Prepared for
Nevada Environmental Response Trust
Henderson, Nevada

Prepared by
Ramboll US Corporation
Emeryville, California

Project Number
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ANNUAL REMEDIAL PERFORMANCE REPORT FOR CHROMIUM AND PERCHLORATE

NEVADA ENVIRONMENTAL RESPONSE TRUST SITE HENDERSON, NEVADA

RAMBOLL

Annual Remedial Performance Report for Chromium and Perchlorate

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

Nevada Environmental Response Trust (NERT) Representative Certification
I certify that this document and all attachments submitted to the Division were prepared at the request of, or under the direction or supervision of NERT. Based on my own involvement and/or my inquiry of the person or persons who manage the 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: 11/9/18

Annual Remedial Performance Report for Chromium and Perchlorate

Nevada Environmental Response Trust Site (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.

11/9/18

John M. Pekala, PG
Principal

Date

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

The following individuals provided input to this document:

John M. Pekala, PG
Allan J. DeLorme, PE
Christopher J. Ritchie, PE
Christopher M. Stubbs, PhD, PE
Alka Singhal, PhD
Jonathan Hunt, PhD
Pejman Rasouli, PhD
Lisa A. Taylor, MESM
Katie Elich, MS
Lynsey Parker, MS
Ann Ruengvivatpant, MS
Mia Sosa, MS
Ruhui Zhao, MS
Craig J. Knox
Marcella Valentine
Annika Deurlington
Ruben So

Annual Remedial Performance Report for
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Date	**November 9, 2018**
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Project No **1690006941**

Ramboll
2200 Powell Street
Suite 700
Emeryville, CA 94608
USA
T +1 510 655 7400
F +1 510 655 9517
www.ramboll.com

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ACRONYMS AND ABBREVIATIONS

ACH	alumina chlorohydrate
ARP	Athens Road Piezometer
AMPAC/Endeavour	American Pacific Corporation/Endeavour LLC
AWF	Athens Road Well Field
bgs	below ground surface
BCL	Basic Comparison Level
BMI	Black Mountain Industrial
BMP	Best Management Practice
BRC	Basic Remediation Company LLC
BTU	British thermal unit
CEM	Certified Environmental Manager
CO_2	carbon dioxide
COH	City of Henderson
COPC	chemical of potential concern
DO	dissolved oxygen
DTS	distributed temperature survey
DVSR	Data Validation Summary Report
EDD	Electronic Data Deliverable
Envirogen	Envirogen Technologies, Inc.
FBR	fluidized bed reactor
gpm	gallons per minute
GWETS	groundwater extraction and treatment system
GWM	groundwater monitoring
GWTP	Groundwater Treatment Plant
HAP	hazardous air pollutants
IWF	Interceptor Well Field
IX	ion exchange
lbs	pounds
lbs/day	pounds per day
MCL	maximum contaminant level
mg/L	milligrams per liter

MWh	Megawatt Hours
NDEP	Nevada Division of Environmental Protection
NERT	Nevada Environmental Response Trust
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
ORP	oxidation reduction potential
OSSM	Olin/Stauffer/Syngenta/Montrose
OU	Operable Unit
PM	particulate matter
Qal	Quaternary alluvium
Ramboll	Ramboll US Corporation
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
SEFA	Spreadsheets for Environmental Footprint Analysis
Site	Nevada Environmental Response Trust Site
SNWA	Southern Nevada Water Authority
SO_x	sulfur oxides
SWF	Seep Well Field
TDS	total dissolved solids
Tetra Tech	Tetra Tech, Inc.
TIMET	Titanium Metals Corporation
TIR	thermal infared
Tronox	Tronox LLC
Trust	Nevada Environmental Response Trust
μg/L	micrograms per liter
UMCf	Upper Muddy Creek Formation
USB	Universal Serial Bus
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	volatile organic compound
WBZ	water-bearing zone
WRF	Water Reclamation Facility
ZVI	Zero Valent Iron

1. INTRODUCTION

Ramboll US Corporation (Ramboll) has prepared this remedial performance report for submittal to the Nevada Division of Environmental Protection (NDEP) on behalf of the Nevada Environmental Response Trust (the Trust or NERT) for the Nevada Environmental Response Trust Site (the Site). The Site[1] is located within the Black Mountain Industrial (BMI) Complex in unincorporated Clark County and is surrounded by the city of Henderson, Nevada.

1.1 Purpose

This report describes the performance of the groundwater extraction and treatment system (GWETS) in removing and treating groundwater contaminated with perchlorate and hexavalent chromium. The primary infrastructure of the GWETS was completed by Kerr-McGee Chemical Corporation in the early 2000s in accordance with an Order issued by NDEP. The GWETS currently operates as a removal action designed to capture the highest concentrations of perchlorate and hexavalent chromium present in groundwater. 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, with the exception of the ion exchange (IX) treatment system associated with perchlorate treatment of water originating from dewatering activities associated with Southern Nevada Water Authority's (SNWA) construction of Sunrise Mountain Weir and Historic Lateral Weir, as discussed in Section 2.3. This report, covering the period July 2017 through June 2018, presents data collected during this period while providing discussion of groundwater conditions in the vicinity of the Site as well as GWETS performance relative to the established performance metrics.[2] This report expands upon the information included in the 2017 Semi-Annual Remedial Performance Memorandum and contains additional text, tables, and figures documenting groundwater conditions, the status of remediation efforts, and a detailed performance evaluation of the GWETS. GWETS performance will continue to be evaluated in future remedial performance submittals throughout the Remedial Investigation and Feasibility Study (RI/FS) process and implementation of the final remedy. Once the final remedy is in place, the monitoring program and associated reporting, including evaluation of the performance metrics, will be adapted for the final remedy.

Sections 3 through 7 of this report present evaluations of groundwater conditions and concentration trends. These evaluations are aided by the presentation of a potentiometric surface map and isoconcentration maps for chromium, perchlorate, chloroform, and total dissolved solids (TDS). Similar to previous annual reports, concentration trends are discussed at various well lines within the plume, beginning in the southern portion of the plume and progressing downgradient to the north towards Las Vegas Wash. As requested by NDEP in the December 6, 2016 comment letter on the

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[1] Herein "Site" will be used to refer to the NERT Site property boundary owned by the Trust.

[2] Performance metrics were developed as part of the 2013 GWETS Optimization Work Plan (ENVIRON 2013), approved by NDEP on December 3, 2013 (NDEP 2013). These performance metrics differ from the metrics being utilized as part of the Trust's monthly GWETS operations reporting, which were developed by Tetra Tech and included in their Enhanced Operational Metrics Proposal dated August 20, 2014 (Tetra Tech 2014).

2015-2016 Annual Report (NDEP 2016b), this report incorporates statistical analyses of the trends observed at these well lines.

Section 8 presents an evaluation of GWETS performance with respect to the performance metrics. For the purposes of the ongoing RI/FS, two investigation areas were defined in 2014: the NERT Site and the NERT Off-Site Study Area.[3] The NERT RI Study Area was expanded to include two additional study areas: the Downgradient Study Area (investigations beginning in 2016) and the Eastside Study Area (investigations beginning in late 2017). The RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach Technical Memorandum (the Performance Metrics Technical Memorandum) describes the updated framework for estimating contaminant mass and evaluating revised performance metrics to incorporate all of these study areas (Ramboll Environ 2017d). The Performance Metrics Technical Memorandum was submitted to NDEP on October 5, 2017 and approved by NDEP on October 19, 2017. The performance metrics evaluation presented herein includes updates to the methodology used for evaluating the metrics compared to previous submittals using data that are currently available, in accordance with the implementation schedule outlined in the Performance Metrics Technical Memorandum and described in Section 8.1. These updates include:

- Incorporation of available preliminary data from the RI data collection efforts (the Phase 1 RI, the Phase 2 RI, the Phase 3 RI, and the Downgradient Study Area Investigation) and the Trust’s ongoing treatability studies;
- Evaluation of remaining contaminant mass across the entire NERT RI Study Area using a revised methodology as presented in the Performance Metrics Technical Memorandum and described in the 2018 Mass Estimate for the Remedial Investigation Study Area included as Attachment A;
- Evaluation of horizontal mass flux across the Operable Unit (OU) boundaries; and
- Evaluation of vertical mass flux between the alluvium and Upper Muddy Creek Formation (UMCf) across the entire NERT RI Study Area.

1.2 Organization

This report is provided in both hard copy and electronic forms. Where electronic files are referenced or information is stated as provided on Universal Serial Bus (USB) flash drive, this information is contained on the USB flash drive attached to the hard copy report.

This report is organized as follows:

- **Section 1** presents the purpose and organization of the report.
- **Section 2** provides a summary of GWETS operations.
- **Section 3** presents area groundwater conditions.
- **Section 4** provides a summary of the chromium removal and extent during the reporting period.

[3] The NERT Off-Site Study Area was formerly defined in the RI/FS Work Plan (ENVIRON 2014) as the Downgradient Plume Area, and has been referred to in prior performance evaluations as the Off-Site NERT RI Study Area.

- **Section 5** provides a summary of the perchlorate removal and extent during the reporting period.
- **Section 6** provides a summary of the extent of chloroform and other volatile organic compounds (VOCs) during the reporting period.
- **Section 7** presents a discussion on other measured parameters, including TDS, chlorate, and nitrate.
- **Section 8** provides an evaluation of GWETS performance relative to the established performance metrics.
- **Section 9** provides an update on ongoing and proposed future activities related to the GWETS and groundwater monitoring program.
- **Section 10** lists citations for key documents referenced in this memorandum.
- **The Electronic Map** (on the USB flash drive) is a Google Earth compatible file showing the locations of all former and current wells in the vicinity.
- **Appendix A** contains Table A-1, which presents the previous five quarters of analytical and groundwater elevation data collected as part of the groundwater monitoring program and Las Vegas Wash sampling events. Table A-2 includes groundwater field parameters (e.g., dissolved oxygen [DO], oxidation reduction potential [ORP], temperature, pH, conductivity) collected as part of the groundwater monitoring program and Las Vegas Wash sampling events conducted between January and June 2018. Table A-3 contains VOC analytical data collected during the reporting period. Table A-4 contains supplemental second quarter 2018 analytical and groundwater elevation data collected by American Pacific Corporation/Endeavour LLC (AMPAC/Endeavour), Olin/Stauffer/Syngenta/Montrose (OSSM), Titanium Metals Corporation (TIMET), and SNWA, which were used in the preparation of this report. Table A-4 also includes additional 2016 data received from AECOM and 2014-2015 data from Basic Remediation Company LLC (BRC).
- **Appendix B** (on the USB flash drive) contains well data sheets for monitoring and extraction wells that are part of the groundwater monitoring program, which show groundwater elevations, perchlorate concentrations, and chromium concentrations over time for each well, in addition to well construction details and the location of the UMCf contact. In addition, extraction wells' pumping rates, specific capacities, and estimated mass removals of perchlorate and chromium over time are shown.
- **Appendix C** (on the USB flash drive) contains statistical trends for water levels and analytical data at well locations in the groundwater monitoring program.
- **Appendix D** (on the USB flash drive) contains the field records from the January through June 2018 groundwater monitoring program and Las Vegas Wash sampling events.
- **Appendix E** (on the USB flash drive) contains the Data Validation Summary Report (DVSR).
- **Appendix F** (on the USB flash drive) contains the Electronic Data Deliverable (EDD), which includes an Access© compatible data file containing analytical results, an Access© compatible data file containing water level monitoring data, and analytical lab

reports for the January through June 2018 groundwater monitoring program and Las Vegas Wash sampling events.

- **Appendix G** (on the USB flash drive) contains an inventory of energy and materials used, wastes generated, and activities and services conducted at the Site for the purpose of an environmental footprint analysis for July 2017 through June 2018 conducted using the United States Environmental Protection Agency (USEPA) Spreadsheets for Environmental Footprint Analysis (SEFA).

2. MONITORING AND OPERATIONS SUMMARY

This section provides a summary of groundwater monitoring and GWETS operations during the period of performance from July 2017 through June 2018 (the reporting period).

2.1 Groundwater Monitoring Program Summary

Detailed information regarding the Site's groundwater monitoring program (including the scope of sampling events, key roles and responsibilities, and data collection procedures) are described in the Remedial Performance Groundwater Sampling and Analysis Plan (Ramboll Environ 2017a), which was approved by NDEP on April 7, 2017. Figure 1 shows the locations of all monitoring wells included in the current monitoring program. The electronic map, included on USB flash drive, shows the locations of all former and current wells in the vicinity.

2.2 Groundwater Extraction

The GWETS utilizes three groundwater capture well fields, as shown on Figure 1: the Interceptor Well Field (IWF); the Athens Road Well Field (AWF); and the Seep Well Field (SWF). The IWF coupled with the on-site bentonite-slurry groundwater barrier wall (the "barrier wall") provides capture of the highest concentrations of perchlorate and chromium 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, captures moderate concentrations of both perchlorate and chromium (in comparison to groundwater captured by the IWF), but operates at higher extraction rates than the IWF, resulting in significant contributions to overall perchlorate mass removal from the environment and reduction of perchlorate mass flux. The SWF, located in close proximity to Las Vegas Wash, operates at the highest extraction rate of the three well fields, but captures groundwater containing significantly lower perchlorate concentrations than both the IWF and AWF.

The AP Area Soil Flushing Treatability Study, located approximately 300 feet south of the IWF just west of AP-5, was implemented in 2016 and operated independently of the IWF. Following completion of the treatability study in early 2018, the AP Area extraction wells continued operating as part of the GWETS.

Average discharge rates for the IWF, AWF, SWF, and AP Area during the reporting period and from the previous four years are shown in Table 1, Table 2, Table 3, and Table 4, respectively. Monthly extraction rates during the reporting period for individual IWF, AWF, SWF, and AP Area wells are presented in Table 5.

During the reporting period, the combined discharge rate of the IWF extraction wells averaged 61.3 gallons per minute (gpm), which is generally consistent with the prior reporting period. As seen in Table 5, average monthly IWF extraction rates ranged from 57.3 to 63.7 gpm during the reporting period.

Total combined discharge at the AWF averaged 463.1 gpm during the reporting period, which is an increase of approximately 108 gpm compared to the prior reporting period. Average AWF flow rates increased compared to the prior reporting period primarily as a result of infrastructure updates at extraction wells ART-8/8A and ART-2/2A and Lift Station 3 completed in mid-2017. Extraction rates further increased during the current reporting period due to increased extraction at ART-9. As shown in Table 5, total combined flow rates at the AWF during the current reporting period ranged from 454.0 to 474.4 gpm.

Total combined discharge at the SWF averaged 757.5 gpm during the reporting period, which is an average increase of approximately 173 gpm over the prior reporting period. This increase was possible following the construction and operation of the IX treatment system, which began operating in February 2017. The IX treatment system was designed to treat a portion of groundwater captured by the SWF such that the Trust could reduce in-flows to the GW-11 Pond and maintain a higher level of storage capacity within the pond. Extraction at PC-120 and PC-121 was also re-initiated following startup of the IX treatment system, resulting in an overall increase in average extraction at the SWF. While wells PC-120 and PC-121 have relatively low concentrations of perchlorate when compared to neighboring wells in the SWF (see Section 5.2.7), the Trust has re-initiated extraction at these wells in order to minimize perchlorate loading to Las Vegas Wash. During the reporting period, SWF extraction ranged from a low of 729.5 gpm in January 2018 to a high of 804.8 gpm in September 2017. These variations in total average extraction are primarily a result of the Trust's ongoing efforts to actively monitor and rebalance system-wide extraction.

Total combined discharge from the AP Area extraction wells averaged 10.1 gpm during the reporting period, which is an increase of approximately 7 gpm compared with the prior reporting period. This increase is due to the activation of additional extraction wells in July 2017 as part of the AP Area Soil Flushing Treatability Study. The combined average extraction of these additional extraction wells was approximately 6.2 gpm during the reporting period. As shown in Table 5, total AP Area extraction increased from a low of 6.8 gpm in July 2017 to a high of 11.9 gpm in December 2017 during the reporting period, primarily as a result of increased extraction rates at these additional extraction wells over the course of the reporting period.

2.3 Groundwater Treatment System

Treatment of chromium-contaminated groundwater extracted at the IWF and the AP Area occurs via the on-site Groundwater Treatment Plant (GWTP),[4] which chemically reduces hexavalent chromium and removes total chromium via chemical precipitation. Treatment of perchlorate-contaminated groundwater extracted at the IWF, AWF, SWF, or AP Area occurs via either 1) the on-site fluidized bed reactors (FBRs), which biologically remove perchlorate as well as chlorate, nitrate, and trace concentrations of residual chromium, or 2) an IX treatment system.

The FBR and IX systems discharge treated water to Las Vegas Wash from a combined effluent pipe that discharges to a side channel of Las Vegas Wash located immediately west of the Pabco Road erosion control structure under authority of National Pollutant Discharge Elimination System (NPDES) Permit NV0023060. A simplified process flow diagram is presented on Figure 2.[5] The performance of the GWETS system, including well field extraction rates, operational metrics for the various treatment systems, and

[4] 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.

[5] The average total extraction rates reported in Table 5 differ from the average total effluent of the GWETS as shown in Figure 2. The discrepancy is the result of flow into and out of GW-11, evaporation from GW-11, and additions of stabilized Lake Mead water, which are used for maintenance operations.

information regarding GW-11 and the AP Area extraction wells, is reported to NDEP monthly as part of the GWETS Enhanced Operational Metrics.

In January 2018, pursuant to an order issued to the Trust by NDEP, the Trust began operating a separate groundwater treatment plant using an IX system associated with perchlorate treatment of water originating from dewatering activities associated with SNWA's construction of Sunrise Mountain and Historic Lateral Weir. Dewatering activities at Historic Lateral Weir were completed in June 2018 and dewatering activities at Sunrise Mountain Weir were completed in August 2018. Summaries of system performance, including operations, maintenance, and estimated perchlorate mass removal, have been reported to NDEP monthly (Tetra Tech 2018a-h). This system is not considered part of the GWETS (as defined for the purpose of this report), and therefore, its performance is not specifically evaluated herein; however, system operations have been incorporated in the evaluation of the GWETS performance metrics as necessary for the purposes of explaining mass capture and mass loading to Las Vegas Wash, as discussed in Section 8.

3. AREA GROUNDWATER CONDITIONS

The NDEP has defined three water-bearing zones (WBZs) of interest in the vicinity of the Site, including the Shallow, Middle, and Deep WBZ. 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 WBZ, which contains the saturated portions of the Quaternary alluvium (Qal) and the uppermost portion of the UMCf.

Plate 1, a potentiometric surface map for the Site and surrounding area, is based on groundwater elevation measurements collected by the Trust, AMPAC/Endeavour, OSSM, SNWA, and TIMET during second quarter 2018. The potentiometric surface map for the Shallow WBZ was created using the updated Phase 5 groundwater model (as described in Section 8.1) and ArcGIS. The groundwater model was updated with second quarter 2018 pumping rates for all known extraction wells within the model domain. The resulting water table contours from the model along with the measured second quarter 2018 groundwater elevations in the shallow zone were then interpolated using ArcGIS Spatial Analyst.[6]

Groundwater flow direction at the Site is generally north to northwesterly, whereas north of the Site, the direction changes to north-northeast. This generally uniform flow pattern may be modified locally by subsurface alluvial channels cut into the underlying UMCf; the NERT and TIMET barrier walls; localized areas of recharge from on-site storm water retention basins; off-site recharge from the City of Henderson (COH) Bird Viewing Ponds; groundwater extraction from the IWF, AWF, and SWF; and nearby groundwater extraction conducted by OSSM, TIMET, and AMPAC/Endeavour. During the reporting period, shallow groundwater was generally encountered in on-site wells between approximately 20 and 60 feet bgs and is generally deepest in the southern portion of the Site. North of the Site, shallow groundwater was generally encountered between approximately 4 and 40 feet bgs, becoming shallower as it approaches Las Vegas Wash.

As shown on Plate 1, areas of unsaturated alluvium are present within the AWF and in the area north of Sunset Road and Boulder Highway. Additional locations where groundwater elevations have been observed below the alluvium within the UMCf are highlighted yellow on Plate 1. An additional unsaturated zone is also present in the vicinity of the IWF. Deeper shallow WBZ and middle WBZ data collected as part of the Phase 2 RI are expected to provide information necessary to delineate this area of unsaturated alluvium, which will be presented in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019. Areas of unsaturated alluvium are also present in the eastern and northeastern interior portions of the Eastside Sub-Area within the Eastside Study Area, as discussed in the RI/FS Work Plan Addendum: Phase 3 Remedial

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[6] In the vicinity of the IWF, the barrier wall has a significant effect on the potentiometric surface, so a different approach was used to generate contours for the inset map showing the IWF. The potentiometric surface near the IWF was estimated by fitting the trend in water levels using an analytical element model and then kriging the well measurements after removing the trend. The simple analytic element model included the extraction wells at the IWF and the barrier wall, and was developed using the TimML software v3.4 (a multiaquifer analytical element model). The final potentiometric surface was calculated as the sum of the trend obtained from the analytical element model and the output from kriging of the detrended data. The resulting grid of interpolated water levels was contoured using ArcGIS Spatial Analyst in the same way as for the other areas.

Investigation, Revision 1 (Ramboll Environ 2017e). An evaluation of the extent of this unsaturated area based on data collected during the Phase 3 RI will also be presented in the OU-1/OU-2 RI Report.

Plates 2, 3, and 4 show the May 2018 water levels in the IWF, AWF, and SWF pumping wells, respectively, in addition to water levels in adjacent monitoring wells. Plate 2 shows the series of narrow, shallow alluvial channels separated by UMCf ridges along the IWF, some of which are above the current groundwater level. Plate 3 shows the Qal overlying the UMCf ridge along the AWF continues to be partially dewatered. Plate 4 shows that the alluvial channel in the vicinity of the SWF is much less incised into the underlying UMCf than at the AWF; the configuration of the alluvial channel is a broad shallow feature about 800 feet wide and averaging about 45 feet thick. In May 2001, before pumping began, the groundwater level within the SWF area was shallow and would intersect the surface each winter forming a seep. Groundwater elevations in this area still remain relatively shallow.

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 Zones that generally increases with depth. In the area immediately downgradient of the IWF, vertical head differences between Middle and Shallow Zone wells ranged from 5 to 26 feet during the reporting period, with calculated vertical gradients ranging between 0.05 and 0.2 ft/ft in the upward direction. Upward vertical gradients were generally more prominent near the western and central portions of the barrier wall. At the AWF, two wells were installed as part of the Phase 1 RI that are screened deeper within the shallow WBZ, PC-134D and PC-137D, to depths of 90 feet. During the reporting period, the vertical head differences measured between PC-134D and PC-137D and corresponding wells screened within the Qal were 6.0 and 2.8 feet, respectively, with upward vertical gradients of 0.1 and 0.05 ft/ft. Vertical gradients have not been evaluated near the SWF due to an absence of wells screened below the Qal.

In response to the June 24, 2016 letter from NDEP commenting on the 2016 Groundwater Monitoring Optimization Plan (NDEP 2016a), 21 transducers were deployed in the NERT Site and NERT Off-Site Study Area in August 2017. An additional 18 transducers were deployed in the Eastside Sub-Area in October 2017 and three additional transducers were deployed in the Northeast Sub-Area in April 2018. The purpose of these transducers is to record groundwater elevation data at key monitoring well locations in order to evaluate seasonal hydraulic trends and vertical gradients. The current transducer network will be re-evaluated in 2019 as part of Revision 1 of the Remedial Performance Groundwater Sampling and Analysis Plan (SAP) anticipated to be submitted in mid-2019. The transducer network will be revised if necessary to better monitor groundwater elevation trends throughout the entire NERT RI Study Area.

Vertical gradients were evaluated using available transducer data collected during the reporting period along with manual groundwater elevation measurements collected during second quarter 2018 (available in Table A-1 and Table A-4). Clusters of wells within an approximately 135-ft radius were first identified and vertical gradients were then calculated for each well within each cluster. The location of the mid-screen elevation for each well within the model layers of the updated Phase 5 model was used to determine whether each well was within the Shallow, Middle, or Deep WBZ. Model layers 1 through 5 represent the Shallow WBZ, layers 6 through 8 represent the Middle

WBZ, and layers 9 and 10 represent the Deep WBZ. These well clusters and approximate vertical gradients for the Shallow, Middle, and Deep WBZs are shown on Figures 3a, 3b, and 3c, respectively. These vertical gradient data will also be used to further refine and calibrate the Phase 6 Groundwater Model, anticipated to be submitted to NDEP in second quarter 2019.

As shown on these figures, there is generally an upward vertical gradient that increases with depth at the Site and surrounding areas, with the exception of two locations: 1) the area in the vicinity of AMPAC/Endeavour's deep extraction wells west of the Site where a downward vertical gradient is present between the Middle and Shallow WBZs due to operation of these deep extraction wells, and 2) wells AA-07 and MCF-07 in the Northeast Sub-Area where a downward vertical gradient was observed. Transducers in wells AA-07 and MCF-07 were installed in April 2018, and as such limited data were available to evaluate the magnitude and direction of the vertical gradient in this area. Vertical gradients in this area will be further evaluated in future submittals once sufficient data are available from deployed transducers and the Phase 3 RI.

Seasonal hydraulic trends were evaluated using an autocorrelation method with available transducer data. Because the transducers were recently deployed in late 2017, insufficient data are available at the majority of transducer locations to conduct a full evaluation of the presence of seasonal trends. However, a preliminary evaluation of transducer data available for locations near the COH Bird Viewing Ponds and Las Vegas Wash has been included herein, as data for these locations were collected beginning in 2016 as part of the SWF Flow Quantification Study (Ramboll Environ 2016d). The autocorrelation of a time series is a measure of the degree of correlation that any point in the time series has with other points in the same series. This is shown in figures 4a and 4b as a function of the difference in time between any two points in the series. A high autocorrelation is shown at a difference of one month for all wells, indicating the elevation in one month is highly correlated with the elevation in the prior and next months. A seasonal trend would be observed as a high autocorrelation at a difference of 12 months (possibly also at differences of multiples of 12 months). This pattern is not seen in any of the wells for which sufficient data are available for this analysis, indicating that any trends seen in these wells are not seasonal in nature, but may be responses to more irregular recharge events. Once sufficient data are available from additional transducer locations throughout the NERT RI Study Area, this evaluation will be expanded in future performance submittals to determine the presence of seasonal groundwater elevation trends.

4. CHROMIUM

4.1 Chromium Removal

During the reporting period, a total of approximately 2,530 pounds of total chromium were captured and removed from groundwater, as shown in Table 6.[7] This is generally consistent with the 2,500 pounds of chromium removed between July 2016 and June 2017.

Total and hexavalent chromium concentrations in the treated effluent discharge during the reporting period are presented in Table 7. Effluent hexavalent chromium concentrations were between <0.00025 milligrams per liter (mg/L) and 0.00049 J mg/L during the reporting period – well below the NPDES effluent discharge limitation of 0.01 mg/L (daily maximum). Total chromium was reported in effluent samples at concentrations ranging from <0.0025 to 0.018 mg/L – also below the NPDES effluent discharge limitation of 0.1 mg/L (daily maximum).

4.2 Chromium Concentration Trends

Plate 5 presents an isoconcentration map of the chromium plume from its on-site source northward to Las Vegas Wash.[8] The data used to develop the chromium isoconcentration contours includes second quarter 2018 shallow groundwater data collected by the Trust, OSSM, SNWA, and TIMET, in addition to second quarter 2016 shallow groundwater data collected by AECOM and 2014/2015 shallow groundwater data collected by BRC. These data are available in Table A-1 and Table A-4. Available preliminary data from the RI and the Trust's ongoing treatability studies were also evaluated and incorporated into the plume map interpretation. These preliminary data are not shown on the plume map but will be presented in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019.

The following sections describe chromium concentration trends at various well lines within the chromium plume, beginning with the southern-most well line and progressing downgradient to the north towards Las Vegas Wash. The west-east well lines evaluated in this section are consistent with those evaluated in prior reports and include the following (as shown on Figure 1 and Plate 5):

- **The IWF**, comprised of the 30 IWF extraction wells;
- **Downgradient of the Barrier Wall**, comprised of shallow monitoring wells located immediately north (downgradient) of the barrier wall for which data were available during the reporting period; and
- **The AWF**, comprised of the eight AWF extraction wells (ART-1/1A, ART-2/2A, ART-3/3A, ART-4/4A, ART-7A/7B, ART-8/8A, ART-9, and PC-150) and shallow monitoring wells located along the AWF for which data were available during the reporting period.

[7] Chromium mass removal, reported herein, was calculated using a methodology which has been approved by NDEP (Tetra Tech 2015).

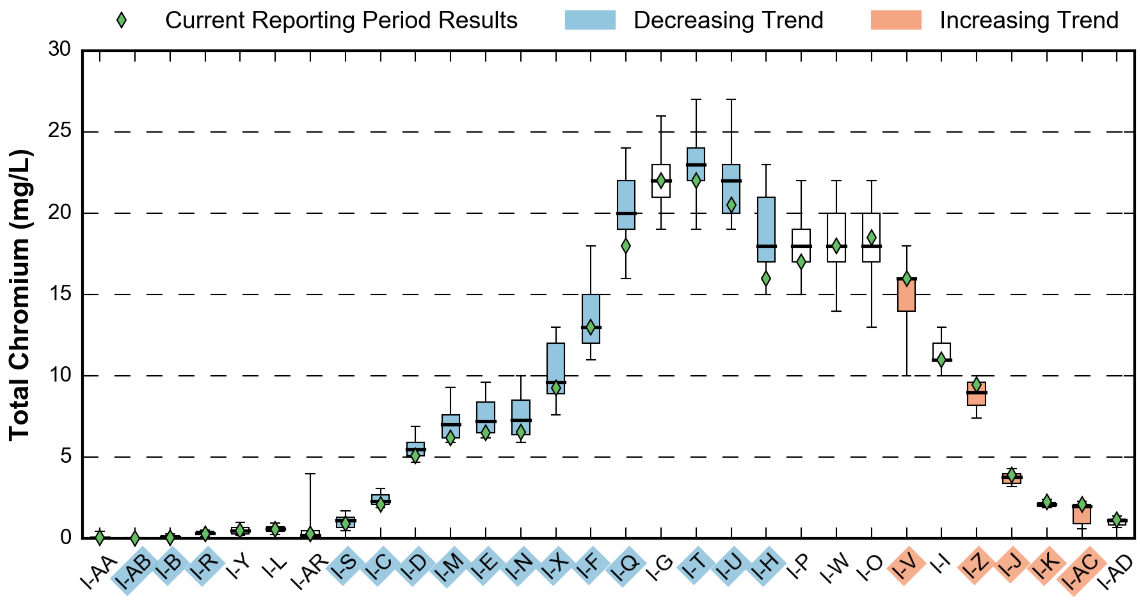
[8] The presence of total and hexavalent chromium within the Eastside Sub-Area will be investigated and remediated by BRC, if necessary, pursuant to the terms of the Settlement Agreement and Administrative Order on Consent, BMI Common Areas, Phase 3, with NDEP in 2006 (AOC3). As part of the Phase 3 RI Work Plan, chromium and hexavalent chromium have been included in the analyte list for the Northeast Sub-Area for consistency with investigation of the Downgradient Study Area.

Chromium concentration trends at additional well lines downgradient of the AWF were not evaluated because total chromium concentrations downgradient of the AWF are typically less than the federal maximum contaminant level (MCL) of 100 micrograms per liter (µg/L) for total chromium, which the State of Nevada has adopted. Chromium concentration trends were also not evaluated at the AP Area extraction wells, as the AP Area Soil Flushing Treatability Study was recently completed in early 2018 and therefore limited data are available.

As requested by NDEP in the December 6, 2016 comment letter on the 2015-2016 Annual Remedial Performance Report (NDEP 2016b), this report incorporates statistical analyses of well line concentration trends. The box plots incorporated within the text below, as well as the statistical information for each well in Appendix C, are designed to help distinguish between long-term concentration trends and seasonal/short-term variations. The box plots use color to depict statistically significant (95% confidence) concentration trends, as established using the Mann-Kendall test on the last four years of available data (July 2014 to June 2018). The Mann-Kendall test was selected because it is non-parametric and therefore more generally applicable than regression analysis. Appendix C includes linear regression analysis (calculation of residual normality and linear slopes), Mann-Kendall testing, calculation of the non-parametric Theil-Sen slope, and calculation of an autocorrelation function for each well in the sampling program with sufficient chromium data going back up to 10 years (as well as perchlorate and groundwater elevation data).

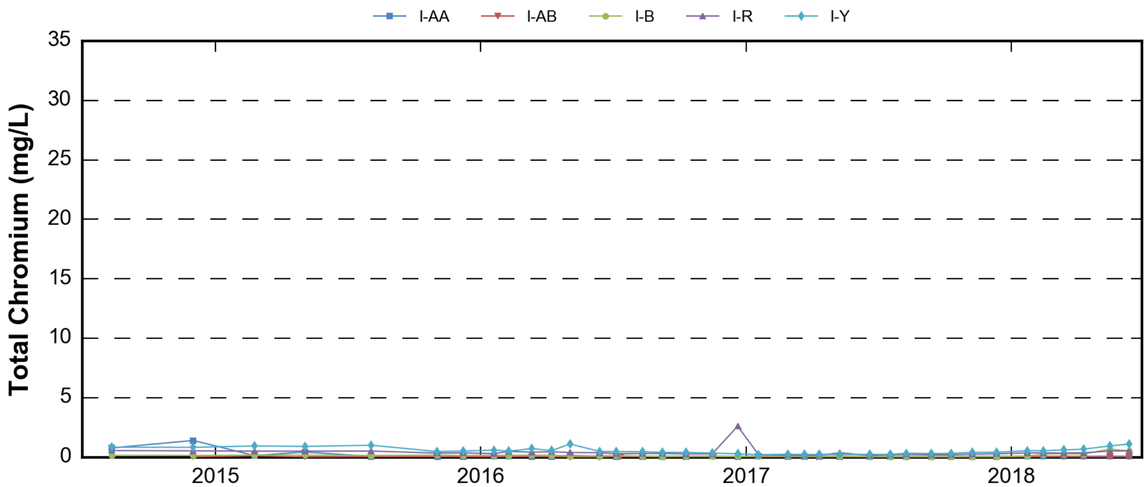
4.2.1 Interceptor Well Field

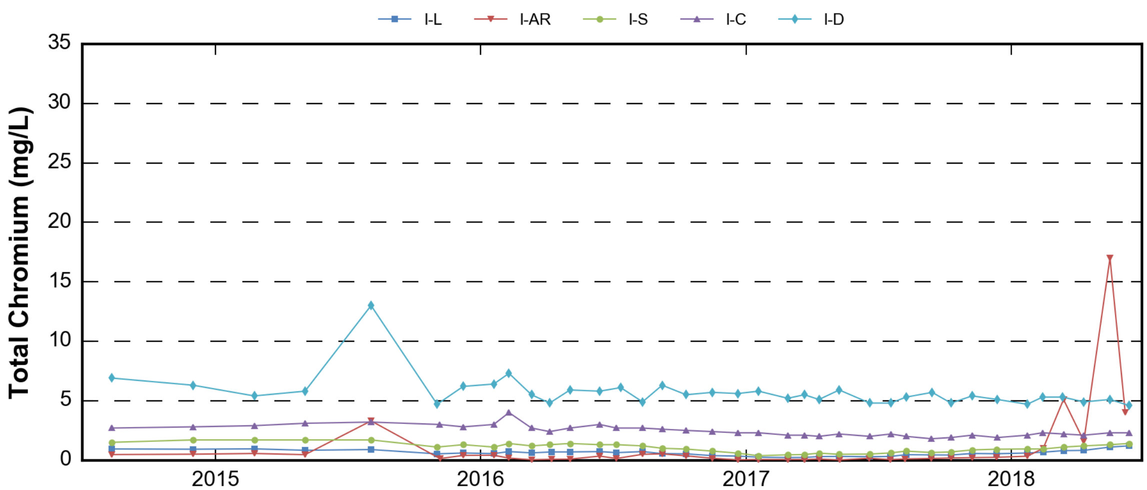
The box plots and time series plots below present chromium data over the last four years at the IWF extraction wells in geographical order from west to east. As shown in the box plots, chromium concentrations are highest and most variable in the central and eastern portions of the IWF. The statistical analysis indicates that concentrations in half of the IWF wells (15 wells) have decreased over the last four years in the western and central portions of the IWF. The statistical analysis also indicates that concentrations in five wells located in the eastern portion of the IWF have increased over the last four years; however, these wells are located within the IWF and AWF capture zones. Statistically significant trends were not identified in the other 10 extraction wells. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.

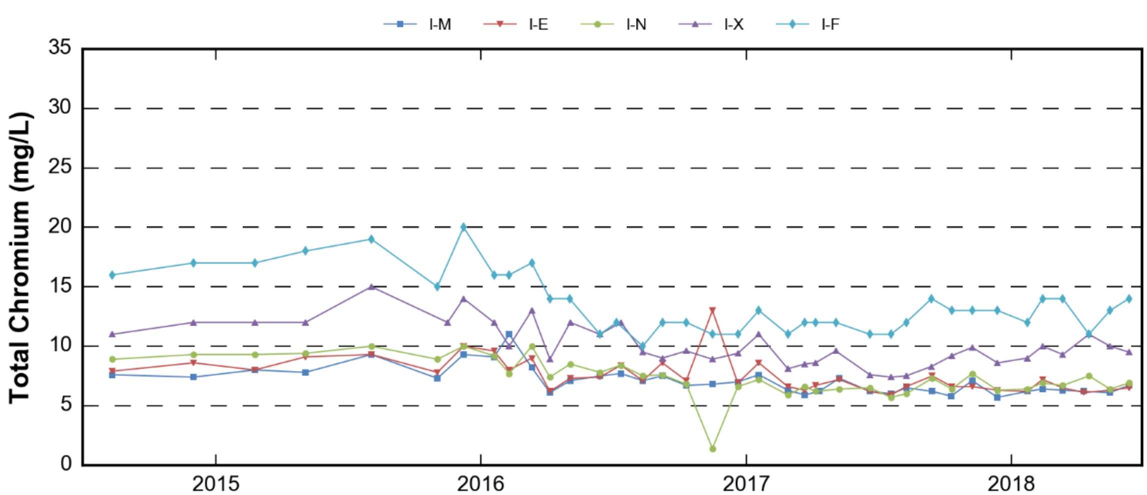


Box Plots: IWF Chromium Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

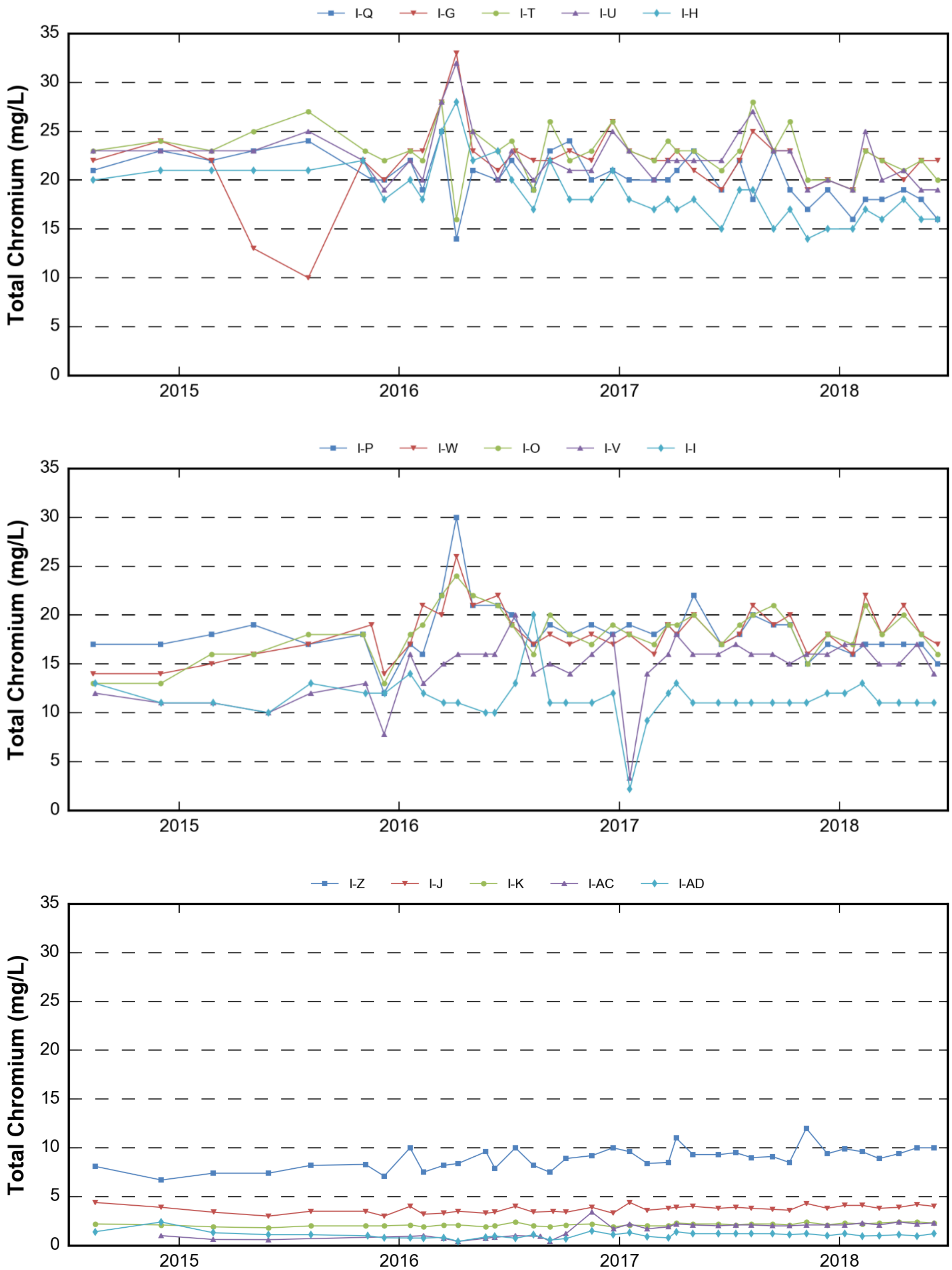
As shown on the time series plots presented below, concentrations during the reporting period appear generally consistent with the observed statistical trends over the last four years discussed above, with the exception of concentrations in well I-AR from March 2018 through the end of the reporting period. Concentrations in this well were generally higher and showed increased variability during the reporting period compared to historical data. A review of hexavalent chromium data for this well during this timeframe found that hexavalent chromium concentrations were generally consistent with historical trends and did not exhibit the same variability observed in the total chromium data. The increase in the total chromium concentration in well I-AR did not result in a statistically significant trend for the period from July 2014 to June 2018. Results in this area may have been impacted by the nearby AP Area Soil Flushing Treatability Study, which was completed in early 2018. Chromium concentrations in this area will continue to be evaluated in future remedial performance reports.







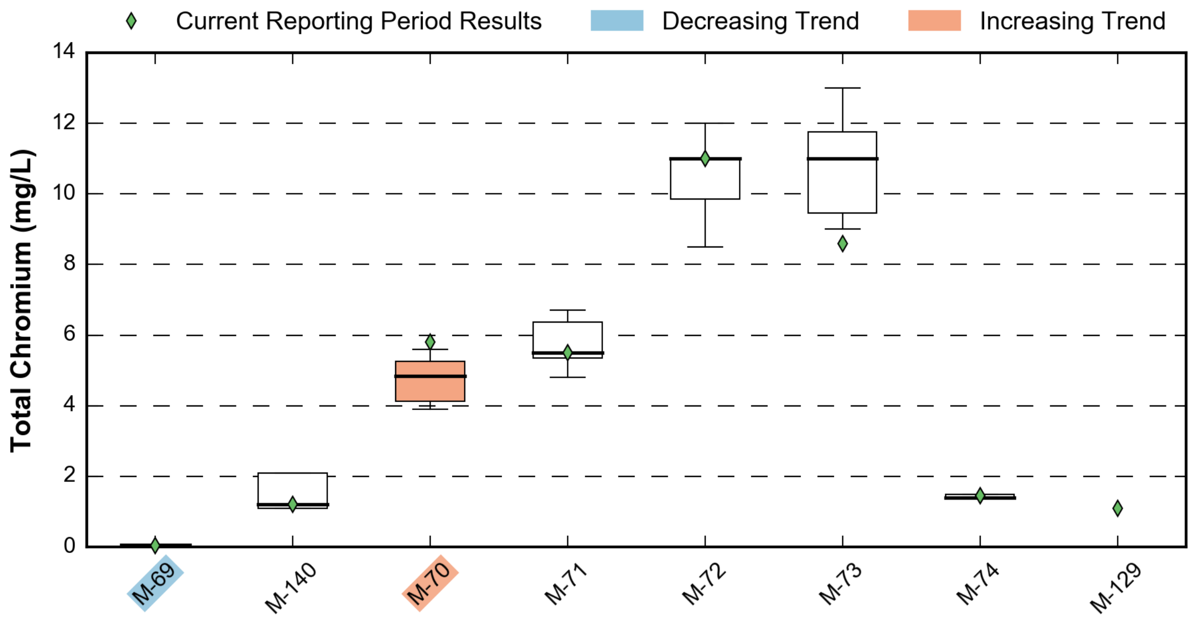
Time Series Plots: IWF Chromium Concentrations. These charts depict chromium concentration data collected in IWF wells during the last four years, presented in geographical order from west to east.



Time Series Plots: IWF Chromium Concentrations. These charts depict chromium concentration data collected in IWF wells during the last four years, presented in geographic order from west to east.

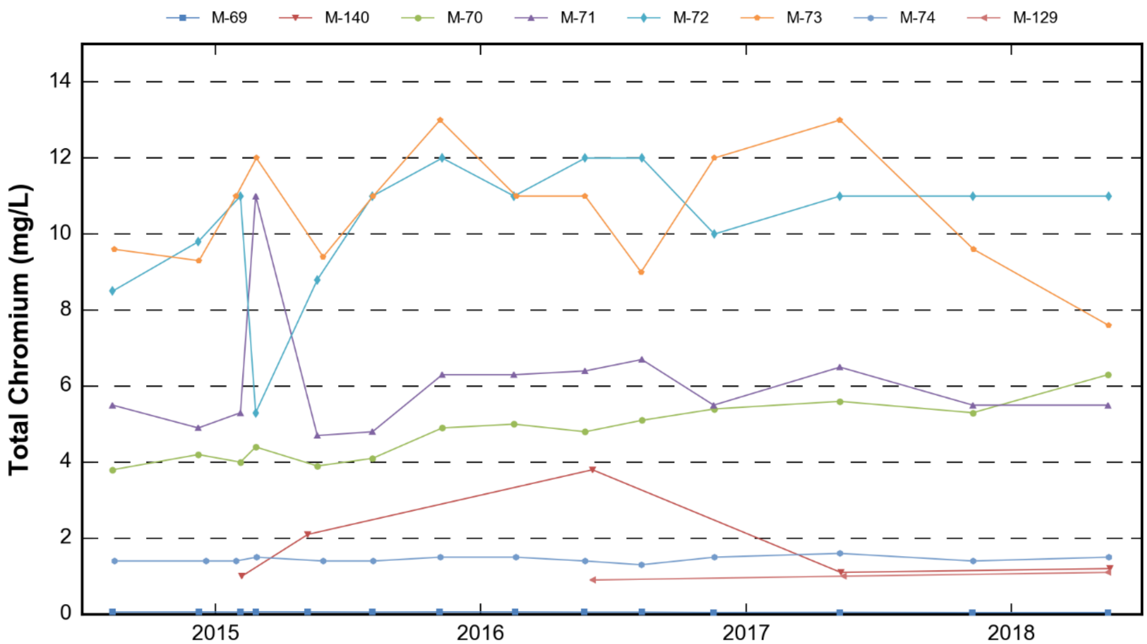
4.2.2 Downgradient of the Barrier Wall

The box plots and time series plots below present chromium data over the last four years at shallow monitoring wells located immediately downgradient of the barrier wall. Similar to the IWF, chromium concentrations are highest and most variable in the central and eastern portions of the well line. The statistical analysis indicates that chromium concentrations increased in M-70 and decreased in M-69 over the last four years; statistically significant trends were not identified in the other monitoring wells. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.



Box Plots: Chromium Concentrations Downgradient of the Barrier Wall. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25^{th}-75^{th} percentile; the "whiskers" represent data in the 5^{th}-95^{th} percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend). For wells with fewer than 4 data points available, box plots are not shown; instead, only the median value during the reporting period is plotted.

Chromium concentrations during the reporting period (as shown on the time series plots below) appear generally consistent with the observed statistical trends over the last four years discussed above. Chromium concentrations in these wells have increased since November 2010, following the shutdown of the recharge trenches in September 2010. This suggests that the former recharge trenches either diluted chromium concentrations in groundwater at these wells, prevented lateral migration through or around the barrier wall, or mitigated the upward migration of chromium from the UMCf. An evaluation of the integrity and effectiveness of the barrier wall, as outlined in the NDEP-approved Barrier Wall Integrity Field Evaluation Work Plan (Ramboll Environ 2017b), is being conducted in 2018 and will be reported in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019.



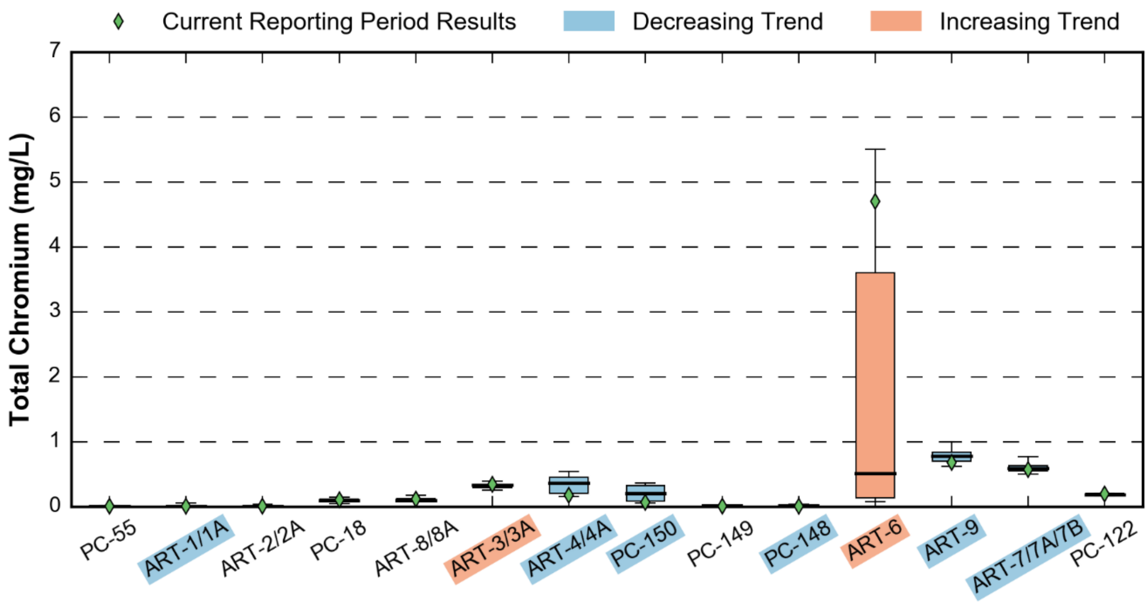
Time Series Plots: Chromium Concentrations Downgradient of the Barrier Wall. This chart depicts chromium concentration data collected immediately downgradient of the barrier wall during the last four years.

4.2.3 Athens Road Well Field

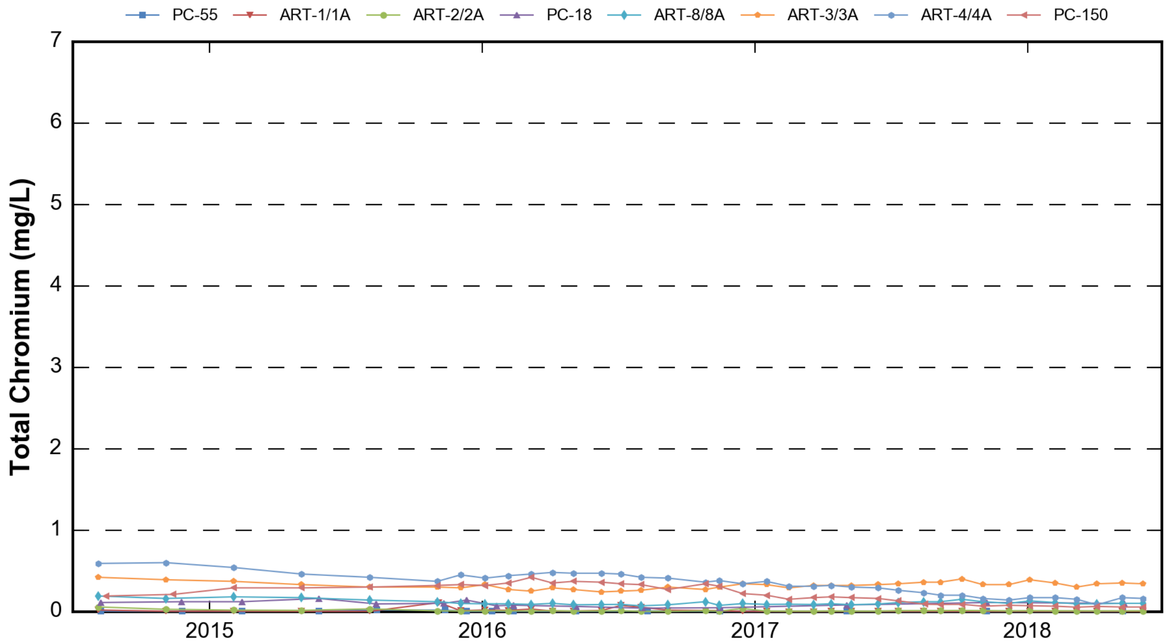
The charts below show concentrations of total chromium from the last four years in groundwater within the eight AWF pumping wells (ART-1/1A, ART-2/2A, ART-3/3A, ART-4/4A, ART-7A/7B, ART-8/8A, ART-9, and PC-150) and several shallow monitoring wells located along the AWF. Chromium concentrations in the western sub-channel (represented by wells west of PC-149) are lower relative to those in the eastern sub-channel (represented by wells east of PC-148). The statistical analysis indicates that chromium concentrations decreased in six wells and increased in two wells in the AWF over the last four years. Statistically significant trends were not identified in the other six wells. Five of the wells with decreasing trends and both of the wells with increasing trends are extraction wells. The increasing trends were observed in the central portion of each subchannel, and are within the capture zone of the AWF. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.

Concentrations in ART-6 exhibit more variability over the last four years compared to other AWF wells. Concentrations in ART-6 also increased during the reporting period, as shown on the time series plot below. The reason for this variability may be related to the fact that this well is routinely sampled using a bailer, which may be causing sediments to be churned up during the sampling process, potentially resulting in increased turbidity and elevated chromium concentrations due to the presence of suspended colloidal particles. This trend will be further evaluated as part of the AWF Capture Evaluation and Matrix Diffusion Study Work Plan, which was submitted in September 2017 and approved by NDEP on October 3, 2017 (Ramboll Environ 2017c).

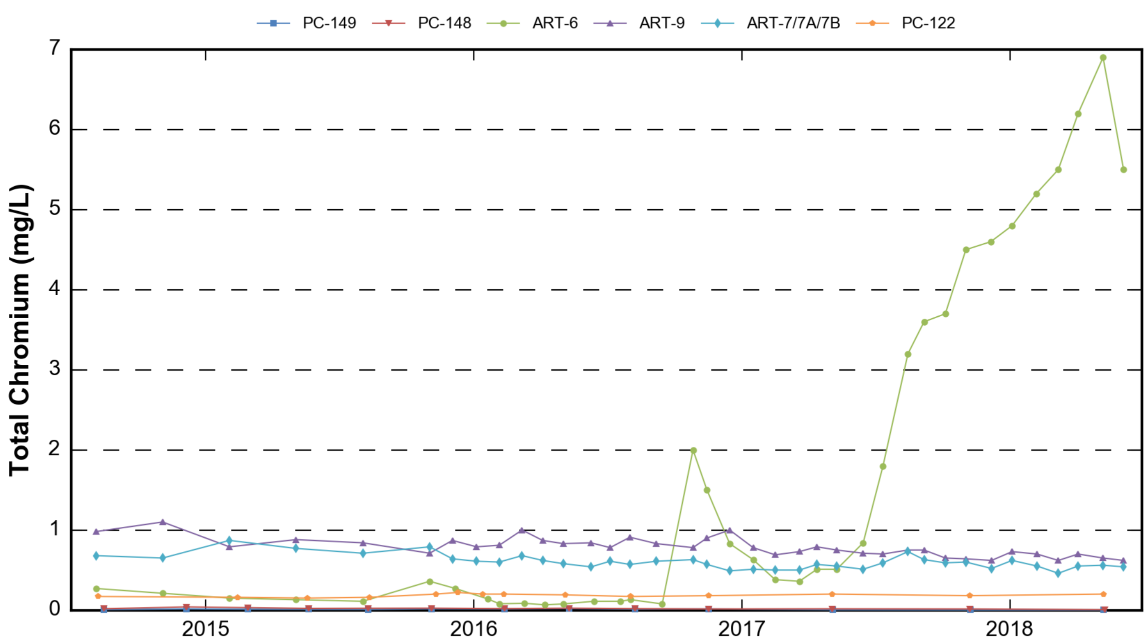
The results of this study will be reported in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019. Sampling methods for this well will also be re-evaluated as part of the revised Remedial Performance Groundwater SAP to be submitted in mid-2019.



Box Plots: AWF Chromium Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25^{th}-75^{th} percentile; the "whiskers" represent data in the 5^{th}-95^{th} percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).



Time Series Plots: Western AWF Chromium Concentrations. This chart depicts chromium concentration data collected at the western half of the AWF over the last 4 years.



Time Series Plots: Eastern AWF Chromium Concentrations. This chart depicts chromium concentration data collected at the eastern half of the AWF over the last 4 years.

4.2.4 Seep Well Field

Total chromium concentrations in groundwater samples collected from the wells in the SWF were generally non-detect during the reporting period. For the purpose of the statistical trend analysis presented in Appendix C, half of the detection limit was substituted for non-detected results. Statistical analysis of chromium concentrations in the SWF extraction wells (PC-99R2/R3, PC-115R, PC-116R, PC-117, PC-118, PC-119, PC-120, PC-121, and PC-133) indicate that PC-99R2/R3 has a decreasing trend; no statistically significant trends were identified in the other SWF wells.

5. PERCHLORATE

5.1 Perchlorate Removal

During the reporting period, a total of approximately 404,100 pounds of perchlorate were captured and removed from groundwater by the GWETS, as shown in Table 8.[9] This is a 3.6% increase compared to the 389,900 pounds removed between July 2016 and June 2017. Mass removal increased at the AWF and SWF due to infrastructure updates, efforts by the Trust to actively monitor and rebalance system-wide extraction, and operation of the IX treatment system, as discussed in Section 2.2. Mass removal also increased at the AP Area as a result of the AP Area Treatability Study.

Perchlorate concentrations in the treated effluent discharge during the reporting period are presented in Table 9. Perchlorate concentrations were between <0.00050 and 0.0037 mg/L during the reporting period – well below the NPDES effluent discharge limitation of 0.018 mg/L (30-day average).

5.2 Perchlorate Concentration Trends

Plate 6 shows the contoured perchlorate plume from the south end of the Site to Las Vegas Wash. The data used to develop the perchlorate isoconcentration contours includes second quarter 2018 shallow groundwater data collected by the Trust, AMPAC/Endeavour, OSSM, SNWA, and TIMET, in addition to second quarter 2016 shallow groundwater data collected by AECOM and 2014/2015 shallow groundwater data collected by BRC. These data are available in Table A-1 and Table A-4. Available preliminary data from the RI and the Trust's ongoing treatability studies were also evaluated and incorporated into the plume map interpretation. These preliminary data are not shown on the plume map, but will be presented in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019.

The following sections describe perchlorate concentration trends at various well lines within the perchlorate plume, beginning with the southern-most well line and progressing downgradient to the north towards Las Vegas Wash. The west-east well lines evaluated in this section are consistent with those evaluated in prior reports and include the following (as shown on Figure 1 and Plate 6):

- **The IWF**, comprised of the 30 IWF extraction wells;
- **Downgradient of the Barrier Wall**, comprised of shallow monitoring wells located immediately north (downgradient) of the barrier wall for which data were available during the reporting period;
- **The AWF**, comprised of the eight AWF extraction wells (ART-1/1A, ART-2/2A, ART-3/3A, ART-4/4A, ART-7A/7B, ART-8/8A, ART-9, and PC-150) and shallow monitoring wells located along the AWF for which data were available during the reporting period;
- **The Athens Road Piezometer (ARP) Well Line,** comprised of shallow monitoring wells located approximately 250 feet north of the AWF;

[9] Perchlorate mass removal, reported herein, was calculated using a methodology which has been approved by NDEP (Tetra Tech 2015).

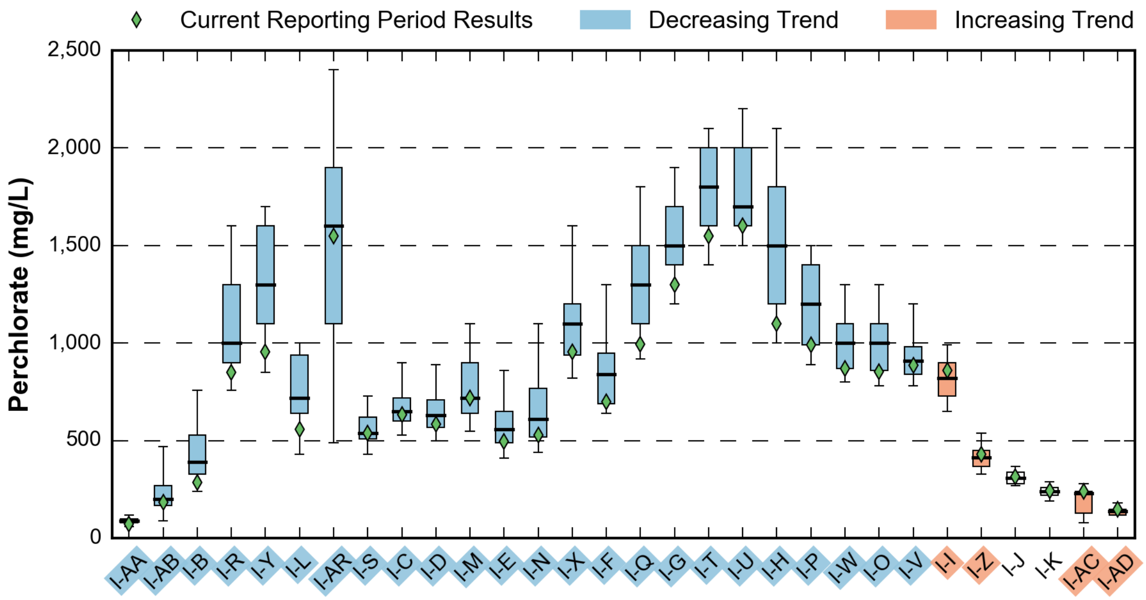
- **The COH Water Reclamation Facility (WRF) Well Line,** comprised of shallow monitoring wells located east of the COH Bird Viewing Ponds and approximately 2,200 feet north of the AWF;
- **The Lower Ponds Well Line,** comprised of shallow monitoring wells located approximately 4,400 feet north of the AWF and 2,200 feet north of the COH WRF Well Line; and
- **The SWF,** comprised of the 10 SWF extraction wells, two of which (PC-99R2 and PC-99R3) are connected and operate as one combined well.

Perchlorate concentration trends at well lines downgradient of the AWF are evaluated in this section because perchlorate concentrations in groundwater exist above NDEP's provisional action level of 18 µg/L between the AWF and Las Vegas Wash. Perchlorate concentration trends at the AP Area extraction wells were not evaluated, as the AP Area Soil Flushing Treatability Study was recently completed in early 2018 and therefore limited data are available.

As requested by NDEP in the December 6, 2016 comment letter on the 2015-2016 Annual Report (NDEP 2016b), this report incorporates statistical analyses of well line concentration trends, as described in Section 4.2.

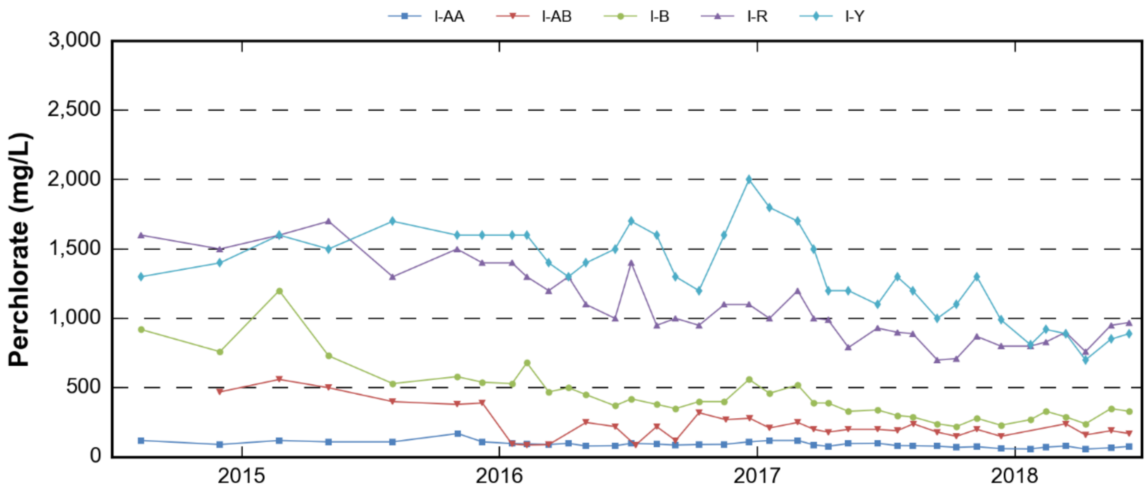
5.2.1 Interceptor Well Field

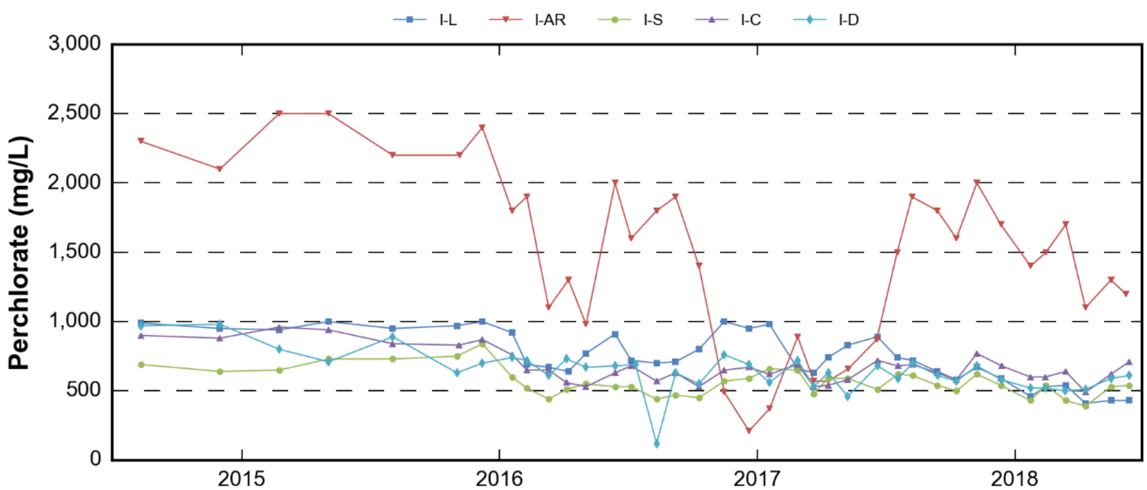
The box plots and time series plots below present perchlorate data over the last four years at the IWF extraction wells in geographical order from west to east. As shown in the box plots, the highest concentrations are located in the western and central portions of the well line. The statistical analysis indicates that concentrations in groundwater in a majority of the IWF wells (24 wells) have decreased over the last four years, with the exception of concentrations in groundwater at four extraction wells (I-I, I-Z, I-AC, and I-AD) where concentrations have increased. These four wells are located along the eastern edge of the well field in an area with groundwater concentrations less than 1,000 mg/L of perchlorate, and are within the IWF and AWF capture zones. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail. Statistically significant trends were not identified in the other two extraction wells (I-J and I-K).

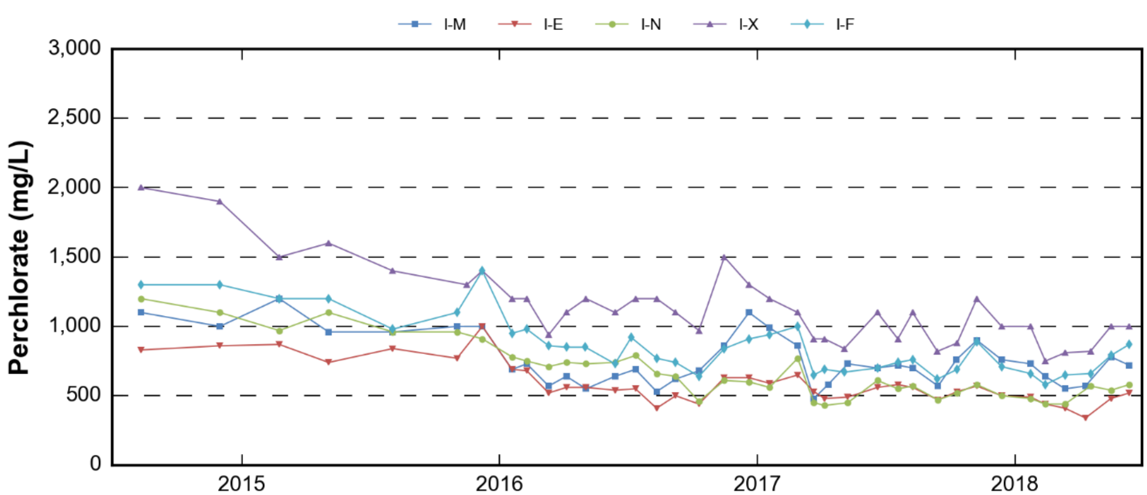


Box Plots: IWF Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

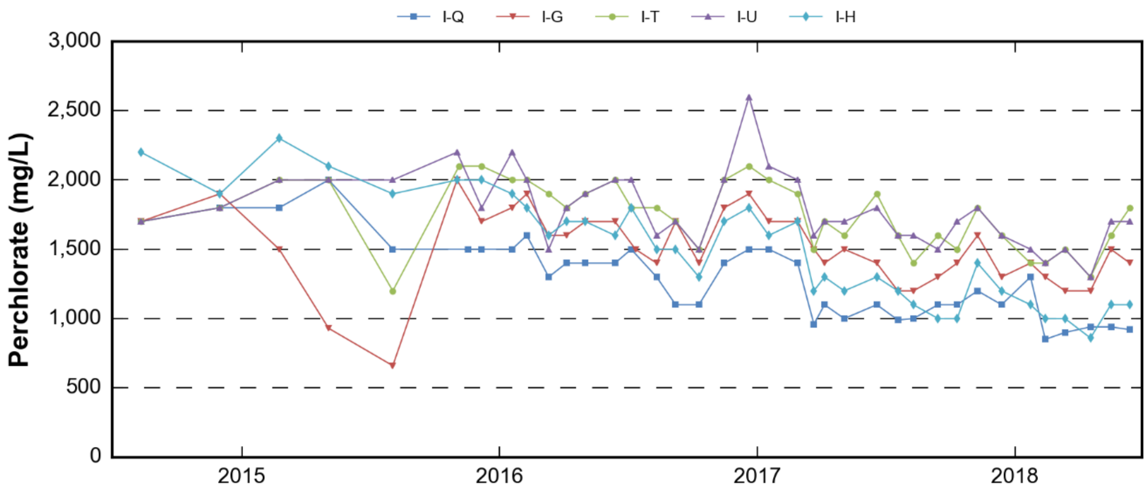
Concentrations measured during the reporting period, as shown on the time series plots below, appear generally consistent with the observed statistical trends over the last four years discussed above, with the exception of concentrations in well I-AR. I-AR exhibited historically low concentrations from November 2016 through June 2017 before increasing to concentrations between 1,100 and 2,000 mg/L for the remainder of the reporting period. I-AR is located near the nearby AP Area Soil Flushing Treatability Study. Flushing and extraction wells began operating as part of the study in November 2016. Flushing ceased when the study was completed in early 2018, but the extraction wells continued operating as part of the GWETS. Perchlorate concentrations in this area will continue to be evaluated in future remedial performance reports.

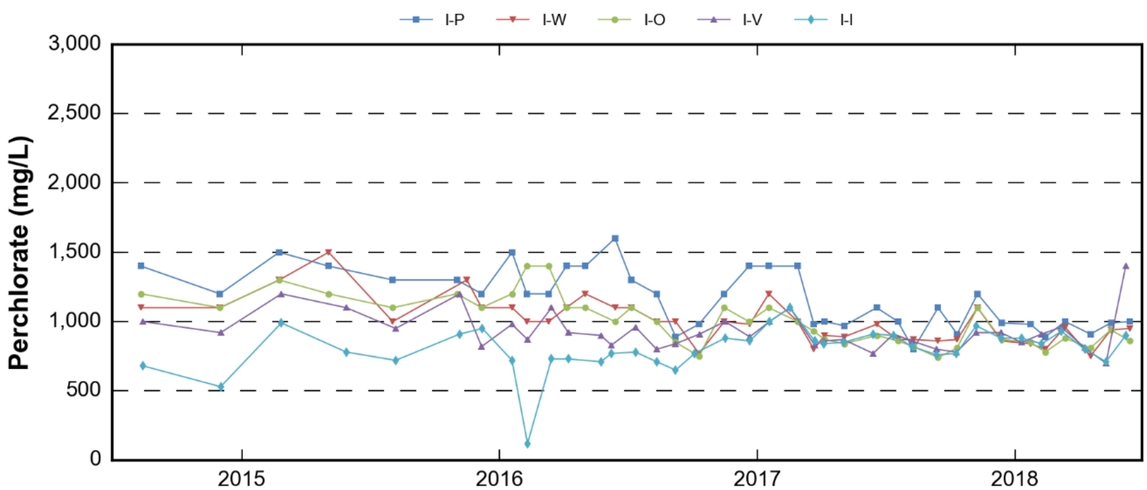


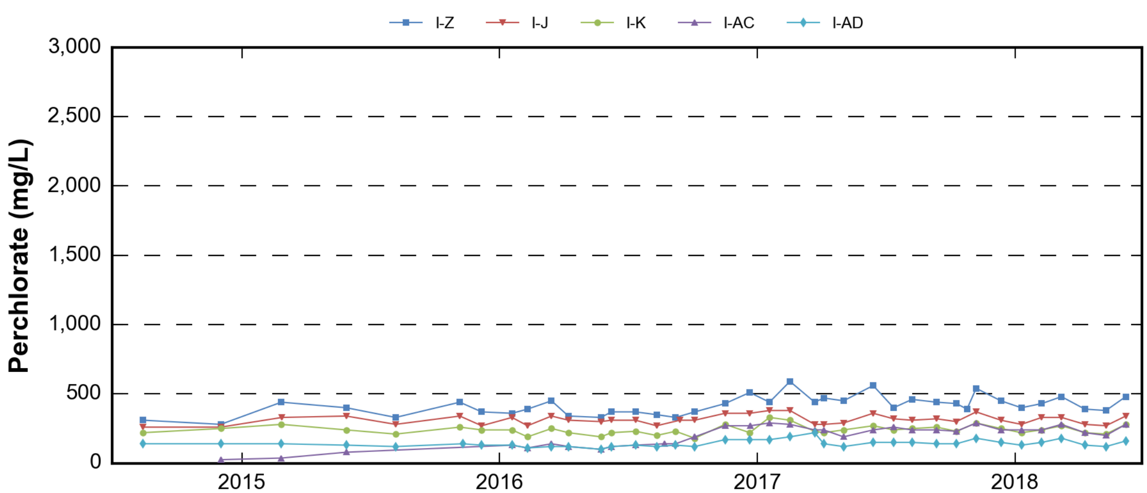




Time Series Plots: IWF Perchlorate Concentrations. These charts depict perchlorate concentration data collected in IWF wells during the last four years, presented in geographical order from west to east.



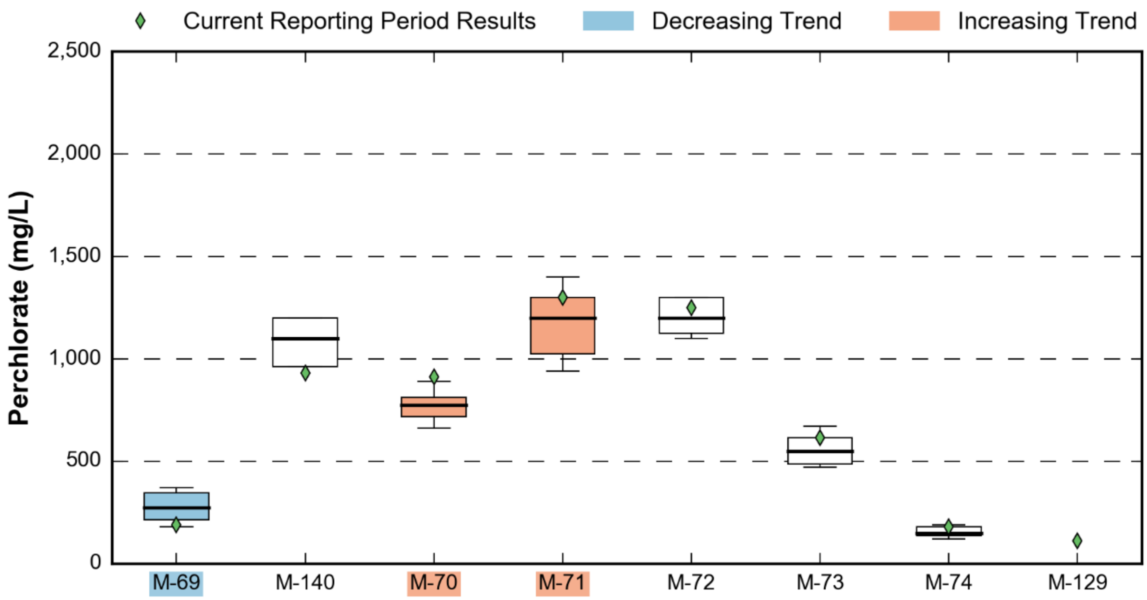




Time Series Plots: IWF Perchlorate Concentrations. These charts depict perchlorate concentration data collected in IWF wells during the last four years, presented in geographical order from west to east.

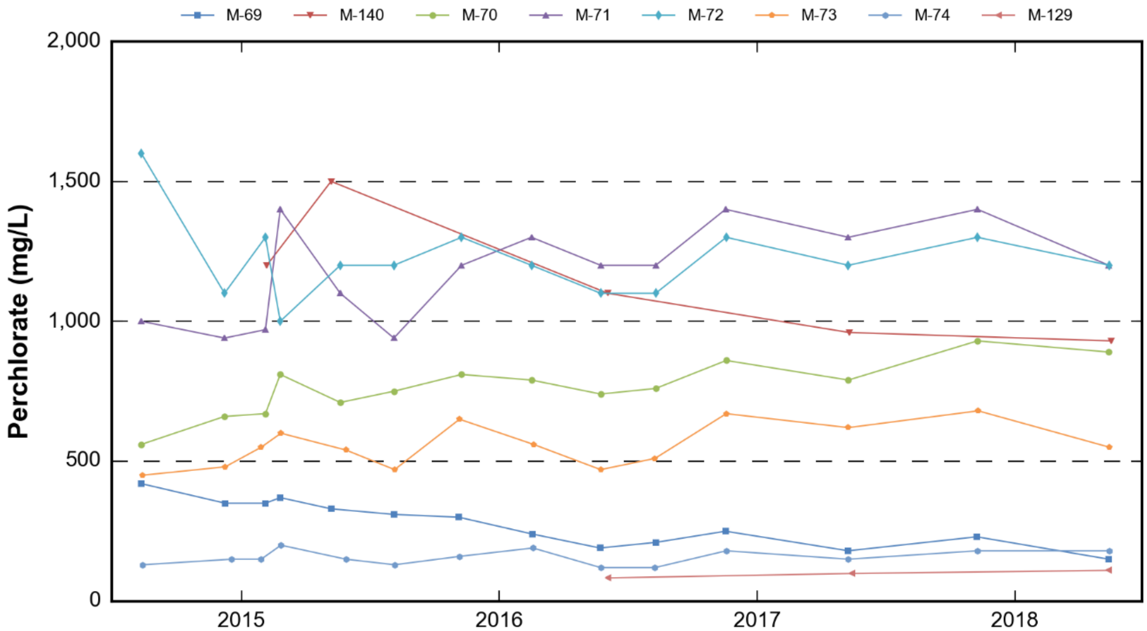
5.2.2 Downgradient of Barrier Wall

As shown below, the statistical analysis indicates that perchlorate concentrations in wells located between the barrier wall and former recharge trenches have increased in M-70 and M-71 and decreased in M-69. Statistically significant trends were not identified at the other five monitoring wells. Similar to the IWF, the highest concentrations are located in the central and western portions of the well line. Perchlorate concentrations in groundwater in this area are below 1,500 mg/L and located within the capture zone of the AWF. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.



Box Plots: Perchlorate Concentrations Downgradient of the Barrier Wall. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend). For wells with fewer than 4 data points available, box plots are not shown; instead, only the median value during the reporting period is plotted.

Perchlorate concentrations during the reporting period (as shown on the time series plots below) appear generally consistent with the observed statistical trends over the last four years discussed above. Perchlorate concentrations in these wells have generally increased since November 2010, following the shutdown of the recharge trenches in September 2010. This suggests that the former recharge trenches either diluted perchlorate concentrations in groundwater at these wells, prevented lateral migration through or around the barrier wall, or mitigated the upward migration of perchlorate from the UMCf. As described in Section 4.2.2, an evaluation of barrier wall effectiveness is being conducted in 2018 and will be reported in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019.

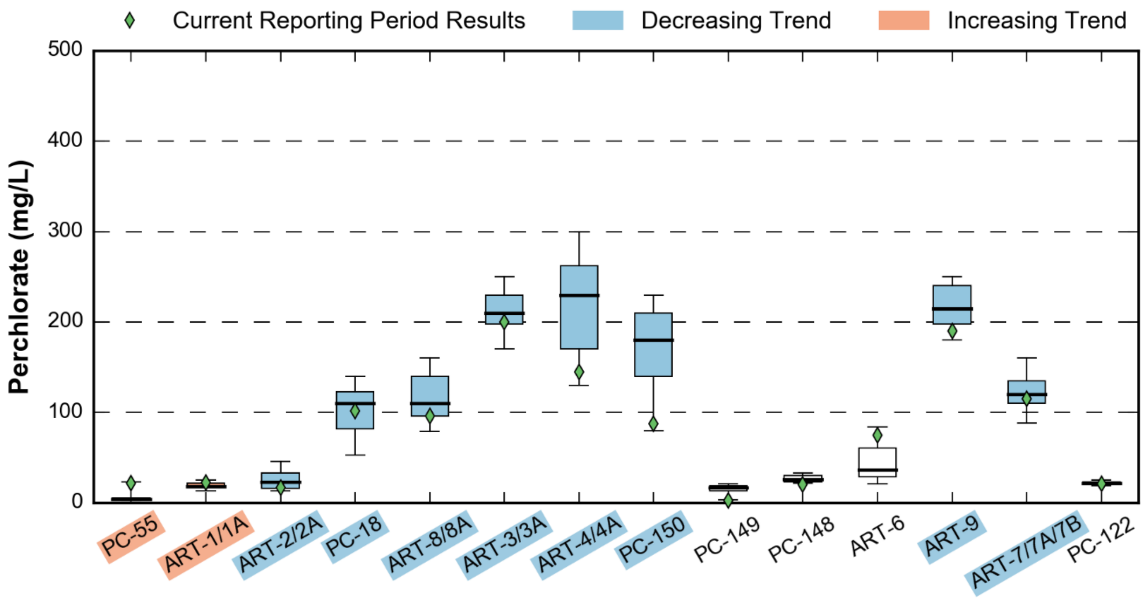


Time Series Plots: Perchlorate Concentrations Downgradient of the Barrier Wall. This chart depicts perchlorate concentration data collected immediately downgradient of the barrier wall over the last four years.

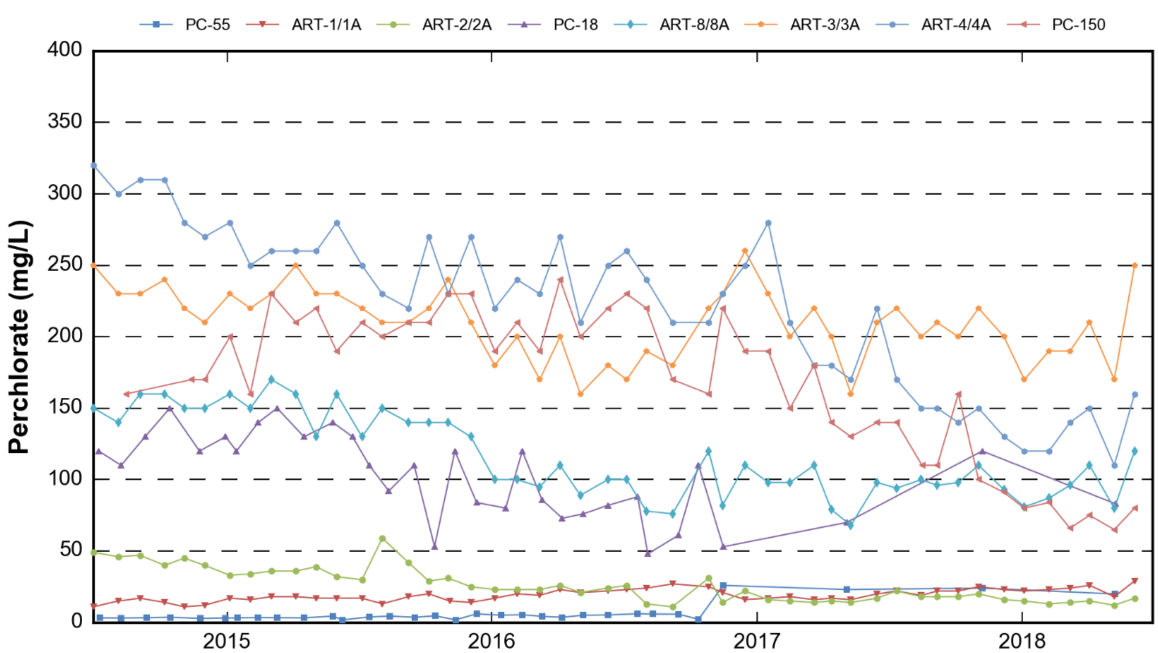
5.2.3 Athens Road Well Field

Perchlorate concentrations in the AWF's eight pumping well pairs and several shallow monitoring wells located along the AWF are shown in the charts below. Perchlorate concentrations in the western sub-channel (represented by wells west of PC-149) are higher relative to those in the eastern sub-channel (represented by wells east of PC-148). The statistical analysis indicates that perchlorate concentrations decreased in 8 wells over the last four years, but increased in two wells (PC-55 and ART-1/1A) located at the west end of the well line. Statistically significant trends were not identified for the other four monitoring wells over the last four years. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.

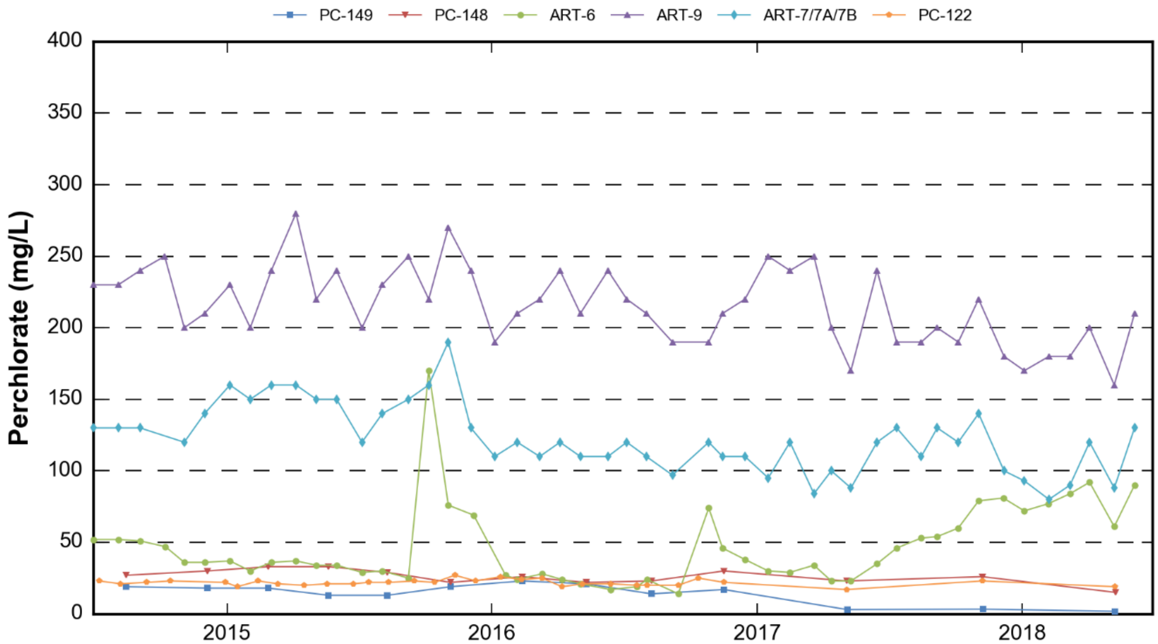
As discussed in Section 8.2.3 and 8.2.6, the capture zone of the AWF extends to the west where the perchlorate plume associated with the AMPAC/Endeavour Site is located. The eastern lobe of the AMPAC/Endeavour plume becomes comingled with the plume from the NERT Site in this area, as shown on Plate 6. During the reporting period, perchlorate concentrations were generally consistent with the observed statistical trends over the last four years discussed above, with the exception of ART-6. Concentrations in ART-6 increased during the reporting period, as shown on the time series plot below. The reason for this increase is currently unclear, but will be further evaluated as part of the AWF Capture Evaluation and Matrix Diffusion Study Work Plan, which was submitted in September 2017 and approved by NDEP on October 3, 2017 (Ramboll Environ 2017c). The results of this study will be reported in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019.



Box Plots: AWF Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).



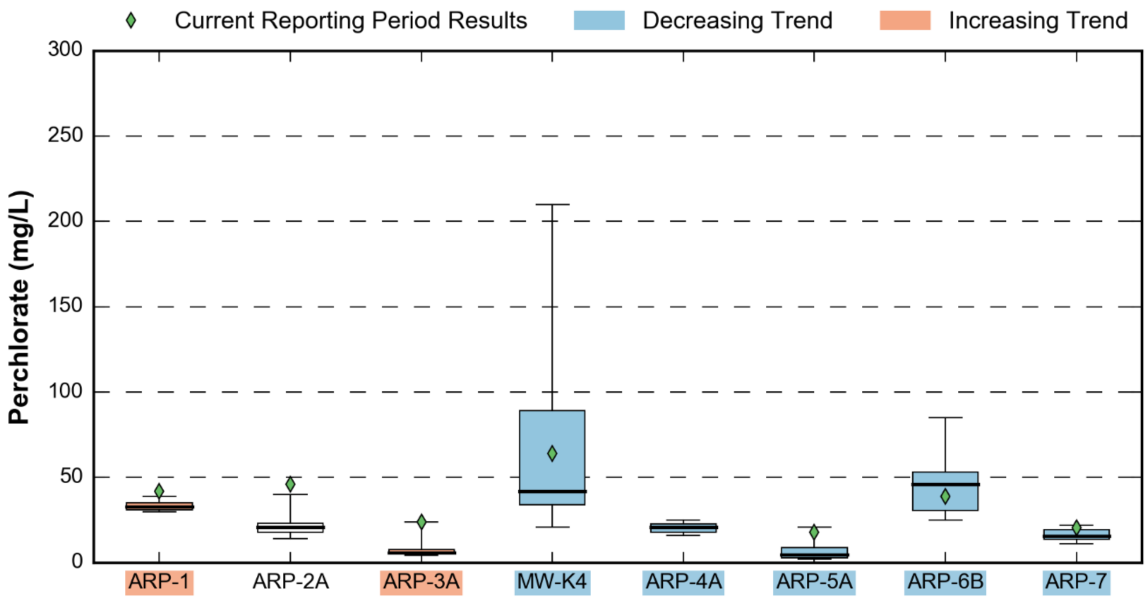
Time Series Plots: Western AWF Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the western half of the AWF over the last four years.



Time Series Plots: Eastern AWF Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the eastern half of the AWF over the last four years.

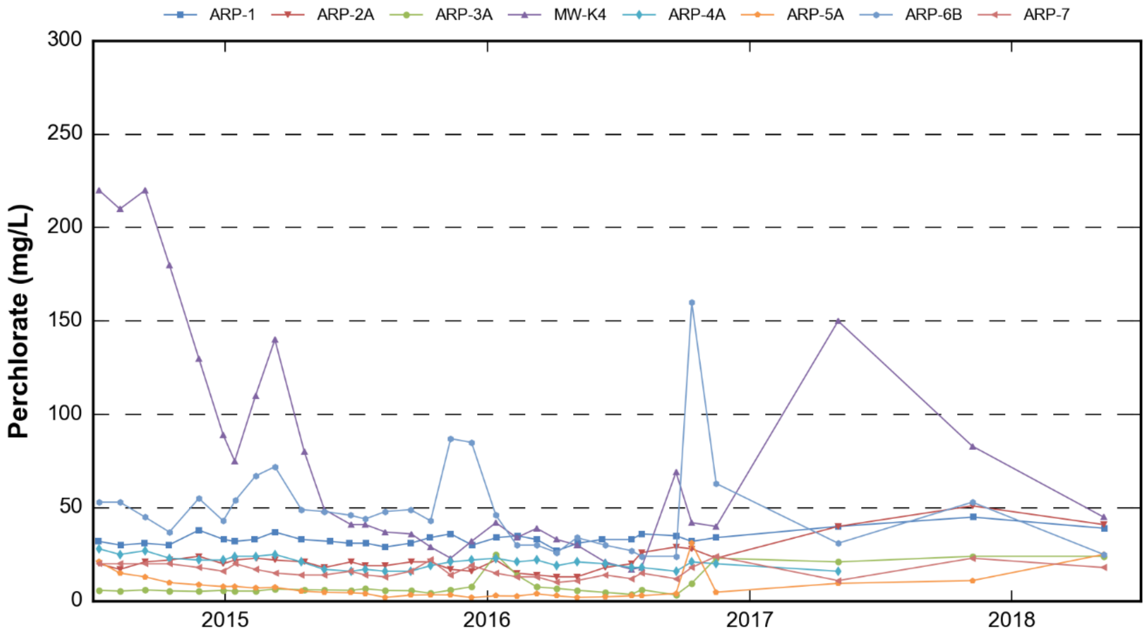
5.2.4 Athens Road Piezometer Well Line

Concentrations of perchlorate within the ARP Well Line were consistently less than 100 mg/L during the last four years with the exception of concentrations at well MW-K4, as shown on the box plots below. The statistical analysis indicates that perchlorate concentrations in the central and eastern portion of the well line (MW-K4, ARP-4A, ARP-5A, ARP-6B, and ARP-7) have decreased over the last four years, while concentrations on the western end of the well line (ARP-1 and ARP-3A) have increased. A statistically significant trend was not identified in ARP-2A. As shown in the plume map on Plate 6 and discussed in the previous section, the wells on the western edge of the ARP well line are impacted by the perchlorate plume originating from the former AMPAC/Endeavour site. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.



Box Plots: ARP Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

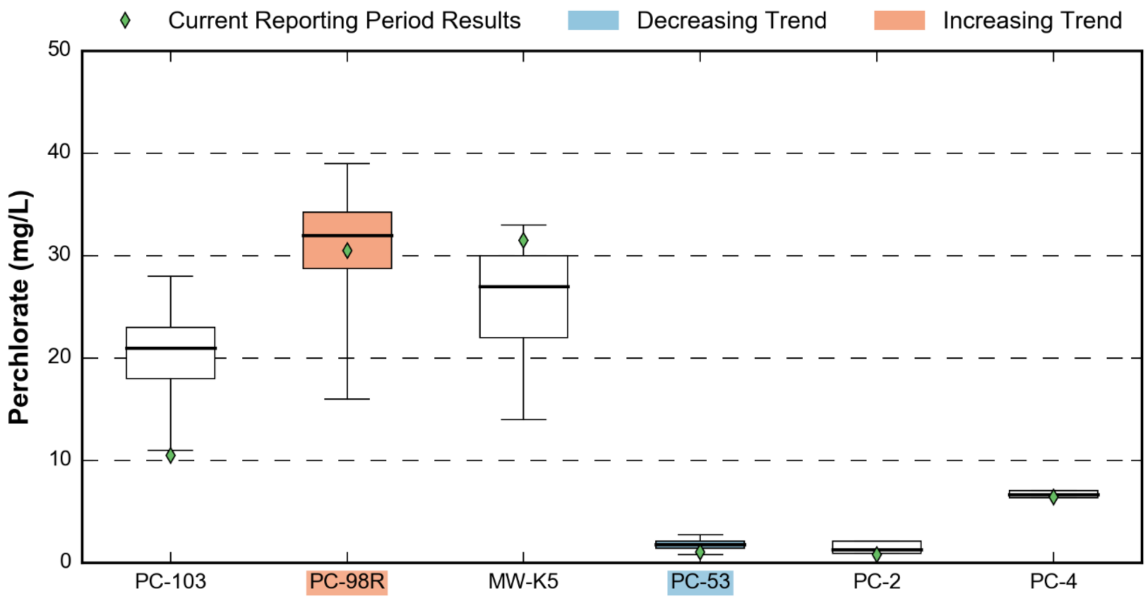
During the reporting period, perchlorate concentrations were generally consistent with the observed statistical trends over the last four years discussed above, as shown on the time series plots below. ARP-6B and MW-K4 continued to show elevated and variable concentrations relative to other nearby wells. 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 relatively high and variable concentrations in MW-K4 (ENVIRON 2012). PC-150 was activated in November 2014, and perchlorate concentrations generally decreased following activation. However, MW-K4 exhibited elevated concentrations during second quarter 2017. Concentrations then decreased through the remainder of the reporting period and were less than 50 mg/L in second quarter 2018. The variable perchlorate concentrations in groundwater at MW-K4 may be influenced by perchlorate mass present in the UMCf and upward flow caused by the natural vertical gradient, as discussed in the Phase 1 Remedial Investigation Data Evaluation Technical Memorandum (Ramboll Environ 2016c). The cause of these concentration trends are being further evaluated as part of the AWF Capture Evaluation and Matrix Diffusion Study Work Plan, which was submitted in September 2017 and approved by NDEP on October 3, 2017 (Ramboll Environ 2017c). The results of this evaluation will be presented in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019.



Time Series Plots: ARP Perchlorate Concentrations. This chart depicts perchlorate concentration data collected from the ARP wells over the last four years.

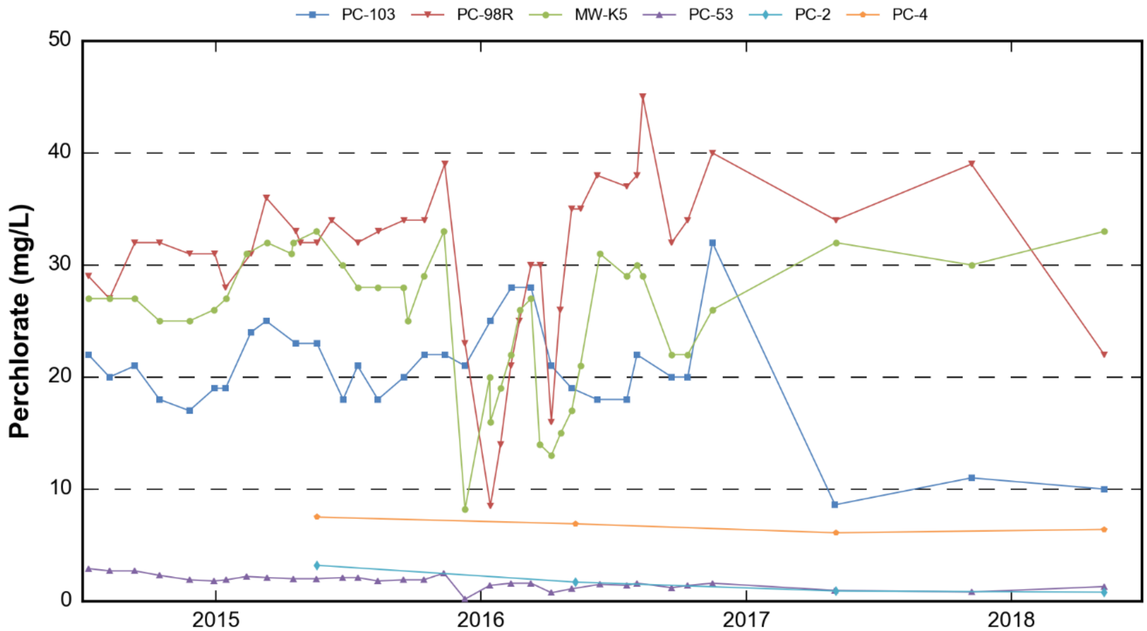
5.2.5 City of Henderson Water Reclamation Facility Well Line

Perchlorate concentrations in the COH WRF Well Line are shown in the charts below. Well PC-98R, located on the western edge of the COH WRF Well Line, has shown a statistically significant increase in concentration over the last four years, while concentrations in PC-53 have decreased. Statistically significant trends were not identified at the other wells. As shown on Plate 6 and discussed in Section 5.2.3, the perchlorate concentrations in PC-98R are impacted by the adjacent AMPAC/Endeavour perchlorate plume. The forthcoming OU-3 RI Report anticipated to be submitted in mid-2020 will discuss groundwater quality in this area in greater detail.



Box Plots: COH WRF Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

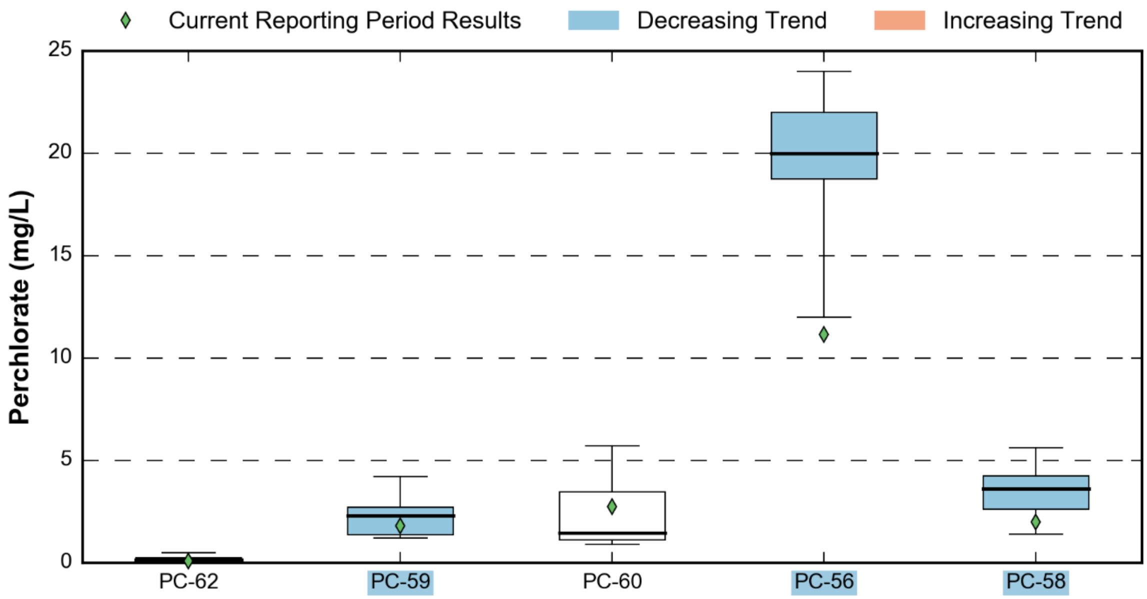
As shown on the time series plots, concentrations measured during the reporting period were generally consistent with the observed statistical trends over the last four years discussed above, with the exception of concentrations in PC-103 which have remained relatively low since second quarter 2017 and concentrations in PC-98R which were relatively low during second quarter 2018. The cause of these trends is unclear; however, it is noted that these wells are located adjacent to the COH Bird Viewing Ponds, and as such may be impacted by pond operations. The cause of these trends will be further evaluated in future submittals and the OU-3 RI Report anticipated to be submitted in mid-2020.



Time Series Plots: COH WRF Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the COH WRF well line over the last four years.

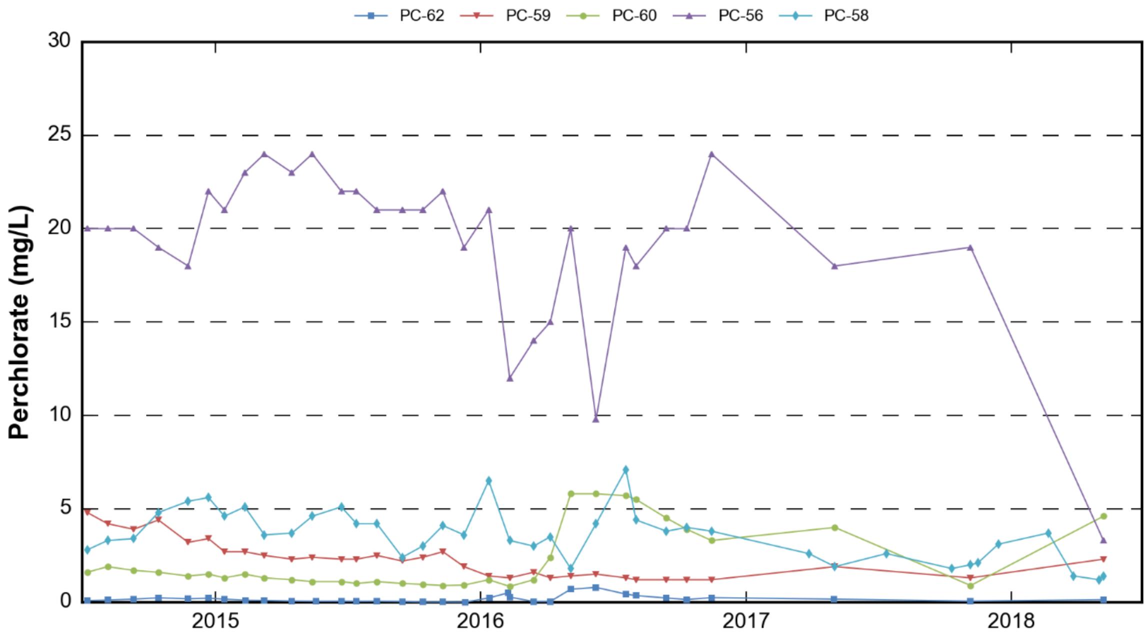
5.2.6 Lower Ponds Well Line

As shown below, the highest concentrations in the Lower Ponds Well Line are in well PC-56. Perchlorate concentrations in well PC-56 have historically been higher and more variable than concentrations in other wells along the Lower Ponds Well Line, and may be related to the well's location with respect to the paleochannels as shown on Plate 6. The statistical analysis indicates that perchlorate concentrations in wells PC-59, PC-56, and PC-58 have decreased over the last four years. Statistically significant trends were not identified in the other two wells (PC-62 and PC-60).



Box Plots: Lower Ponds Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

Concentrations measured during the reporting period are generally consistent with the observed statistical trends over the last four years discussed above, as shown in the time series plots below. During the current reporting period, PC-56 exhibited a sudden decrease in concentration in May 2018. The reason for this decrease is currently unclear, but will be evaluated in future remedial performance reports.

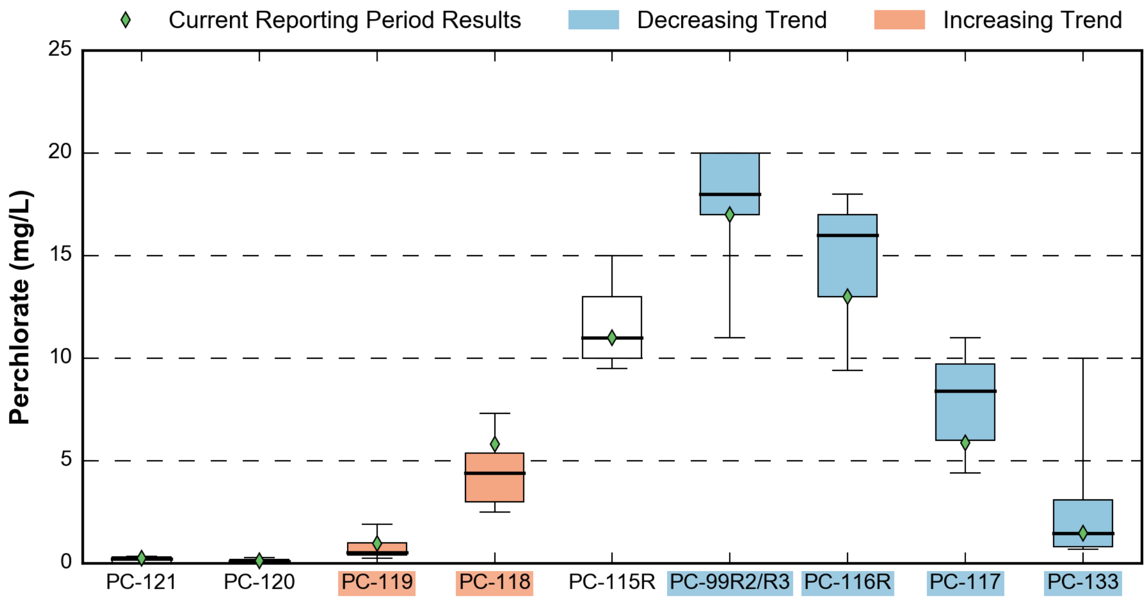


Time Series Plots: Lower Ponds Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the Lower Ponds well line over the last four years.

5.2.7 Seep Well Field

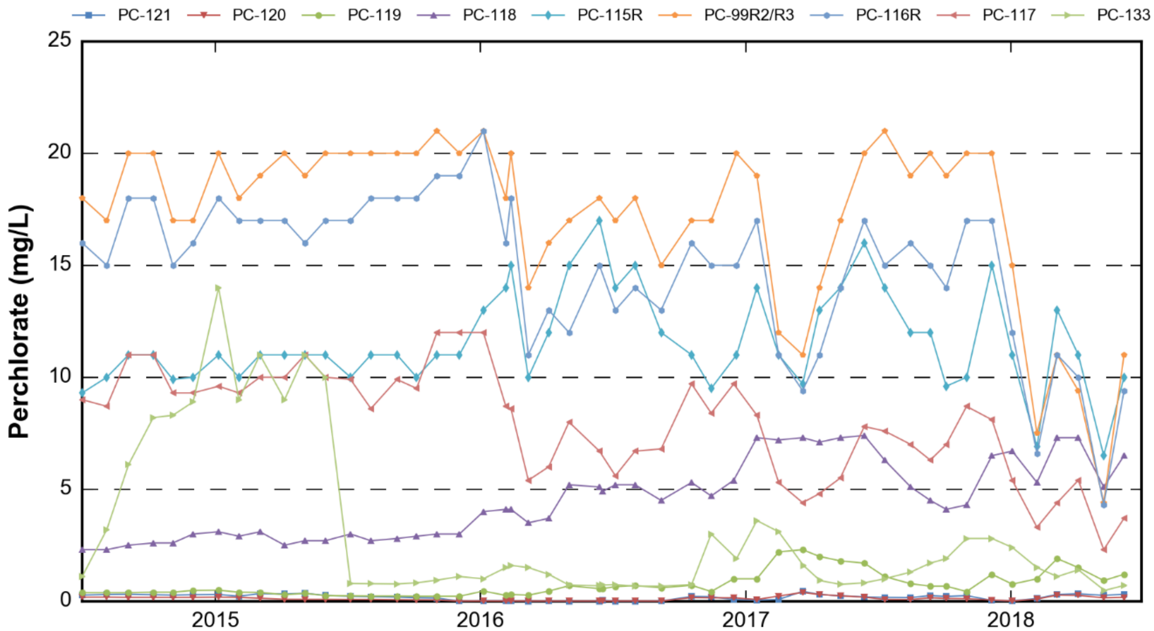
The SWF is located approximately 1 mile downgradient (north) of the AWF and is the last point of extraction and contaminant removal before groundwater intersects Las Vegas Wash. While the SWF wells contribute approximately 60% of the total volume of treated water to the GWETS, the relatively low perchlorate concentrations in these wells means that changes in their concentration do not have a large impact on the overall quantity of perchlorate removed from the environment.

As shown in the box plots below, the highest concentrations of perchlorate are located in the central portion of the well line near PC-99R2/R3. The statistical analysis indicates that concentrations in groundwater in the central and eastern portion of the SWF (PC-99R2/R3, PC-116R, PC-117, and PC-133) have decreased over the last four years. Statistically significant trends were not identified in the other three extraction wells. Concentrations in groundwater on the east end of the SWF have also generally shown higher variability over the last four years compared to other wells in the SWF. Wells PC-118 and PC-119, located in the western portion of the well field, have both shown statistically significant increases in perchlorate concentration over the last four years. The source of the increase is unknown, although chlorate and nitrate concentrations have also increased in this portion of the well field over the same period, as discussed in Sections 7.2.3 and 7.3.3. This trend will continue to be evaluated in future remedial performance reports and in the forthcoming OU-3 RI Report anticipated to be submitted in mid-2020.



Box Plots: SWF Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

As shown on the time series plots below, concentrations measured during the reporting period were generally consistent with the observed statistical trends over the last four years discussed above. Sudden decreased concentrations were observed in samples collected from PC-99R2/R3, PC-116R, and PC-115R in February and May 2018. Less pronounced decreases were also observed in PC-118 and PC-117 in February and May 2018. The cause of these decreases is unclear, but may be related to the wells' locations with respect to the paleochannel as shown on Plate 6 and similar decreases observed in upgradient monitoring wells within the same paleochannel, as discussed in Section 5.2.6 and Section 5.2.5.



Time Series Plots: SWF Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the SWF over the last four years.

6. CHLOROFORM AND OTHER VOLATILE ORGANIC COMPOUNDS

6.1 Volatile Organic Compounds

Chloroform and other VOCs were added to the groundwater monitoring program as part of the 2016 Groundwater Monitoring Optimization Plan after initial evaluation of RI data suggested that these chemicals were present at detectable levels throughout the Site and the NERT Off-Site Study Area (Ramboll Environ 2016b). Beginning in May 2017, comprehensive VOC sampling has been conducted on an annual basis during the second quarter sampling event. The VOC results from the second annual event sampled during the second quarter 2018 sampling event are presented in Table A-3.[10] The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss the extent of VOCs in groundwater in greater detail.

Chloroform was the most widely detected VOC and the only VOC defined as a chemical of potential concern (COPC) within the NERT Off-Site Study Area as part of the RI, and is therefore the focus of the remainder of this section. Of the 62 VOCs analyzed, 30 were detected in addition to chloroform in groundwater within the NERT Site and Off-Site Study Area as follows:

- 1,2,3-Trichloropropane was detected in groundwater at 120 wells, with concentrations ranging from 0.0025 J µg/L to 0.50 µg/L, which exceeds the Basic Comparison Level (BCL) of 0.00224 µg/L for 1,2,3-Trichloropropane (NDEP 2017a). The distribution of 1,2,3-Trichloropropane is generally similar to, but less extensive than, the distribution of chloroform within the NERT Site and Off-Site Study Area.
- 1,4-Dioxane was detected in groundwater at 71 wells, with concentrations ranging from 0.50 J µg/L to 23 µg/L. The BCL of 0.672 µg/L was exceeded in groundwater at 49 of these locations, most of which were distributed in the vicinity or downgradient of the Site's Unit Buildings and the Central Retention Basin, near OSSM's VOC extraction and treatment system (located near the northwest Site boundary), within Parcel A and B, or downgradient of the Site in the vicinity of the Sunset Road and ARP well lines.
- Trichloroethene was detected in groundwater at 66 wells, with concentrations ranging from 0.25 J µg/L to 38 µg/L. The MCL of 5 µg/L was exceeded in groundwater at 12 of these locations, most of which were distributed in the vicinity or downgradient of the Site's Unit Buildings and the Central Retention Basin, near OSSM's VOC extraction and treatment system, or within Parcel A and B.
- Carbon tetrachloride, 1,2-Dichlorobenzene, 1,4-Dichlorobenzene, 1,1-Dichloroethane, and Tetrachloroethene were detected in groundwater at 43 to 54 locations, but had fewer than 10 locations where applicable BCLs or MCLs were exceeded. Locations where applicable BCLs or MCLs were exceeded are primarily located along the western Site boundary. Some exceedances were also measured in the Off-Site Study Area as far north as the AWF.

[10] Table A-3 also includes data collected during the reporting period in August 2017 from the artesian wells included in the groundwater monitoring program following repair of these wells.

- Chlorobenzene and 1,3-Dichlorobenzene were detected in groundwater at 24 to 33 locations, but had 12 or fewer locations where applicable BCLs or MCLs were exceeded in groundwater. Locations where applicable BCLs or MCLs were exceeded are primarily located within the NERT Site along the western Site boundary.
- Benzene, Bromodichloromethane, Dibromochloromethane, 1,2-Dichloroethane, Hexachlorobutadiene, Methylene Chloride, Naphthalene, 1,1,2,2-Tetrachloroethane, 1,1-Dichloroethene, and 1,2,4-Trimethylbenzene were detected in groundwater at fewer than 20 locations, and had 10 or fewer locations where applicable BCLs or MCLs were exceeded in groundwater. Locations where applicable BCLs or MCLs were exceeded are primarily located within the NERT Site.
- 1,2,4-Trichlorobenzene, Bromoform, Toluene, and 1,2,3-Trichlorobenzene were detected in groundwater at 25 or fewer wells. Cis-1,2-Dichloroethene, Bromobenzene, 2-chlorotoluene, 4-chlorotoluene, 1,3,5-trimethylbenzene, and ortho-xylene were each detected in one well. None of these detections exceeded applicable MCL or BCL groundwater screening levels.

The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss in greater detail the extent of each of these constituents that were detected above applicable BCLs or MCLs. The OU-1/OU-2 RI Report will evaluate the distribution of these constituents and discriminate between constituents that are detected at isolated locations versus constituents that are detected at multiple locations.

6.2 Chloroform Concentration Trends

Plate 7 shows the contoured chloroform plume from the south end of the Site to Las Vegas Wash.[11] The data used to develop the chloroform isoconcentration contours includes second quarter 2018 shallow groundwater data collected by the Trust, OSSM, and TIMET, in addition to 2014/2015 shallow groundwater data collected by BRC. These data are available in Table A-1 and Table A-4. Additional preliminary data collected as part of the RI and the Trust's ongoing treatability studies were also evaluated and incorporated into the plume map interpretation. These preliminary data are not shown on the plume map, but will be presented in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019.

The following sections describe chloroform concentration trends at various well lines within the chloroform plume, beginning with the southernmost well line and progressing downgradient to the north towards Las Vegas Wash. The west-east well lines evaluated in this section are generally similar to those evaluated for perchlorate, with the exception of the extraction well fields. VOCs were not collected from extraction wells due to the potential for volatilization of organics when sampled from an extraction well; as such, chloroform concentrations were not evaluated at the extraction well fields. Chloroform concentrations were instead evaluated at alternative well lines comprised of shallow monitoring wells located upgradient of the extraction well fields. The well lines evaluated in this section include the following (as shown on Figure 1 and Plate 7):

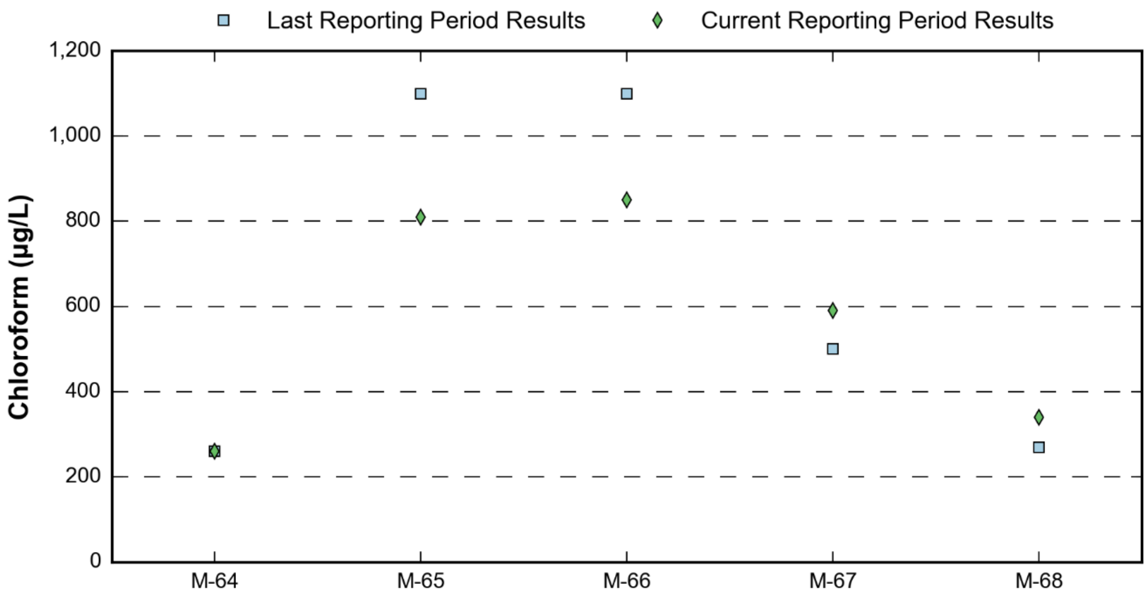
[11] The presence of chloroform and other VOCs within the Eastside Sub-Area will be investigated and remediated by BRC, if necessary, pursuant to the terms of the 2006 AOC.

- **Upgradient of the IWF**, comprised of shallow monitoring wells located approximately 100 feet south (upgradient) of the IWF for which data were available during the reporting period;
- **Downgradient of the Barrier Wall**, comprised of shallow monitoring wells located immediately north (downgradient) of the barrier wall for which data were available during the reporting period;
- **Sunset Road Well Line,** comprised of shallow monitoring wells located along Sunset Road, approximately 1,400 feet upgradient of the AWF;
- **The ARP Well Line,** comprised of shallow monitoring wells located approximately 250 feet north of the AWF;
- **The COH WRF Well Line,** comprised of shallow monitoring wells located east of the COH Bird Viewing Ponds and approximately 2,200 feet north of the AWF;
- **The Lower Ponds Well Line,** comprised of shallow monitoring wells located approximately 4,400 feet north of the AWF and 2,200 feet north of the COH WRF Well Line.

These well lines were selected in order to evaluate chloroform concentrations between the Site and Las Vegas Wash. The data visualizations presented in this section are limited by the fact that only two comprehensive sampling events have been conducted to date. Box plots and time series plots will be incorporated into future annual reports as more data are collected.

6.2.1 Upgradient of the Interceptor Well Field

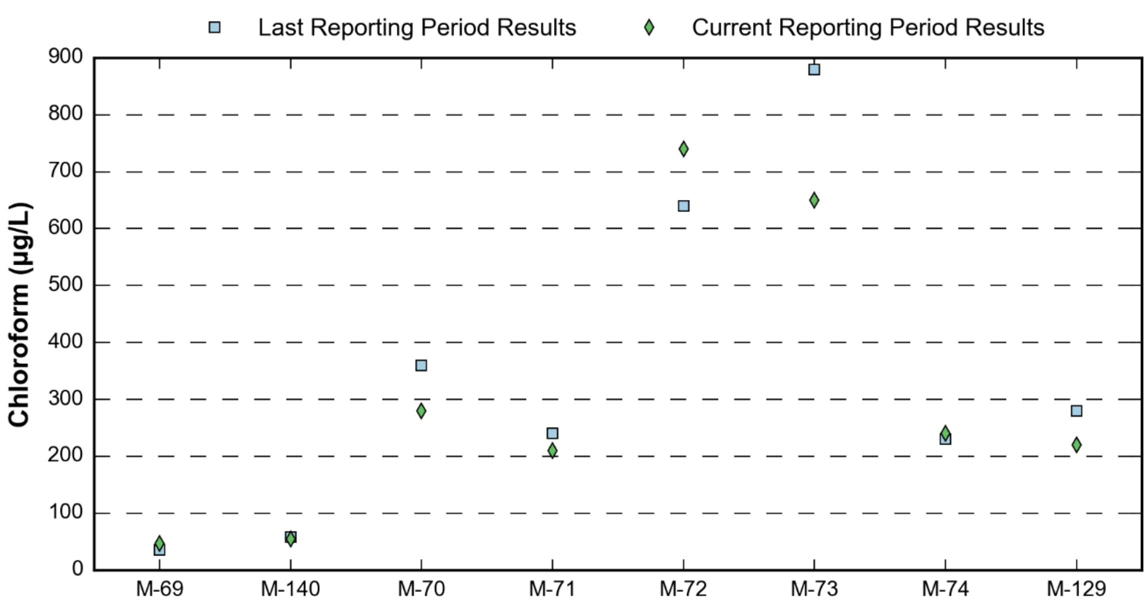
The wells plotted below are located approximately 100 feet south (upgradient) of the IWF. As shown below and on Plate 7, it appears chloroform concentrations are higher near the center of the IWF and lower towards the edges of the well field. Chloroform concentrations immediately upgradient of the IWF are generally less than 900 µg/L.



Scatter Plot: Chloroform Concentrations Upgradient of the IWF. This chart depicts chloroform concentration data collected upgradient of the IWF during the second quarter 2017 and 2018 sampling events.

6.2.2 Downgradient of the Barrier Wall

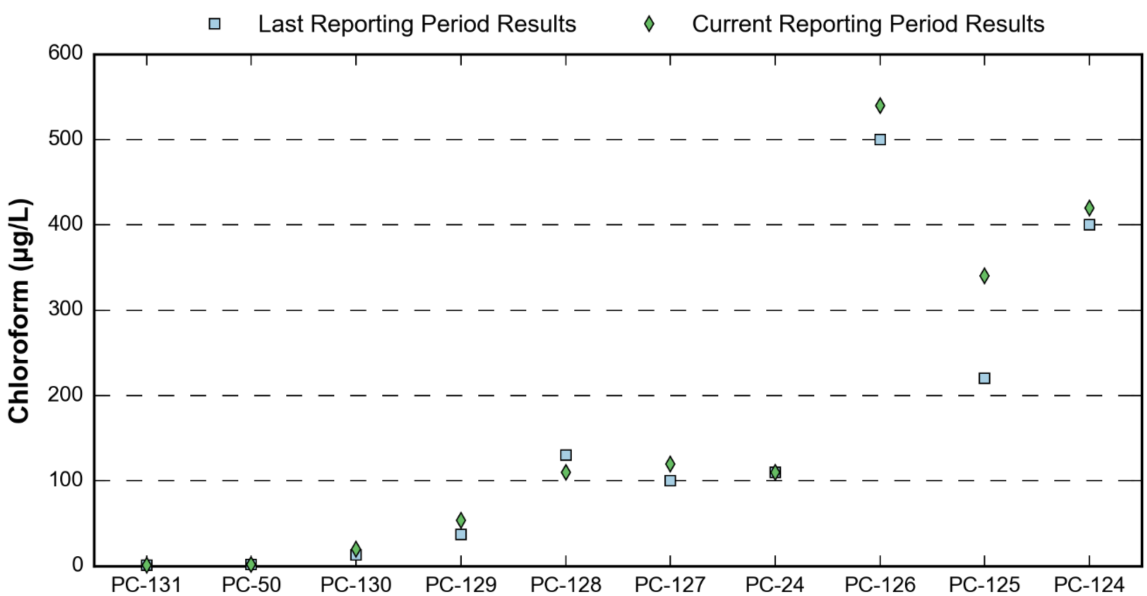
As shown below and on Plate 7, chloroform concentrations in wells located between the barrier wall and former recharge trenches are generally less than 800 µg/L and somewhat lower than those upgradient of the barrier wall. The highest concentrations were observed in the eastern-central portion of the well line.



Scatter Plot: Chloroform Concentrations Downgradient of the Barrier Wall. This chart depicts chloroform concentration data collected downgradient of the barrier wall during the second quarter 2017 and 2018 sampling events.

6.2.3 Sunset Road Well Line

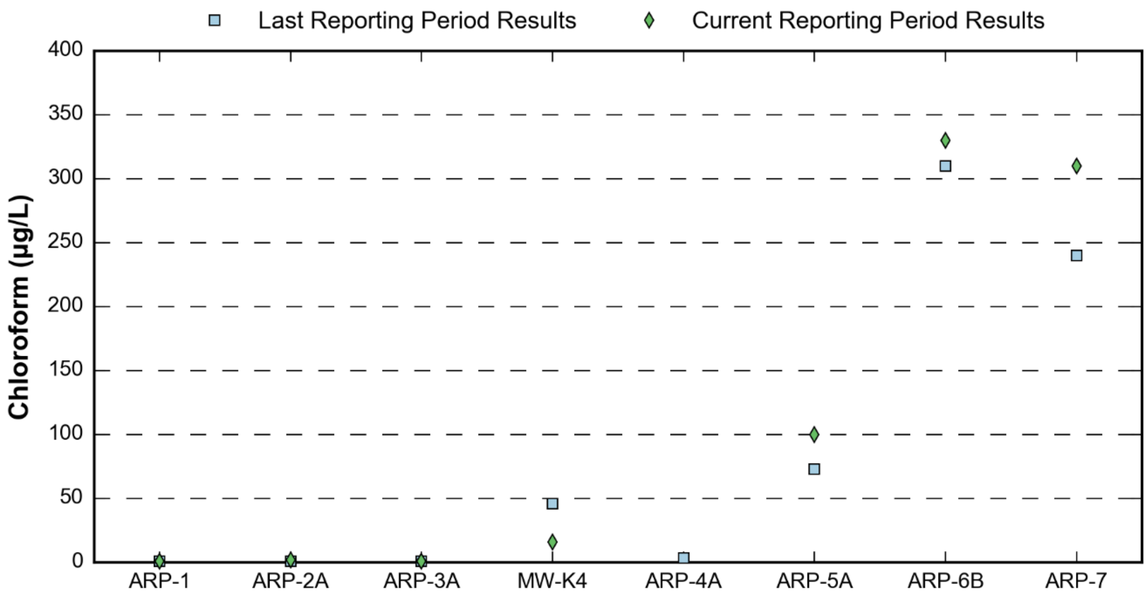
As shown below, chloroform concentrations are generally lower along the Sunset Road Well Line than within the NERT site, with higher chloroform concentrations measured in groundwater from wells located on the east side of the well line. As shown on Plate 7, the chloroform plume likely extends further east of the Sunset Road Well Line; however, shallow groundwater data are currently not available in the area immediately east of the Sunset Road Well Line. The extent of chloroform in this area as shown on Plate 7 has been interpreted based on available data within the Eastside Study Area. This interpretation will be further refined based on available data as part of the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019. The presence of chloroform and other VOCs within the Eastside Sub-Area will be investigated and remediated by BRC, if necessary, pursuant to the terms of the 2006 AOC.



Scatter Plot: Chloroform Concentrations on Sunset Road. This chart depicts chloroform concentration data collected along Sunset Road during the second quarter 2017 and 2018 sampling events.

6.2.4 Athens Road Piezometer Well Line

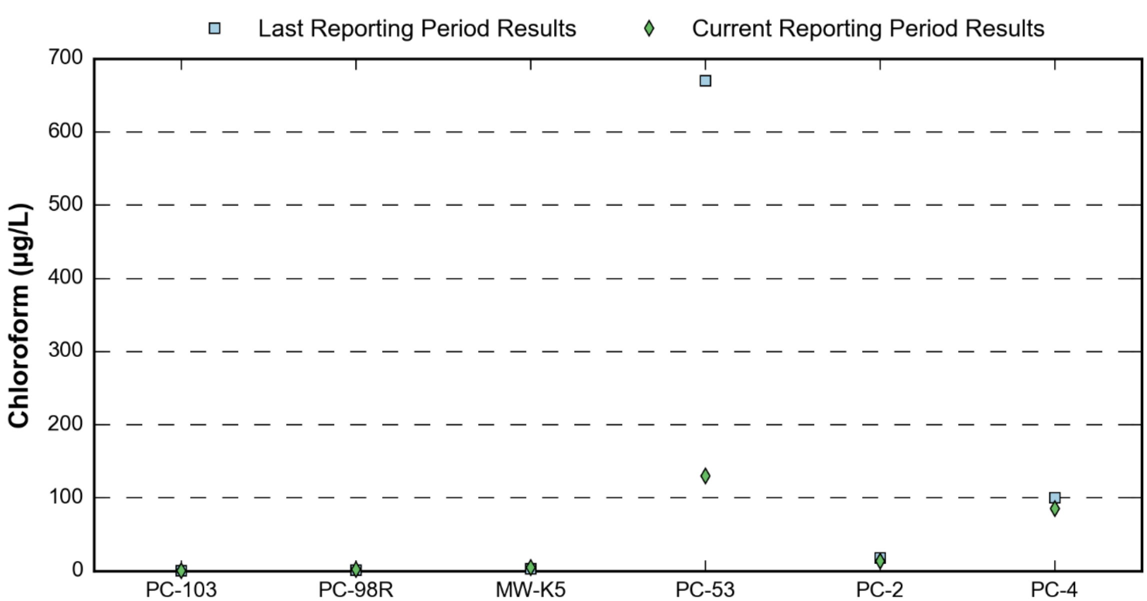
Chloroform concentrations across the ARP Well Line are presented below. Concentrations were less than 350 µg/L along this well line during the reporting period, with the highest concentrations observed on the east side of the well line.



Scatter Plot: Chloroform Concentrations at the Athens Road Piezometers. This chart depicts chloroform concentration data collected from the Athens Road Piezometers during the second quarter 2017 and 2018 sampling events.

6.2.5 City of Henderson Water Reclamation Facility Well Line

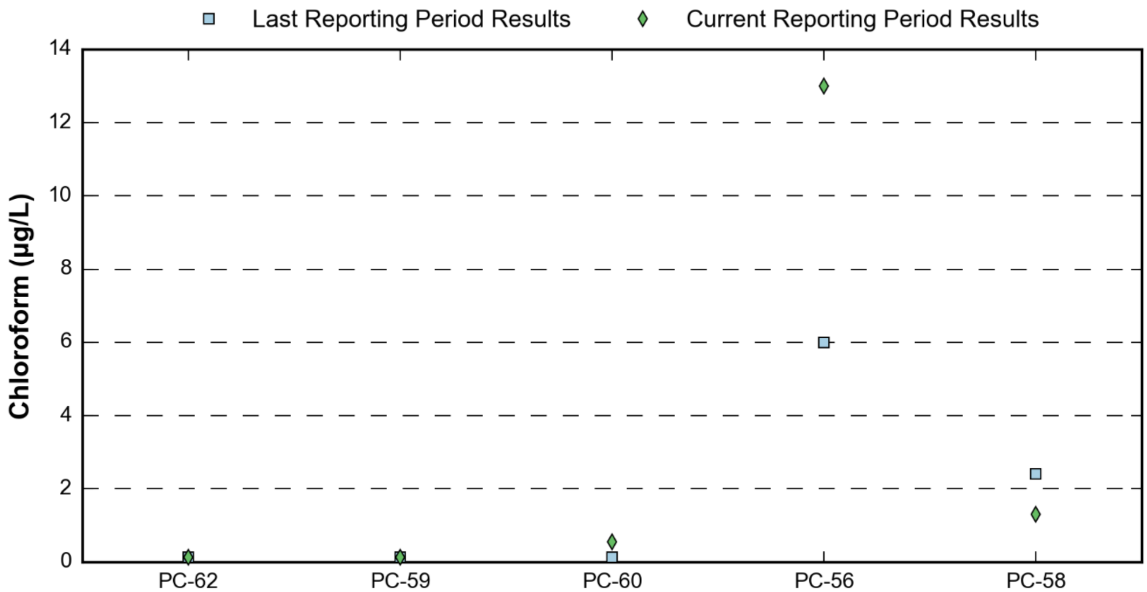
Chloroform concentrations across the COH WRF Well Line were less than 100 µg/L during the reporting period with the exception of PC-53. The chloroform concentration in PC-53 was 670 µg/L in May 2017 and 130 µg/L in May 2018, indicating there are relatively high chloroform concentrations in the central portion of this well line.



Scatter Plot: COH WRF Chloroform Concentrations. This chart depicts chloroform concentration data collected near the COH WRF during the second quarter 2017 and 2018 sampling events.

6.2.6 Lower Ponds Well Line

Chloroform concentrations in the Lower Ponds Well Line ranged from non-detect to less than 14 µg/L during the reporting period. Similar to the second quarter 2017 sampling event, the highest concentration in this well line in second quarter 2018 was observed in well PC-56.



Scatter Plot: Lower Ponds Chloroform Concentrations. This chart depicts chloroform concentration data collected along the Lower Ponds well line during the second quarter 2017 and 2018 sampling events.

7. OTHER MEASURED PARAMETERS

This section discusses other measured parameters including TDS, chlorate, and nitrate at the IWF, AWF, and SWF. Consistent with prior reports evaluating TDS trends, the west-east well lines evaluated in this section are limited to the extraction well lines and do not include time series plots. Similarly, chlorate and nitrate evaluations are also limited to the extraction well lines.

As requested by NDEP in the December 6, 2016 comment letter on 2015-2016 Annual Report (NDEP 2016b), this report incorporates statistical analyses of well line concentration trends, as described in Section 4.2.

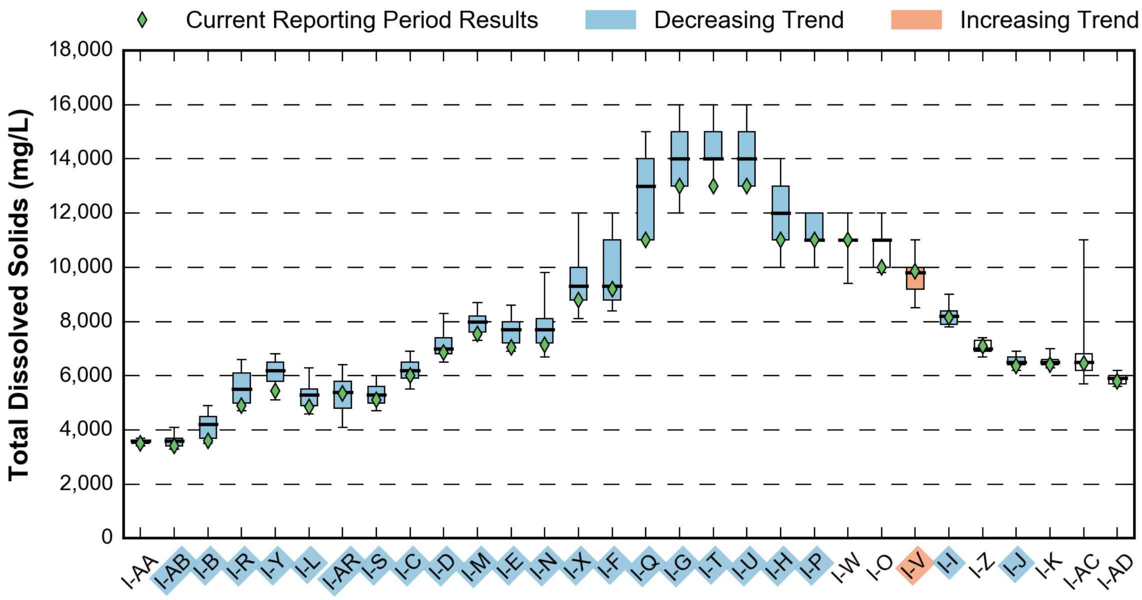
7.1 Total Dissolved Solids

Plate 8 presents the isoconcentration contours for TDS from the southern end of the Site northward to Las Vegas Wash. The data used to develop the TDS isoconcentration contours includes second quarter 2018 shallow groundwater data collected by the Trust, OSSM, SNWA, TIMET, and AMPAC/Endeavour, in addition to second quarter 2016 shallow groundwater data collected by AECOM and 2014/2015 shallow groundwater data collected by BRC. These data are available in Table A-1 and Table A-4. Additional preliminary data collected as part of the RI and the Trust's ongoing treatability studies were also evaluated and incorporated into the plume map interpretation. These preliminary data are not shown on the plume map, but will be presented in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019.

The following sections describe TDS concentration trends at the IWF, AWF, and SWF.

7.1.1 Interceptor Well Field

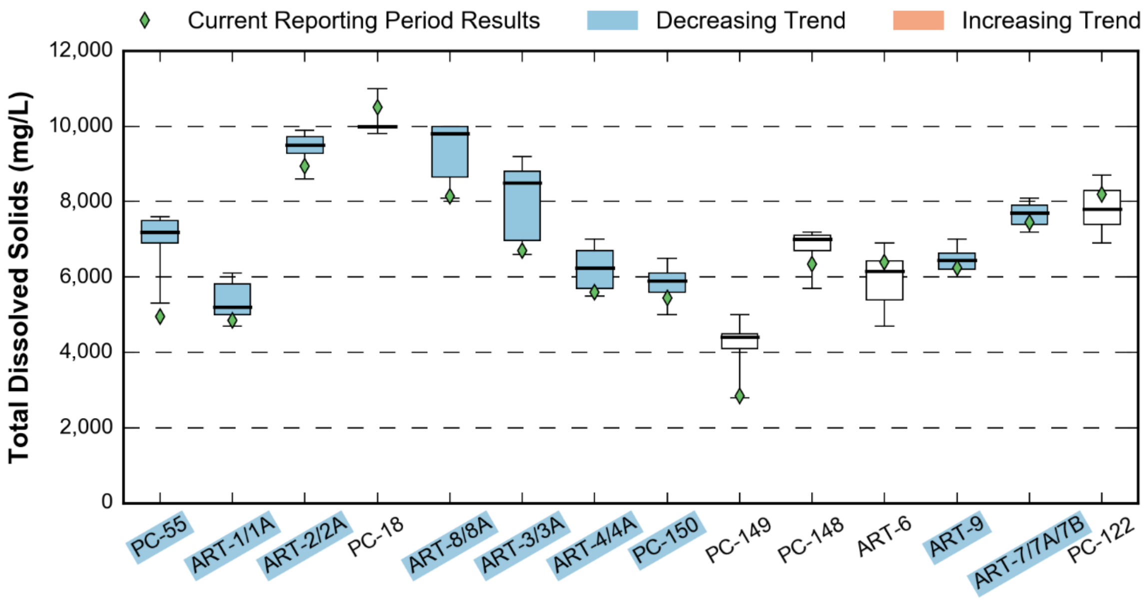
As shown in the box plot below, TDS concentrations in groundwater are higher near the center of the IWF. Statistical analysis indicates that TDS concentrations in the majority of IWF wells (22 of the 30 wells) have decreased over the last four years, with the exception of one well (I-V) where concentrations have increased. Statistically significant trends were not identified in data from the other extraction wells. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.



Box Plots: IWF TDS Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.1.2 Athens Road Well Field

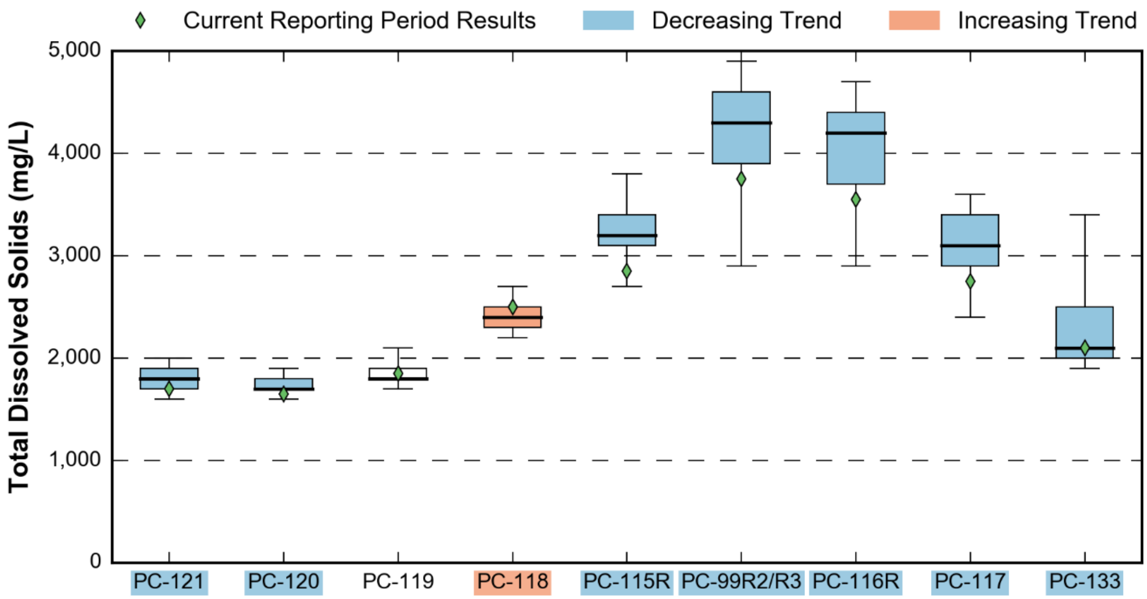
TDS concentrations in groundwater from the AWF's eight pumping well pairs are shown in the chart below, in addition to monitoring wells ART-6, PC-18, PC-55, PC-122, PC-148, and PC-149. Similar to perchlorate, TDS concentrations in the western sub-channel (represented by wells west of PC-149) are generally higher relative to those in the eastern sub-channel (represented by wells east of PC-148). The statistical analysis indicates that TDS concentrations in groundwater in a majority of these well (9 wells) have decreased over the last four years. Statistically significant trends were not identified in data from the other wells.



Box Plots: AWF TDS Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.1.3 Seep Well Field

TDS concentrations in groundwater collected from the SWF are generally less than 5,000 mg/L, with the highest concentrations near the east-central portion of the well field, as shown below. The statistical analysis indicates that TDS concentrations in a majority of the SWF wells (7 wells) have decreased over the last four years, with the exception of well PC-118 where concentrations have increased. A statistically significant trend was not identified in the other extraction well (PC-119). The forthcoming OU-3 RI Report anticipated to be submitted in mid-2020 will discuss groundwater quality in this area in greater detail.



Box Plots: SWF TDS Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25^{th}-75^{th} percentile; the "whiskers" represent data in the 5^{th}-95^{th} percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

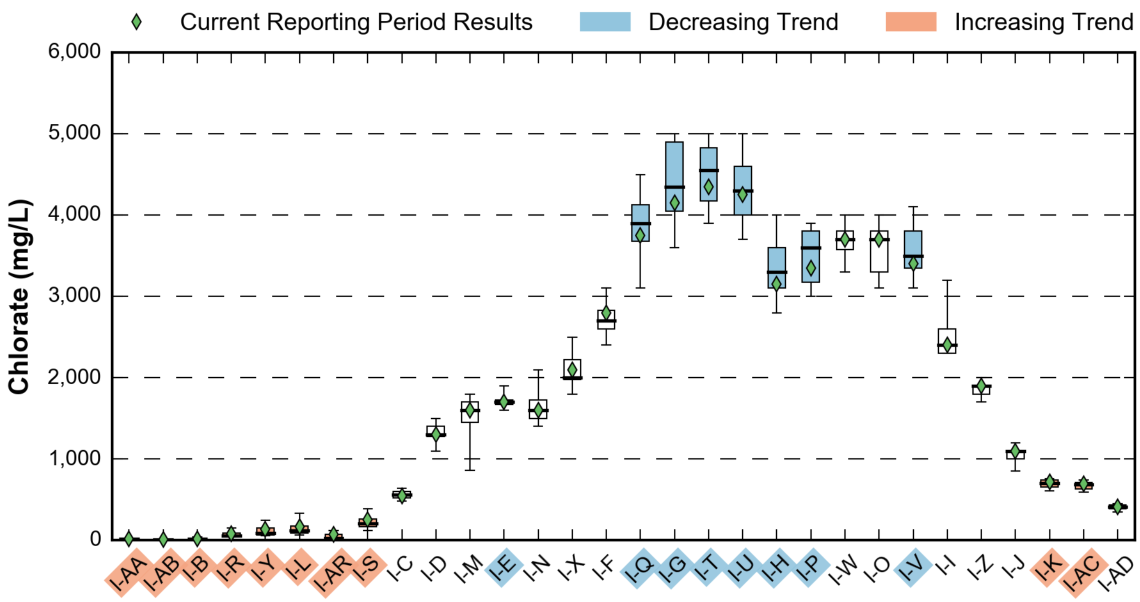
7.2 Chlorate

Chlorate monitoring was significantly expanded as part of the 2016 Groundwater Monitoring Optimization Plan to include all monitoring wells during the semi-annual (fourth quarter) and annual (second quarter) sampling events (Ramboll Environ 2016b). Chlorate was also added to the monthly sampling of extraction wells for the purpose of better understanding its impact on GWETS performance. Chlorate significantly contributes to contaminant loading at the FBRs, which biologically remove perchlorate, chlorate, and nitrate. The distribution of chlorate will also be critical to understand as the Trust evaluates remedial alternatives as part of the forthcoming FS.

A plume map for chlorate was generated as part of the Annual Report prior to 2012. The map is no longer routinely prepared following NDEP's comment that a chlorate isoconcentration map is not necessary because the extent of chlorate is closely aligned with the distribution of NERT's perchlorate (NDEP 2011).

7.2.1 Interceptor Well Field

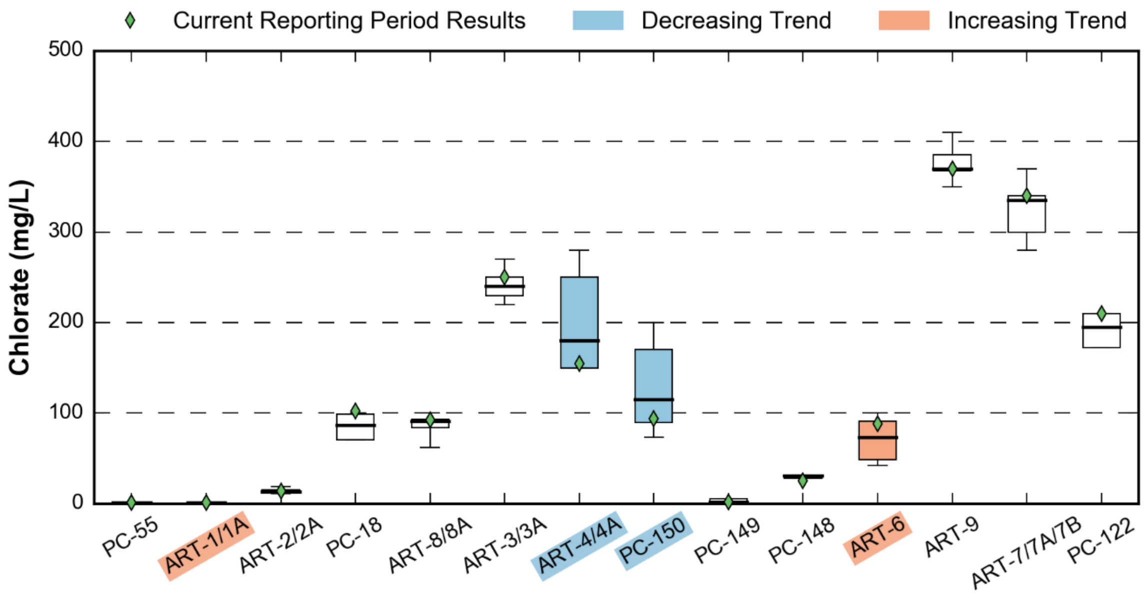
As shown in the box plot below, chlorate concentrations in groundwater are higher near the center of the IWF. The statistical analysis indicates that chlorate concentrations decreased in eight wells in the central portion of the IWF over the last four years. The statistical analysis indicates that concentrations have increased in 10 wells over the last four years, eight of which are located on the western end of the IWF and two of which are located in the eastern portion of the IWF. All wells identified as having an increasing trend had concentrations under 1000 mg/L. Statistically significant trends were not identified in the other 12 extraction wells. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.



Box Plots: IWF Chlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.2.2 Athens Road Well Field

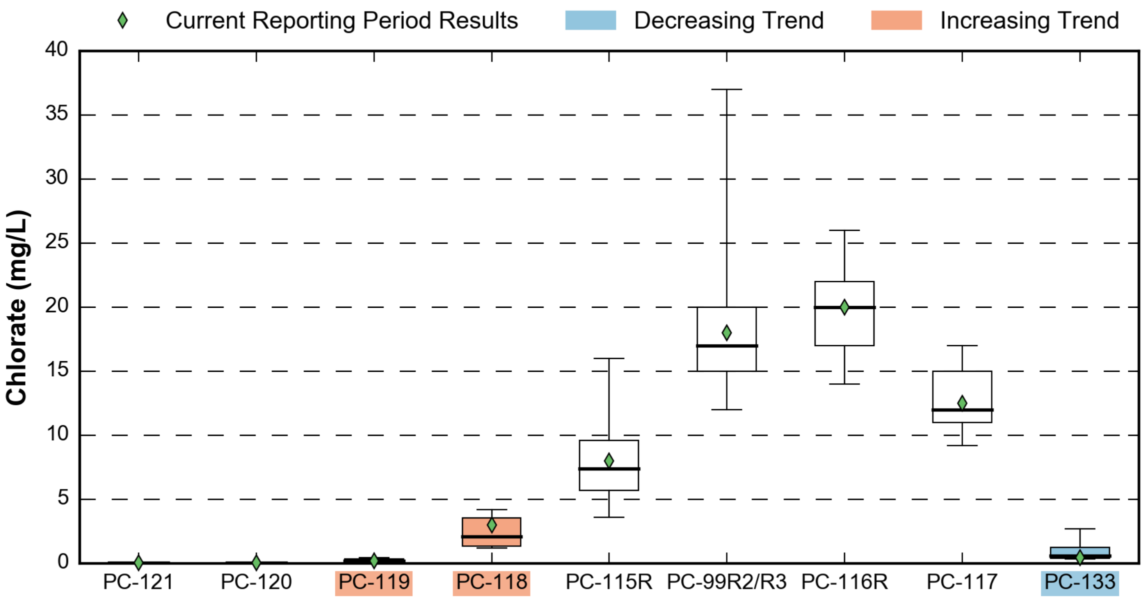
Chlorate concentrations in groundwater collected from the AWF's eight pumping well pairs are shown in the chart below, in addition to monitoring wells ART-6, PC-18, PC-55, PC-122, PC-148, and PC-149. Chlorate concentrations are generally less than 400 mg/L, and are highest in the central and eastern portions of the well field. The statistical analysis indicates that chlorate concentrations decreased in ART-4/4A and PC-150 and increased in ART-1/1A and ART-6 over the last four years; however, statistically significant trends were not identified in data from the other 10 wells. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.



Box Plots: AWF Chlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.2.3 Seep Well Field

Chlorate concentrations in the SWF are generally less than 25 mg/L, with the highest concentrations near the east-central portion of the well field. Statistical analysis indicates that chlorate concentrations in groundwater in well PC-133 have decreased, while concentrations in PC-119 and PC-118 have increased. The increasing chlorate concentrations in this area of the SWF are aligned with the area of increasing perchlorate concentrations in wells PC-118 and PC-119 discussed in Section 5.2.7. Statistically significant trends were not identified in the other 6 extraction wells. The forthcoming OU-3 RI Report anticipated to be submitted in mid-2020 will discuss groundwater quality in this area in greater detail.



Box Plots: SWF Chlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

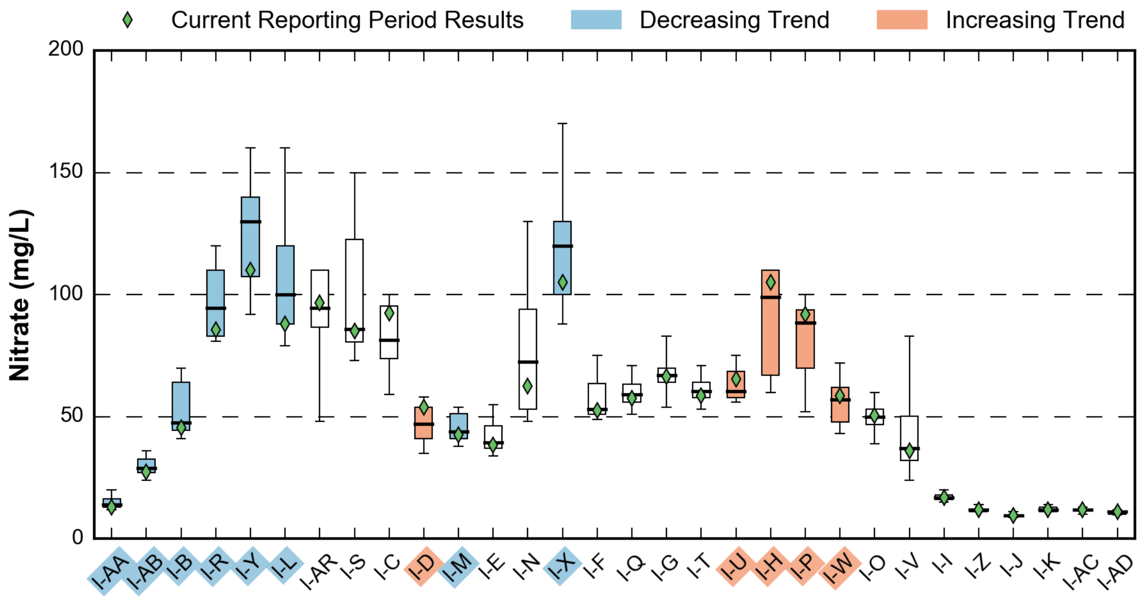
7.3 Nitrate

Nitrate monitoring was significantly expanded as part of the 2016 Groundwater Monitoring Optimization Plan to include all monitoring wells during the semi-annual (fourth quarter) and annual (second quarter) sampling events (Ramboll Environ 2016b). Nitrate was also added to the monthly sampling of extraction wells for the purpose of better understanding its impact on GWETS performance. Nitrate significantly contributes to contaminant loading at the FBRs, which biologically remove perchlorate, chlorate, and nitrate. The distribution of nitrate will also be critical to understand as the Trust evaluates remedial alternatives as part of the forthcoming FS.

Similar to chlorate, a plume map for nitrate was generated as part of the Annual Report prior to 2012. The map is no longer routinely prepared following NDEP's suggestion that a nitrate isoconcentration map is not necessary because the extent of nitrate is closely aligned with the distribution of perchlorate (NDEP 2011).

7.3.1 Interceptor Well Field

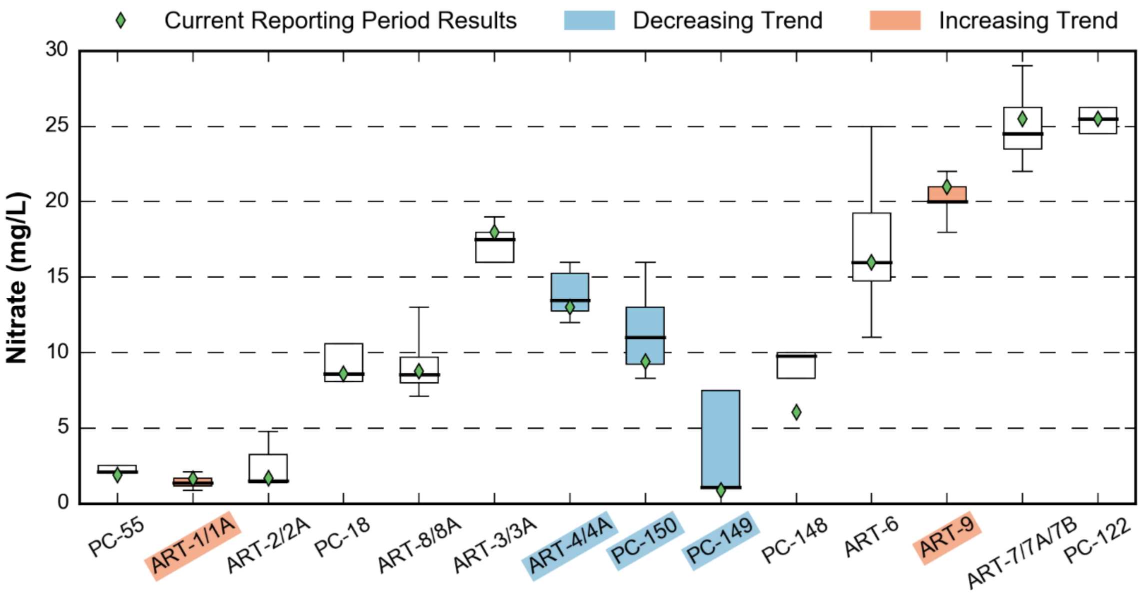
As shown in the box plot below, nitrate concentrations are higher in groundwater in the central to west-central portion of the IWF. Statistical analysis indicates that nitrate concentrations in groundwater in five of the IWF wells have increased, while concentrations in groundwater in eight wells located primarily in the western portion of the IWF have decreased. Statistically significant trends were not identified in the other 17 extraction wells. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.



Box Plots: IWF Nitrate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25^{th}-75^{th} percentile; the "whiskers" represent data in the 5^{th}-95^{th} percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.3.2 Athens Road Well Field

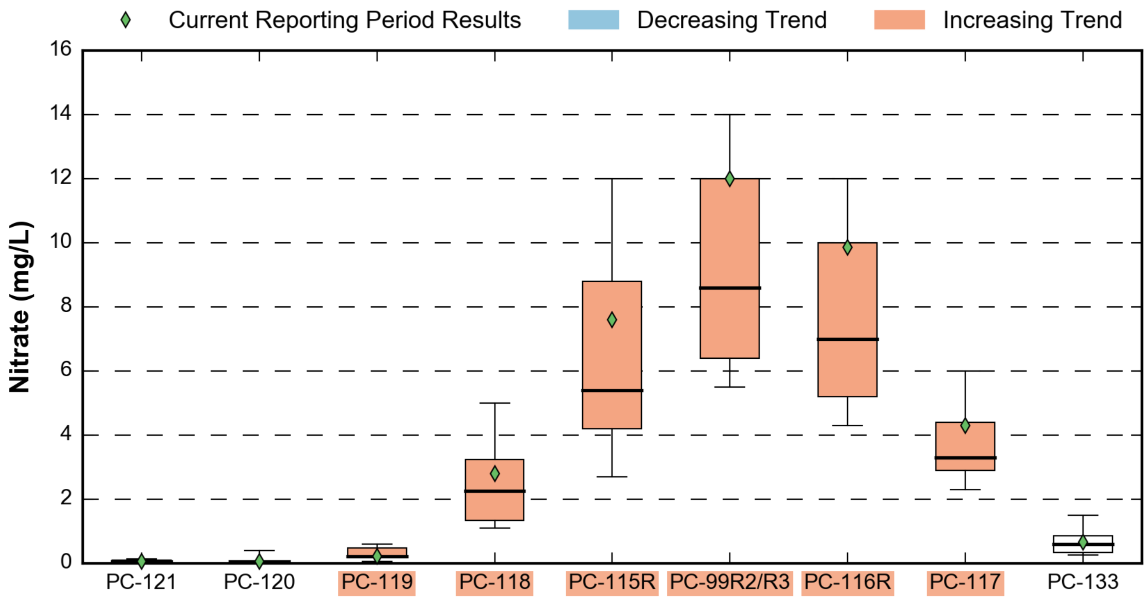
Nitrate concentrations in groundwater collected from the AWF's eight pumping well pairs are shown in the chart below, in addition to monitoring wells ART-6, PC-18, PC-55, PC-122, PC-148, and PC-149. Concentrations are generally highest in the central and eastern portions of the well line. Statistical analysis indicates that nitrate concentrations decreased in ART-4, PC-150, and PC-149, while concentrations increased in ART-1 and ART-9. Statistically significant trends were not identified in the other 9 wells. The forthcoming OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 will discuss groundwater quality in greater detail.



Box Plots: AWF Nitrate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.3.3 Seep Well Field

Nitrate concentrations in groundwater collected from the SWF are less than 14 mg/L, with the highest concentrations near the east-central portion of the well field. The statistical analysis indicates that nitrate concentrations increased in groundwater at six of the wells. Statistically significant trends were not identified in data from the 3 other extraction wells. The forthcoming OU-3 RI Report anticipated to be submitted in mid-2020 will discuss groundwater quality in this area in greater detail.



Box Plots: SWF Nitrate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2014 to June 2018 are displayed as follows: the thick black line represents the median value; the box represents data in the 25^{th}-75^{th} percentile; the "whiskers" represent data in the 5^{th}-95^{th} percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

8. PERFORMANCE EVALUATION

This section provides an evaluation of the performance of the GWETS against a set of performance metrics. The primary infrastructure of the GWETS was installed in the early 2000s in accordance with an Administrative Order issued by NDEP. The GWETS currently operates as a removal action designed to capture the highest concentrations of perchlorate and hexavalent chromium present in groundwater. The performance metrics are intended to establish a consistent framework for evaluating performance of the current GWETS and, ultimately, are expected to be modified to evaluate the performance of the NERT final remedy.

The performance metrics were originally developed as part of the 2013 GWETS Optimization Work Plan (ENVIRON 2013), approved by NDEP on December 3, 2013 (NDEP 2013). These original metrics included those identified in the 2013 GWETS Optimization Work Plan and additional metrics requested in the April 9, 2014 letter from NDEP (NDEP 2014) on the 2013 Semi-Annual Performance Report.

The Performance Metrics Technical Memorandum, approved by NDEP in October 2017, describes the updated framework for estimating contaminant mass and evaluating revised performance metrics for the entire NERT RI Study Area (Ramboll Environ 2017d). The performance metrics evaluation presented herein includes updates to the methodology used for evaluating the metrics, including expanding the evaluation to incorporate the entire NERT RI Study Area using data that are currently available, in accordance with the implementation schedule outlined in the Performance Metrics Technical Memorandum and described in Section 8.1. GWETS performance will continue to be evaluated in future remedial performance submittals throughout the RI/FS process and implementation of the final remedy. Once the final remedy is in place, the monitoring program and associated reporting, including evaluation of the performance metrics, will be adapted for the final remedy.

8.1 Performance Metrics

Performance metrics are discrete measures of performance that are used to understand and adjust GWETS operations over time. The performance metrics evaluated include the following:[12]

- Mass Removal;
- Remaining Contaminant Mass;
- Capture Zone Evaluation;

[12] GW-11's operation as an equalization basin was evaluated as part of the performance metrics in previous performance evaluations. The evaluation of GW-11's operations has since been incorporated into the GWETS Enhanced Operational Metrics, which are evaluated as part of NERT's monthly GWETS operations reporting; therefore, GW-11's operations are no longer evaluated as part of the performance metrics within this report. An analysis of the barrier wall's performance was also previously evaluated as part of the performance metrics in previous performance evaluations. An evaluation of the integrity and effectiveness of the barrier wall, as outlined in the NDEP-approved Barrier Wall Integrity Field Evaluation Work Plan (Ramboll Environ 2017b), is being conducted in 2018 and will be reported in the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019. Future evaluations of the barrier wall's performance will therefore no longer be included as part of the performance metrics within this report.

- Well Field Capture Efficiency;
- Estimated Mass Flux across the RI Study Area;
- Perchlorate Mass Loading in Las Vegas Wash;
- Environmental Footprint of the GWETS and Groundwater Monitoring Program; and
- Surface Water and Groundwater Interaction Near the SWF.

Several updates to the methodology used for evaluating the metrics have been incorporated in the evaluations presented herein compared to previous submittals as described in the Performance Metrics Technical Memorandum, including the expansion of the evaluation to incorporate the entire NERT RI Study Area. These updates include:

- Incorporation of available preliminary data from the RI (the Phase 1 RI, the Phase 2 RI, the Phase 3 RI, and the Downgradient Study Area Investigation) and ongoing treatability studies;
- Evaluation of remaining contaminant mass across the entire NERT RI Study Area using a revised methodology as presented in the Performance Metrics Technical Memorandum (approved by NDEP in October 2017);
- Evaluation of horizontal mass flux across the OU boundaries; and
- Evaluation of vertical mass flux between the alluvium and UMCf across the entire NERT RI Study Area.

An updated steady-state version of the transient Phase 5 Groundwater Model (the Phase 5 model) was used to simulate second quarter 2018 conditions for the evaluation of remaining contaminant mass, well field capture zones, and estimated mass flux (Ramboll Environ 2016e). Available preliminary data from the RI and ongoing treatability studies were incorporated into the updated Phase 5 model and a preliminary perchlorate transport component was also added. As part of the Phase 6 Groundwater model (the Phase 6 model) development, the current model will be further refined to simulate contaminant transport and incorporate additional data from the RI and ongoing treatability studies. The Phase 6 model will be submitted to NDEP in second quarter 2019, at which point the Phase 6 model will be used for subsequent evaluations of the performance metrics.

The evaluation of the performance metrics presented herein incorporates available preliminary data from the RI and the Trust’s ongoing treatability studies. Performance evaluations will continue to be refined and updated in future submittals as additional data become available. The next evaluation of remaining contaminant mass will be prepared as part of the OU-1/OU-2 RI Report in early 2019 and the next evaluation of the remaining GWETS performance metrics will be included in the 2018 Semi-Annual Remedial Performance Memorandum to be submitted in April 2019. These evaluations will include the complete results of the RI Phase 2 and Phase 3 sampling that is currently in progress and the results from the Trust’s recently initiated pilot and treatability studies. Specifically, data that will be incorporated into these evaluations in the future include but are not limited to the following:

- Data collected from additional wells and soil borings being installed pursuant to recent modifications to the scope of the Phase 2 and Phase 3 RI;

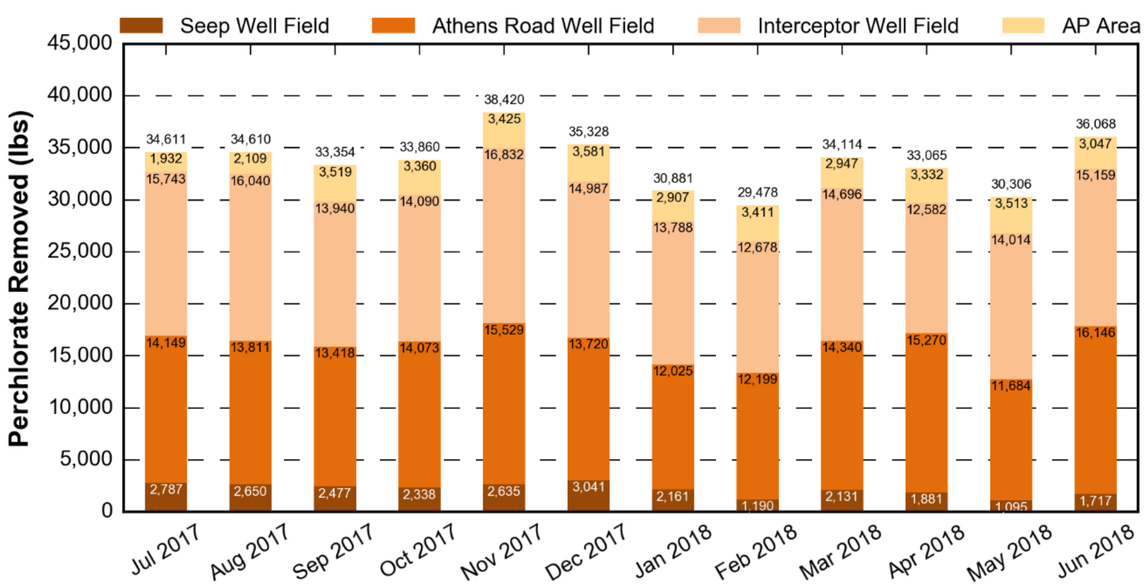
- Data collected from recently initiated pilot and treatability studies being conducted by the Trust, including the Las Vegas Wash Pilot Test for Downstream Reduction of Perchlorate Flux, the Galleria Drive Bioremediation Treatability Study, and the Galleria Drive Zero Valent Iron (ZVI) Treatability Study; and
- Data collected from wells to be installed as part of the Downgradient Study Area Investigation.

8.2 Evaluation of Performance

In this section, the performance of the GWETS is discussed in relation to the current performance metrics presented in Section 8.1. It is important to note that the GWETS operates as a removal action designed to capture perchlorate and chromium originating from releases to groundwater that occurred at the NERT Site (OU-1). The GWETS was not designed or intended to capture perchlorate that migrated to the Eastside Study Area.

8.2.1 Mass Removal

During the reporting period, approximately 404,100 pounds of perchlorate were captured and removed from groundwater by the GWETS as shown in Table 8 and in the figure below. Of this total, approximately 174,500 pounds were captured by the IWF, approximately 166,400 pounds were captured by the AWF, approximately 26,100 pounds were captured by the SWF, and approximately 37,100 pounds were captured by the AP Area extraction wells.[13] During the 2017 calendar year, a total of approximately 415,900 pounds of perchlorate were captured and removed from the environment.

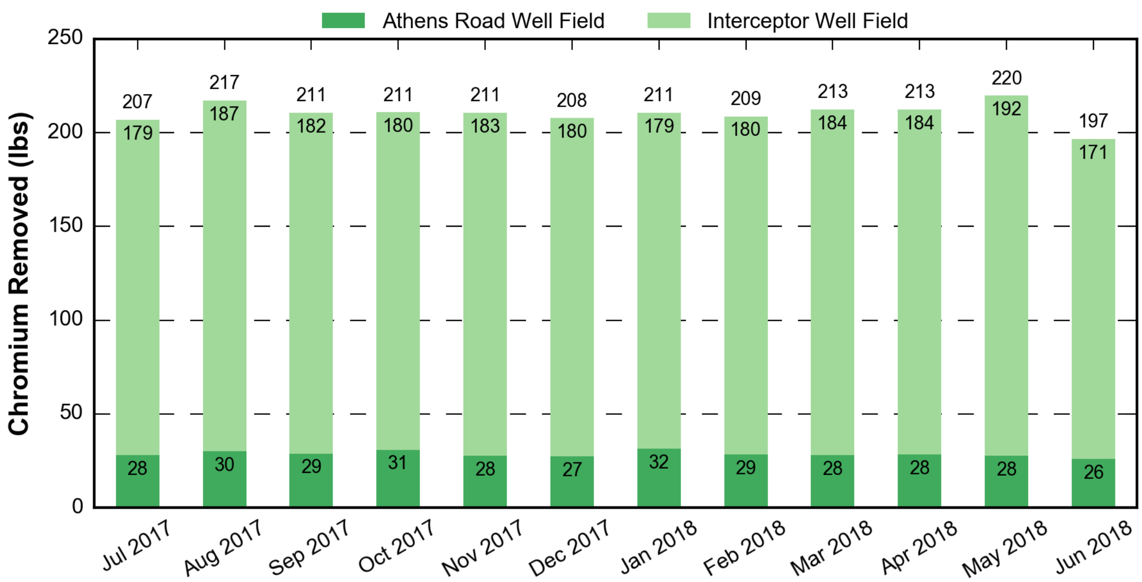


Perchlorate Mass Removal. This chart shows monthly perchlorate removed by the GWETS, including the IWF, AWF, SWF, and AP Area extraction wells, during the reporting period. The total amount of perchlorate removed is shown above each bar.

[13] Average extraction rates, concentrations, and total mass removal from the AP Area are reported in the GWETS operation monthly reports submitted to NDEP (Envirogen 2017a-e, 2018a-g).

The total combined perchlorate mass removal from all extraction wells during the reporting period increased by 3.6% compared to the 389,900 pounds removed between July 2016 and June 2017. The increase in removal is primarily the result of increased mass removal at the AWF, SWF, and AP Area due to the operational changes discussed in Section 2.2.

Approximately 2,530 pounds of total chromium were captured and removed from groundwater by the GWETS during the reporting period, as shown in Table 6 and in the figure below. This is consistent with the approximately 2,500 pounds of chromium removed between July 2016 and June 2017. Of the total chromium mass removed during the reporting period, approximately 2,180 pounds were captured by the IWF and 340 pounds were captured by the AWF.



Chromium Mass Removal. This chart shows monthly total chromium removed by the IWF, AWF, SWF, and AP Area during the reporting period. The total amount of chromium removed is shown above each bar. Chromium mass removal at the SWF and AP Area are relatively small and therefore are not printed on the chart but are reflected in the total mass removal numbers.

8.2.2 Remaining Contaminant Mass

This section summarizes the comprehensive estimate of contaminant mass remaining in the subsurface representing conditions in second quarter 2018. Greater detail is provided in Attachment A. Mass estimates of perchlorate and chromium remaining in groundwater have been presented in the annual remedial performance reports since 2013. Previous estimates only included mass present within the NERT Site and the NERT Off-Site Study Area in the saturated alluvium and the saturated UMCf to a maximum depth of 50 feet below the contact with the alluvium (with the assumption that the impacted UMCf thickness is zero north of the AWF). This previous methodology did not include the vadose zone or deeper impacts within the UMCf that have been discovered during recent investigations. As described in the Performance Metrics Technical Memorandum, a revised mass estimate methodology was used beginning with this report that includes contaminant mass within the entire NERT RI Study Area, including both the vadose and saturated zones, with more accurate estimates of mass in deeper groundwater as compared to the prior methodology. In addition to supporting the evaluation of current GWETS performance, the mass estimate will be used in the upcoming feasibility study to evaluate alternative future remedies and to lay the foundation for the long-term evaluation of NERT's selected final remedy.

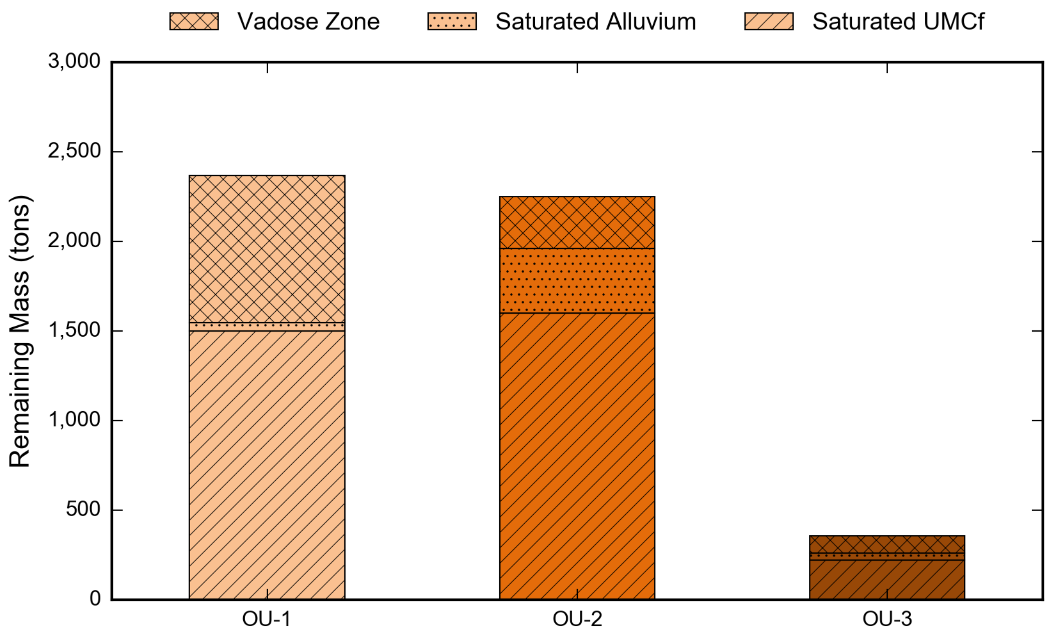
This new framework was devised by the Trust as part of a comprehensive multi-year program that has been implemented in a phased manner pending the receipt of data from ongoing and planned investigations being conducted throughout the NERT RI Study Area. Available preliminary data from the RI have been incorporated into the 2018 mass estimate described in this report. The mass estimate will next be updated as part of the OU-1/OU-2 RI Report to be submitted to NDEP in first quarter 2019 and will incorporate additional data available from the RI and ongoing treatability studies, as discussed in Section 8.1. Since future mass estimates will incorporate additional data as they become available, mass estimates will change as contaminant mass is removed from the environment through ongoing removal actions and as areas of the NERT RI Study Area are better characterized leading to more accurate mass estimates.

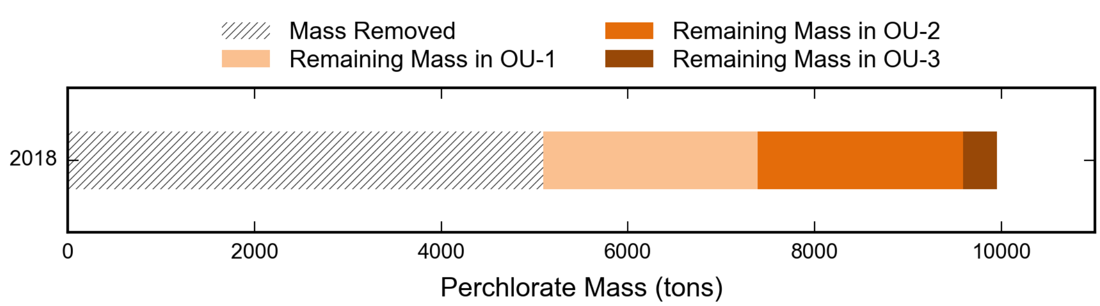
The remaining contaminant masses as of second quarter 2018 are estimated to be approximately 4,900 tons for perchlorate and 57 tons for hexavalent chromium, as summarized in the tables and figures below. The mass estimate boundary for perchlorate includes the entire NERT RI Study Area, while the mass estimate boundary for chromium is limited to OU-1 and the Off-Site Study Area as described in Attachment A. [14,15] The mass estimate excludes perchlorate mass from the AMPAC plume present in the RI Study Area. The figures below present perchlorate and chromium mass estimates for 2018 with subdivisions showing estimated mass within each OU (OU-1, OU-2, and OU-3) and within each geologic unit (vadose zone, saturated alluvium, and saturated UMCf). The figures also depict estimated cumulative mass removal by the GWETS through June 2018 based on the mass removal estimates presented in Table 6 and Table 8. As discussed in Section 8.2.4, the capture zones of the AWF and SWF extend to the west of the western boundary of the Off-Site Study Area where the AMPAC/Endeavour perchlorate plume is located. This indicates that some of the mass captured and removed from the environment by the AWF and SWF originated from the AMPAC/Endeavour plume.

[14] For the sole purpose of the mass estimate, the boundary of OU-1 has been extended to include adjacent areas where perchlorate and chromium originating from the NERT Site may have migrated (Mass Estimate Extension Area), as described in Attachment A.

[15] The potential presence of hexavalent chromium and chromium in groundwater within and migrating from the Eastside Sub-Area will be investigated and remediated by BRC, if necessary, pursuant to the terms of the Settlement Agreement and Administrative Order on Consent, BMI Common Areas, Phase 3, with NDEP (AOC3) in 2006.

	Remaining Perchlorate Mass (tons)[16,17]			
Unit	**OU-1**	**OU-2**	**OU-3**	**Total By Unit**
Vadose Zone	820	290	97	**1,200**
Saturated Alluvium	47	360	41	**450**
Saturated UMCf	1,500	1,600	220	**3,300**
Total by OU	**2,300**	**2,200**	**360**	**4,900**





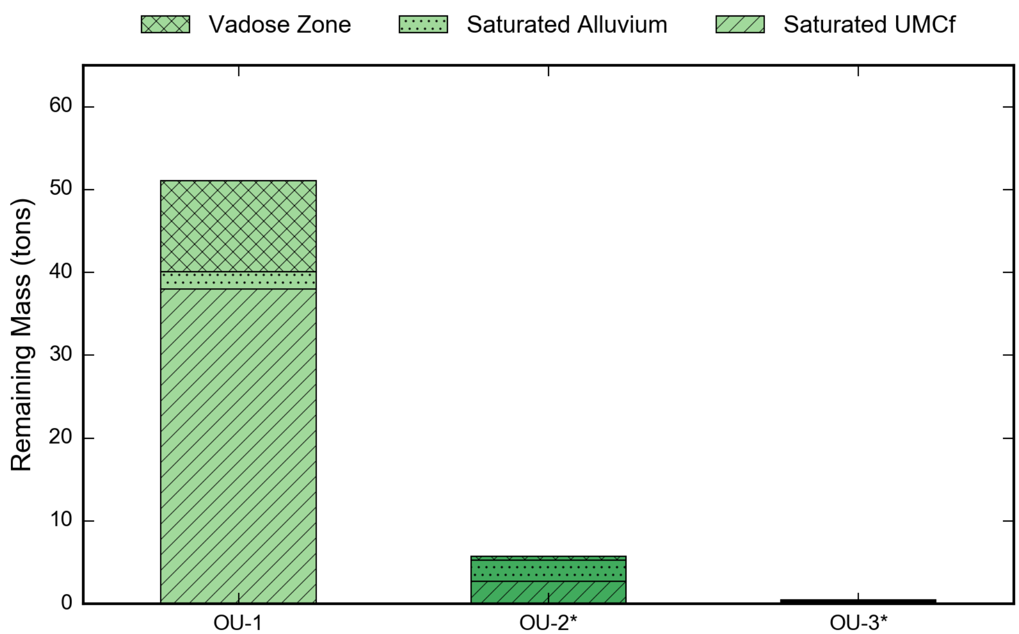
Remaining Perchlorate Mass. The table and figures shown above summarize the remaining perchlorate mass estimates and cumulative perchlorate mass removal within the OU boundaries and geologic units.

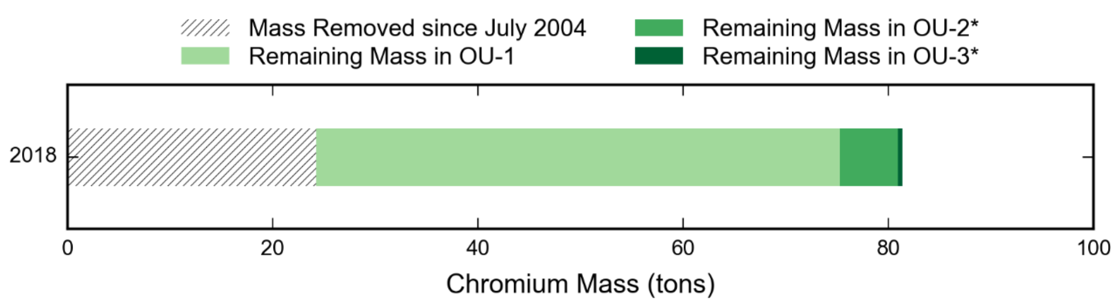
[16] The remaining contaminant mass estimates presented herein are based on data available as of the date of this report. These estimates will be updated in future submittals as additional data become available.

[17] Values presented in tables are rounded to two significant digits. Totals shown were calculated prior to rounding.

	Remaining Chromium Mass (tons)[18,19]			
Unit	**OU-1**	**OU-2***	**OU-3***	**Total By Unit**
Vadose Zone	11	0.42	0.021	**11**
Saturated Alluvium	2.1	2.6	0.21	**4.9**
Saturated UMCf	38	2.7	0.21	**41**
Total by OU	**51**	**5.7**	**0.44**	**57**

*Mass estimate is limited to mass within the NERT Off-Site Study Area.





Remaining Chromium Mass. The table and figures shown above summarize the remaining chromium mass estimates and cumulative perchlorate mass removal within the OU boundaries and geologic units.

[18] The remaining contaminant mass estimates presented herein are based on data available as of the date of this report. These estimates will be updated in future submittals as additional data become available.

[19] Values presented in tables are rounded to two significant digits. Totals shown were calculated prior to rounding.

8.2.3 Capture Zone Evaluation

Capture zones for each of the well fields were estimated in the Shallow, Middle, and Deep WBZs based on second quarter 2018 pumping rates using forward particle tracking with the updated Phase 5 model. Particles were released in the center of each model cell in model layers 1 through 5 (representing the Shallow WBZ), layers 6 through 8 (representing the Middle WBZ), and layers 9 and 10 (representing the Deep WBZ).[20] This methodology is consistent with the methodology used to evaluate this metric in prior performance evaluations, and it is anticipated this methodology will continue to be used in future evaluations. Simulated steady-state capture zones in the Shallow, Middle, and Deep WBZs are shown in Figures 5a, 5b, and 5c, respectively.

Since the GWETS operates as a removal action designed to address groundwater contamination originating from the NERT Site, the capture zones are evaluated by comparing their extent to the NERT Site and Off-Site Study Area. This analysis is used to determine how effective the GWETS is in capturing releases from the NERT Site and not from the Eastside Study Area. As shown in Figure 5a, the majority of shallow groundwater within the NERT Site boundary and NERT Off-Site Study Area is captured by the combination of the IWF, AWF, SWF, and AP Area wells. There are two areas of shallow groundwater that are not captured by the existing system: 1) a small area between the SWF and Las Vegas Wash where perchlorate concentrations were generally less than 3 mg/L during the reporting period, and 2) an area east of the SWF where perchlorate concentrations collected from well PC-94 ranged from 0.75 to 6.3 mg/L during the reporting period. As shown on Plate 6, the uncaptured area between the SWF and Las Vegas Wash within the Off-Site Study Area is impacted by the AMPAC/Endeavour perchlorate plume and thus is not targeted by the GWETS. Contamination in the uncaptured area outside of the capture zone to the east of the SWF within the NERT Off-Site Study Area may have originated from the Eastside Study Area and will be addressed as part of the ongoing RI/FS in OU-3.

The capture zones of the AWF and SWF extend beyond the boundaries of the Off-Site Study Area both to the west and to the east. West of the boundary is the perchlorate plume associated with the AMPAC/Endeavour Site, as shown on Plate 6. This indicates that some of the mass flux captured by the AWF and SWF originates from the AMPAC/Endeavour plume. East of the boundary is the Eastside Study Area, indicating that mass flux captured by the AWF and SWF also includes mass from this area.

Figure 5a also shows approximate capture zones for the dewatering trenches associated with SNWA’s construction of the Sunrise Mountain Weir and Historic Lateral Weir. Dewatering operations began in January 2018 and continued until June 2018 (Historic Lateral Weir) and August 2018 (Sunrise Mountain Weir). Although the dewatering operation is not part of the GWETS, the associated capture zones are shown for reference because the dewatering trenches temporarily reduced the flux of perchlorate to Las Vegas Wash. The capture zones for the weir dewatering trenches were developed assuming that 50% of the water extracted from the trenches originated from groundwater and that the duration of dewatering was six months. The capture zone of the Sunrise Mountain Weir dewatering trenches includes the northwest corner of the Off-Site Study Area that is impacted by the perchlorate plume associated with the

[20] The model layers were revised slightly in the updated Phase 5 model to incorporate available data from the RI data collection efforts and ongoing treatability studies.

AMPAC/Endeavour site. The capture zone of the Historic Lateral Weir dewatering trenches includes a small portion of the northeast corner of the Off-Site Study Area to the north of PC-94.

As shown in Figures 5b and 5c, the capture zones in the Middle WBZ and Deep WBZ are similar to those in the Shallow WBZ, except that the capture zones do not extend as far north. In the area of the NERT Site, there is capture of groundwater in the Deep WBZ down to a depth of more than 300 ft bgs. Groundwater in the Shallow WBZ and Middle WBZ within the NERT Site is captured by a combination of the IWF, AP Area wells, and AWF, and groundwater in the Deep WBZ within the NERT Site is captured by the AWF. Since the vertical extent of impacted groundwater at the NERT Site is less than 300 ft bgs, this evaluation indicates that all impacted groundwater originating at the NERT Site is captured by one of the well fields of the existing GWETS. The northern portion of the NERT Off-Site Study Area outside of the capture zones in the Middle and Deep WBZs is generally not impacted by perchlorate or chromium. Thus, the vertical extent of the GWETS capture zone is sufficient to capture impacted groundwater in the Middle and Deep WBZs within the entire NERT Site and Off-Site Study Area. Areas of impacted groundwater outside the GWETS capture zones within the NERT RI Study Area east of the Off-Site Study Area will be addressed as part of the ongoing RI/FS.

8.2.4 Well Field Capture Efficiency

To evaluate the performance of the IWF, AWF, and SWF during the reporting period, the portion of mass flux captured by the GWETS was estimated along transects located immediately upgradient of the well fields within the NERT Off-Site RI Study Area, as shown on Figure 6. For the IWF, the transect extends from the western to the eastern property boundaries of the NERT Site just south of the well field. At the AWF and SWF, the transects extend from western to eastern boundaries of the NERT Off-Site Study Area just south of the well fields. Uncaptured mass flux outside of the NERT Site and NERT Off-Site Study Area is not included in this evaluation of capture efficiency. An initial evaluation of mass flux across the entire RI Study Area is evaluated in Section 8.2.5. As discussed previously, GWETS performance will continue to be evaluated in future remedial performance submittals throughout the RI/FS process and implementation of the final remedy. Once the final remedy is in place, the monitoring program and associated reporting, including evaluation of the performance metrics and well field capture efficiency, will be adapted for the final remedy.

The captured mass flux was estimated as the well field mass removal rate, based on the monthly average pumping rates and extraction well concentrations associated with each month in second quarter 2018. The mass flux outside of the capture zone at each transect was calculated using the updated steady state version of the Phase 5 model and interpolated second quarter 2018 concentrations, as described in Section 8.2.5. The capture efficiency is the percentage of mass captured versus the total mass flux (sum of captured mass and uncaptured mass). Using these approaches, mass fluxes and capture efficiencies were calculated as follows:

	Perchlorate Mass Flux			Chromium Mass Flux		
Well Field	**Mass Captured (lbs/day)**	**Mass Not Captured (lbs/day)**	**Capture Efficiency**	**Mass Captured (lbs/day)**	**Mass Not Captured (lbs/day)**	**Capture Efficiency**
IWF	459	14.3	97.0%	6.0	0.01	99.8%
AWF	474	14.7	97.0%	0.9	0.06	93.5%
SWF	52	1.1	97.8%	--	--	--

The capture efficiency of the IWF only includes the mass flux captured by the IWF itself. All of the mass flux at the IWF transect not captured by the IWF is captured by the AWF. Similarly, all of the mass flux at the AWF transect not captured by the AWF is captured by the SWF. This is illustrated by the capture zones in the vicinity of the IWF and AWF shown on Figure 6. Thus, the overall capture efficiencies for the GWETS as a whole at the IWF and AWF are 100%. As described in Section 8.2.3, the capture zones below each of the well fields extend well beyond the depth of impacted groundwater. The depth of capture is approximately 300 ft bgs at the IWF and AWF, and approximately 150 ft bgs at the SWF. As a result, the overall capture efficiency within the Middle and Deep WBZs is 100% at all three well fields. Only the SWF has an overall capture efficiency of less than 100% due to the gap in capture within the Shallow WBZ located to the east of the SWF.

In previous performance submittals, the capture efficiency of each well field was estimated using an alternative calculation method in addition to the method above, as requested in NDEP's April 9, 2014 letter on the 2013 Semi-Annual Remedial Performance Report (NDEP 2014). Since the mass flux estimates are now calculated as described in the NDEP-approved Performance Metrics Technical Memorandum, the alternative calculation method is no longer presented.

8.2.5 Estimated Mass Flux Across RI Study Area

The following sections present horizontal and vertical mass flux estimates for perchlorate and chromium at various locations throughout the NERT RI Study Area. As described in the Performance Metrics Technical Memorandum (Ramboll Environ 2017d), mass flux estimates calculated herein have been expanded compared to previous evaluations to include flux throughout the entire NERT RI Study Area.

8.2.5.1 Horizontal Mass Flux

Perchlorate and chromium horizontal mass flux were evaluated at a total of 5 transects, as shown on Figure 7a. The horizontal mass flux transects have been revised and extended compared to previous submittals to incorporate the entire NERT RI Study Area. The following transects were evaluated:

- Transects located along the western, northern, and eastern NERT Site boundaries;
- Transect located along the boundary between OU-2 and OU-3; and
- Transect located along Las Vegas Wash.

Horizontal mass flux as presented on Figure 7a was calculated using the methodology described in the Performance Metrics Technical Memorandum (Ramboll Environ 2017d) based on a transport simulation using the updated steady state version of the Phase 5 model. Transport was simulated for one day to estimate mass flux at each transect with the initial concentrations defined by the three-dimensional interpolation of second quarter 2018 concentrations described in Attachment A. Figure 7a indicates both the total mass flux across each transect and the portion of that flux that is captured by any of the GWETS well fields.

The estimated perchlorate mass flux across the western NERT Site boundary is 3.9 lbs/day. As shown by the capture zones on Figure 7a, the flux moves northwest across the western boundary and is ultimately captured by the AWF or SWF. The estimated mass flux across the northern NERT Site boundary is 123 lbs/day, which is directly captured by the AWF. The estimated perchlorate mass flux across the eastern NERT Site boundary is 17 lbs/day, which is ultimately captured by the AWF or SWF.

The estimated perchlorate mass flux across the transect at the OU-2/OU-3 boundary is 43 lbs/day, with 36 lbs/day captured by the SWF and 7 lbs/day ultimately discharging to Las Vegas Wash. The mass flux across the eastern uncaptured portion of the transect is smaller than the flux across the western portion because the alluvium in the Eastside Sub-Area has a significantly smaller saturated thickness, as discussed in Section 3.

The estimated perchlorate mass flux across the transect along Las Vegas Wash is 67 pounds per day (lbs/day). This is similar to the average mass loading measured at Rainbow Gardens weir (LVW 3.5) of 68.1 lbs/day from July through December 2017. Since the perchlorate mass flux estimate does not account for the removal of perchlorate by the Sunrise Mountain Weir and Historic Lateral Weir dewatering trenches, it was compared to the measured mass loading in Las Vegas Wash from July to December 2017, which was prior to the operation of the dewatering trenches. As shown on Plate 6, there are two separate plumes crossing the transect along Las Vegas Wash: the AMPAC/Endeavour plume crossing the transect upstream of the Pabco Road weir, and the NERT Site and Eastside Study Area plume crossing the transect downstream of Pabco Road weir. The estimated mass flux across the transect is 25 lbs/day for the portion upstream of the Pabco Road weir and 42 lbs/day for the portion downstream of the Pabco Road weir. Further discussion of perchlorate mass loading to Las Vegas Wash from the AMPAC/Endeavour plume is provided in section 8.2.6.

8.2.5.2 Vertical Mass Flux

As discussed in the Performance Metrics Technical Memorandum (Ramboll Environ 2017d), the evaluation of vertical mass flux of perchlorate and chromium has been expanded to include OU-1, OU-2, and OU-3, as shown on Figure 7b. The vertical mass flux was estimated in these three areas using a transport simulation with the updated Phase 5 model. For these estimates, the vertical mass flux between model layers 1 and 2 was used, which is representative of flux between the UMCf and the alluvium. In areas where the alluvium is unsaturated, the vertical mass flux between model layers 2 and 3 was used. The vertical mass flux in OU-2 and OU-3 are considered preliminary estimates because they are based on the updated Phase 5 model which does not include the recent results from the Phase 3 RI and Downgradient Study Area Investigation. As shown on Figure 7b, there is an upward mass flux in all three OUs, which reflects the net overall upward flow of groundwater from the UMCf to the alluvium.

The estimated perchlorate vertical mass flux in OU-1 is 238 lbs/day. All of this vertical mass flux is ultimately captured by one of the NERT well fields. The estimated perchlorate vertical mass flux in OU-2 is 209 lbs/day. Of this total flux, 196 lbs/day is captured by the AWF and SWF. The remaining flux of 13 lbs/day is not captured and will be addressed as part of the OU-1/OU-2 FS and final remedy. The estimated perchlorate vertical mass flux in OU-3 is 29 lbs/day. Of this total flux, 16 lbs/day is captured by the SWF. The remaining flux of 13 lbs/day is not captured and will be addressed as part of the OU-3 FS and final remedy.

8.2.6 Perchlorate Mass Loading in Las Vegas Wash

As discussed in the Performance Metrics Technical Memorandum (Ramboll Environ 2017d), the evaluation of perchlorate mass loading in Las Vegas Wash was expanded beginning with the 2017 Semi-Annual Remedial Performance Memorandum to include additional locations (Ramboll 2018b). The Trust began collecting monthly surface water samples at the locations shown on Figure 8a and 8b in June 2017, with the exception of locations LVW 4.75 (Calico Ridge) and LVW 8.85 (Las Vegas Wasteway) which the Trust began sampling in May 2018 and July 2018, respectively, following approval of RI Phase 2 Modification No. 10 (Ramboll 2018a).[21]

Perchlorate mass loading estimates are calculated at each location using measured perchlorate concentrations in surface water and the corresponding stream flow rate at the time of surface water sampling. Stream flows used in the calculations are recorded by co-located United States Geological Survey (USGS) gaging stations (where available) as shown on Figures 8a and 8b. Since there are currently no co-located gaging stations at LVW 6.6 (Sunrise Mountain) and LVW 4.75 (Calico Ridge), flow rates were estimated for these locations using flows recorded at upstream location LVW 7.2 (Duck Creek) to estimate flow at LVW 6.6 and downstream location LVW 4.2 (Homestead) to estimate flow at LVW 4.75. The estimated travel time between locations was used to determine the approximate instantaneous flow rates at LVW 6.6 and LVW 4.75 at the time of sampling.[22] For instances where perchlorate concentrations were below the detection limit, the Kaplan-Meier approach was used to estimate average mass loading at a given location during the reporting period (Singh 2007).

Average perchlorate mass loading estimates during the reporting period at each location are presented in Table 10 and the charts below. Analytical data and flow rates used for these calculations are presented in Table 11. As discussed in Section 2.3, dewatering activities associated with SNWA's construction of Sunrise Mountain and Historic Lateral Weir commenced in January 2018, which have impacted mass loading estimates in Las Vegas Wash. Therefore, mass loading estimates presented in the charts below are separated into two timeframes during the reporting period: 1) prior to dewatering activities (July through December 2017), and 2) during dewatering activities (January

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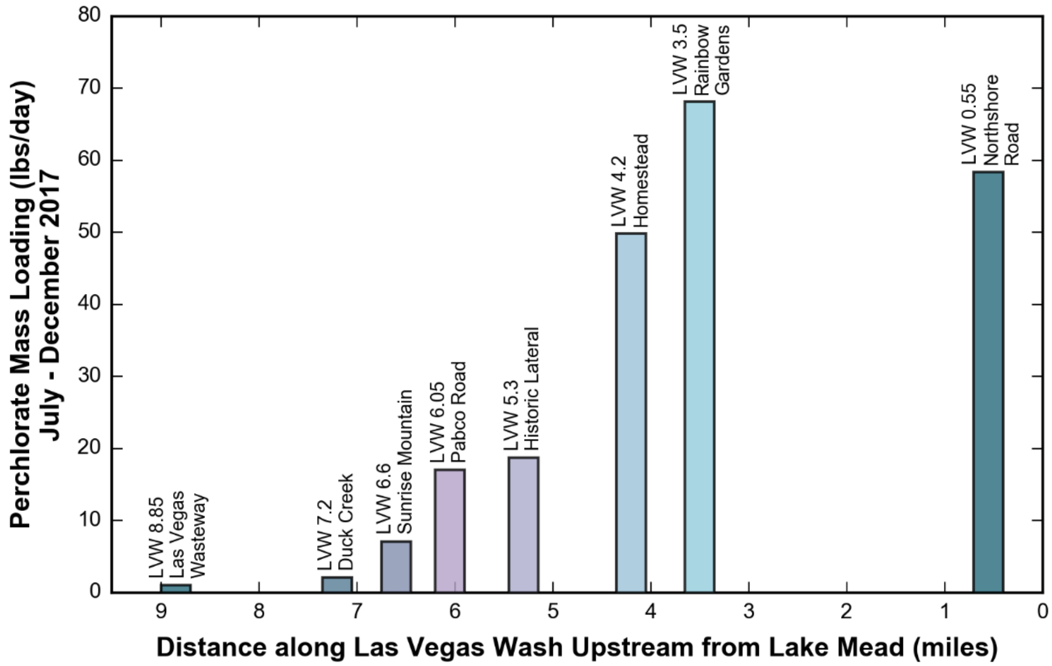
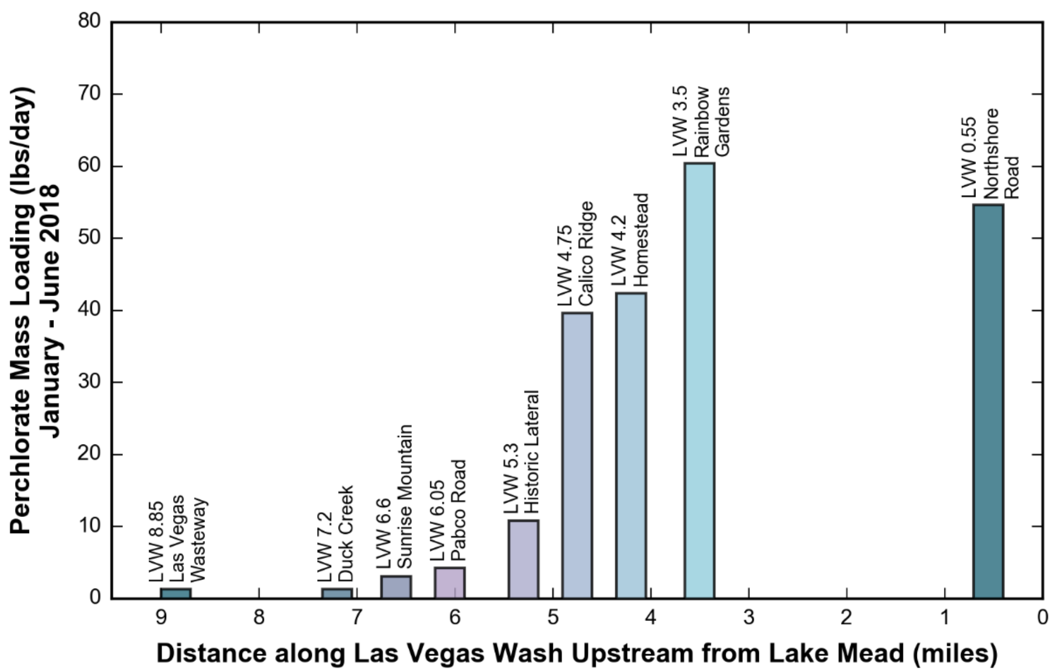
[21] Location LVW 8.85 is also sampled monthly by SNWA. Mass loading estimates for this location presented herein were calculated using available perchlorate concentration data from SNWA for loading estimates prior to July 2018.

[22] USGS personnel reported that the approximate travel time between LVW 7.2 (Duck Creek) and LVW 6.05 (Pabco Road) is 75 minutes and the approximate travel time between LVW 5.3 (Above Bostick) and LVW 4.2 (Above Homestead) is 30 minutes (USGS 2018). Based on the location of LVW 6.6 (Sunrise Mountain) relative to LVW 7.2 and LVW 6.05, the assumed travel time between LVW 7.2 and LVW 6.6 is approximately 31 minutes. Based on the location of LVW 4.75 (Below Calico Ridge) relative to LVW 5.3 and LVW 4.2, the assumed travel time between LVW 4.75 and LVW 4.2 is approximately 14 minutes.

through June 2018). On the charts below, the sampling locations are shown from west to east beginning with the western-most station shown on the far left. Mass loading estimates for July through December 2017 and January through June 2018 are also depicted on Figures 8a and 8b, respectively.





Mass Loading to Las Vegas Wash. These charts show average mass loading to Las Vegas Wash from July to December 2017 and January to June 2018 at sampled locations.

As shown in Table 10, estimated loading at LVW 3.5 (Rainbow Gardens) was approximately 64.3 lbs/day during the reporting period, while estimated loading at downstream location LVW 0.55 (Northshore Road) was approximately 56.5 lbs/day during the reporting period. Historic mass loading estimates at LVW 3.5 (Rainbow Gardens) are not available for previous reporting periods, and mass loading at LVW 0.55 (Northshore Road) during the current reporting period is consistent with the loading measured in the previous two reporting periods. The reason for this decrease in loading downstream is currently being investigated and will continue to be evaluated in future submittals.

The estimated mass loading at LVW 3.5 (Rainbow Gardens) can generally be attributed to mass flux entering Las Vegas Wash in the reaches between sampling locations shown in the following table and on Figures 8a and 8b:

Reach of Las Vegas Wash[1]	July – December 2017 Mass Loading Change Within Reach (lbs/day)	January – June 2018 Mass Loading Change Within Reach (lbs/day)
LV Wasteway to Duck Creek	1.1	0.0
Duck Cr to Sunrise Mountain	5.0	1.8
Sunrise Mountain to Pabco Road	9.9	1.1
Pabco Road to Historic Lateral	1.7	6.6
Historic Lateral to Calico Ridge	31.1	28.8
Calico Ridge to Homestead		2.8
Homestead to Rainbow Gardens	18.3	18.0

[1] Each reach is defined as the segment of Las Vegas Wash between the listed sampling locations.

The perchlorate mass flux entering Las Vegas Wash between Las Vegas Wasteway and Pabco Road originates from the AMPAC/Endeavour perchlorate plume as shown on Plate 6. As shown in the table above, the measured perchlorate mass flux entering Las Vegas Wash downstream of Las Vegas Wasteway and upstream of Pabco Road was 16.0 lbs/day from July to December 2017, decreasing to 2.9 lbs/day from January to June 2018 due to the operation of the Sunrise Mountain weir dewatering system. According to AMPAC/Endeavour's recent monitoring and performance reports (Endeavour 2018a,b), there are two components of perchlorate mass flux from the AMPAC/Endeavour plume that are not captured by the AMPAC/Endeavour remediation system: 1) surface water in the Athens Drainage Channel that infiltrates near Las Vegas Wash, and 2) shallow groundwater in the AMPAC/Endeavour plume not captured by the AMPAC/Endeavour extraction wells.

For the first component of uncaptured mass flux, AMPAC/Endeavour reported that the average perchlorate flux through the Athens Drainage Channel from the AMPAC/Endeavour plume was 18.1 lbs/day from July to December 2017 (Endeavour 2018a, pg. 11) and 16.3 lbs/day from January to June 2018 (Endeavour 2018b, pg. 12). The perchlorate flux through the Athens Drainage Channel originates from groundwater within the AMPAC/Endeavour plume leaking into the Eastgate Storm Drain, a subsurface storm drain running primarily north-south along Eastgate Road that discharges to the Athens Drainage Channel and subsequently discharges into an unlined area adjacent to

Las Vegas Wash (Ramboll Environ 2016a). The discharge area is shown on Figures 8a and 8b. The perchlorate flux reported by AMPAC/Endeavour for July to December 2017 of 18.1 lbs/d is approximately equal to the measured flux in this period of 16.1 lbs/day. During January to June 2018, the measured flux was much lower than the flux reported by AMPAC/Endeavour because a significant portion of the flux was captured by the Sunrise Mountain weir dewatering trenches.

For the second component of uncaptured mass flux, AMPAC/Endeavour reported that the perchlorate flux in shallow groundwater not captured by their extraction wells was 3 to 5 lbs/day in the second half of 2017 (Endeavour 2018a, pg. 17) and 4 to 5.7 lbs/day in the first half of 2018 (Endeavour 2018b, pg. 19). This uncaptured perchlorate flux is in addition to the flux from the Athens Drainage Channel. As shown on Plate 6, the AMPAC/Endeavour perchlorate plume originating from the Former PEPCON Site bifurcates into western and eastern lobes just to the south of the COH Bird Viewing Preserve. The western lobe moves north past the COH Bird Viewing Preserve before turning northeast and discharging into Las Vegas Wash primarily upstream of the Pabco Road weir. The eastern lobe becomes comingled with the plume from the NERT Site and is captured by the AWF and SWF as indicated by the capture zones shown in Figure 5a. The Shallow Capture Zone Assessment Memorandum submitted by Geosyntec on behalf of AMPAC/Endeavour also concludes that a portion of AMPAC/Endeavour's reported perchlorate flux in shallow groundwater is captured by the SWF (Geosyntec 2017).

The perchlorate mass flux entering Las Vegas Wash downstream of Pabco Road weir originates primarily from the NERT Off-Site Study Area and the Downgradient and Eastside Study Areas as shown on Plate 6.[23] This uncaptured mass flux will be addressed as part of the OU-3 FS and final remedy in the early 2020s. As shown in the table above, the measured perchlorate mass flux entering Las Vegas Wash downstream of Pabco Road was 51.1 lbs/day from July to December 2017 and 56.2 lbs/day from January to June 2018. The small increase in mass flux from the first period to the second period occurred in the reach from Pabco Road to Historic Lateral. In reaches downstream of Historic Lateral, the mass fluxes measured in the two periods were approximately unchanged.

As discussed in Section 8.2.4, an estimated 1.1 lbs/day was discharged to Las Vegas Wash from the NERT Off-Site Study Area during second quarter 2018. As reported in the most recent semi-annual performance memorandum, an estimated 1.9 lbs/day was discharged to Las Vegas Wash from the NERT Off-Site Study Area during fourth quarter 2017. This mass flux enters Las Vegas Wash downstream of Pabco Road. The remainder of the mass flux entering Las Vegas Wash downstream of Pabco Road of 49.2 lbs/day (July-December 2017) and 55.1 lbs/day (January-June 2018) results from discharge of groundwater from the Downgradient and Eastside Study Areas, located east of the Off-Site Study Area. The reaches with the highest mass fluxes are the Historic Lateral to Calico Ridge reach and the Homestead to Rainbow Gardens reach.

This is consistent with the preliminary findings of the Downgradient Study Area Investigation, currently being conducted by AECOM, which identified the toes of the

[23] The mass flux entering Las Vegas Wash downstream of Pabco Road weir may also include minor amounts of mass flux from either or both of the components of mass flux originating from the AMPAC/Endeavour plume that migrate in groundwater in an easterly direction before discharging into Las Vegas Wash.

Calico Ridge and Three Kids Weirs as the areas with the highest flux of perchlorate to Las Vegas Wash. These findings were based on an aerial thermal infrared (TIR) survey, a fiber-optic distributed temperature survey (DTS), transect sampling, and a comparison of surface water levels to nearby groundwater levels. Data from AECOM's investigations will be evaluated as they become available in future performance submittals and in the OU-3 RI Report anticipated to be submitted in mid-2020. Given the variances in sample collection dates and sample locations compared with data collected by the Trust, variances in reported perchlorate load in Las Vegas Wash are to be expected.

Subsurface French drains are likely present at the golf course and residential developments in the Northeast Sub-Area, which may be a potential source of additional perchlorate loading to Las Vegas Wash. RI Phase 2 Modification No. 14, which was approved by NDEP on September 12, 2018, proposed monthly sampling at two additional locations to quantify the perchlorate mass loading to Las Vegas Wash that appears to originate from subdrains beneath the Chimera Golf Course and nearby Tuscany residential area. Further evaluation of these contributions to total mass loading in Las Vegas Wash will be included in future performance evaluations once sufficient data are available.

8.2.7 Environmental Footprint

As requested by USEPA in April 2017, a quantitative analysis of the environmental footprint of the GWETS and Groundwater Monitoring (GWM) program during the current reporting period has been conducted using the USEPA's SEFA Excel workbooks. The SEFA workbooks were used to calculate environmental footprint metrics using an inventory of energy and materials used, wastes generated, and activities and services conducted for GWETS and GWM efforts. The information used for this analysis was obtained from internal documents maintained by the Trust, Envirogen, Tetra Tech, and Ramboll. As necessary to fill remaining data gaps, Ramboll solicited input from Envirogen and Tetra Tech. In cases where specific information was not available, estimates have been provided based on professional judgement. The sources of information used are further detailed in Table G-1 in Appendix G. The inventory data used as input into the SEFA workbooks are available in Tables G-2 through G-8 in Appendix G. The SEFA workbooks are also included in Appendix G (electronically on the report USB flash drive). The SEFA workbooks are comprised of three separate workbooks, which should be opened concurrently in order to view the SEFA inputs, calculations, and results. A summary of the results from the SEFA workbooks is shown in the table below.

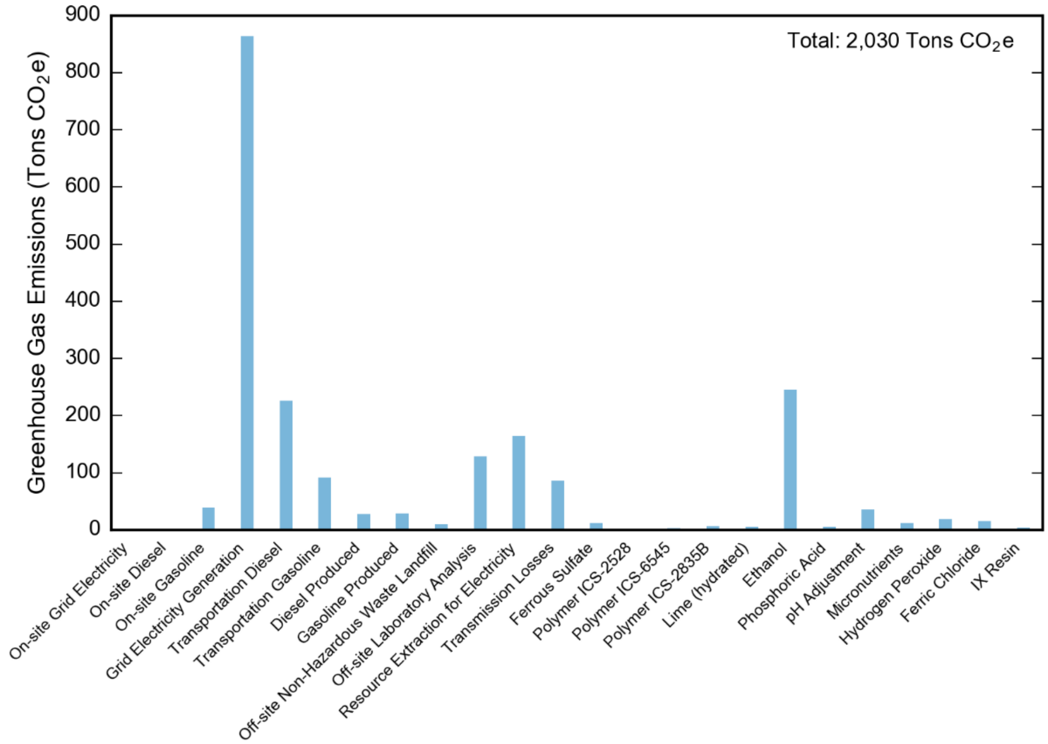
Core Element	Metric	Footprint	Units
Materials & Waste	Refined materials used on-site	1,590	Tons
	Non-hazardous waste disposed of off-site	825	Tons
Water	Groundwater use	679	Million Gallons
	Surface water use	23.2	Million Gallons
	Water evaporation	37.6	Million Gallons
Energy	Total energy used (on-site and off-site)	103,000	Million British Thermal Units (BTU)
	Electricity Use - Groundwater Extraction (electricity supplied by NV Energy)	1,510	Megawatt Hours (MWh)
	Electricity Use – Groundwater Treatment (hydroelectric power supplied by Colorado River Commission)	5,160	MWh
Air	Total nitrogen oxides (NO_x)emissions	10,700	lbs
	Total sulfur oxides (SO_x) emissions	19,900	lbs
	Total particulate matter (PM) emissions	860	lbs
	Total hazardous air pollutants (HAP) emissions	150	lbs
	Total greenhouse gas emissions	2,030	Tons CO_2 equivalents

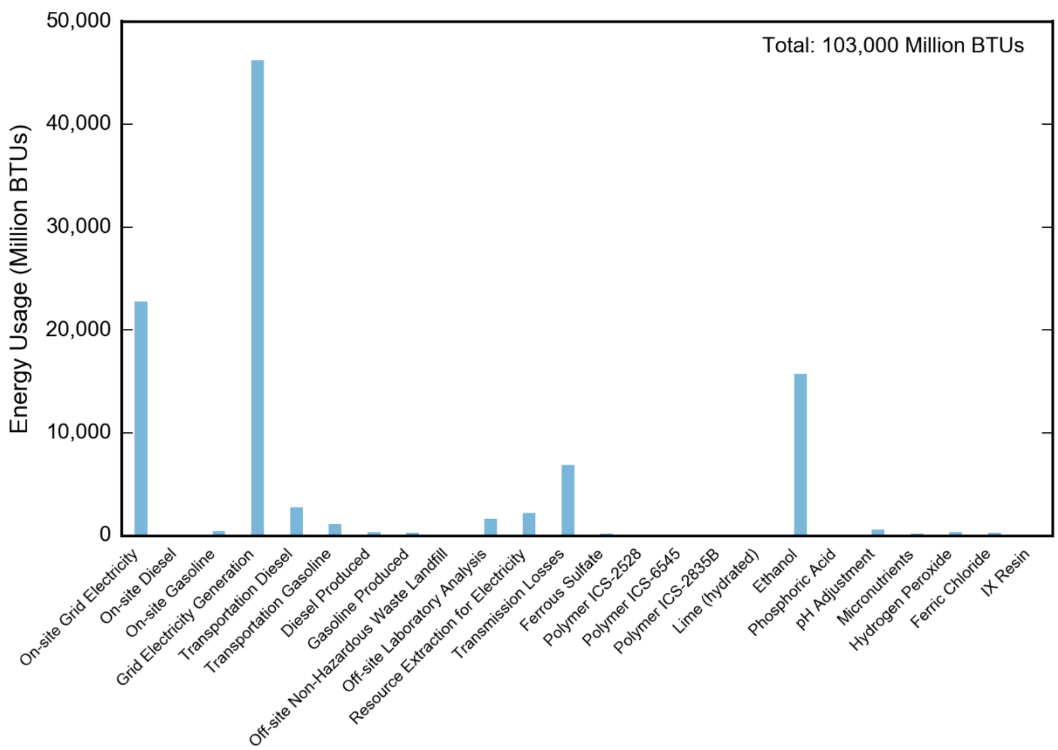
Major contributors to each core element (or core element component) of the overall environmental footprint, and their relative percent contribution, are presented in the table below. Additional details regarding key contributors to greenhouse gas emissions and energy usage are shown in the charts below.

Core Element	Contributors
Materials	Groundwater treatment chemicals – **98.1%**
	IX Resin – **1.9%**
	GAC **– 0%**
Wastes	FBR Sludge – **87.8%**
	GWTP Sludge – **2.9%**
	IX Resin – **2.1%**
	Excavated Soil – **7.3%**
	Used Gear Oil – **0.01%**
Water	Groundwater Use – **91.8%**
	Surface water use – **3.1%**
	Water evaporation – **5.1%**
Energy	Electricity for groundwater treatment – **57.1%**
	Electricity for groundwater extraction and conveyance **– 18.9%**
	Non-electricity energy usage **– 24.0%**
Air (Greenhouse Gas)[24]	Electricity for groundwater extraction and conveyance – **55.0%**
	Transportation (materials, waste, personnel, equipment) **– 15.7%**
	Manufacture of treatment chemicals and materials – **17.8%**
	Off-site laboratory analysis – **6.3%**
	Other off-site activities (fuel processing, waste management) – **3.3%**
	On-site equipment use (vehicles, generators, compressor) **– 1.9%**
	Electricity for groundwater treatment[25] – **0%**

[24] For air emissions, only greenhouse gas emissions are evaluated by major contributor, consistent with USEPA's evaluation of the 2015-2016 environmental footprint.

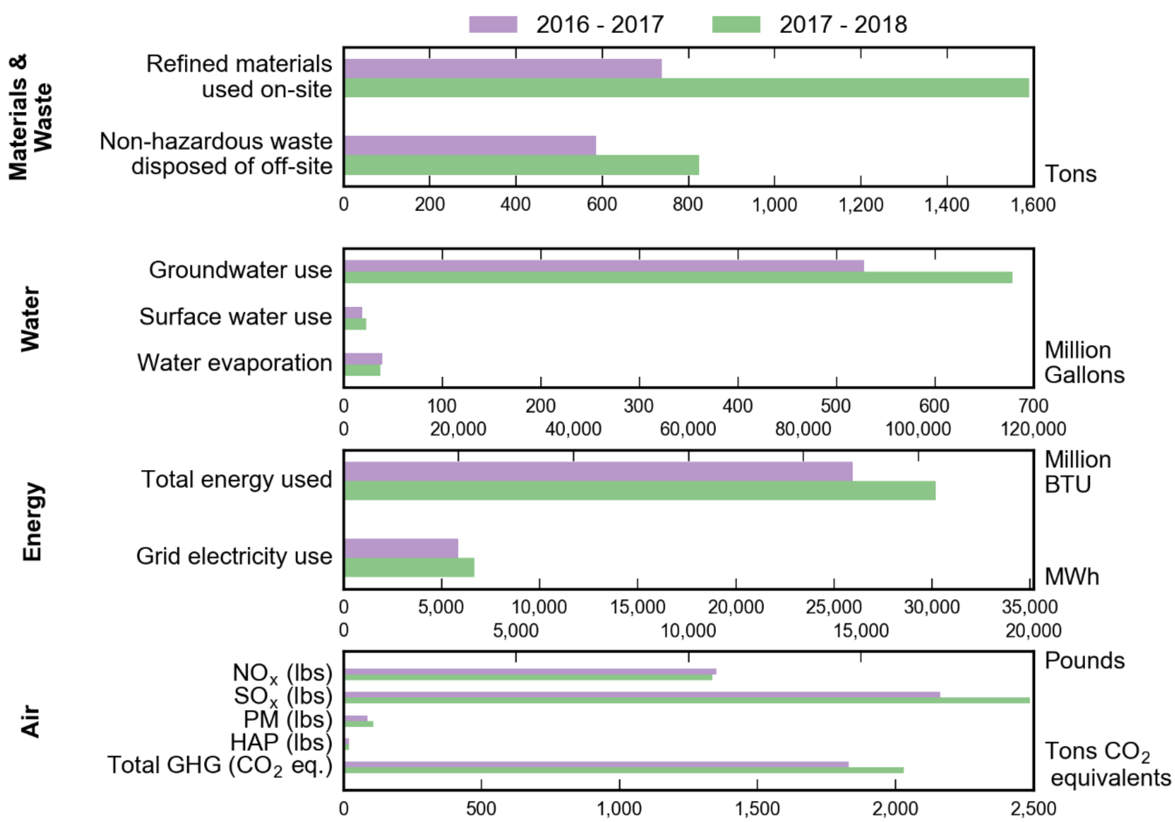
[25] Electricity for groundwater treatment is provided by hydroelectric power supplied by Colorado River Commission, and therefore does not contribute to the greenhouse gas component of the footprint.





Key Contributors. These charts show the key contributors to greenhouse gas emissions and energy usage during the current reporting period. These results were obtained from the SEFA workbooks included in Appendix G.

A comparison of the environmental footprint during the current and prior reporting period is shown in the bar charts below. The environmental footprint analysis for the current reporting period indicates increases in materials used, wastes generated, groundwater and surface water usage, and energy usage compared to the prior reporting period. These increases are expected given current mass removal and containment objectives, which has required maximizing extraction by the GWETS in order to minimize perchlorate loading to Las Vegas Wash. The increased energy usage and materials usage corresponds to the increased volume of groundwater extracted and treated, which increased at the AWF, SWF, and AP Area during the reporting period, as discussed in Section 2. The increased surface water usage is associated with AP Area flushing during the reporting period and the removal and treatment of solids from AP-5. Initial AP-5 solids removal activities were completed in early 2017 and residual solids removal activities were completed in July 2018. Treatment of AP-5 water through the FBRs began in July 2017. The increase in waste generated is due to increased production of FBR sludge as a result of increased flow through the FBRs. Waste generated was also somewhat higher during the reporting period due to disposal of excavated soil associated with Site operations. Air emissions and greenhouse gas emissions also increased somewhat compared to the prior reporting period as a result of increases in materials used, wastes generated, and energy usage as discussed above. As part of the RI/FS process, the Trust will consider potential environmental footprint impacts of ongoing monitoring and operation of the final remedy as one of the criteria for remedy selection, and will continue to evaluate practices for implementation that may reduce future footprint impacts.



Environmental Footprint Analysis. This chart compares the core elements and metrics of the environmental footprint during the current reporting period to the prior reporting period.

In April 2017, USEPA requested the Trust conduct a review of potential Best Management Practices (BMPs) for the GWETS and GWM Program following the ASTM Standard Guide for Greener Cleanups (E2893-16). An initial review of potential BMPs was conducted in 2017, and results of this review were presented to USEPA and NDEP during first quarter 2018. Based on this review, the Trust, in coordination with USEPA and NDEP, has selected one BMP to be implemented in 2018 and five BMP Feasibility Analyses to be performed in 2018 or early 2019, as discussed in the 2018 Greener Cleanup Best Management Practice Implementation Work Plan, Revision 1 (the 2018 BMP work plan) (Ramboll 2018c). The 2018 BMP work plan describes the BMP process, the one BMP and four BMP Feasibility Analyses selected, the proposed approach for implementing the selected BMP and performing the BMP Feasibility Analyses, the proposed schedule, and estimated costs. The results of BMP implementation, including a summary of actions taken and an evaluation of footprint reductions achieved, will be documented in future remedial performance submittals. An additional 30 BMPs will also be further evaluated in 2019. Following additional evaluation, the Trust will determine whether to implement any of these additional BMPs and will propose timeframes for implementation.

Although not selected as part of the formal BMP evaluation process discussed above, the Trust has implemented several BMPs during the reporting period as part of ongoing RI efforts and GWETS process improvements. These BMPs include:

- Relocation of Ramboll and Tetra Tech field personnel to the local area, which will reduce fuel usage associated with personnel transportation;
- Use of solar panels to power the on-site Ramboll trailer; and
- Completion of a coagulant pilot study by Envirogen, which identified an aluminum-based coagulant to replace the previously used ferric chloride coagulant that is expected to result in reduced materials usage.

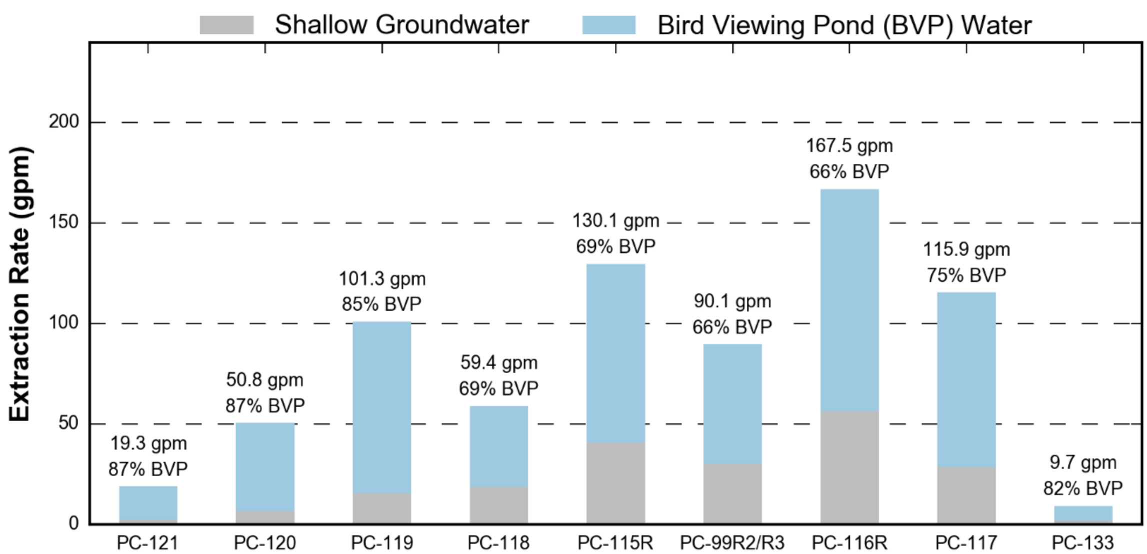
The Trust will continue to identify potential BMPs for implementation as opportunities arise, and will summarize BMPs implemented and footprint reductions achieved in future remedial performance submittals.

8.2.8 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 has the potential to induce water originating at these two surface water bodies to flow into the SWF extraction wells. Analyses presented in the Seep Well Field Flow Quantification Technical Memorandum, which was submitted to NDEP on September 9, 2016 (Ramboll Environ 2016d), evaluated the potential contributions of these sources to SWF extraction. This analysis was not a comprehensive evaluation of all potential source waters comprising SWF extraction, but rather was a focused analysis of potential surface water influences. This evaluation indicated that water extracted at the SWF is likely influenced by the COH Bird Viewing Ponds, whereas Las Vegas Wash does not appear to contribute significantly to SWF extraction.

Since the surface water from the COH Bird Viewing Ponds is comprised primarily of treated municipal wastewater effluent, minimization of this inflow would reduce the volume of clean water extracted by the SWF. However, given the presence of perchlorate in groundwater in the vicinity of the SWF, reduction of extraction rates would potentially result in increased perchlorate mass flux to the Las Vegas Wash. Until final remedial decisions are made, the Trust will continue operating the SWF in its current configuration. The interactions between surface water bodies and groundwater will be an important consideration when evaluating performance of the overall long-term remedy and will be evaluated in further detail in the forthcoming OU-3 RI Report anticipated to be submitted to NDEP in mid-2020.

A simple mixing calculation using TDS as a tracer was performed to quantify the amounts of COH Bird Viewing Pond water and upgradient shallow groundwater extracted at the SWF, the results of which are shown in the figure below. It is important to note this calculation does not consider other potential sources of contribution to SWF extraction. The calculation is based on May 2018 SWF extraction rates and May 2018 TDS concentrations in the COH Bird Viewing Ponds, upgradient shallow monitoring wells, and SWF extraction wells. This calculation suggests that the SWF is extracting primarily COH Bird Viewing Pond water, with the majority of COH Bird Viewing Pond water extracted on the western and eastern ends of the SWF. Although the SWF is likely extracting a large percentage of COH Bird Viewing Pond water, operation of the SWF in its current configuration is necessary in order to minimize loading to Las Vegas Wash.



SWF Surface Water Extraction. This chart shows the extraction rate and the estimated percentage of Bird Viewing Pond water extracted at each SWF extraction well during May 2018.

9. ONGOING AND FUTURE ACTIVITIES

The table below lists the current status of upcoming tasks related to the GWETS and groundwater monitoring program.

Task	Purpose	Current Status	Planned Activities
Treatment System			
AP-5 Solids Removal and Pond Closure	Remove solids from AP-5 in order to decommission the pond.	The AP-5 Pond Closure Plan was submitted to NDEP on November 18, 2016 and approved on January 27, 2017. Tetra Tech completed initial solids removal activities in early 2017 and completed residual solids removal activities in July 2018. Treatment of AP-5 water through the FBRs began in July 2017 and is ongoing.	Complete transfer of remaining liquids within AP-5 Pond and liner containment sump to AP-5 Process Tanks for treatment. Continued treatment of water from AP-5 Process Tanks. Complete planning and begin final closure of AP-5 Pond. Solids management anticipated to begin in first quarter 2020.
Alumina Chlorohydrate (ACH) Pilot Study	Identify alternative coagulants to avoid the growth of iron bacteria within the GWETS effluent pipeline	A pilot program using ACH as the coagulant instead of ferric chloride was conducted by ETI from May through July 2018. The NERT Perchlorate Treatment System Operations Manual Revision 6 included the use of ACH as a coagulant and was submitted to NDEP on August 28, 2018 and approved on September 28, 2018.	ETI will transition to the use of ACH as a coagulant instead of ferric chloride.
Geo-tube Pilot Study	Evaluate the effectiveness of Geo-tubes for sludge dewatering in increasing the capacity of the Chromium Treatment Plant.	A pilot test was conducted by Envirogen during May and June 2018, and the summary report was completed in July for Trust review.	The Trust will evaluate the pilot study findings to determine if infrastructure modifications at the Chromium Treatment Plant are appropriate at this time.

Task	Purpose	Current Status	Planned Activities
Performance Metrics[26]			
Mass Loading at Additional Las Vegas Wash Locations	Refine perchlorate loading estimates at various locations along Las Vegas Wash.	Monthly perchlorate sampling at five additional locations began in June 2017. Monthly sampling at two additional locations began in May and July 2018 following approval of RI Phase 2 Modification No. 10. Data from these locations have been incorporated in the mass loading estimates presented herein.	RI Phase 2 Modification No. 14 was approved by NDEP in September 2018 to propose additional monthly sampling locations. Data from these locations will be incorporated into future mass loading estimates.
Perchlorate Mass Estimate for NERT RI Study Area	Establish perchlorate mass estimate for the entire NERT RI Study Area, including the Downgradient Study Area and Eastside Study Area	RI Phase 2 data collection was completed in November 2017, and RI Phase 3 data collection was completed during third quarter 2018. Preliminary available data have been incorporated into the mass estimate herein.	Mass estimates will incorporate additional data from the RI and ongoing treatability studies collected from the entire NERT RI Study Area and will be estimated using the revised methodology as described in the Performance Metrics Technical Memorandum and Attachment A.
Mass Flux of Perchlorate at the OU Transects and Vertical Mass Flux between Qal and UMCf	Establish the mass flux of perchlorate movement across 1) the OU transects established within the entire NERT RI Study Area and 2) between the Qal and UMCf	RI Phase 2 data collection was completed in November 2017, and RI Phase 3 data collection was completed during third quarter 2018. Preliminary available data have been incorporated into the mass flux estimates herein. Mass flux estimates have been expanded to evaluate the OU transects and entire NERT RI Study Area.	The horizontal and vertical mass flux estimates will incorporate additional data from the RI and ongoing treatability studies collected from the entire NERT RI Study Area and will be calculated using the Phase 6 model.

[26] The implementation schedule for the revised GWETS Performance Metrics was presented in the Performance Metrics Technical Memorandum, which was submitted to NDEP on October 5, 2017 (Ramboll Environ 2017d) and approved by NDEP on October 19, 2017 (NDEP 2017b).

Task	Purpose	Current Status	Planned Activities
Phase 6 Groundwater Model	The new model will simulate contaminant transport and incorporate data collected during the RI Phase 2 and 3 and other investigations.	Development of the Phase 6 model is currently underway.	The majority of Phase 6 model updates will take place in 2018. The Phase 6 model is anticipated to be submitted to NDEP in second quarter 2019.
Other Activities			
Greener Cleanup Best Management Practices	Reduce the environmental footprint of the current GWETS operations and GWM program activities.	A revised work plan was submitted on October 26, 2018 outlining the one BMP and 4 BMP Feasibility Analyses selected for implementation in late 2018 and early 2019. Selected BMPs were chosen by the Trust based on a 2017 review completed by Ramboll in accordance with the ASTM Standard Guide for Greener Cleanups (E2893-16) and discussions with NDEP and USEPA in first quarter 2018.	Following completion of the BMP Feasibility Analyses, additional BMPs may be implemented in 2019. An additional 30 BMPs will also be evaluated in 2019 for potential future implementation.
Temporary Perchlorate Treatment Plant During SNWA Weir Construction	Treat water from dewatering activities associated with Sunrise Mountain and Historic Lateral weir construction.	Plant began receiving water from both weir construction sites beginning January 2018. Dewatering activities at the Historic Lateral Weir were completed in June 2018, and dewatering activities at Sunrise Mountain Weir were completed in August 2018.	Site restoration activities at the pumping stations and treatment plant sites began in fourth quarter 2018 and are expected to be complete in second quarter 2019.

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