the optimization of the IWF, AWF, and SWF;
- Revisions to the Site's groundwater flow model, as described in Attachment A; and
- Proposed future activities.

This report is provided in both hard copy and electronic forms. Where electronic files are referenced or information is stated as provided on compact disc (CD), this information is contained on the CD attached to the hard copy report. Appendix A contains Table A-1 (as hard copy and on the report CD), which has five quarters of groundwater elevation and analytical data from the Site. The analytical lab reports for the third and fourth quarter 2013 groundwater monitoring events are also included in Appendix A (on the report CD). Appendix B contains the field records from July to December 2013 (on the report CD). Appendix C contains the Data Validation Summary Report (DVSR) (on the report CD). Appendix D contains the Electronic Data Deliverable (EDD). The EDD includes an Access© compatible data file (on the report CD) containing the analytical results from the period July to December 2013, and an Access© compatible data file (on the report CD) containing water level monitoring data from the period July to December 2013. Attachment A describes the updates made to the groundwater flow model.

2 Groundwater Conditions

The locations of the groundwater extraction well fields are shown on Figure 1, a location map covering the area between the Site and Las Vegas Wash. This section provides a discussion of the performance of each of the well fields, starting with the on-site extraction well field and proceeding to the successively northward (downgradient) extraction well fields. Plate 1 shows the locations of all former and current wells in the vicinity.

Ground surface elevations across the Site range from 1,677 to 1,873 feet above mean sea level. The ground surface across the Site generally slopes downward to the north at a gradient of approximately 0.02 feet per foot (ft/ft). Off site to the north, the topographic surface continues at the same gradient to approximately Sunset Road, at which point it flattens to a gradient of 0.01 ft/ft to the Las Vegas Wash. The shallow groundwater gradient generally mimics the surface topography.

The NDEP has defined three water-bearing zones (WBZs) that are of interest in the vicinity of the Site, including the Shallow, Middle, and Deep Zones.[6] The Shallow WBZ, which extends to approximately 90 feet below ground surface (bgs), is unconfined to partially confined, and is considered the water table aquifer. Unless otherwise stated, discussions of groundwater in this report refer to the Shallow Zone, which contains the saturated portions of the Quaternary alluvium (Qal) and the uppermost portion of the Upper Muddy Creek Formation (UMCf).

Investigations of the Middle WBZ at the Site and surrounding sites indicate, with a few exceptions, a vertical upward gradient between the Middle and Shallow WBZs that generally increases with depth. Wells screened in the Middle WBZ were not sampled during this performance period but previous measurements in the vicinity of the IWF have found vertical upward gradients between the Middle and Shallow WBZ wells ranging from three to ten feet (ENVIRON 2013c). Vertical gradients measured near the AWF were +3 to -1.4 feet during the same period. Consistent vertical gradients have not been observed near the SWF due to a lack of wells screened below the Qal.

During the current reporting period, shallow groundwater is generally encountered in on-site wells between 20 and 50 feet bgs and is generally deepest in the southernmost portion of the Site. North of the Site, beyond Boulder Highway, shallow groundwater is generally encountered between four and 30 feet bgs, becoming shallower as it approaches the Las Vegas Wash. As discussed in the report entitled *Annual Remedial Performance Report for Chromium and Perchlorate, Nevada Environmental Response Trust Site; Henderson, Nevada; July 2012 – June 2013 dated August 30, 2013* (ENVIRON 2013d), the groundwater flow direction is generally north to northwesterly; whereas north of the Site, the direction changes slightly to the north-northeast. This generally uniform flow pattern may be modified locally by subsurface alluvial channels cut into the underlying UMCf; the on-site bentonite-slurry groundwater barrier wall (the “barrier wall”); localized areas of recharge on-site from storm water retention basins; off-site recharge from the ponds at the City of Henderson (COH) Bird Viewing Preserve (Bird Viewing Ponds); groundwater extraction from the IWF, AWF, and SWP; and nearby

---

[6] NDEP guidance for the water-bearing zones can be viewed at http://ndep.nv.gov/bmi/docs/090106_hydro_litho.pdf

groundwater extraction conducted by Olin Chlor-Alkali/Stauffer/Syngenta/Montrose (OSSM) and American Pacific Corporation (AMPAC). Historically, on- and off-site artificial groundwater highs or "mounds" were observed around the on-site recharge trenches[7] and the COH Water Reclamation Facility (WRF) Rapid Infiltration Basins (RIBs)[8]; however, both of these have ceased operation.

During the 2011 interim soil removal action, the Site was graded such that storm water would be retained on-site. Two main designated retention basins and a drainage channel were constructed: the Central Retention Basin located approximately 800 feet south (upgradient) of the IWF and the Northern Retention Basin located approximately 300 feet north (downgradient) of the IWF. Surface runoff from off-site areas and water collected in the majority of the storm sewer network within the Tronox-leased area is directed to the Central Retention Basin. Storm water also enters the Site from the west through surface flow, which is collected in an on-site conveyance trench that flows into the Central Retention Basin. Surface runoff from north of the former Beta Ditch is directed to the Northern Retention Basin. This basin also accepts overflow from the Central Retention Basin during major storm events through a channel constructed along the eastern side of the Site. The design capacities of the Central and Northern Retention Basins are approximately 1,295,470 and 1,219,680 cubic feet, respectively (RCI Engineering 2010). Following a series of storm events between August and October 2012, storm water collected in the Central Retention Basin, which appeared to likely altering local infiltration pathways and influencing downgradient groundwater conditions at the IWF, the effects of which are still observable as described below.

During the current reporting period ending December 2013, groundwater levels at the Site were relatively consistent with previous years, although groundwater levels remain elevated in the vicinity of the barrier wall. As discussed in the 2012 Semi-Annual (ENVIRON 2013a) and 2012-2013 Annual Performance Reports (ENVIRON 2013d), groundwater levels in most of the active IWF pumping wells (I-series wells) and nearby monitoring wells were elevated during portions of 2012 and 2013. Groundwater elevations in many of the IWF pumping wells and monitoring wells in the vicinity of the barrier wall remained elevated through December 2013. Water level measurements collected in monitoring wells just south (upgradient) of the barrier wall (e.g. wells I-Y, M-55, M-56, M-60, M-64, M-65, M-66, M-67, and M-68) were generally one to four feet higher during the current reporting period than those collected in the four quarters prior to November 2012. These changes in groundwater elevation were generally greater in upgradient areas near the western and central portions of the barrier wall and less in upgradient areas near the eastern portion of the barrier wall. Similarly, groundwater elevations to the north (downgradient) of the barrier wall (e.g. wells M-69, M-70, M-71, M-72, M-73) remained elevated by approximately two feet through the end of the reporting period. The continued presence of elevated water levels near the IWF is likely related to heavy rainfall between August and

---

[7] Reinjection of stabilized Lake Mead water ceased in September 2010 as the recharge trenches were removed to accommodate soil excavation and remediation activities at the Site. They have not been replaced.

[8] Since the completion of the COH WRF in 2008, discharge of treated effluent to the Pabco Road RIBs has ceased; however, groundwater mounding events, although lessening in intensity, continued to be observed into late 2011. The most recent mounding events are likely attributable to the operation of the COH Bird Viewing Ponds located west of the RIBs.

October of 2012 and the resulting infiltration, which was likely intensified in the area upgradient of the IWF due to the collection of storm water in the Central Retention Basin.

2.1 Interceptor Well Field Area

The location of the IWF area is shown on Figure 1. A bentonite-slurry wall was constructed as a physical barrier across the higher concentration portion of the perchlorate/chromium plume on the Site in 2001. The barrier wall is approximately 1,600 feet in length and 60 feet deep and constructed to tie into approximately 30 feet of UMCf. The IWF consists of a series of 23 active groundwater extraction wells that are situated south (upgradient) of the barrier wall. Seven additional extraction wells (I-W, I-X, I-Y, I-AA, I-AB, I-AC, and I-AD) were installed and connected to the well field in 2010-2011; however, extraction from these wells has not commenced. We understand that these additional extraction wells were installed in response to Data Gap #3 identified in the March 2010 Interim Groundwater Capture Evaluation and Vertical Delineation Report prepared by Northgate Environmental Management, Inc. (Northgate) on behalf of Tronox (Northgate 2010a).

An initial analysis of groundwater capture at the IWF, completed as part of the 2011-2012 Annual Performance Report (ENVIRON 2012), led to recommendations to turn on I-W, I-X, I-Y, I-AA, I-AB, I-AC and I-AD. The 2013 GWETS Optimization Project Work Plan was prepared to describe the steps necessary to activate these wells (in addition to two wells at the AWF), perform well testing to set preliminary extraction rates, update and refine the groundwater model, and develop performance metrics for evaluation of the GWETS (ENVIRON 2013e). ENVIRON is currently implementing the 2013 GWETS Optimization Project Work Plan with the objective of turning on these additional wells by April 14, 2014.

The average discharge rate for each IWF well active during July through December 2013 is shown in Table 1, along with the annual average discharge rates from the previous four years. The combined discharge of the IWF averaged 67.1 gallons per minute (gpm) from July to December 2013, which is generally consistent with previous years. Over the last four and a half years of operation, the combined discharge of the IWF averaged 68.2 gpm. For comparison, in June 2001, prior to the installation of the barrier wall, the 22 wells comprising the IWF at that time averaged a combined discharge of 24.7 gpm.

Groundwater recharge trenches located north (downgradient) of the barrier wall were originally installed to receive extracted and treated groundwater, but were used in the more recent past to inject stabilized Lake Mead water into the subsurface to replace water extracted by the IWF. Reinjection ceased in September 2010 when the recharge trenches were removed to accommodate soil excavation and remediation activities at the Site.

Figures 2a through 2d present historical (May 2006 to December 2013) water elevations for selected pairs of monitoring wells located on opposite sides of the barrier wall. As shown on the figures, between July and December 2013, water levels in wells directly downgradient (north) of the barrier wall (wells M-69 through M-72) were generally five to ten feet lower than water elevations in corresponding wells upgradient (south) of the wall (wells I-Y, M-55, M-56, and M-58). The large drop in measured groundwater elevations across the barrier wall indicates that the wall is generally an effective barrier to shallow groundwater flow. However, concentrations of perchlorate and chromium observed in wells immediately downgradient of the wall suggest that there may be some flow past the wall. The performance of the barrier wall, including what effects the operation of the former recharge trenches may have had, is being evaluated and it is anticipated that this evaluation will be discussed in the 2013-2014 Annual Performance Report.

Figures 2a through 2d show that starting in May 2006 water levels in downgradient wells showed a continual decline until February 2008 when refurbishment of the recharge trench was completed allowing increased recharge rates and a corresponding rise in water levels. Peaks in water levels in downgradient wells around July 2008 and May 2010 observed on Figures 2a through 2c (and to a lesser extent on Figure 2d) are in response to increased recharge rates during those times. These figures also show a significant decline in water elevations in the downgradient wells beginning around September 2010, when the recharge trenches were shut down and groundwater mounding associated with the recharge began to dissipate.

As seen on Figures 2a through 2d, groundwater elevations downgradient of the barrier wall remained elevated during the current reporting period, the continuation of a trend that began in September 2012. Beginning in November 2012, water elevations in upgradient wells were approximately two to six feet higher than typical and remained elevated by a similar amount throughout the current reporting period.

2.2 Athens Road Well Field Area

Figure 1 shows the location of the AWF, which is approximately 8,200 feet north (downgradient) of the barrier wall and the IWF. The AWF was constructed as a series of 14 groundwater extraction wells screened in the Qal at seven paired well locations that span approximately 1,200 feet across two alluvial paleochannels located on either side of an UMCf ridge. The AWF was completed in March 2002 and continuous pumping began in mid-October of that year. The well pairs act in concert with one well pumping while the adjacent well is used to measure water levels and monitor the effect of pumping on the aquifer. In September 2006, a fifteenth standalone well, ART-9, began full-time operation replacing ART-6A after groundwater elevations at the AWF dropped below a level where ART-6/6A could be effective.

The average discharge rate for each AWF pumping well from July to December 2013 is shown on Table 2, along with the average annual discharge rates for the previous four years. The combined discharge rate of the AWF averaged 278.2 gpm from July to December 2013, which is generally consistent with the previous four years. Over the last four and a half years of operation, the combined discharge of the AWF averaged 269.3 gpm.

Groundwater levels are currently much lower than they were in 2002 before pumping began, and the Qal overlying the UMCf ridge has been partially dewatered. Historical groundwater level trends for selected wells are shown on Figure 3. In general, the water elevations in the AWF are consistent with water elevations from one year ago.

In June/July 2010, additional groundwater wells were installed in the AWF including seven monitoring wells (PC-141 through PC-147) and four large diameter monitoring wells (ART-7B, PC-148, PC-149, and PC-150) that could be used as additional extraction wells. The new eight-inch diameter well, ART-7B, is co-located with the ART-7/ART-7A extraction well pair, but with a screened interval extending deeper, down to the Qal/UMCf interface and to the reported bottom of the eastern alluvial channel. Two new six-inch diameter wells, PC-148 and PC-149, are standalone wells that are situated across the top of the UMCf ridge with screened intervals almost entirely within the UMCf. Another new six-inch diameter well, PC-150, is a standalone well located west of the UMCf ridge in the western channel and is screened entirely within the Qal.

As with the new IWF wells discussed in Section 2.1, an initial evaluation of these new wells and the performance of the AWF in general was included as part of the 2011-2012 Annual Performance Report (ENVIRON 2012). As a result of that evaluation, a potential gap was identified in the capture zone of the AWF in the vicinity of well PC-150, which is located immediately west of the UMCf ridge. This potential gap is believed to be the reason for elevated concentrations in MW-K4, which is located downgradient of PC-150. The initial capture zone analysis suggested that starting to extract from wells ART-7B and PC-150 could improve capture efficiency of shallow groundwater on either side of the UMCf ridge (ENVIRON 2012). These proposed changes have been evaluated as part of the 2013 GWETS Optimization Project and ENVIRON is currently in the process of activating wells ART-7B and PC-150.

2.3 Seep Well Field Area

The SWF and the seep capture sump, located approximately 4,500 feet north (downgradient) of the AWF near the Las Vegas Wash, are shown on Figure 1. When pumping began in July 2002, the SWF consisted of three recovery wells (PC-99R2/R3, PC-115R, and PC-116R) situated over the deepest part of the alluvial channel and a seep capture sump for an intermittent surface seep. Five additional wells (PC-117, PC-118, PC-119, PC-120, and PC-121) were completed in February 2003 and an additional well (PC-133) was completed in December 2004, all in the SWF area. Presently, the SWF consists of 10 extraction wells—two of which (PC-99R2 and PC-99R3) are connected and operate as one combined well. The wells comprising the SWF are screened across the full thickness of the Qal and across the deepest portion of an alluvial channel. The SWF has been effective in lowering groundwater levels in this vicinity, such that the surface seep has not flowed since April 2007.

The average discharge rate for each SWF pumping well during July through December 2013 is shown in Table 3, along with the discharge rates for the previous four years. The combined discharge rate of the SWF averaged 514.3 gpm over the last six months (July – December 2013). While this average discharge rate was less than during the previous reporting period, flows in the SWF were generally consistent with combined pumping rates between July 2010 and June 2012. As discussed in the 2012-2013 Annual Performance Report, higher groundwater levels near the SWF may have contributed to higher extraction rates during the July 2012 to June 2013 reporting period. Envirogen, the GWETS operator, reports that no significant operational adjustments were made to the SWF pumping rates during the current performance period. Over the last four and a half years of operation, the combined discharge of the SWF averaged 550.3 gpm.

2.4 Groundwater Treatment Overview

Treatment of chromium-contaminated groundwater (primarily from the IWF) occurs via the on-site Groundwater Treatment Plant (GWTP),[9] which chemically reduces hexavalent chromium and removes total chromium via chemical precipitation. A small ferrous sulfate drip system is located at the AWF lift station (Lift Station #3) to treat chromium present (at lower concentrations) in groundwater extracted by the AWF. Treatment of perchlorate-contaminated groundwater from all well fields occurs via the on-site fluidized bed reactors (FBRs), which biologically remove perchlorate as well as chlorate, nitrate, and trace concentrations of residual chromium. A simplified process flow diagram is presented on Figure 4. Monthly extraction rates for individual IWF, AWF, and SWF wells are presented in Table 4.[10] Routine maintenance is completed as needed at the GWTP and FBRs. The performances of the chromium and perchlorate treatment systems are described in Sections 3.2 and 4.2, respectively.

---

[9] By convention, the "GWTP" consists of only the on-site hexavalent chromium treatment plant. The name pre-dates the installation of any of the perchlorate treatment systems and related components.

[10] The average total influent reported in Table 4 differs from the average total effluent of the GWETS. The discrepancy is the result of flow into and out of GW-11 as well as additions of stabilized Lake Mead water, which is used to maintain the mechanical pump seals. Perchlorate removal calculations are based on the extraction rates at each individual extraction well for the AWF and the SWF. For the IWF, the influent flow rates prior to entering the GWTP are used for perchlorate removal calculations.

3 Chromium Capture and Treatment

The components of the chromium capture system consist of the IWF, the barrier wall, and the AWF. As discussed previously, recharge trenches located downgradient of the barrier wall were formerly part of the chromium capture system. The locations of these components are shown on Figure 1. For the 6-month period lasting from July to December 2013, a total of approximately 1,500 pounds of chromium were captured and removed from groundwater. The treatment of chromium-contaminated groundwater is discussed in Section 3.2.

3.1 Chromium Plume Configuration

A chromium plume map is not included in this mid-period report. Plume maps are included as part of the detailed evaluation and presentation of data contained in the Annual Performance Report submitted in August of each year. This section presents data to supplement the 2012-2013 Annual Performance Report and the plume maps contained therein.

Table A-1 in Appendix A contains analytical and groundwater elevation data for the last five quarters. Based on November 2013 total chromium analytical results, the portion of the chromium plume with the highest concentrations remains south (upgradient) of the barrier wall where it is captured by the IWF. During November 2013, the highest chromium concentrations continued to be centered near well I-T (28 milligrams per liter, or mg/L). North of the barrier wall, the highest total chromium concentration was 9.2 mg/L in well M-73, located north of wells I-I and I-Z. This is a decrease from 10 mg/L measured in November 2012. North of the former recharge trenches, the highest total chromium concentration detected was 3.2 mg/L in well PC-136, located at the AWF and screened within an alluvial sub-channel east of the UMCf ridge. This concentration is an increase from 1.7 mg/L measured in November 2012, but it does not appear that this increase is part of a general upward trend. Concentrations in well M-12A, located on the trailing edge of the main plume, have been generally declining. In November 2013, the concentration in M-12A was 8.0 mg/L compared with 25 mg/L in May 2002.

Total chromium concentrations in wells immediately downgradient of the barrier wall (M-70, M-71, M-72, M-73 and M-74) have increased slightly over the previous year, except in wells M-70 and M-73 where the concentration decreased slightly or were very similar to concentrations from the previous year.

The overall lower concentrations observed in on-site wells located downgradient of the barrier wall compared with those upgradient indicate that the IWF is generally an effective barrier to migration of the main portion of the chromium plume. However, concentrations of chromium observed in wells immediately downgradient of the wall, suggest that there could be some flow past the wall.

3.1.1 On-Site Interceptor Well Field Area

The IWF captures the highest concentrations and the main portion of the groundwater plume located downgradient of the on-site source area. Figure 5 shows the concentrations of total chromium in the 23 active IWF pumping wells over the last five quarters. Five additional I-series wells (I-AA, I-AB, I-W, I-X, and I-Y), which are not currently operated as pumping wells, were regularly sampled beginning in June 2013 and are also included in Figure 5. Chromium concentrations during November 2013 were generally similar to previous quarters with the exception of wells I-T and I-U, adjacent wells near the center of the IWF. As shown on Figure 5, chromium concentrations were lower in these wells in November 2012, May 2013, and August 2013. The variability in chromium concentration in wells I-T and I-U do not appear to be related to any specific events.

Chromium concentration data from select wells (M-11, M-23, M-36, M-72, and M-86)[11] over time are presented in Figure 6. In monitoring well M-11, located immediately downgradient of the former primary source area (Units 4 and 5), concentrations have remained relatively stable over the last nine years with a concentration of 1.7 mg/L reported in November 2013. Total chromium concentrations measured in well M-36,[12] located upgradient of the IWF, declined over the reporting period (to 22 mg/L), a continuation of a trend dating back to 2004 when the concentration was 43 mg/L. Concentrations in well M-72, located between the barrier wall and former recharge trenches, have increased slightly during the reporting period to a concentration of 7.7 mg/L in the November 2013 sampling event from 6.6 mg/L in November 2012. Concentrations in well M-72 and surrounding wells have been gradually increasing since approximately November 2010, following the shutdown of recharge trenches in September 2010 suggesting that the former recharge trenches either diluted concentrations in these wells or mitigated the flow past the barrier wall by reducing the gradient across the wall. The performance of the barrier wall, including what effects the operation of the former recharge trenches may have had, is being evaluated and it is anticipated that this evaluation will be discussed in the 2013-2014 Annual Performance Report.

3.1.2 Athens Road Well Field / Seep Well Field Areas

The AWF is designed to intercept residual chromium in groundwater downgradient of the IWF and the Site. Based on total chromium concentrations in groundwater downgradient of the AWF, the system is operating effectively; however, capture gaps identified in the 2011-2012 Annual Performance Report indicate that chromium capture could be further improved by activating certain currently idle extraction wells, namely ART-7B and PC-150. Activation of these wells is being performed as part of the 2013 GWETS Optimization Project. Downgradient of the AWF in the Athens Road Piezometer of “ARP” well line, the highest measured concentration of total chromium during the November 2013 sampling event was 0.27 mg/L in well ARP-6B, identical to the sampling result from November 2012. Chromium concentrations in MW-K4, located further west, are typically equal or greater to the concentrations in ARP-6B.

Figure 7 shows the concentrations of total chromium across the seven AWF pumping wells in addition to monitoring wells PC-18, PC-55, PC-122, PC-148, PC-149, and PC-150 over the last five quarters, where data are available. As mentioned previously, PC-148 and PC-149 are monitoring wells that are situated across the top of the UMCf ridge with screened intervals primarily within the UMCf. As shown on Figure 7, chromium concentrations in the western sub-channel (represented by wells west of PC-149) have been low relative to those in the eastern

[11] These wells were selected because they are the five “Consent Order Appendix J Wells” that were historically presented for evaluating performance of the chromium mitigation program.

[12] M-36 was damaged in June 2013 and is currently inaccessible for sampling. Data collected from nearby well M-38 will be presented in Figure 6 until M-36 is repaired.

sub-channel (represented by wells east of PC-148). An additional extraction well, ART-9, was installed in this area in 2006 to capture this narrow channel of chromium-impacted groundwater. Total chromium concentrations in well PC-122 have remained relatively low since the start-up of ART-9. Well PC-122 contained a total chromium concentration of 0.21 mg/L in November 2013. Total chromium present in groundwater collected in this area continues to be treated at Lift Station #3 where metered ferrous sulfate is added before the water is sent to the on-site perchlorate treatment system.

Wells in the SWF continue to generally contain less than 0.01 mg/L total chromium. Total chromium concentrations in wells to the east of the SWF are slightly higher, but remained generally constant over the reporting period. For example, in November 2013 concentrations of total chromium in extraction well PC-133, located in the easternmost portion of the well field, and monitoring well PC-94, located east of the well field, were measured at 0.038 mg/L and 0.030 mg/L, respectively.

3.2 Chromium Treatment System

The operation and maintenance of the chromium treatment system, as well as the rest of the GWETS, was contracted to Veolia between 2003 until July 24, 2013. As discussed in Section 1, following that date, Envirogen took over operation and maintenance duties at the Site.

Table 5 contains the July to December 2013 process treatment data from the on-site GWTP. The treated groundwater from the GWTP is pumped to the equalization tanks, where it is combined with water from the off-site groundwater collection systems. From the equalization tanks, the blended water flows through activated carbon beds before being pumped to the FBRs for treatment to remove perchlorate, chlorate, and nitrate.

As shown in Table 5, the total chromium inflow concentration to the GWTP has been relatively stable in the range of 8.6 to 10.6 mg/L, which is similar to the range of 8.7 to 10.5 mg/L from one year ago. The chemical reduction of hexavalent chromium and removal of total chromium via the GWTP during the reporting period has been consistently effective. The average monthly total chromium outflow concentrations for the last six months ranged from 0.176 to 0.563 mg/L. The average monthly hexavalent chromium outflow concentration during the reporting period ranged from non-detectable (<0.00025) to 0.0004 mg/L. As seen in Table 5, for the period between July and December 2013, approximately 1,460 pounds of chromium were removed from groundwater by the GWTP.

A trace amount of chromium is also removed in the FBRs. Results of total chromium analysis from weekly FBR influent and effluent samples are presented in Table 6. Based on an average influent total chromium concentration of 0.028 mg/L and an average flow rate of 904 gpm[13], the FBRs were receiving about 0.31 pounds of chromium per day from the equalization tanks. This

[13] This flow rate is measured at the effluent totalizer and measures the throughput at the FBRs. This flow is not the same as the cumulative groundwater extraction rate as measured by the extraction well totalizers, since these readings do not account for flow into and out of GW-11 as well as additions of stabilized Lake Mead water, which is used to maintain the mechanical pump seals.

total includes chromium captured in the AWF and reductively treated with ferrous sulfate drip at Lift Station #3.

The FBRs discharge treated water to the Las Vegas Wash just upgradient of the Pabco Road erosion control structure under authority of National Pollution Discharge Elimination System (NPDES) Permit NV0023060. Results of discharge monitoring performed between July and December 2013 are presented in Table 6. Effluent hexavalent chromium concentrations have been between non-detect (<0.00025 mg/L) and 0.00056 mg/L – well below the effluent discharge limitation of 0.01 mg/L (7-day average). Total chromium was detected in effluent samples at concentrations ranging from non-detect (<0.0020 mg/L) to 0.045 mg/L and at an average concentration of 0.01 mg/L – well below the effluent discharge limitation of 0.1 mg/L (7-day average).

The FBR system removed approximately 40 pounds of additional chromium over the 6-month period. The sum of the chromium captured and removed from groundwater between July and December 2013 by the GWETS and FBRs totaled approximately 1,500 pounds.

4 Perchlorate Capture and Treatment

The components of the perchlorate capture system consist of the IWF, the barrier wall, the AWF, the SWF, and the seep capture sump. As discussed previously, recharge trenches located downgradient of the barrier wall were formerly part of the GWETS. The locations of these components are shown on Figure 1. The daily average mass of perchlorate removed by the IWF, AWF, and SWF is presented in Table 7. Figure 8 presents the monthly perchlorate recovery totals and the relative contribution of the IWF, AWF, and SWF.

During the period July through December 2013, a total of approximately 272,430 pounds of perchlorate (approximately 1,480 pounds per day [lbs/day]) have been captured and removed from groundwater by the GWETS. Of this total, approximately 163,960 pounds (approximately 890 lbs/day) were captured by the IWF; approximately 98,900 pounds (approximately 540 lbs/day) were captured by the AWF; and approximately 9,580 pounds (approximately 50 lbs/day) were captured by the SWF.

The quantity of perchlorate removed during the current reporting period represents a gradual return to conditions as they existed prior to late 2012. Starting in September 2012 there was a significant increase in the quantity of perchlorate captured and removed from groundwater at the Site.[14] As described below, perchlorate concentrations generally decreased over the current reporting period, particularly in the IWF.

4.1 Perchlorate Plume Configuration

A perchlorate plume map is not included in this mid-period report. Plume maps are included as part of the detailed evaluation and presentation of data contained in the Annual Performance Report submitted in August of each year. This section presents data to supplement the 2012-2013 Annual Performance Report and the plume maps contained therein.

Table A-1 in Appendix A contains analytical and groundwater elevation data for the last five quarters. Based on November 2013 perchlorate analytical results, the highest perchlorate concentration south (upgradient) of the barrier wall occurred in well I-AR (1,900 mg/L). As seen in Figure 9, perchlorate concentrations at the IWF were highly variable between November 2012 and November 2013. Recent changes in perchlorate concentrations within the IWF are further discussed in Section 4.1.1.

North of the barrier wall, the highest perchlorate concentration was detected in well M-71 (1,400 mg/L) in November 2013. This is an increase from 690 mg/L in November 2012. While year-over-year perchlorate concentrations fell in wells M-72 and M-73, perchlorate concentrations were greater in most wells immediately north of the barrier wall (M-69, M-70, M-71 and M-74). As previously discussed in relation to chromium, the observed increases in perchlorate concentration downgradient of the barrier wall suggest that there may be some flow past the wall. The performance of the barrier wall, including what effects the operation of the former

[14] Perchlorate captured and removed by the three wells fields rapidly increased from approximately 1,300 lbs/day in August 2012 to 1,730 lbs/day in September 2012. In October 2012, perchlorate removal reached a peak of approximately 1,980 lbs/day.

recharge trenches may have had, is being evaluated and it is anticipated that this evaluation will be discussed in the 2013-2014 Annual Performance Report.

North of the former recharge trenches, the highest perchlorate concentration was 590 mg/L in well M-44, located between Warm Springs Road and Boulder Highway. North of the AWF, at the ARP well line, the highest concentration was 190 mg/L in well MW-K4 in November 2013. The highest perchlorate concentration reported at the SWF was 16 mg/L in well PC-99R2/R3.

4.1.1 Interceptor Well Field Area

The IWF targets the highest concentrations of perchlorate at the Site. In general, perchlorate concentrations in groundwater downgradient of the IWF and barrier wall (up to 2,300 mg/L in well M-25) are below concentrations observed in groundwater upgradient of the IWF and barrier wall (up to 1,900 mg/L in well M-71). Figure 9 represents a west-east transect through the IWF showing perchlorate concentrations for the 23 active IWF wells in May 2002 compared to the last five quarters. As previously mentioned, five additional I-series wells (I-AA, I-AB, I-W, I-X, and I-Y), which are not currently operated as pumping wells, were first regularly sampled in June 2013 and are included in Figure 9.

Since November 2012, there has been significant variability in the perchlorate concentrations in the IWF wells. However, perchlorate concentrations in well I-N have gradually decreased to 1,100 mg/L, consistent with historical levels prior to November 2012. West of I-N, wells between I-S and I-E increased in February and May 2013, but have decreased in concentration more recently. A broad area of higher concentrations centered at I-V also moderated during August and November 2013.

A combination of factors is likely responsible for the observed increase and subsequent decrease in perchlorate concentrations within many of the IWF wells during the previous five quarters. These factors include high levels of precipitation during late 2012, the alteration of Site drainage patterns resulting from recent Site excavation and grading, and the potential mobilization of soil-bound perchlorate from infiltration at the recently constructed Central Retention Basin. The decrease in measured perchlorate concentration across the IWF during this period of performance indicates that the Site is gradually returning to pre-November 2012 conditions. Figure 10 charts perchlorate concentrations for select wells at the IWF over time and, while there is insufficient historical data regarding well operation and Site conditions to determine the root cause of historical perchlorate cycles, the graph shows generally decreasing trends since sampling for perchlorate began in 2002. Figure 10a charts perchlorate concentrations at the IWF over the last five quarters showing again that concentrations have generally been stable or decreasing since November 2012. The changes in perchlorate concentrations within the IWF during November 2012 (as discussed above in relation to Figure 9) coincide with groundwater elevations which were often significantly higher in IWF and nearby monitoring wells than during the previous four quarters. It is likely that additional perchlorate mass was mobilized via infiltration of storm water following the large rain events in the fall of 2012 and the effects on the IWF are still being observed, though as noted previously the effects are diminishing.

Figure 11 is a west-east transect through the IWF which charts total dissolved solids (TDS) concentrations over the last five quarters. A comparison of Figure 9 and Figure 11, which show perchlorate and TDS, respectively, in each of the IWF wells, indicates that a broad zone of high TDS in the central part of the IWF remains present and coincides with the eastern area of elevated perchlorate concentrations. Starting in November 2012, TDS concentrations in some IWF wells were significantly different than during previous quarters. TDS concentrations were higher than typical in the central portion of the IWF (centered at well I-N) and lower than typical in well I-T and I-U. Increases in TDS were also noted in certain western (I-L and I-S), to a lesser extent, in and eastern (centered at well I-V) wells. Wells with higher than normal concentrations of TDS generally align with the higher perchlorate results discussed above with the notable exception of wells I-U and I-T. As with perchlorate, concentrations of TDS generally returned to pre-November 2012 levels across the IWF during the current performance period.

As shown on Figure 12, the monthly average perchlorate concentrations captured at the IWF generally decreased from a high of about 1,890 mg/L in October 2002 to 732 mg/L in June 2012, the lowest recorded average concentration. The IWF's monthly average perchlorate concentration then doubled to 1,491 mg/L in December 2012. The calculated perchlorate mass removal has generally followed a similar trend, from a high of about 45,000 pounds removed in the month of January 2003 to a low of approximately 20,300 pounds removed during the month of August 2012. By December 2012, the calculated perchlorate mass removal increased to approximately 40,300 pounds, the highest estimated monthly mass removal since January 2003. By June 2013, the calculated perchlorate mass removal decreased to 26,600 pounds and by December 2013 the mass removal was 24,800 pounds. As reported previously, it is likely that additional perchlorate mass was mobilized via infiltration of storm water following the large rain events in the fall of 2012 leading to the historically high perchlorate concentrations and mass removals at the IWF. Barring additional events, it is expected that the elevated perchlorate concentrations and mass removals will continue to decrease to levels similar to those prior to December 2012.

Figure 13 charts perchlorate concentration and water elevation trends in monitoring wells M-100 and M-23, located approximately 700 and 1,300 feet north (downgradient) of the former recharge trenches, respectively. Figure 13 indicates a sharp decrease in perchlorate concentrations in both wells beginning in early 2002, shortly after the barrier wall was installed at the IWF. Water level trends reflect infiltration and mounding of water recharged to the subsurface through the former recharge trenches. Clogging of the trenches and reduced infiltration are reflected in the decreasing water levels beginning about May 2007. The trenches were subsequently refurbished in February 2008 and June 2009 with water levels in well M-100 quickly rebounding and water levels in well M-23 rebounding somewhat slower. Due to conflicts with the soil excavation program at the Site, operation of the trenches was suspended in September 2010, which corresponds with decreases in water levels in both wells M-100 and M-23. Well M-100 has been dry since December 2010. The water level in well M-23 has decreased approximately seven feet since the trenches were shut down. Perchlorate concentrations in well M-100 remained relatively stable from 2008 through 2010. Perchlorate concentrations in well M-23 have remained relatively stable since July 2006.

4.1.2 Athens Road Well Field Area

The AWF captures perchlorate in groundwater at concentrations generally less than 500 mg/L. A west-east transect through the AWF which charts perchlorate concentrations for the last five quarters is shown on Figure 14. Perchlorate concentrations in the AWF's seven pumping wells are shown, in addition to monitoring wells PC-18, PC-55, PC-122, PC-148, PC-149, and PC-150. As shown on the figure, the plume is stable and perchlorate concentrations on the western (PC-55 and ART-1) and eastern (PC-122) edges of the well field continue to remain relatively low.

The perchlorate concentration trends of the pumping wells in the AWF are shown on Figures 15 and 15a. Figure 15 shows that overall perchlorate concentrations in the AWF have generally been declining since 2002. Concentrations in individual wells fluctuate with each sampling event, but for most wells these fluctuations have moderated with time. Figure 15a, an expanded view of the last five quarters of Figure 15, indicates that recent concentrations in the AWF pumping wells have remained relatively stable with some variation in May 2013, particularly in ART-4 and ART-9. The reason for the variability in the perchlorate concentrations in these wells in May 2013 is not immediately apparent. As shown on Figure 16, the perchlorate concentration measured in the AWF is currently at the low-end of its historical range. The estimated perchlorate mass removed from the AWF was approximately 13,970 pounds in December 2013.

Starting in August 2006, TDS data have been collected from the AWF. Figure 17 is a west-east transect through the AWF which charts TDS concentrations for the last five quarters. The figure shows that two zones of higher TDS exist at the AWF: one centered on wells PC-18/ART-8 on the west side of the AWF (both 10,000 mg/L in November 2013) and one at well PC-122 on the east end of the AWF (8,600 mg/L in November 2013).

Approximately 250 feet north of the AWF, eight wells comprise the Athens Road Piezometer or "ARP" well line. Perchlorate concentrations across the ARP well line are presented on Figure 18, and perchlorate concentrations in these wells over time are shown on Figures 19 and 19a. Figure 19 contains concentration-time plots beginning in late 2001, and Figure 19a shows an expanded view of the last five quarters.

As shown on Figure 18, perchlorate concentrations in the western side of the well line (represented by ARP-1, ARP-2/2A, and ARP-3/3A) and the eastern side of the well line (represented by ARP-4/4A, ARP-5/5A, ARP-6/6A/6B and ARP-7) have significantly decreased since 2002. This indicates that the AWF has been effective in capturing perchlorate contaminated groundwater in these sections of the plume. Perchlorate concentrations in the center of the ARP well line at MW-K4 are significantly lower than in 2002, but remain elevated relative to the other sections of the plume. As shown on Figures 19 and 19a, with the exception of wells MW-K4 and ART-6/6A/6B, concentration trends in the ARP well line appear relatively stable. Concentrations in well MW-K4 initially declined with the onset of AWF operation in 2002 and dropped further when ART-9 began pumping in September 2006. Perchlorate concentrations in MW-K4 generally declined between January 2010 (300 mg/L) and December 2011 (150 mg/L), but rebounded from January 2012 to September 2012, once again reaching 300 mg/L. During the last three months of 2012, perchlorate levels in MW-K4 declined to 210 mg/L before increasing during the first four months of 2013, reaching 280 mg/L in April 2013.

No groundwater samples were collected in well MW-K4 during May and June 2013 due to an obstruction in the well. Perchlorate concentrations in MW-K4 generally declined during the current reporting period to a low of 160 mg/L during December 2013. These increases and decreases in perchlorate concentration in MW-K4 do not appear related to changes in water elevation. The higher and more variable perchlorate concentrations in well MW-K4 may be influenced by the well's location with respect to subsurface alluvial channels within the UMCf. Analysis first presented in Appendix E of the 2011-2012 Annual Performance Report indicated that there could be a gap in the capture zone that may be responsible for the elevated concentrations in MW-K4 (ENVIRON 2012). That analysis recommended activating PC-150 as an extraction well to address this gap. As part of the 2013 GWETS Optimization Project, PC-150 will be activated with a proposed start date of April 14, 2014.

Between the ARP well line and the SWF are the COH WRF and the Lower Ponds monitoring well lines. Perchlorate concentration in the COH WRF wells on a west-east transect are shown on Figure 20. Figures 21 and 21a present perchlorate concentration trends for these same wells over time. As shown in the figures, current perchlorate concentrations are well below levels measured in the same wells in May 2002, especially in the center of the well line as shown on Figure 20. As shown on Figure 21, perchlorate concentrations at the COH WRF well line have been stable since mid-2007.

Figure 22 shows historical water elevations at the COH WRF well line. This figure indicates that many of the historical low-concentration events in the wells appear to be associated with a rapid increase in the water levels, likely the result of increased infiltration from the COH WRF surface ponds. The significant groundwater "mounding events" since 2008 (when the operation of the COH RIBs ceased) are not as pronounced as previous ones and are presumed to be related to operation of the COH Bird Viewing Ponds. However, no significant mounding events have occurred since late-2011.

The Lower Ponds well line is approximately 2,200 feet north of the COH WRF well line. Figures 23, 24, and 24a, the perchlorate west-east transect and trend graphs for the Lower Ponds well line, show that current perchlorate concentrations are well below levels measured in the same wells in May 2002, especially at well PC-56 (Figure 23). Figure 24 shows that perchlorate concentrations present in the Lower Ponds well line are generally low and, with the exception of well PC-56, have been relatively stable since 2007. As shown on Figures 24 and 24a, perchlorate concentrations in well PC-56 historically have been more variable than in other wells on the Lower Ponds well line. Concentrations in well PC-56 were 3.3 mg/L in January 2011, 12 mg/L in February 2011, 7 mg/L in June 2011, and 23 mg/L in September 2012. At the end of the current reporting period, the concentrations had decreased to 17 mg/L. The higher and more variable perchlorate concentrations in well PC-56 may be influenced by the well's location with respect to a mapped subsurface alluvial channel that runs north-south back towards the AWF. According to boring logs for these wells, the UMCf was encountered 12 to 20 feet deeper in PC-56 compared to nearby wells PC-58 and PC-60 indicating it is within a narrow alluvial channel incised within the UMCf.

4.1.3 Seep Well Field Area

At present, the SWF consists of 10 extraction wells – two of which (PC-99R2 and PC-99R3) are connected and operate as one – positioned over the deepest part of the alluvium channel that contains the highest concentrations of perchlorate (relative to other SWF wells). The well field is located approximately 600 feet upgradient of the seep capture sump; however, the seep has not flowed since April 2007. The original three recovery wells in the SWF commenced pumping in August 2002. In February 2003, five additional wells (PC-117, PC-118, PC-119, PC-120, and PC-121), and in December 2004, one additional well (PC-133), were completed in the SWF. Wells PC-120 and PC-121, located at the west end of the SWF line and away from the deepest portion of the subsurface alluvial channel, have not been continuously pumped since 2005 due to their low perchlorate removal efficiencies when compared with the remainder of SWF wells. Wells PC-120 and PC-121 are turned on for sampling and are actively pumped when other SWF wells are not operating due to malfunction or maintenance.

The SWF contributes the highest flows (an average flow rate of 514 gpm between July and December 2013) compared with the IWF (an average flow rate of 67 gpm) and the AWF (an average flow rate of 278 gpm) to the GWETS, but captures significantly lower concentrations of perchlorate (generally less than 20 mg/L). Because of the low concentrations captured at the SWF, the perchlorate mass removed from the environment via the SWF is substantially less than that removed via the IWF or AWF (see Figure 8 and Table 7).

Figure 25 shows perchlorate concentrations for the last five quarters along with concentrations for each well during its first month of operation. Figure 26 shows that perchlorate concentrations have significantly decreased in the original pumping wells since 2002. As seen on Figures 26 and 26a, concentrations in wells PC-99R2/R3, PC-115R, and PC-116R are markedly lower during November 2012 than during the months directly preceding and following. Figure 26a shows that SWF wells with low concentrations of perchlorate (PC-119, PC-120, PC-121) have been relatively stable over the last year with the exception of PC-133, which steadily increased from 0.63 mg/L in May 2012 to a high of 16.0 mg/L in February 2013. However, starting in March 2013, perchlorate concentrations in PC-133 have decreased to a low of 2.7 mg/L in December 2013. Based on our review of lithologic logs, water levels, nearby concentrations, and flow rates at the SWF, a definitive cause for the observed increase and subsequent decrease in perchlorate concentrations in PC-133 has not been identified. It is noted that PC-133 is on the eastern edge of the alluvial channel away from the other SWF pumping wells, which pump at significantly higher rates compared to PC-133. It is further noted that PC-133 was rehabilitated on September 30, 2013 to remove roots from the well in an effort to increase its extraction rate; however, the work, which included swabbing and pumping the well and replacing the pump and motor with higher capacity units, did not result in significant increases in the extraction rate.

TDS concentrations in the SWF wells for the last five quarters are plotted on Figure 27. The highest TDS concentration (4,500 mg/L) in November 2013 was measured in well PC-99R2/R3, which corresponds with the highest perchlorate concentration in the SWF. Higher TDS concentrations generally corresponded with higher perchlorate concentrations in SWF wells over the previous year.

As shown on Figure 28, the monthly average perchlorate concentrations captured at the SWF generally decreased from a high of approximately 82 mg/L in March 2003 to an average of approximately 8.4 mg/L between July 2013 and December 2013. The calculated perchlorate mass removal has generally followed a similar trend, from a high of about 19,900 pounds removed in the month of April 2003 to an average of approximately 1,600 pounds removed per month between July 2013 and December 2013. The total amount of perchlorate removed by the SWF during the current reporting period (9,580 pounds) is approximately 1,100 pounds less than the same period in 2012.

4.2 Perchlorate Treatment System

Throughout the reporting period, groundwater was captured both on-site and off-site, conveyed to the on-site treatment facilities, and treated biologically in the FBRs to remove perchlorate, chlorate and nitrate. Effluent from the FBRs has been discharged into Las Vegas Wash within the limits specified in the NPDES NV0023060 discharge permit, except as discussed below. As shown on Table 8, between July and December 2013, the perchlorate influent to the FBRs ranged from 93 mg/L to 140 mg/L. Perchlorate was generally not detected at concentrations exceeding the laboratory sample quantitation limit (SQL) (<0.00095, <0.0025, or <0.0048mg/L) with the notable exception of effluent samples from the first week and last week of July 2013.

As reported in a memo to NDEP's Bureau of Water Pollution Control on August 29, 2013 (ENVIRON 2013c), a number of events occurred during the weeks of June 30 to July 9, 2013 (first week of July) and July 28 to August 3, 2013 (last week of July) that interfered with treatment operations at the Site. The perchlorate results for the effluent composite results from these two weeks were 74 micrograms per liter (µg/L) and 15 µg/L, respectively. The 30-day average perchlorate effluent concentration for July 2013 was 18.5 µg/L, slightly above the Site's NPDES permit limitation of 18 µg/L. Following the 30-day average exceedance in July, GWETS operations have stabilized and effluent samples have not exceeded the Site's permit limits.

5 Performance Evaluation

This section provides an evaluation of the performance of the GWETS against a set of performance metrics developed in coordination with NDEP. These metrics are intended to establish a consistent framework for evaluating performance of the GWETS, including evaluating the effectiveness of current and future optimization efforts.

5.1 Performance Metrics

A set of performance metrics was developed as part of the 2013 GWETS Optimization Work Plan (ENVIRON 2013e), approved by NDEP on December 3, 2013 (NDEP 2013d). The metrics include those identified in the October 10, 2013 letter from NDEP (NDEP 2013b) commenting on the 2012-2013 Annual Performance Report and additional metrics identified by ENVIRON. The approved performance metrics are outlined below:

1. Monthly perchlorate and chromium mass removal rates from the IWF, AWF, and SWF;
2. Perchlorate and chromium plume mass estimates;
3. The concentrations at which the Site is achieving 90% and 99% capture of perchlorate and chromium;
4. Perchlorate and chromium capture efficiency of the IWF, AWF, and SWF;
5. Mass loading of perchlorate and chromium in the Las Vegas Wash at Northshore Road;
6. The fraction of mass loading in Las Vegas Wash at Northshore Road that originates from the Site;
7. The amount of surface water from Las Vegas Wash and the COH Bird Viewing Ponds that is being extracted by the SWF; and
8. The environmental footprint of the GWETS with a focus on energy use.

The numbering of the metrics presented above was done only for clarity and does not reflect a hierarchy. The metrics are discrete measures of performance that will be used to understand and adjust GWETS performance over time.

5.2 Groundwater Model

A key tool for developing and implementing the performance metrics is the groundwater model. A groundwater model for the Site was originally developed by Northgate and documented in the Capture Zone Evaluation Report (Northgate 2010b). The model was approved on April 4, 2013 by NDEP (NDEP 2013a). As part of the 2013 GWETS Optimization Project, the existing model was refined and updated to recent steady-state conditions. The modeling work follows the 2013 GWETS Optimization Study Work Plan submitted by ENVIRON to NDEP (ENVIRON 2013e). The updated model, “ENVIRON Phase I Model,” is described in Attachment A of this report. The model has been updated with October 2013 pumping rates for evaluations presented in this report, as shown on Tables 1 through 3. The third and fourth quarter 2013 pumping rates for OSSM and AMPAC wells were provided by both companies.

The performance metrics are focused mainly on perchlorate because the perchlorate plume is the most spatially extensive (i.e., the spatial extent of the chromium plume is contained within the perchlorate plume) and perchlorate represents the more immediate threat to off-site receptors due to its potential impacts on Las Vegas Wash. This is consistent with the focus of previous capture zone evaluations at the Site. The evaluation of GWETS performance using the metrics is consistent with United States Environmental Protection Agency (USEPA) guidance on evaluating capture zones for groundwater pump and treat systems (USEPA 2008).

5.3 Performance Evaluation Approach and Organization

An overall approach for evaluating metrics was established in the 2013 GWETS Optimization Study Work Plan (ENVIRON 2013e) as follows:

- In order to calculate several of the metrics, study area boundaries had to be defined. For this purpose, the plume mass estimate boundaries first presented in Attachment 1 of the 2012-2013 Annual Performance Report are being used (ENVIRON 2013d).
- Target capture zones are graphically compared to the actual capture zones achieved by well fields as estimated by the groundwater model.
- The total mass flux being transported by groundwater flow across hypothetical east-west lines passing through the IWF, AWF, and SWF is estimated using measured mass flux at extraction wells and modeled groundwater flow rates and interpolated concentrations.
- The fraction of the total mass flux being captured by the IWF, AWF, and SWF is estimated using capture zones from the groundwater model. Capture efficiency is the ratio of captured mass flux to total mass flux.
- Estimates of perchlorate and chromium plume mass follow a similar approach to that used in the 2012-2013 Annual Performance Report (ENVIRON 2013d).
- Mass loading at Northshore Road and other locations in the Las Vegas Wash is calculated as the product of the flow rate at the stream gage and perchlorate concentrations measured in Las Vegas Wash near the stream gage.

Because some of the metrics (as listed in Section 5.1) are closely related or share certain calculations, the discussion of the metrics is organized to acknowledge this and clarify the presentation as follows:

- Metrics 1 and 2 are discussed in Section 5.4.1 *Mass Removal and Remaining Plume Mass*;
- Metrics 3 and 4 are discussed in Section 5.4.2 *Capture Zone Evaluation and Estimated Mass Flux*;
- Metrics 5 and 6 are discussed in Section 5.4.3 *Perchlorate Mass Loading to Las Vegas Wash;*
- Metric 7 is discussed in Section 5.4.4 *Surface Water Effects on the SWF*; and

- Metric 8 is discussed in Section 5.4.5 *Environmental Footprint*.

5.4 Evaluation of Performance

In this section, the performance of the GWETS is discussed in relation to the metrics described in Section 5.1. The methodologies used for these evaluations are also described.

5.4.1 Mass Removal and Remaining Plume Mass

During the period July through December 2013, approximately 272,430 pounds of perchlorate (approximately 1,480 lbs/day) were captured and removed from groundwater by the GWETS as shown in Table 7. Of this total, approximately 163,960 pounds (approximately 890 lbs/day) were captured by the IWF; approximately 98,900 (approximately 540 lbs/day) were captured by the AWF; and approximately 9,580 pounds (approximately 50 lbs/day) were captured by the SWF.

Estimates of remaining chromium and perchlorate plume mass were presented in the 2012-2013 Annual Performance Report, Attachment 1 and will be updated as part of the 2013-2014 Annual Performance Report. Tables 9 and 10 present plume mass estimates for perchlorate and total chromium based on three interpolation methods (e.g., kriging, spline, and contour) (ENVIRON 2013d). The mass estimates for the three methods are generally in agreement. The results demonstrate decreasing concentrations of perchlorate and chromium for both on-site and off-site areas of the plume over the course of the study period. The total plume masses as of 2012 were estimated to be between 2,950 and 4,110 tons[15] for perchlorate and between 25 and 27 tons for chromium.

5.4.2 Capture Zone Evaluation and Estimated Mass Flux

Capture zones for each of the well fields were estimated in the alluvium and UMCf using forward particle tracking, calculated using MODPATH (Pollock 1994) and the updated steady-state groundwater model. Particles were released in the center of each model cell in model layer 1 (representing the alluvium) and layer 2 (representing the vertical extent of UMCf impacted by perchlorate). Capture zones for each well field were defined using an analysis of the particle tracking endpoints.

Based on pumping rates from October 2013, simulated capture zones in the alluvium and UMCf are shown in Figure 29a and Figure 29b, respectively. In order to evaluate the capture zones for this performance metric, the simulated capture zones are compared to a target capture zone, which was defined as the combination of the Site and Downgradient Plume Areas, as outlined on the figures. Comparing the target capture zone to the simulated capture zones indicates that the combination of the IWF, AWF and SWF almost completely capture the target area, except for a small area between SWF and Las Vegas Wash, where the perchlorate concentrations are generally less than 10 mg/L. These simulated capture zones may change once the groundwater model is revised as part of the Phase II model update of the 2013 GWETS Optimization Project.

[15] The plume mass estimates for perchlorate and chromium were originally reported in the 2012-2013 Annual Performance Report, Attachment 1 in metric tons. For ease of comparison as a performance metric, the plume masses are presented herein as short tons (2,000 pounds/ton).

To further evaluate the performance of each well field in more detail, perchlorate mass flux at the IWF, AWF and SWF within the study area boundary was estimated at three transects, located just upgradient of the respective well fields. The locations of the transects are shown on Figure 30a. The transect lines were drawn perpendicular to the groundwater flow direction with mass flux calculated using the methods described by the Interstate Technology and Regulatory Council (ITRC) guidance (ITRC 2010). The distributions of perchlorate mass flux at the IWF, AWF, and SWF along the transects are shown in Figures 30b, Figure 30c, and Figure 30d, respectively.

Perchlorate mass flux across each transect was calculated differently depending on whether that portion of the transect was inside or outside of the simulated capture zone. The perchlorate mass flux within the capture zone was estimated by averaging the mass loading at each extraction well in the AWF and SWF for the period July to December 2013, as reported in GWETS operations spreadsheets provided by Envirogen. For the IWF, the perchlorate loading at individual extraction wells is not recorded in the GWETS operations spreadsheet. Hence, the mass loading at each IWF well was determined using the average pumping rate over July through December 2013 and the perchlorate concentration measured in each well in November 2013.

The estimates of perchlorate mass flux outside of the capture zone at each transect were calculated from modeled flow rates and interpolated concentrations. For each model cell on the transect, the flux was calculated as the product of the average perchlorate concentration for July through December 2013, modeled groundwater flow rate, model cell width, and saturated thickness of the alluvium. For calculating the mass flux in UMCf, it was assumed that perchlorate is present throughout model layer 2 only. Further, it was assumed that perchlorate has not reached the UMCf in the vicinity of the SWF. At IWF and AWF, the mass fluxes in the UMCf were estimated based on the thickness of layer 2 which is the estimated saturated thickness of perchlorate-impacted UMCf.

The overall capture efficiency of each well field was calculated as the ratio of the total captured mass flux to the total mass flux across the transect. The capture efficiencies of the IWF, AWF, and SWF were calculated as 97%, 95%, and 93%, respectively. The results show that during the period of July through December 2013, an estimated average of 3.6 lbs/day of perchlorate discharged into Las Vegas Wash from the study area. Based on an evaluation of concentration trends in observation wells downgradient from the well fields, the capture efficiency may be overestimated for the IWF and AWF. As described in Section 2.1, the concentrations of perchlorate and chromium observed in wells immediately downgradient of the IWF barrier wall suggest that there may be some flow past the wall. The performance of the barrier wall is currently being evaluated. Similarly, as described in Section 2.2, the elevated perchlorate concentrations observed in well MW-K4 may indicate a gap in capture at the AWF immediately west of the UMCf ridge. To address this gap in capture at the AWF, ENVIRON is in the process of activating the currently idle wells ART-7B and PC-150 as part of the 2013 GWETS Optimization Project. Due to the inconsistencies between the measured concentrations and the model outputs at the IWF and AWF, the groundwater model in the vicinity of the well fields is also being evaluated and refined as part of the 2013 GWETS Optimization Project.

5.4.3 Perchlorate Mass Loading to Las Vegas Wash

The water in the Las Vegas Wash is sampled for perchlorate monthly or quarterly at various locations by the GWETS operator (for compliance with the site's NPDES permit) and by Southern Nevada Water Agency (SNWA). Based on the measured perchlorate concentrations in stream water and corresponding stream flow, perchlorate mass loading at the following three locations was estimated: Las Vegas Wasteway (LW8.85), Pabco Road (LW 6.05), and Northshore Road (LW0.55). These sampling stations are co-located with USGS gauging stations and are shown on Figure 31a.

Currently, perchlorate concentration and mass loading to Las Vegas Wash is reported to NDEP using data from Northshore Road, which is located approximately six river miles downstream of the Site and just upstream from Lake Mead. For the purpose of this performance evaluation, it is useful to also calculate mass loading at Pabco Road to evaluate what portion of the perchlorate mass loading at Northshore Road is coming from upstream of Pabco Road versus downstream of Pabco Road. In order to estimate background levels of perchlorate, mass loading was also calculated at the Las Vegas Wasteway stream gauging station, located about 2.8 river miles upstream of the SWF.

When reporting perchlorate mass loading at Northshore Road in the past, the established procedure is to multiply the measured perchlorate concentration by the 15-minute average flow rate corresponding to the time period closest to the sample collection time. Flow rates in the Las Vegas Wash exhibit a strong diurnal pattern due to the dominance of wastewater flows. The perchlorate samples at Northshore Road are collected during the morning near the low flow point of the diurnal cycle. Thus, this instantaneous mass loading calculation method yields lower mass loading estimates than methods using a longer flow averaging time.

Surface water samples have been collected at various time intervals in the past, but at a minimum samples were collected quarterly. In order to compare mass loading estimates at the three stations, mass loading at Northshore Road has been recalculated using quarterly average flow rates and quarterly average concentrations. A comparison of mass loading rates using the quarterly averaging method and the instantaneous method is shown on Figure 31b. The mass loading rates using the different methods are similar, but the quarterly average method tends to yield slightly higher values.

Quarterly perchlorate mass loading at the three stations (Northshore Road, Pabco Road and Las Vegas Wasteway) are shown on Figure 31c. Over the period from fourth quarter 2007 to fourth quarter 2013, the average perchlorate mass loading was 2 lbs/day at Las Vegas Wasteway, 22 lbs/day at Pabco Road, and 91 lbs/day at Northshore Road. Thus, this analysis indicates that approximately 22% of the mass loading measured at Northshore Road can be attributed to mass flux entering the Las Vegas Wash between the Las Vegas Wasteway and Pabco Road stations, while 76% can be attributed to mass flux entering Las Vegas Wash between the Pabco Road and Northshore Road stations.

5.4.4 Surface Water and Groundwater Interaction Near the SWF

Because the SWF is located near two surface water bodies (Las Vegas Wash and the COH Bird Viewing Ponds), pumping at the SWF likely induces surface water flow into the SWF extraction wells. The surface water from both Las Vegas Wash and the COH Bird Viewing Ponds is comprised primarily of treated municipal wastewater effluent. It is inefficient for the SWF to extract any more surface water from these sources than necessary. One of the goals of this (and future) performance evaluations is to better characterize surface water interactions in the vicinity of the SWF.

The USGS stream gage at the Pabco Road weir (USGS # 09419700) is located approximately 1,000 feet downgradient of the SWF. Daily historical gauge height (i.e., stream stage) data from the Pabco Road weir is available from the USGS for this station starting October 1, 2000. A comparison of stream gauging height with groundwater elevations measured in nearby shallow monitoring wells is shown on Figure 32. The hydrographs show that by 2007, the groundwater elevations in monitoring wells near the SWF were below the stream gauging height, with the exception of well PC-97. This data suggests that in the area of the SWF, surface water from the Las Vegas Wash is being pulled into the SWF. As described in the Remedial Investigation and Feasibility Study (RI/FS) Work Plan (ENVIRON 2014), additional monitoring wells and data collection in planned in this area to better characterize stream-aquifer interactions.

Along with surface water from the Las Vegas Wash, the SWF appears to also be pulling a significant quantity of water directly from the COH Bird Viewing Ponds. This is indicated by the TDS plume in shallow groundwater from second quarter 2012, which is shown on Figure 33. A region of low TDS concentration (<2,500 mg/L) originating at the Bird Viewing Ponds appears to be captured by the SWF. Treated effluent from the COH WRF is being discharged into the Bird Viewing Ponds at an average rate of approximately 1.2 million gallons per day (850 gpm). Discharge into the Bird Viewing Ponds began on May 2, 2008.

In an effort to better understand the potential surface water inputs to groundwater near the SWF, additional samples will be collected from three wells in the western portion of the SWF area (PC-117, PC-118, and PC-121), two wells in the eastern portion of the SWF area (PC-91 and PC-133), three wells at the AWF (MW-K4, ART-4, and ART-9), and two wells likely influenced by the COH Bird Viewing Ponds (PC-62 and PC-103). The samples will be analyzed for analytes not typically monitored as part of the annual sampling program (e.g., dissolved cations, total suspended solids [TSS], chloride, fluoride, sulfate, ortho-phosphate, ammonia, nitrate, nitrite, total alkalinity) and compared with samples collected from Las Vegas Wash by the United States Department of the Interior's Bureau of Reclamation (Bureau of Reclamation 2012). The samples are being collected during the first quarter 2014 sampling event and results will be discussed in the 2013-2014 Annual Performance Report.

As part of the 2013 GWETS Optimization Project, the portion of SWF extraction that originates from the Bird Viewing Ponds and Las Vegas Wash will be further quantified using the updated groundwater model.

5.4.5 Environmental Footprint

A footprint analysis of Site operations was submitted to NDEP on August 8, 2013 (ENVIRON 2013b). The report documents energy and materials used at the Site, as well as wastes generated for activities and services conducted. Based on information compiled for the footprint analysis, the GWETS used approximately 4.6 million kilowatt hours per year (kWh/yr) and the wells and pump stations used approximately 1.4 million kWh/yr. Monthly energy use by the GWETS varied from 352,092 to 404,540 kWh between July 2011 and June 2012. Monthly use by the wells and lift stations varied from 109,870 to 129,270 kWh during the same period. Given that Site operations have not undergone any major alterations since this data was compiled, energy use at the Site should be substantially the same during the current performance period.

5.5 Summary of GWETS Performance Evaluation

A summary of the performance metrics is shown in Table 11. As described in the 2013 GWETS Optimization Project Work Plan, the performance metrics for GWETS described above will be used to adjust the operation of the GWETS to more effectively and efficiently meet the performance objectives. Currently, the system is effective at capturing more than 90% of the perchlorate mass flux migrating from the Site area to the Las Vegas Wash. As part of the 2013 GWETS Optimization Project, additional currently idle extraction wells are being activated and a set of recommendations for optimizing the performance will be proposed.

6 Conclusions

The GWETS consists of three groundwater capture well fields: the IWF, the AWF, and the SWF. The IWF coupled with the barrier wall provides capture of the highest concentrations of perchlorate and chromium at the Site and significantly reduces the amount of perchlorate and chromium in downgradient groundwater. The off-site AWF, located approximately 8,200 feet downgradient of the IWF, has been in continuous operation since October 2002. The AWF captures significantly lower concentrations of both perchlorate and chromium; however due to its higher extraction rates compared with the IWF, it significantly contributes to the overall mass of perchlorate removed from the environment and mitigates its migration in groundwater. The SWF, located over the main part of the alluvium channel in close proximity to Las Vegas Wash, contributes the highest flows (average of 514 gpm between July and December 2013) compared with the IWF (67 gpm) and the AWF (278 gpm) to the GWETS, but captures significantly lower concentrations than the other well fields. The surface seep has not flowed since April 2007.

Treatment of chromium-contaminated groundwater (primarily from the IWF) occurs via the on-site GWTP, which chemically reduces hexavalent chromium and removes total chromium. A small ferrous sulfate drip system also treats lower concentrations of chromium from the AWF. Treatment of perchlorate-contaminated groundwater from all well fields occurs via the on-site FBRs, which biologically remove perchlorate as well as chlorate, nitrate, and residual chromium.

For the 6-month period ending in December 2013, the capture of perchlorate-contaminated groundwater from all three well fields, and biological treatment in the on-site FBRs, has removed a total of approximately 272,430 pounds of perchlorate from the environment. This was a decrease from 311,200 pounds of perchlorate removed during 6-month period ending in December 2012, but represented a return to Site conditions as they were prior to late 2012.

For the same 6-month period, the capture of chromium-contaminated groundwater at the IWF and AWF, and treatment at the on-site GWTP, has removed approximately 1,460 pounds of chromium. Adding the 40 pounds of chromium removed by the FBRs for the same period, a total of 1,500 pounds of chromium were removed from groundwater between July and December 2013.

As reported in a memo to NDEP's Bureau of Water Pollution Control on August 29, 2013 (ENVIRON 2013c), a number of events occurred during the weeks of June 30 to July 9, 2013 and July 28 to August 3, 2013 that interfered with treatment operations at the Site. As discussed in Section 4.2 herein, this resulted in a 30-day average perchlorate effluent concentration for July of 18.5 µg/L, slightly above the Site's NPDES permit limitation of 18 µg/L. Following this exceedance, GWETS operations have stabilized and effluent samples have not exceeded the Site's permit limits.

During the current reporting period, groundwater elevations remained elevated in areas adjacent to the barrier wall. Within the IWF itself, the significant increases in perchlorate concentration that were first observed in November 2012 have gradually decreased. As first discussed in the 2012-2013 Annual Performance Report, the above average rainfall in the fall of 2012 and the infiltration of storm water within the Central Retention Basin have likely resulted in mobilization of additional soil-bound perchlorate upgradient of the IWF. The historically high perchlorate mass removal rates at the IWF between November 2012 and May 2013 support this conclusion. Monitoring of Site groundwater during the current performance period has shown that conditions at the IWF are returning to what they were before November 2012.

Performance metrics have been developed for the GWETS and have been presented for the first time in this report as part of the routine performance reporting. A summary of the performance metrics is presented in Table 11. These metrics form the basis for evaluating the performance of the GWETS on a comparative basis moving forward.

7 Proposed Future Activities

As part of the 2011-2012 Annual Groundwater Monitoring report, a preliminary analysis of current groundwater capture was performed that recommended both adjusting extraction rates of individual wells and bringing idle extraction wells online to improve capture efficiency and maximize mass removal. These recommendations are being implemented as part of the 2013 GWETS Optimization Project, which is described in a November 22, 2013 work plan (ENVIRON 2013d) approved by NDEP on December 3, 2013. The scope of work for the 2013 GWETS Optimization Project includes making operational adjustments to the extraction wells in the IWF and AWF, including initiating extraction in seven currently idle wells in the IWF (I-W, I-X, I-Y, I-AA, I-AB, I-AC, and I-AD) and two wells in the AWF (ART-7B and PC-150). This work will include well testing, construction related to connecting ART-7B and PC-150 to the GWETS, well startup, updating the groundwater model, data evaluation and modeling, and reporting of results.

The updates to the NDEP-approved groundwater model will provide a better understanding of projected groundwater extraction rates at the IWF, AWF, and SWF. For the purpose of initial optimization, the model will continue to be used in steady-state mode; however, ENVIRON anticipates that a transient model will be developed, as requested by NDEP, to evaluate the changes in capture zones over time resulting from time-varying pumping rates. The task of developing the transient model is anticipated to be performed as part of the RI/FS for the Site and is therefore not included in the 2013 GWETS Optimization Project.

In an effort to better understand the potential surface water inputs to groundwater near the SWF, additional analyses will be performed on groundwater samples collected from three wells in the western portion of the SWF area (PC-117, PC-118, and PC-121), two wells in the eastern portion of the SWF area (PC-91 and PC-133), three wells at the AWF (MW-K4, ART-4, and ART-9), and two wells likely influenced by the COH Bird Viewing Ponds (PC-62 and PC-103). The samples will be analyzed for analytes not typically monitored as part of the annual sampling program (e.g., dissolved cations, total suspended solids [TSS], chloride, fluoride, sulfate, ortho-phosphate, ammonia, nitrate, nitrite, total alkalinity) for comparison to sampling results from Las Vegas Wash performed by the Bureau of Reclamation. The samples are being collected during the first quarter 2014 sampling event. In addition, the performance of the barrier wall, including what effects the operation of the former recharge trenches may have had, is currently being evaluated. It is anticipated that the results of both of these efforts will be discussed in the 2013-2014 Annual Performance Report.

Other proposed future activities include commencement of aspects of the scope of work outlined in the RI/FS Work Plan, Revision 1 which was submitted to NDEP on January 10, 2014 (ENVIRON 2014). The proposed activities relating to the RI/FS are contingent on the NDEP approval of the RI/FS Work Plan and associated budgets.

8 References

Bureau of Reclamation. 2012. Las Vegas Wash Water Quality Monitoring Program 2011 Report: A Water Quality Assessment. July.

ENVIRON International Corporation (ENVIRON). 2012. Annual Remedial Performance Report for Chromium and Perchlorate, Nevada Environmental Response Trust Site; Henderson, Nevada; July 2011 – December 2012. August 31. NDEP approved July 2, 2013.

ENVIRON. 2013a. Semi-Annual Remedial Performance Report for Chromium and Perchlorate, Nevada Environmental Response Trust Site; Henderson, Nevada; July 2012 – December 2012. March 1.

ENVIRON 2013b. Inventory of Resources, Materials, Activities, and Services for Environmental Footprint Analysis Groundwater Removal Action; NERT Site; Henderson, Nevada. August 8. Under NDEP review.

ENVIRON. 2013c. July 2013 Groundwater Extraction and Treatment System (GWETS) Upsets and Effluent Perchlorate Results, Nevada Environmental Response Trust Site; Henderson, Nevada; NPDES Permit NV0023060. August 19. Acknowledged by NDEP via email on September 3, 2013.

ENVIRON. 2013d. Annual Remedial Performance Report for Chromium and Perchlorate, Nevada Environmental Response Trust Site; Henderson, Nevada; July 2012 – June 2013. August 30. NDEP approved October 10, 2013.

ENVIRON. 2013e. 2013 GWETS Optimization Project Work Plan, Revision 1, Nevada Environmental Response Trust Site; Henderson, Nevada. November 22. NDEP approved December 3, 2013.

ENVIRON. 2014. Remedial Investigation and Feasibility Study Work Plan, Revision 1, Nevada Environmental Response Trust Site; Henderson, Nevada. January 10. Under NDEP review.

Interstate Technology & Regulatory Council (ITRC). 2010. Use and Measurement of Mass Flux and Mass Discharge. August.

Northgate Environmental Management, Inc. (Northgate). 2010a. Interim Groundwater Capture Evaluation and Vertical Delineation Report, Tronox LLC, Henderson, Nevada. March 23. NDEP commented on April 30, 2010. Northgate submitted a Response to Comments on May 17, 2010. NDEP approved response to comments on May 20, 2010.

Northgate. 2010b. Capture Zone Evaluation Report, Henderson, Nevada. December 10. ENVIRON resubmitted the NERT Site groundwater model on February 21, 2013. NDEP approved April 4, 2013.

Nevada Division of Environmental Protection (NDEP). 2013a. Nevada Division of Environmental Protection (NDEP) Response to: Hydrogeologic Flow Model, Supporting Documentation, and Response to Comments on the Model for the Nevada Environmental Response Trust Site; Henderson, Nevada; Dated April 25, 2012 and updated February 21, 2013. April 4.

NDEP. 2013b. Nevada Division of Environmental Protection (NDEP) Response to: Annual Remedial Performance Report for Chromium and Perchlorate, Nevada Environmental Response Trust, Henderson, Nevada, July 2012 – June 2013. October 10.

NDEP. 2013c. Nevada Division of Environmental Protection (NDEP) Response to: 2013 GWETS Optimization Project Work Plan, Revision 1; Date November 22, 2013. December 3.

Pollock, D.W. 1994. User's Guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite difference ground-water flow model: U.S. Geological Survey Open-File Report 94-464, 6 Ch.

RCI Engineering. 2010. Technical drainage study for Tronox soil remediation treatment basins. RCI Engineering, Las Vegas, NV. October 2010.

United States Environmental Protection Agency (USEPA). 2008. A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems: U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/003.

Zheng, C. 1990. MT3D, A modular three-dimensional transport model for simulation of advection, dispersion, and chemical reactions of contaminants in groundwater systems, Report to the Kerr Environmental Research Laboratory, US Environmental Protection Agency, Ada, OK.

Tables

Figures

Plate

Appendix A

Groundwater Elevations and Analytical Data

Appendix B

Groundwater Field Records

Appendix C

Data Validation Summary Report (DVSR)

(Provided on CD)

Appendix D

Electronic Data Deliverable (EDD)

(Database files provided electronically or on CD separately)

Attachment A

Phase I Groundwater Model Refinement