Phase I Groundwater Model Refinement

Nevada Environmental Response Trust Site; Henderson, Nevada

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1 Introduction

On behalf of the Nevada Environmental Response Trust (the Trust), ENVIRON International Corporation, Inc. (ENVIRON) has prepared this report describing refinements made to the groundwater flow model of the Nevada Environmental Response Trust Site (the Site), located in Clark County, Nevada. The initial purpose of the groundwater model is to support the optimization of the existing groundwater extraction and treatment system (GWETS) at the Site, as described in the 2013 GWETS Optimization Work Plan (ENVIRON 2013b), approved by the Nevada Division of Environmental Protection (NDEP) on December 3, 2013 (NDEP 2013). In addition, the groundwater model will be used to support the remedial investigation and feasibility study (RI/FS), as described in the RI/FS Work Plan (ENVIRON 2014a).

The initial version of the groundwater model for the Site was developed by Northgate Environmental Management Inc. (Northgate) and was approved on April 4, 2013 by NDEP for use in capture zone evaluation and is referred to as the "Northgate Model." The Northgate Model is a steady-state flow model calibrated to Site conditions in 2008/2009, which is documented in the Capture Zone Evaluation Report (Northgate 2010). As described in the 2013 GWETS Optimization Project Work Plan, modifications to the Northgate Model are being implemented by ENVIRON in two phases. The first phase of modifications, which is discussed in this report, includes: 1) an update of the model to reflect more recent conditions and pumping and injection rates of the GWETS, American Pacific Corporation (AMPAC) and Olin/Stauffer/Syngenta/Montrose (OSSM) remediation systems; 2) preliminary refinement of the model representation of stream-aquifer interactions near Las Vegas Wash; and 3) other changes to the model requested by NDEP or necessary to support the 2013 GWETS Optimization Project. In addition, a conceptual water budget for the model area was developed as part of the first phase activities.

The updated model resulting from this work is referred to as the "Phase I Model". This report documents the updates and refinements to the Northgate Model made to develop the Phase I Model. The components of the Phase I Model that were not modified from the Northgate Model are generally not described in this report since they are described in the Northgate Model documentation (Northgate 2010). The Phase I Model has been used to support the calculation of GWETS performance metrics that are presented in the 2013 Semi-Annual Remedial Performance Report for Perchlorate and Chromium (ENVIRON 2014b).

The second phase of modifications will involve updating and recalibrating the model to incorporate the results of aquifer testing and the conceptual water balance, and further refine the representation of stream-aquifer interactions at Las Vegas Wash. This "Phase II Model" will then be used to evaluate the performance of alternative extraction scenarios at the Site well fields as part of the 2013 GWETS Optimization Project.

2 Site Background

A brief summary of Site background relevant to the discussion of the groundwater model is provided in this section. A complete background summary is provided in the RI/FS Work Plan (ENVIRON 2014a).

The Site is located within the Las Vegas Valley in the southern region of Clark County, Nevada. Las Vegas Valley is bordered by a set of mountains that includes the Spring Mountains to the west, the Sheep Range and Las Vegas Range to the north, the Frenchman Mountains and Sunrise Mountains to the east, and the River Mountains and McCullough Mountains to the south (Figure 1). The most significant stream in the valley is the Las Vegas Wash, which flows generally from west to east before discharging into Lake Mead. The climate in the area varies from semi-arid in the mountains to arid in the lowlands. Rainfall averages about 4.5 inches per year and occurs in storms of high intensity and short duration that often lead to floods. Evaporation in the area is significant and can be higher than 80 inches per year in the lower portion of the valley (UNLV 2003).

NDEP has defined three water-bearing zones (WBZs) that are of interest in the vicinity of the Site: the Shallow, Middle, and Deep WBZs (NDEP 2009). Groundwater flow occurs predominantly in shallow quaternary alluvium (Qal) which overlies the much lower hydraulic conductivity Upper Muddy Creek formation (UMCf). A distinct paleo-channel drainage network is present in the shallow aquifer system. The ground surface across the Site generally slopes downward to the north. The Shallow WBZ extends to approximately 90 feet below ground surface (bgs), and consists of saturated portions of the Qal and the uppermost portion of the UMCf. The Shallow WBZ is unconfined to partially confined, and is considered the water table aquifer. The groundwater in the shallow aquifer flows to the north and the groundwater gradient generally mimics the surface topography. There is generally an upward vertical gradient from the UMCf to the alluvium. The extraction wells at the Site are screened in the Shallow WBZ.

There are currently three operating extraction wells fields that are associated with the Site: 1) the on-site Interceptor Well Field (IWF) with downgradient barrier wall; 2) the off-site Athens Road Well Field (AWF); and 3) the off-site Seep Well Field (SWF). These well fields are operated to remove perchlorate and hexavalent chromium from shallow groundwater and reduce the amount of perchlorate discharged to Las Vegas Wash. In addition to these well fields, neighboring companies AMPAC and OSSM operate separate groundwater capture systems west of the Site. Groundwater monitoring is being conducted at the Titanium Metals Corporation (TIMET) site, located to the east of the Site. TIMET's groundwater remediation system construction began in 2009 and is expected to be operational in March 2014 (GEI 2014).

3 Previous Groundwater Models

The Phase I Model is based on the original groundwater flow model developed for the Site by Northgate. The Northgate Model is a steady-state model calibrated to Site conditions existing during 2008/2009 (Northgate 2010). The primary focus of developing the Northgate Model was to carry out capture zone analyses of the IWF and AWF. The Las Vegas Wash in the model is beyond these two regions of interest and was simulated using a constant head boundary for simplicity. Hence, the surface-groundwater interactions that occur along the Las Vegas Wash were not simulated in detail in the model.

The active area of the Northgate Model domain is wedge-shaped, narrowing from south to north towards the Las Vegas Wash and covering an area of about 10,000 acres. From south to north, the model domain extends from south of Lake Mead Parkway to the Las Vegas Wash, an area approximately 20,000 feet (about 4 miles) in total length. Laterally, the model extends west of the Site to include the existing AMPAC and OSSM groundwater capture systems, and east of the Site to include the monitoring wells at the TIMET site. The model is discretized laterally into 200 by 200 foot grid cells. In the vertical direction, the model domain extends downwards from Shallow WBZ, and through the Middle WBZ and ends near the top of the Deep WBZ. These units were discretized vertically into six model layers.

In addition to the Northgate Model, several other groundwater flow models have been developed and documented for the Black Mountain Industrial (BMI) Complex and surrounding region. The subsections below describe groundwater flow models pertinent to the Site.

3.1 United States Geological Survey Model

A regional groundwater model of the valley-fill aquifer system of the Las Vegas Valley was developed by the United States Geological Survey (USGS) to evaluate possible groundwater management alternatives related to overdraft problems, while maximizing use of groundwater resources (USGS 1996). The model incorporates processes such as land subsidence due to groundwater withdrawal, discharges to washes, evapotranspiration, and springflow. The four-layered model consists of 60 columns and 72 rows with uniform grid size of 3,000 feet by 3,000 feet. The model was developed in two phases. In the first phase, the predevelopment groundwater conditions, representing a period from 1912 through spring 1972, were simulated. The second phase model simulated the period from summer 1972 through spring 1981, representing development conditions. As a part of the modeling efforts, a conceptual water budget was compiled for the two simulation phases.

3.2 University of Nevada at Las Vegas Model

A groundwater model to study perchlorate transport from several contaminated sites to the Las Vegas Wash was developed by a team at the University of Nevada at Las Vegas (UNLV) on behalf of the United States Environmental Protection Agency (USEPA) (UNLV 2003). The computer model was developed for saturated conditions using the software Visual MODFLOW 2.8 and was calibrated using WinPEST, an automated calibration tool. The model results included an evaluation of the time of travel and potential perchlorate migration pathways from the contaminant sources to the Las Vegas Wash. In addition to the time of travel and concentration distribution, the transport model also evaluated the influence of domestic and industrial wastewater disposal via the infiltration ponds on the development of the plumes.

3.3 Las Vegas Wash Model

A groundwater transport model was developed by NDEP to study groundwater/surface water interactions and perchlorate transport along the Las Vegas Wash (McGinley 2003). The purpose of the modeling work was to develop a predictive tool to address temporal distributions of perchlorate in the Las Vegas Wash. MODFLOW was used to simulate groundwater flow, with the Las Vegas Wash simulated using the River Package. Only the alluvium aquifer system was simulated in the model.

3.4 Athens Road Well Field Model

A solute transport groundwater model was developed by McGinley & Associates to quantify the efficiency of capture at the AWF (McGinley & Associates 2007). The model predicted capture efficiency of 99.5% at the AWF. However, the perchlorate concentration data for downgradient wells did not appear to indicate complete capture was being achieved. The disparity between observations and calculations was attributed to limitations of the conceptual site model developed for the study area.

3.5 Basic Remediation Company Model

A groundwater transport model for the BMI Common Areas was developed by Daniel B. Stephens & Associates on behalf of the Basic Remediation Company (BRC) (BRC 2009). As part of the modeling effort, historical, present, and future conceptual water balances of the study area were developed. A series of predictive solute transport simulations were also conducted for perchlorate, arsenic, hexavalent chromium, and selenium.

3.6 AMPAC Model

On behalf of AMPAC, Geosyntec Consultants (Geosyntec) developed a conceptual and numerical model of groundwater flow in the area north of the former Pacific Engineering and Production Company of Nevada (PEPCON) facility in Henderson, Nevada (Geosyntec 2010). A steady-state numerical model was developed to validate the conceptual model against available site data and to develop quantitative estimates of design parameters and operations to remediate the perchlorate plume in groundwater that originates at the PEPCON site. The model was implemented in MODFLOW 2000 and used to simulate saturated groundwater conditions.

4 Conceptual Water Balance

A conceptual water balance was derived for groundwater within the Phase I Model domain. The model domain is shown on Figure 2. The purpose of the water balance is to provide an independent evaluation of the inflows and outflows of groundwater within the model domain that can be used to guide model refinement. The Phase I Model represents the approximately steady-state period in second quarter of 2012. The conceptual water balance incorporates data from the same time period to allow comparison of water balance components. Vertically, the model domain includes the Shallow and Middle WBZs, but does not include deeper portions of the UMCf.

The methods and data sources for individual water balance components are listed in Table 1a and are described in the following sub-sections.

4.1 Groundwater Outflow

The major groundwater outflow components in the model area are groundwater extraction, groundwater outflow to the Las Vegas Wash, and evapotranspiration from groundwater, each of which are discussed in this section.

4.1.1 Groundwater Extraction

Groundwater extraction is presently conducted from five well fields at three sites within the model area: the Site, OSSM, and AMPAC. The total groundwater extraction at these sites was aggregated from available data for second quarter 2012. At the Site, the combined average extraction rates for second quarter 2012 for the IWF, AWF and SWF were 62 gallons per minute (gpm) (12,012 cubic feet per day [cfd]), 275 gpm (52,885 cfd), and 577 gpm (111,018 cfd), respectively (ENVIRON 2012a). The combined average extraction rate for this time period was 148 gpm (29,125 cfd) for the OSSM system (Hargis and Associates, 2012) and 512 gpm (98,560 cfd) for the AMPAC system (AMPAC 2013).

4.1.2 Outflow to Las Vegas Wash

Since the rate of groundwater discharge from the Site and neighboring areas to the Las Vegas Wash cannot be directly measured, this quantity was indirectly estimated by comparing measured sources of inflows and outfalls along the reach of the Las Vegas Wash that forms the northern model boundary. The data compiled for this estimate includes streamflow data from USGS gauging stations, City of Henderson (COH) treated wastewater outflows, and treated effluent discharge rates from the Site, AMPAC, and TIMET. This data is presented in Table 1b, and the locations of various stream gauge and outfall locations are shown in Figure 1.

For this analysis, the reach of Las Vegas Wash adjoining the model domain was divided into two sub-reaches bounded by USGS stream gauges. Reach A extends from the Las Vegas Wasteway Gauge (#09419679) to the Pabco Road Gauge (#09419700), and includes a tributary of Las Vegas Wash (Duck Creek, #09419696) and inflows from several wastewater outfalls. Reach B extends from the Pabco Road Gauge to the Three Kids Gauge (#09419696). Conceptually, the calculation performed for each sub-reach involved summing all known inflows and outflows of surface water and groundwater. Groundwater inflow to Las Vegas Wash was assumed to be composed of underflow and lateral discharges. Since there was relatively little precipitation during the water balance period, it was assumed that there was no significant rainfall runoff to Las Vegas Wash. After performing the summation, any missing flow was assumed to originate from groundwater discharges along the length of the sub-reach. The groundwater inflow to each of these sub-reaches was estimated separately, scaled to exclude groundwater inflow to Las Vegas Wash beyond the model boundary, and then summed together for entry into the overall water balance. This calculation did not separately estimate potential seepage from Las Vegas Wash due to pumping at the SWF, instead presenting overall groundwater discharge to Las Vegas Wash as a net outflow.

The streamflow data was downloaded from the USGS[1] for the above mentioned stream gauge stations. For the second quarter of 2012, the average streamflow during the water balance period was 250 cubic feet per second (cfs) at the Las Vegas Wasteway Gauge, 5.6 cfs at the Duck Creek Gauge, 281 cfs at the Pabco Road Gauge, and 285 cfs at the Three Kids Gauge. The COH wastewater outfall reportedly discharged 14 cfs to Las Vegas Wash during second quarter 2012[2]. The AMPAC outfall location is approximately 40-50 yards south of the Site discharge location and reportedly produces effluent at a rate roughly equal to the combined extraction rates from the AMPAC wells[3]. The average Site, AMPAC, and TIMET outfalls to Las Vegas Wash were 2.0 cfs[4], 1.1 cfs[5], and 1.0 cfs[6] in second quarter 2012, respectively.

A portion of the streamflow in Las Vegas Wash is lost to evaporation. The total area of Las Vegas Wash (including Duck Creek) is approximately 450 acres between the Las Vegas Wasteway and Pabco Road gauging stations. Available daily evaporation data from 1997-1999 for four stations located in or near Lake Mead indicate an average evaporation rate of 81 inches per year (Westenburg et al. 2006). Multiplying the area of Las Vegas Wash by the evaporation rate results in an estimated 4.2 cfs of surface water evaporated from Las Vegas Wash within the model area. The outflow due to evaporation was allocated to Reaches A and B based on the relative area of each reach.

As shown in Table 1b, after accounting for known and estimated flows, the estimated groundwater inflow to Las Vegas Wash along Reaches A and B from both sides of Las Vegas Wash was 16.1 cfs. Assuming that 80% of the groundwater discharge is from the south side of Las Vegas Wash, there is an estimate groundwater discharge of 8.0 cfs (693,000 cfd) within the model area.

4.1.3 Evapotranspiration From Groundwater

Evapotranspiration from shallow groundwater may occur in the areas of phreatophytes found along Las Vegas Wash. Given the limited areal extent of phreatophytes, evapotranspiration from groundwater is expected to be very small compared to other water balance components. Hence, no estimate of evapotranspiration was developed for the water balance.

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[1] Data downloaded from http://waterdata.usgs.gov/usa/nwis/sw
[2] Per data received via email from Howard Analla of the City of Henderson, dated 7/09/2013.
[3] Per email communication with Gary Carter of AMPAC, dated 9/10/2013.
[4] NERT Effluent Records, NPDES Permit number – NV0023060.
[5] Equivalent to the combined AMPAC pumping as per email communication with Gary Carter of AMPAC, dated 9/10/2013.
[6] Based on the maximum permissible flow rate for TIMET's effluent outfall, NPDES Permit number- NV0000060

4.2 Groundwater Inflow

The major groundwater inflow components in the groundwater model domain are areal recharge, mountain block recharge from the southern edge of the model, seepage from Las Vegas Wash, and vertical inflow from the UMCf.

4.2.1 Areal Recharge From Precipitation

Areal recharge rate from rainfall was estimated from published values for arid and semi-arid regions, which have been found to range between 0.1% and 5% of average total rainfall (Scanlon et al. 2006). Based on interpolated climate data produced by Oregon State University's PRISM Climate Group (PRISM 2013), the average precipitation rate near the Site was 4.32 inches per year for the period 1990-2012. Assuming 2.55% (average of 0.1% and 5%) of precipitation as net areal recharge, the total areal recharge for the model area (4×10^8 square feet) is expected to be 11,000 cfd.

4.2.2 Recharge from Surface Water Bodies

Recharge from several surface water bodies in the model domain were evaluated separately and incorporated into the water balance. A significant source of surficial recharge to groundwater is a series of unlined ponds operated by COH as a bird viewing preserve. An average of 1.22 million gallons per day (MGD) of inflow to the ponds was recorded by COH for the period from 2008 to 2013. The ponds have an area of approximately 110 acres. Assuming COH is maintaining a relatively constant level of surface water in the ponds, and assuming an evaporation rate of 81 inches per year (see Section 4.1.2), the recharge from the ponds to the shallow groundwater aquifer is estimated to be 5.6 feet per year. The total pond recharge rate was estimated to be 74,000 cfd.

Several facilities near the Site operate infiltration ponds and trenches that present potential sources of focused recharge. The OSSM treatment system discharges treated groundwater to recharge trenches located north of the OSSM extraction wells (Figure 1). Based on the OSSM third quarter 2012 monitoring report, an average of 147 gpm (29,000 cfd) of water was discharged to the trenches between January and September 2012 (Hargis and Associates 2012). Other historical sources of focused recharge, including the former recharge trenches at the Site, former COH Rapid Infiltration Basins (RIBs), BMI Pond, TIMET Pond, and the AMPAC reinjection system were not active during the Phase I Model period.

4.2.3 Lateral and Vertical Boundary Inflows

The southern lateral boundary inflow was estimated using the hydraulic conductivity of the UMCf and the head gradient at the southern boundary of the Site. The alluvium is unsaturated along the southern boundary, and the UMCf is partially saturated. Within the water balance domain, the UMCf consists of two distinct interbedded units, composed of either coarse-grained sediments (UMCf-cg) or fine-grained sediments (UMCF-fg) (ENVIRON, 2014a)[7]. Plate 6 of the RI/FS Workplan (ENVIRON 2014a) is a cross-section illustrating the orientation of these units near the southern model boundary. As shown in the Plate 6, the shallowest interval of the UMCf-fg pinches out before reaching the IWF.

[7] The Phase I Model doesn't represent the UMCf-fg and UMCf-cg as separate units.

Based on the depiction of the saturated portion of the UMCf-fg and UMCf-cg in Plate 6, 30% of the southern boundary thickness was allocated to the UMCf-fg, and 70% was allocated to the UMCf-cg. The horizontal hydraulic conductivity for the UMCf from the Northgate Model (0.72 feet per day [feet/day]) was used for the UMCf-fg, and the hydraulic conductivity of the UMCf-cg (6 feet/day) was obtained from the AMPAC model (Geosyntec 2010). The horizontal head gradient measured during second quarter 2012 upgradient of the Site boundary was approximately 0.0077 feet per foot (feet/foot) (ENVIRON 2014a). The southern model boundary is 20,000 feet in length and the thickness of UMCf is 267 feet in the model. Using these values, an inflow of approximately 183,000 cfd is expected from the southern boundary.

The vertical boundary inflow consists of upward flow from the deeper portion of the UMCf in the Deep WBZ. The average vertical head gradient between pairs of wells in the IWF and the AWF was about 0.11 feet/foot during second quarter 2012. The well pairs used for this purpose are M-71/M-163, M-74/M-165, PC-135A/PC-134A, and PC-136/PC-137. Using this head gradient, the total surface area of the model, and a representative UMCf vertical conductivity of 4.8×10^{-3} feet/day, a vertical inflow of approximately 220,000 cfd is expected from the Deep WBZ.

Because the model area is oriented along the general direction of groundwater flow, net inflows and/or outflows along the eastern and western lateral boundaries of the conceptual water balance area are expected to be minimal. However, in the vicinity of Las Vegas Wash, there will be groundwater underflow into the model area on the western boundary and out of the model area on the eastern boundary. These underflows were estimated by roughly estimating the width and depth of saturated alluvium, the hydraulic gradient, and hydraulic conductivity at the model area boundaries. The width of the alluvium was estimated based on the USGS geologic map shown in Figure 1. The depth and hydraulic conductivity of the alluvium were based on McGinley (2003). A hydraulic gradient of 0.005 was assumed for this estimate. The inflow from the western boundary was estimated to be 510,000 cfd, and the outflow at the eastern boundary was estimated to be 31,000 cfd.

5 Phase I Groundwater Model Update

To support the 2013 GWETS Optimization Project, the Northgate Model was updated to reflect the more recent configuration and extraction and injection rates of the Site, AMPAC, and OSSM remediation systems. A regional water balance was prepared (as discussed in Section 4) to guide further model refinements. An initial evaluation of the stream-aquifer interaction in the vicinity of the SWF was also conducted and the model was updated accordingly. The key model components revised in this phase are described in the following sections.

5.1 Model Solver

The Northgate Model was developed using an early and unpublished version of the MODFLOW-NWT code. Minor revisions were made to the model so it can be run using MODFLOW-NWT version 1.0.7 (Niswonger 2011), a recent version of the code that is available on the USGS website[8]. MODFLOW-NWT is a version of MODFLOW-2005 with a Newton formulation of the groundwater flow equation that is designed to solve problems that are nonlinear due to unconfined aquifer conditions and/or some combination of nonlinear boundary conditions.

5.2 Model Extent

The model extent was revised at the northern boundary of the model to more accurately represent Las Vegas Wash. This boundary was revised based on the Las Vegas Stream centerline shape file available at the Clark County Regional Flood Control District (CCRFCD) website[9]. The model boundary was also extended in the northwestern part of the model area to incorporate the Duck Creek tributary stream channel in the simulation. With these changes, the total model area has increased by about 40 acres as compared to the Northgate Model. The revised model extent is shown in Figure 2.

5.3 Selection of Steady-State Time Period

The Northgate Model was calibrated to Site conditions existing during 2008/2009 (Northgate 2010). A goal of the Phase I Model development was to update the groundwater model to reflect more recent hydrologic and pumping conditions. Groundwater hydrographs and other hydraulic records (rainfall and evaporation rates) were reviewed to identify a relatively stable period to use for steady-state modeling. The data reviewed suggests that steady state groundwater conditions existed at the Site between late 2010 and 2012 (Figure 2a through 2d of the 2013 Semi-Annual Report; ENVIRON 2014b). Higher water levels were measured starting in November 2012 due to higher than average rainfall during fourth quarter 2012 through first quarter 2013. Between April and June 2013, many of the active IWF extraction wells, which are located directly upgradient of the barrier wall, had water levels that were approximately 5 to 15 feet higher than the same period in 2012 (ENVIRON 2013a). Therefore, the Phase I Model was revised to represent the most recent observed steady-state period of second quarter 2012.

[8] Available from http://water.usgs.gov/nrp/gwsoftware/modflow_nwt/ModflowNwt.html
[9] Available from ftp://www.ccrfcd.org/Shapefiles/

5.4 Spatial Discretization and Layer Refinement

The following refinements were made to the model layer elevations to better represent the Site topography and stratigraphy:

- Model layers 1 and 2 in the Northgate Model, representing the Qal, were combined together in a single layer in the Phase I Model since the saturated thickness of the alluvium is relatively thin throughout the model area. The revised model has five layers, with the top layer representing the Qal and the lower four layers representing the shallow and deeper parts of the UMCf.
- The layer thicknesses of top two layers were adjusted to match the geometry of the slurry wall as discussed in Section 5.7.1. The updated layer thicknesses are given in Table 4.
- The top surface of model layer 1 was updated to use elevation values from the USGS Digital Elevation Model (DEM) for the Site area.
- The Qal and UMCf contact elevation surface was refined by performing an interpolation using LeapFrog Hydro 3D geological modeling software (LeapFrog). The source data used for the interpolation included Qal/UMCf contact elevations reported for more than 1,000 wells within the model domain (McGinley 2014), and geological cross-sections for the Site well fields and other areas within the model domain.[10] The contact elevation was manually adjusted near the UMCf ridge in the AWF area to produce a more realistic surface. The revised contact elevation was then imported into the model as the bottom elevation of layer 1.

The grid size was further refined within the study area boundary around three well fields as shown in Figure 4. The grid was also refined near Las Vegas Wash to more accurately simulate surface water-groundwater interaction.

5.5 Areal Recharge

The Northgate Model has spatially distributed recharge rates assigned to different areas based on land use. These land use areas were retained in the Phase I Model and are shown in Figure 3.

The areal recharge rates for residential, industrial, undeveloped, and golf course areas selected by Northgate were not changed in the Phase I Model update. Recharge rates that have been updated include:

- Based on the calculations described in Section 4.2.2, an estimated recharge of 5.61 feet/year was applied to the area of the COH Bird Viewing Preserve in the Phase I Model. This estimated value is higher than the recharge rate of 2.43×10^{-3} feet per day or 0.9 feet per year (Appendix E, Table 1E, Northgate 2010) used in the Northgate Model to represent recharge from these ponds.

[10] Particular cross sections incorporated in the interpolation included: Plate 6 from the RI/FS Workplan (ENVIRON, 2012b); Plates 3, 4 and 5 from the 2012 Annual Remedial Performance Report (ENVIRON 2013a); cross-sections presented in the geophysical investigation of Las Vegas Wash (McGinley 2003); and Figure 4-8 of the BRC Closure Plan (BRC 2007) .

- Additional recharge of 0.01 feet/day was assigned in the areas of unlined storm water retention ponds on the Site. It was assumed that 75% of the rainfall falling on the Site will become recharge. No recharge was applied in the lined pond areas around the IWF.
- The former on-site recharge trenches, former COH RIBs, BMI Pond, TIMET Pond, the AMPAC reinjection system are inactive; therefore, no focused recharge is applied in those locations in the Phase I Model.
- The OSSM remediation system discharges treated groundwater to recharge trenches located north of the OSSM extraction wells (Figure 2). Based on the OSSM third quarter 2012 monitoring report, an average of 147 gpm (29,125 cfd) of water was discharged to the trenches from Jan-Sept 2012 (Hargis and Associates 2012). The model was updated to incorporate this recharge rate.

The spatial distribution of recharge rates in the Phase I Model is shown on Figure 3 and listed in Table 2. These preliminary recharge rates may be revised during the next phase of model calibration, as needed.

5.6 Changes to the GWETS and Other Extraction Systems

The Phase I Model was updated to use the available second quarter 2012 extraction and injection rates for on-site and off-site wells. The combined average extraction rates for second quarter 2012 for the IWF, AWF and SWF were 62 gpm (12,012 cfd), 275 gpm (52,885 cfd) and 577 gpm (111,018 cfd), respectively. The combined average extraction rate for the OSSM wells was 148 gpm (29,125 cfd) (Hargis and Associates 2012). The on-site recharge trenches downgradient of the IWF were no longer in use in 2012. The total injection of treated water through OSSM recharge trenches was assumed to be equal to the OSSM combined pumping rate of 148 gpm (29,125 cfd).

For the AMPAC extraction system, the combined average extraction rate for all wells, shown in Figure 2, was 512 gpm for the Phase I Model period (AMPAC 2013). The AMPAC injection wells that were active in the Northgate Model are no longer in use and so are inactive in the revised model. Five new AMPAC extraction wells (AMEW wells) were constructed in the first quarter of 2012. These wells are not active in the revised model because they are screened in a coarse-grained UMCf that is not currently represented in the model. The total AMPAC extraction initially configured in the model is about 237 gpm (46,000 cfd). It is unknown whether this system rate is sustainable over the long-term. Hence, the AMPAC wells were configured in the model to allow extraction to reduce automatically based on the water level at each pumping well. The final modeled flow rate for the AMPAC system is presented in the water balance in Table 5.

The extraction well screen elevations were adjusted based on the revised model layers as discussed in Section 5.4 of this report. The locations of a few wells in the IWF were revised based on the updated coordinates provided by McGinley and Associates (McGinley 2014). The revised extraction rates applied to the Phase I Model are listed in Table 3. The overall extraction rates in the revised model are similar to the Northgate Model.

5.7 Hydraulic Properties

The hydraulic properties of the slurry wall and the alluvium aquifer layer were revised in the Phase I model. The effective porosities of the aquifer material were also updated in the model based on available values.

5.7.1 IWF Barrier Wall

The conductivity of the hydraulic flow barrier (barrier wall), located immediately north of the IWF, was revised based on the reported hydraulic conductivity value of the material used to construct the wall by Vector Engineering. The reported range of conductivities used during construction was 4.7×10^{-8} centimeters per second (cm/sec) to 8.0×10^{-7} cm/sec (Vector 2001). This range is similar to the average hydraulic conductivity measured by permeability testing of the barrier wall at four locations of 8.8×10^{-7} cm/sec, as reported in the Capture Zone Evaluation Report (Northgate 2010). For modeling purposes, the value of 4.7×10^{-8} cm/sec was used to represent the barrier wall's hydraulic conductivity.

According to the conceptual site model developed by ENSR International Corporation (ENSR), the slurry wall is about 1,600 feet long, 3 feet wide, and 60 feet deep, and was constructed to tie into approximately 30 feet of UMCf (ENSR 2005). The layer thicknesses were adjusted in the Phase I Model to accurately represent the slurry wall configuration.

5.7.2 Hydraulic Conductivity Distribution

The hydraulic conductivity distribution in the Phase I Model is mostly unchanged from the Northgate Model. The horizontal and vertical hydraulic conductivities for layers representing the UMCf were not changed. For layer 1 (Qal), areas adjoining Las Vegas Wash were updated with horizontal conductivity values ranging between 250 to 485 feet/day. A horizontal-to-vertical anisotropy ratio of 10:1 was used to define the vertical hydraulic conductivity in the area near Las Vegas Wash. The hydraulic conductivity zones were adjusted to extend the paleochannels in model layer 1 up to the Las Vegas Wash. The hydraulic conductivity values for paleochannels were kept unchanged.

In the area of UMCf ridge in the AWF, the conductivity value of layer 1 was modified to match that of layer 2 since there the alluvium is not saturated in this area. The horizontal hydraulic conductivity values remained unchanged for the remainder of the Qal. The spatial distribution of hydraulic conductivity values in the alluvial aquifer is shown on Figure 4.

5.7.3 Aquifer Porosity

The effective porosities were modified for all model layers in order to produce accurate estimates of groundwater velocities and particle travel times. In the Northgate Model, the porosities for the Qal and UMCf aquifers were set to 0.4 and 0.54, respectively. For the Phase I Model, the Qal layer was set to have a uniform porosity of 0.1, which is the same value used in the UNLV and BRC Models (see Section 3). The effective porosity of layers representing the UMCf was reduced to 0.2, consistent with the value used in the BRC Model and similar to the value used in the UNLV Model (0.25).

5.8 Boundary Conditions

The groundwater model has lateral inflows from the upgradient (southern) boundary and vertical inflow from the bottom boundary of the model. These inflow components were revised as described in the following sections.

5.8.1 Vertical Inflows from Bottom Boundary

The vertical inflow from the bottom boundary is simulated in the model using the general head boundary (GHB) package. The Northgate Model included an area of downward flow from the Qal to UMCf near the downgradient area of the Las Vegas Wash. Since there are no definitive data that show vertically downward flow from the Qal to the UMCf anywhere in the model area, the area of downward flow was removed from the Phase I Model.

The GHB reference heads were refined in certain areas of the Phase I Model to match observed vertical head differences measured at well clusters. It was assumed that these head differences vary along the general direction of groundwater flow, but not transverse to groundwater flow. Near the IWF, the reference heads were revised using the measured head differences between well pairs M-135/M-161 and M-71/M-162, where a vertical head difference of about 11 feet was measured in second quarter 2012. Near the AWF, well pair PC-136/PC-137 showed a vertical head difference of about 2.4 feet measured in second quarter 2012. For areas between the IWF and AWF, the vertical head difference between the alluvium and UMCf was interpolated from values determined from well clusters at the IWF and AWF. This linear relationship was also extrapolated to estimate the head differences in the model domain to the north and south of these well fields. The estimated head difference at each model location was then subtracted from the water table surface from second quarter 2012 to determine the reference head. The resulting reference heads in the Phase I Model now range from 1906 feet at the southernmost boundary to 1530 feet at the northernmost boundary. A constant GHB conductance value of 0.0636 square feet per day was assigned throughout the model domain.

5.8.2 Lateral Boundary Inflows

The upgradient boundary inflows were not changed except for the addition of extra inflows in several cells added to the model due to grid refinement as discussed in Section 5.4. The boundary inflows may be adjusted during the next phase of model calibration.

5.8.3 Model Boundary near Las Vegas Wash

In the Northgate Model, the downgradient model boundary at Las Vegas Wash was simulated using constant head cells. As part of the Phase I Model update, this boundary is now implemented with the MODFLOW Stream Package (Prudic 1989). The Stream Package is intended for modeling stream-aquifer interactions, and can be used to simulate the flow entering and exiting the model domain through Las Vegas Wash.

As described in Section 5.2, the geometry of Las Vegas Wash has been updated in the Phase I Model to align with the centerline of Las Vegas Wash (Figure 5). To implement the Stream Package, the stream stage elevations along Las Vegas Wash were interpolated from the average stream stages recorded in 2012 for the three USGS gauging stations shown in Figure 6. The streambed elevations were interpolated from the streambed elevation profiles given in the Flood Insurance Study Report, Clark County, Nevada (FEMA 2011b). The interpolated streambed elevations along the northernmost model boundary are also shown on Figure 6.

The other important inputs required for the stream boundary were the stream width, thickness of streambed, stream length in each boundary cell, streambed conductivity, and the net flow of surface water entering at each segment of the stream boundary. The stream length within each boundary cell is the actual length of the stream falling in the individual model cell. A uniform stream width of 50 feet was used in the model. The streambed conductivity range of 0.05 feet/day to 0.55 feet/day was used in the model, with lower values in the upstream portion above the Duck Creek confluence. The stream in this area is braided and the streambed is expected to have lower conductivity. The higher conductivity values were applied in the downstream portion of Las Vegas Wash. The streambed conductivity values may be revised during the next phase of model calibration.

Four segments of Las Vegas Wash are simulated in the model. The main segment (Segment #1) extends across the entire downgradient model boundary. Three minor segments that flow to Las Vegas Wash are also simulated, including Duck Creek (Segment # 2), a small tributary stream carrying surface water discharges near Pabco Road (Segment # 3), and the C-1 Channel (Segment # 4) (Figure 5). The inflows entering each stream segment were estimated from various measured sources of discharge to Las Vegas Wash, including streamflow data from USGS gauging stations, COH treated wastewater outflows, and effluent discharge rates from the Site, AMPAC, and TIMET outfalls.

The Las Vegas Wasteway and Duck Creek stream gauges are located upstream of the model boundary, and recorded average streamflows of 250 and 5.6 cfs, respectively, for second quarter 2012. The average rate of COH treated water discharge to Las Vegas Wash was 14 cfs (obtained from COH via e-mail) during the second quarter 2012. The average Site, AMPAC and TIMET outfalls to the Las Vegas Wash were 2.0 cfs, 1.1 cfs and <1 cfs respectively for 2012. For Segment # 3, a combined flow of 16.6 cfs from Site, AMPAC, TIMET, and COH was assigned.

The reported average streamflow at the Pabco Road gauging station for second quarter 2012 was approximately 281 cfs. This value was not used as input to the model, but may be used for calibrating boundary parameter values during the future calibration phase.

6 Model Results

To evaluate the model calibration, the head targets from the Northgate Model were updated with measured groundwater elevation data from the second quarter of 2012. In addition to the 263 targets from the Northgate Model, data from an additional 193 targets were added to the Phase I Model to increase the calibration dataset[11] (Figure 7). There are 12 target locations in the Northgate model that fall in the same cells as the additional targets. These 12 targets were deleted in the Phase I Model. The revised list of target wells and their groundwater elevations for second quarter 2012 is provided in Appendix A. The measured groundwater elevations were also presented in the 2012 Annual Performance Report (ENVIRON 2012a).

6.1 Modeled Groundwater Balance

Table 5 presents a comparison of the major flow components of the conceptual water balance to the Northgate Model and updated Phase I Model. These models simulate different extraction and other boundary conditions. Although the water balances are not directly comparable, they provide confirmation that the major model flow components remain generally similar after the changes made for the Phase I Model update.

A significant difference between the Northgate Model and Phase I Model results is the net outflow to Las Vegas Wash from the model area. This outflow increased by 54,000 cfd in the Phase I Model. The difference may be attributed to the modified stream stage elevations which are about 10 feet higher in the Phase I Model, as compared to the constant head boundary cells in the Northgate Model.

As previously mentioned, the Phase I Model is configured to allow reduced extraction to avoid dewatered conditions. The initial total AMPAC pumping input to the model (46,000 cfd) was automatically reduced by the solver to 33,000 cfd. The conceptual water balance incorporates all AMPAC extraction within the boundary during the second quarter of 2012, including extraction from the deep UMCf wells, and is therefore a higher number (99,000 cfd).

Table 5 demonstrates that the Phase I Model has increased inflow to groundwater due to infiltration from the COH Bird Viewing Preserve, relative to the Northgate Model. This change results from increasing the infiltration rate from 0.8 to 5.6 feet/year. Primarily due to higher heads near the stream boundary, there is also an increase in groundwater outflow due to evapotranspiration in the Phase I Model.

6.2 Calibration Statistics and Simulated Groundwater Elevations

Figure 8 shows a plot characterizing the match between modeled and observed heads at wells used as calibration targets. The plot illustrates that there is generally good agreement between modeled and observed heads, with points generally falling close to the 1:1 correlation line. The simulated heads appear to be biased low near the upgradient model boundary, particularly in layer 5. This deviation will be addressed when the upgradient boundary is recalibrated for the

[11] The groundwater elevations for the extra target wells were obtained from data files received from APMAC, TIMET, and OSSM via email in August 2012.

Phase II Model. No other global bias in the modeled heads is evident. The "goodness-of-fit" R^2 value is 0.98, demonstrating an acceptable fit to the observed heads.

Table 6 provides a comparative summary of calibration statistics for the Northgate Model and updated Phase I Model. A positive residual mean value indicates that the simulated heads are lower than the observed heads. The calibration statistics for the Phase I Model have been presented for both the original set of target wells from the Northgate Model, and the 444 observation wells in the updated target list. However, the results with different target sets and from different calibration periods are not directly comparable.

Figure 9 shows the simulated heads in the Shallow WBZ. The overall heads are generally consistent with the contoured groundwater elevations for second quarter 2012 presented in Plate 2 in the 2012-2013 Annual Performance Report (ENVIRON 2012a).

7 Conclusions

The Phase I Model reasonably simulates groundwater conditions at the Site and can be used to begin evaluating the performance of the GWETS. Upon completion of the aquifer testing program of the 2013 GWETS Optimization Project, the Phase I Model will be recalibrated and verified against the field data and aquifer testing results. In the recalibration phase, the hydraulic parameters of the Site geologic materials will be updated, as needed. The calibration may also require adjusting other parameter values and boundary conditions to improve the overall accuracy of the model. The conceptual water balance will be used to guide model development.

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Tables

TABLE 1A: CONCEPTUAL WATER BALANCE SUMMARY

Nevada Environmental Response Trust Site

Henderson, Nevada

	Parameters	Flow (cfd)	Source Data
Groundwater Inflow	Southern Boundary inflow	183,000	Based on Darcy's Law and horizontal head gradient
	Vertical inflow from UMCf	220,000	Based on Darcy's Law and vertical head gradient
	Western boundary inflow beneath the Wash	510,000	Based on Darcy's Law and horizontal head gradient
	Areal Recharge		
	Infiltration from Bird Viewing Preserve	74,000	Estimated as inflow rate minus evaporation rate
	Rainfall Recharge	11,000	Based on 2.55% of rainfall (Scanlon et al 2006)
	OSSM Injection	29,000	Hargis and Associate 2012
Total Inflow (cfd)		**1,027,000**	
Groundwater Outflow	Groundwater Extraction		
	NERT (IWF)	12,000	ENVIRON 2012a
	NERT (AWF)	53,000	ENVIRON 2012a
	NERT (SWF)	110,000	ENVIRON 2012a
	OSSM	29,000	Hargis and Associate 2012
	AMPAC	99,000	AMPAC 2013
	Groundwater discharge to Wash	693,000	Net discharge estimated in Table 1b
	Eastern boundary outflow beneath the Wash	31,000	Based on Darcy's Law and horizontal head gradient
	Evapotranspiration	NE	Assumed to be small over model area
Total Outflow (cfd)		**1,027,000**	

Notes:

cfd = cubic feet per day

UMCF = Upper Muddy Creek Formation

NA = Not Applicable

NE = Not Evaluated

IWF = Interceptor Well Field

AWF = Athens Road Well Field

SWF = Seep Well Field

AMPAC = American Pacific Corporation

COH = City of Henderson

NERT = Nevada Environmental Response Trust

OSSM = Olin Chlor-Alkali/Stauffer/Syngenta/Montrose

TABLE 1B: GROUNDWATER INFLOWS AND OUTFLOWS AT LAS VEGAS WASH

Nevada Environmental Response Trust Site

Henderson, Nevada

Flows along Reach A (Las Vegas Wasteway to Pabco Road)

	Flow (cfs)	Flow (cfd)	Source
Inflows to Reach A			
Surface inflows to Reach A:			
Las Vegas Wasteway	250	22,000,000	Average flow second quarter 2012 at USGS stream gauge
Duck Creek	5.6	490,000	Average flow second quarter 2012 at USGS stream gauge
COH Wasteway	14	1,200,000	Data provided by COH
NERT Outfall	2.0	180,000	Data collected by NERT
AMPAC Outfall	1.1	98,000	Equal to total pumping
TIMET Outfall	1.0	86,000	Max. permissible flow rate in NPDES permit
Groundwater inflows to Reach A:			
Groundwater inflow along Reach A	*9.8*	850,000	Adjusted to balance Reach A inflow with outflow
Total Surface Water and Groundwater Inflow	**284**	**25,000,000**	

Outflows from Reach A			
Evaporation from Wash	2.4	210,000	Estimated based on the surface area of Wash and recorded evaporation rates
Surface flow at Pabco Road Gauge	281	24,000,000	Average flow second quarter 2012 at USGS stream gauge
Total Surface Water and Groundwater Outflow	**284**	**25,000,000**	

TABLE 1B: GROUNDWATER INFLOWS AND OUTFLOWS AT LAS VEGAS WASH

Nevada Environmental Response Trust Site

Henderson, Nevada

Flows along Reach B (Pabco Road to Three Kids)

	Flow (cfs)	Flow (cfd)	Source
Inflows to Reach B			
Surface flow at Pabco Road Gauge	281	24,000,000	Average flow second quarter 2012 at USGS stream gauge
Groundwater inflow along Reach B	*6.2*	540,000	Adjusted to balance Reach B inflow with outflow
Total Surface Water and Groundwater Inflow	**288**	**25,000,000**	

Outflows from Reach B			
Surface flow at Three Kids Gauge	285	25,000,000	Average flow second quarter 2012 at USGS stream gauge
Evaporation	1.7	150,000	Estimated based on the surface area of wash along Reach B and recorded evaporation rates
Total Surface Water and Groundwater Outflow	**288**	**25,000,000**	

Total Groundwater Inflow to Reaches A and B	**16.1**	**1,390,000**
Total Groundwater Inflow Within Study Area [a]	**8.0**	**693,000**

Notes

cfs = cubic feet per second   cfd = cubic feet per day

[a] Assumes: 80% of groundwater discharge is from the south side of Las Vegas Wash; 71% of Reach A is within model domain; and 48 % of Reach B is within model domain.

TABLE 2: PHASE I GROUNDWATER MODEL - AREAL RECHARGE DISTRIBUTION

Nevada Environmental Response Trust

Henderson, Nevada

Region	Recharge (ft/d)	Source
Residential areas	5.6×10^{-5}	Original Value, not revised
Industrial areas	4.3×10^{-4}	Original Value, not revised
Tuscany Golf Course	1.78×10^{-3}	Original Value, not revised
Undeveloped areas	1.83×10^{-5}	Natural recharge rate - Original Value
COH Birding Preserve	2.0×10^{-2}	COH data sent from Howard Analla on 7/9/13
Northern RIBs	1.83×10^{-5}	No longer active, Natural recharge rate - Original Value
TIMET ponds	None	No longer active
NERT ponds	None	Ponds are double-lined; recharge is insigificant
Stormwater retention basins	1.2×10^{-2}	Assumes 75% of rainfall falling on Site becomes recharge

Notes:

ft/d = feet per day

COH = City of Henderson

NERT = Nevada Environmental Response Trust

RIB = Rapid Infiltration Basin

TIMET = Titanium Metals Corporation

Residential areas, industrial areas, and recharge from Tuscany Golf Course were not revised from the Northgate Model (Northgate 2010).

TABLE 3: GROUNDWATER EXTRACTION RATES - SECOND QUARTER 2012

Nevada Environmental Response Trust Site

Henderson, Nevada

Well Name	Owner	Pumping Rate (cfd)
ART-1	NERT	3,006
ART-2	NERT	12,025
ART-3	NERT	9,016
ART-4	NERT	1,517
ART-6	NERT	0
ART-7	NERT	6,013
ART-8	NERT	12,357
ART-9	NERT	8,950
I-AR	NERT	208
I-B	NERT	258
I-C	NERT	1,058
I-D	NERT	228
I-E	NERT	229
I-F	NERT	1,119
I-G	NERT	34
I-H	NERT	160
I-I	NERT	972
I-J	NERT	985
I-K	NERT	746
I-L	NERT	398
I-M	NERT	528
I-N	NERT	535
I-O	NERT	224
I-P	NERT	358
I-Q	NERT	36
I-R	NERT	540
I-S	NERT	982
I-T	NERT	78
I-U	NERT	115
I-V	NERT	995
I-Z	NERT	1,227
PC-115R	NERT	19,008
PC-116R	NERT	24,014
PC-117	NERT	24,036
PC-118	NERT	18,019
PC-119	NERT	13,646
PC-120	NERT	1
PC-121	NERT	1
PC-133	NERT	769
PC-99R2/R3	NERT	11,523
C	OSSM	2,368

TABLE 3: GROUNDWATER EXTRACTION RATES - SECOND QUARTER 2012

Nevada Environmental Response Trust Site

Henderson, Nevada

Well Name	Owner	Pumping Rate (cfd)
D2	OSSM	1,405
E3	OSSM	4,293
F	OSSM	1,598
G	OSSM	1,290
H2	OSSM	2,175
I	OSSM	1,502
J	OSSM	1,482
K2	OSSM	1,944
L	OSSM	2,214
M2	OSSM	1,579
N	OSSM	173
O	OSSM	2,464
P	OSSM	1,463
Q	OSSM	1,636
R	OSSM	1,540
AMEW-1	AMPAC	25,988
AMEW-2	AMPAC	9,048
AMEW-3	AMPAC	4,043
AMEW-4	AMPAC	4,813
AMEW-5	AMPAC	9,048
APEW-1	AMPAC	0
APEW-2	AMPAC	8,874
APEW-3	AMPAC	1,309
AREW-1	AMPAC	6,545
AREW-2	AMPAC	7,508
AREW-3	AMPAC	5,198
AREW-4	AMPAC	3,850
AREW-5	AMPAC	9,048
AREW-6	AMPAC	3,465

Notes:

cfd = cubic feet per day

AMPAC = American Pacific Corporation

OSSM = Olin Chlor-Alkali/Stauffer/Sygenta/Montrose

NERT = Nevada Environmental Response Trust

AMPAC's AMEW wells are not simulated in the model

TABLE 4: PHASE I GROUNDWATER MODEL LAYERS

Nevada Environmental Response Trust

Henderson, Nevada

Model Layers	Lithology	Layer Thickness (ft)
Layer 1	Alluvium	3.8-153.9
Layer 2	UMCf	30
Layer 3	UMCf	28.3-90.5
Layer 4	UMCf	60
Layer 5	UMCf	108

Notes:

ft = feet

UMCf = Upper Muddy Creek Formation

TABLE 5: MODELED WATER BALANCE SUMMARY

Nevada Environmental Response Trust Site

Henderson, Nevada

	Parameters	Northgate Model	Conceptual Water Balance	Phase I Model
Groundwater Inflow (cfd)	Upgradient Boundary inflow	68,957	183,000	73,007
	Vertical inflow from UMCf	121,701	220,000	109,866
	Inflow from the Wash	438,211	510,000	249,968
	Combined Recharge	91,723	114,000	147,726
	Infiltration from Bird View Pond	14,401	74,000	73,646
	GW-11 Pond Infiltration	30	0	0
	Industrial Recharge	30,547	NE	29,125
	AMPAC Injection	8,528	0	0
	OSSM Injection	19,200	29,000	29,125
	NERT Retention Basin	0	NE	8,070
	Other (rainfall, residential areas)	19,017	11,000	7,759
Total Inflow (cfd)		**720,592**	**1,027,000**	**580,567**
Groundwater Outflow (cfd)	Pumping NERT (IWF)	12,668	12,000	12,012
	Pumping NERT (AWF)	52,433	53,000	52,885
	Pumping NERT (SWF)	110,562	110,000	111,018
	Pumping OSSM	24,834	29,000	29,125
	Pumping AMPAC	49,460	99,000	33,095
	Outflow to the Wash	470,327	724,000	336,510
	Evapotranspiration	286	NE	5,733
Total Outflow (cfd)		**720,570**	**1,027,000**	**580,378**

Notes:

cfd = cubic feet per day

UMCF = Upper Muddy Creek Formation

NE = Not Evaluated

IWF = Interceptor Well Field

AWF = Athens Road Well Field

SWF = Seep Well Field

AMPAC = American Pacific Corporation

NERT = Nevada Environmental Response Trust

OSSM = Olin Chlor-Alkali/Stauffer/Syngenta/Montrose

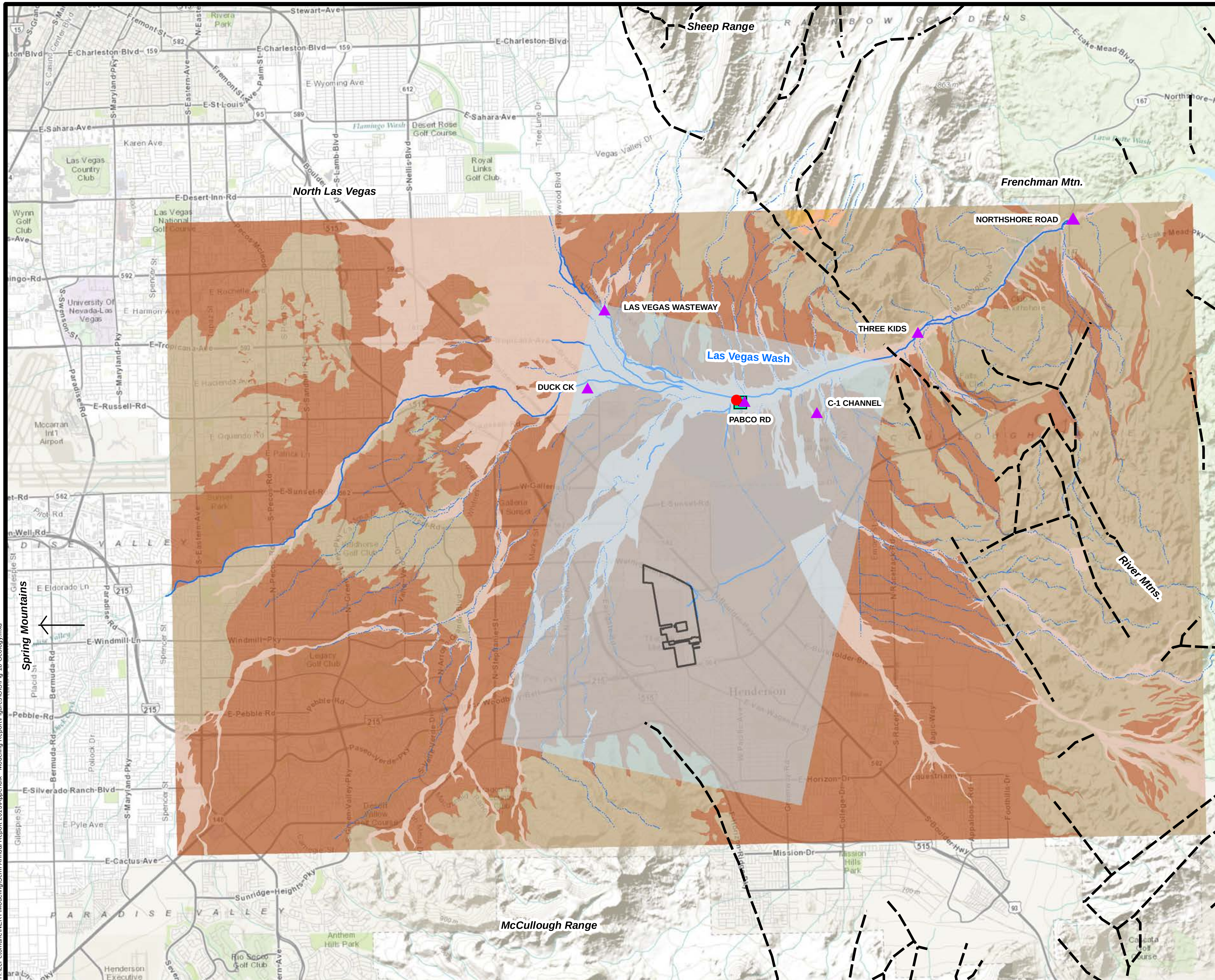
TABLE 6: CALIBRATION STATISTICS

Nevada Environmental Response Trust Site

Henderson, Nevada

Parameters	Northgate Model	Phase I (Northgate Targets)	Phase I Model (Revised Targets)
Residual Mean (RM) in feet	1.76	-0.58	0.02
RMS Error	7.61	7.82	8.55
Residual Standard Deviation	7.40	7.80	8.55
Range of Observations	285.84	286.23	310.17
Residual Sum of Squares	1.52×10^4	1.54×10^4	3.25×10^4
Number of Observations	263	251	444

Figures



EXPLANATION

- USGS Stream Gauge Station
- City Of Henderson -Outfall
- NERT/AMPAC/TIMET Outfall
- NERT Property Boundary
- Study Area

Geology

- Permian
- Quaternary
- Tertiary
- Triassic
- Modern wash deposits
- Fault Lines

Geological Map Reference:

E.C.Bingler, 1977, Geologic Map of the Las Vegas SE Quadrangle, Nevada: Nevada Bureau of Mines and Geology Map 3Ag, 1:24,000 scale

Bell, J.W., 1980, Geologic Map of the Henderson Quadrangle, Nevada: Nevada Bureau of Mines and Geology Map 67, 1:24,000 scale

N S W E

0 1.25 2.5 Miles

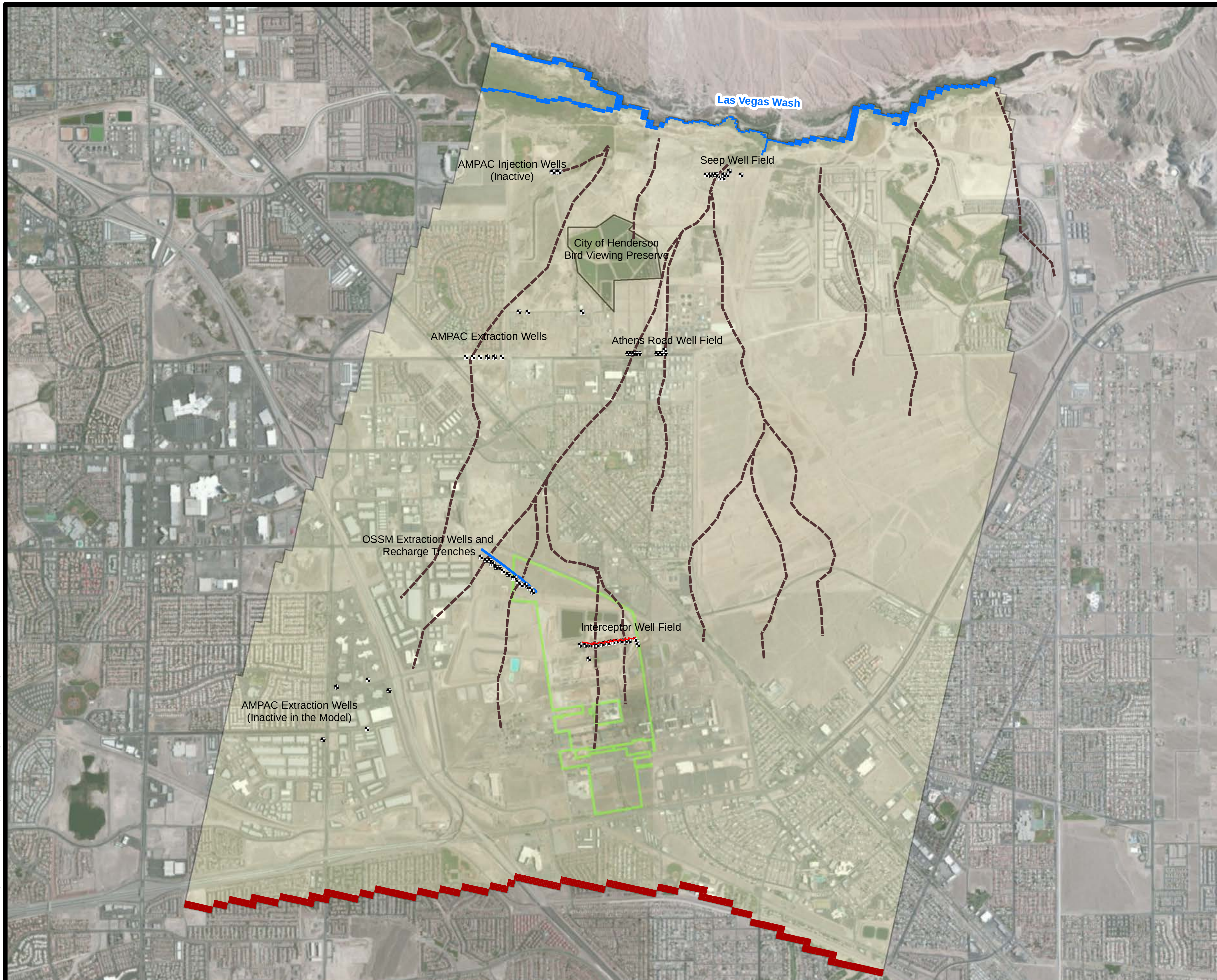
ENVIRON

LOCATION MAP

Nevada Environmental Response Trust Site
Henderson, Nevada

Date: 2/28/2014	Contract Number: 21-34800H		Figure 1
Drafter: AS	Approved:	Revised:	

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 1b-Geology.mxd



EXPLANATION

- Extraction Wells
- Slurry Wall
- OSSM Recharge Trenches
- Paleochannels
- Stream Boundary
- Specified Flux Boundary
- Revised Model Domain
- NERT Property Boundary

NERT = Nevada Environmental Response Trust
AMPAC = American Pacific Corporation
OSSM = Olin/Stauffer/Syngenta/Montrose

N W E S

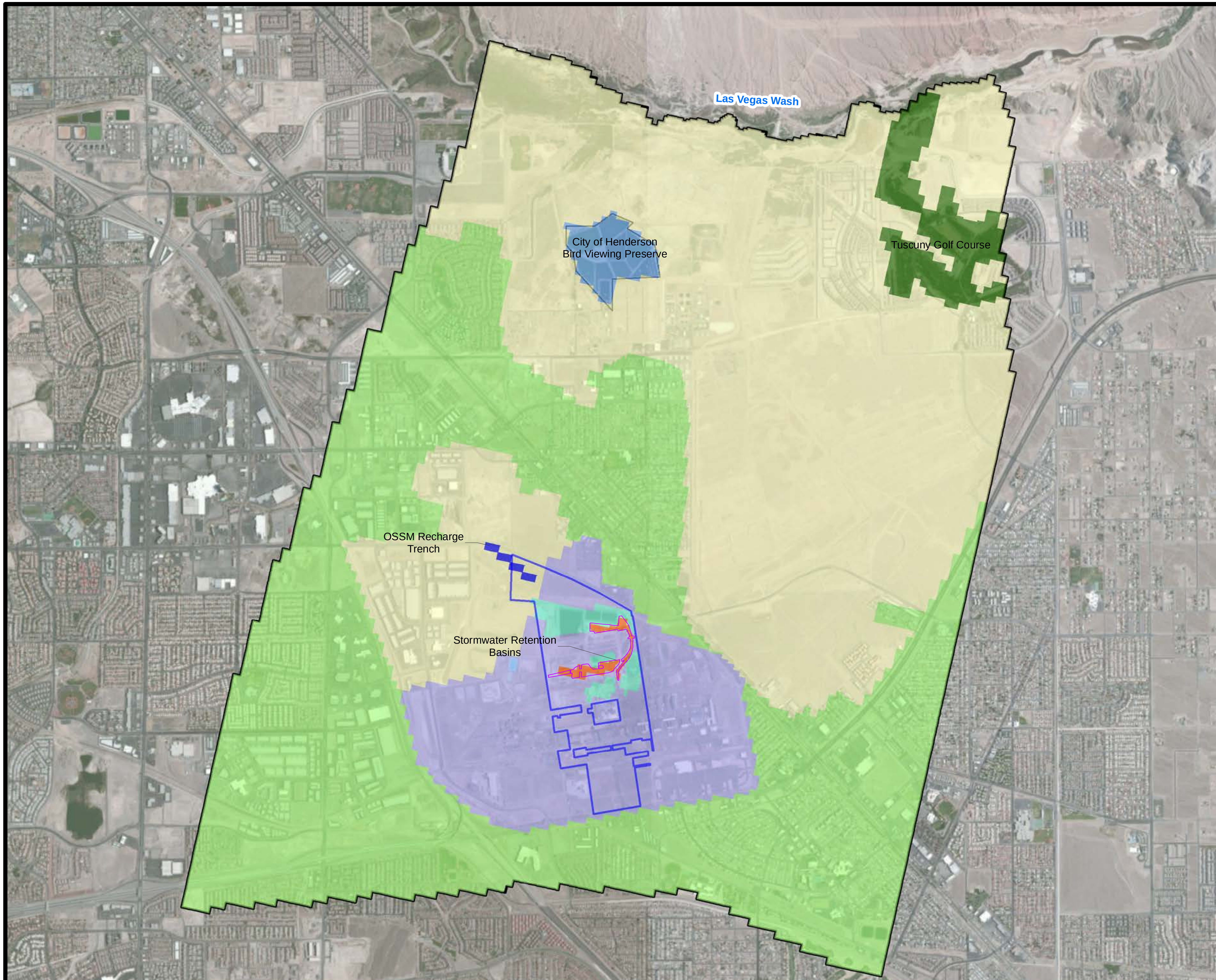
0 0.5 1 Miles

ENVIRON

GROUNDWATER MODEL EXTENT
Nevada Environmental Response Trust Site
Henderson, Nevada

Date: 2/28/2014	Contract Number: 21-34800H		Figure
Drafter: AS	Approved:	Revised:	2

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 2-Model Boundary.mxd



EXPLANATION

- Stormwater Retention Basins
- NERT Property Boundary

Areal Recharge (ft/d)

- Lined Ponds (0)
- Undeveloped Areas (1.8E-5)
- Residential Area (5.6E-5)
- Industrial Area (4.3E-4)
- Retention Basin (1E-3)
- Tuscany Golf Course (1.8E-3)
- COH Birding Pond (1.5E-2)
- OSSM Recharge Trench (1.1E-1)
- Revised Model Domain

NERT = Nevada Environmental Response Trust
AMPAC = American Pacific Corporation
OSSM = Olin/Stauffer/Syngenta/Montrose
ft/d = feet per day

N W E S

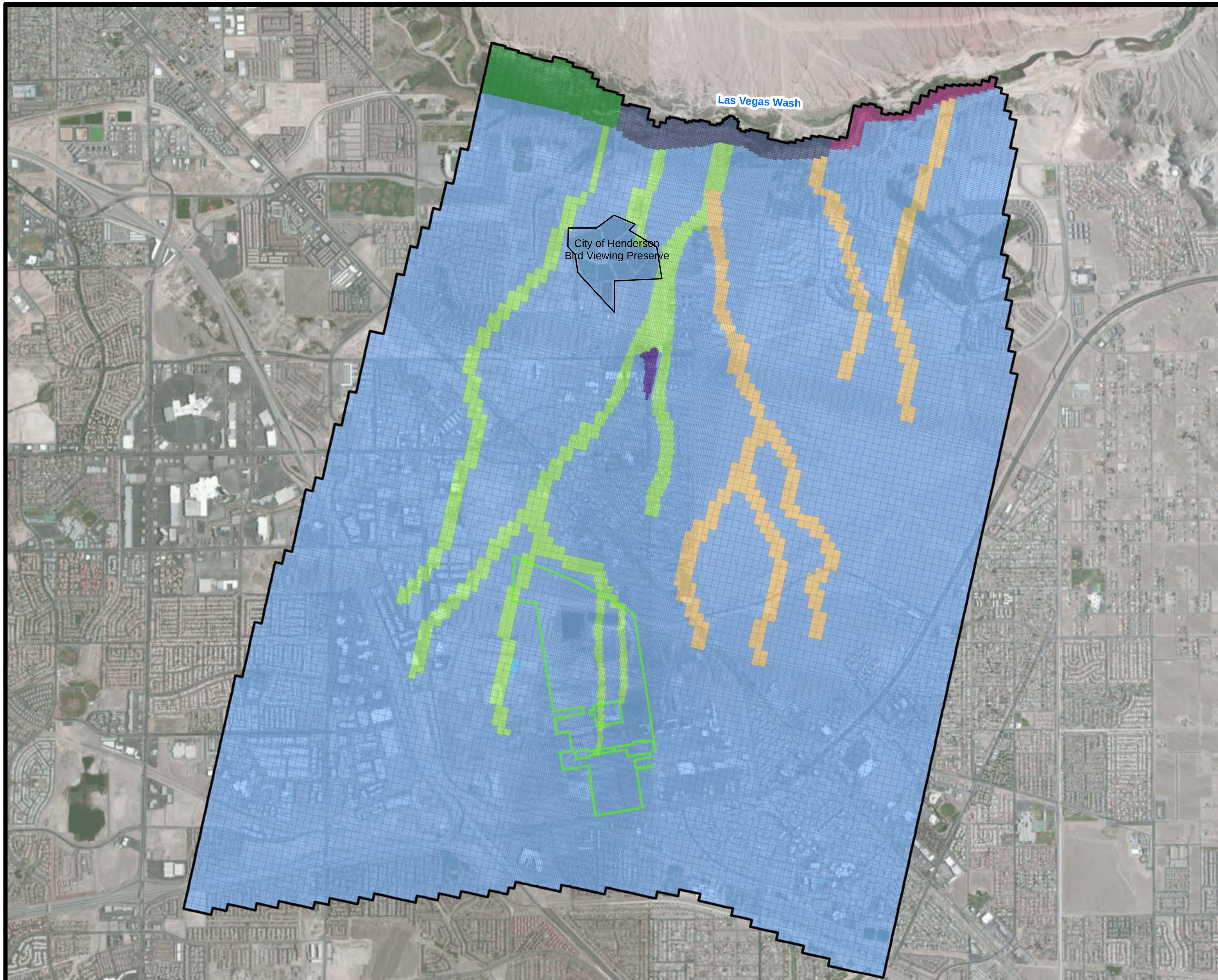
0 0.5 1 Miles

ENVIRON

AREAL RECHARGE DISTRIBUTION
Nevada Environmental Response Trust Site
Henderson, Nevada

Date: 2/28/2014	Contract Number: 21-34800H		Figure 3
Drafter: AS	Approved:	Revised:	

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 3-Areal Recharge.mxd



EXPLANATION

- NERT Property Boundary
- Revised Model Domain

Hydraulic Conductivity (ft/d)

- 0.72
- 35
- 100
- 200
- 250
- 300
- 485

ft/d = feet per day

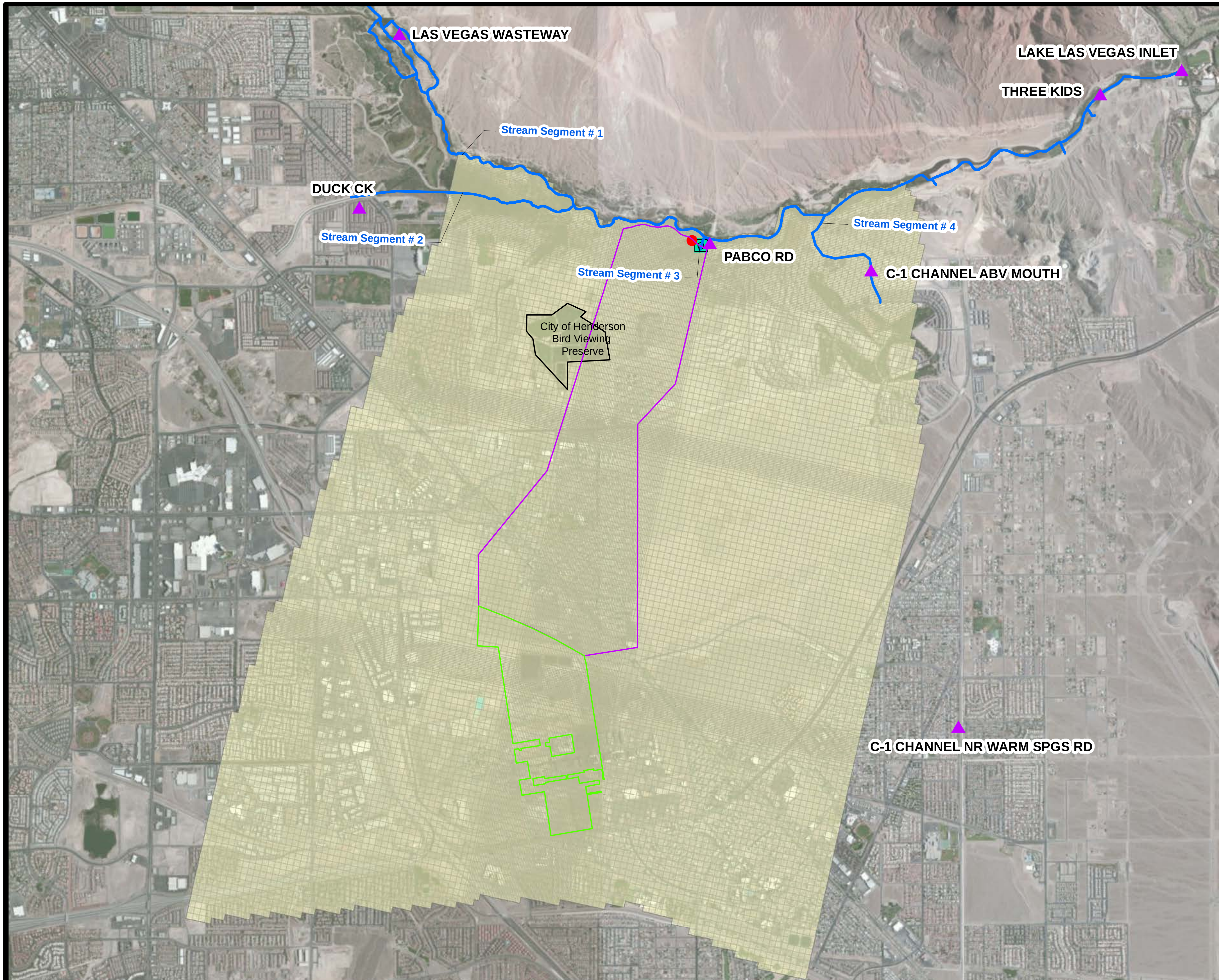
ENVIRON

HYDRAULIC CONDUCTIVITY - LAYER 1

Nevada Environmental Response Trust Site
Henderson, Nevada

Date: 2/28/2014	Contract Number: 21-34800H		Figure
Drafter: AS	Approved:	Revised:	4

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 4-Hydraulic Conductivity Distribution.mxd



EXPLANATION

- USGS Stream Gauge Station
- Las Vegas Wash Centerline
- City Of Henderson -Outfall
- NERT/AMPAC/TIMET Outfall Locations
- Revised Model Domain
- Site Boundary
- Downgradient Plume Area

Note: The outfall locations are approximate.

N W E S

0 0.5 1 Miles

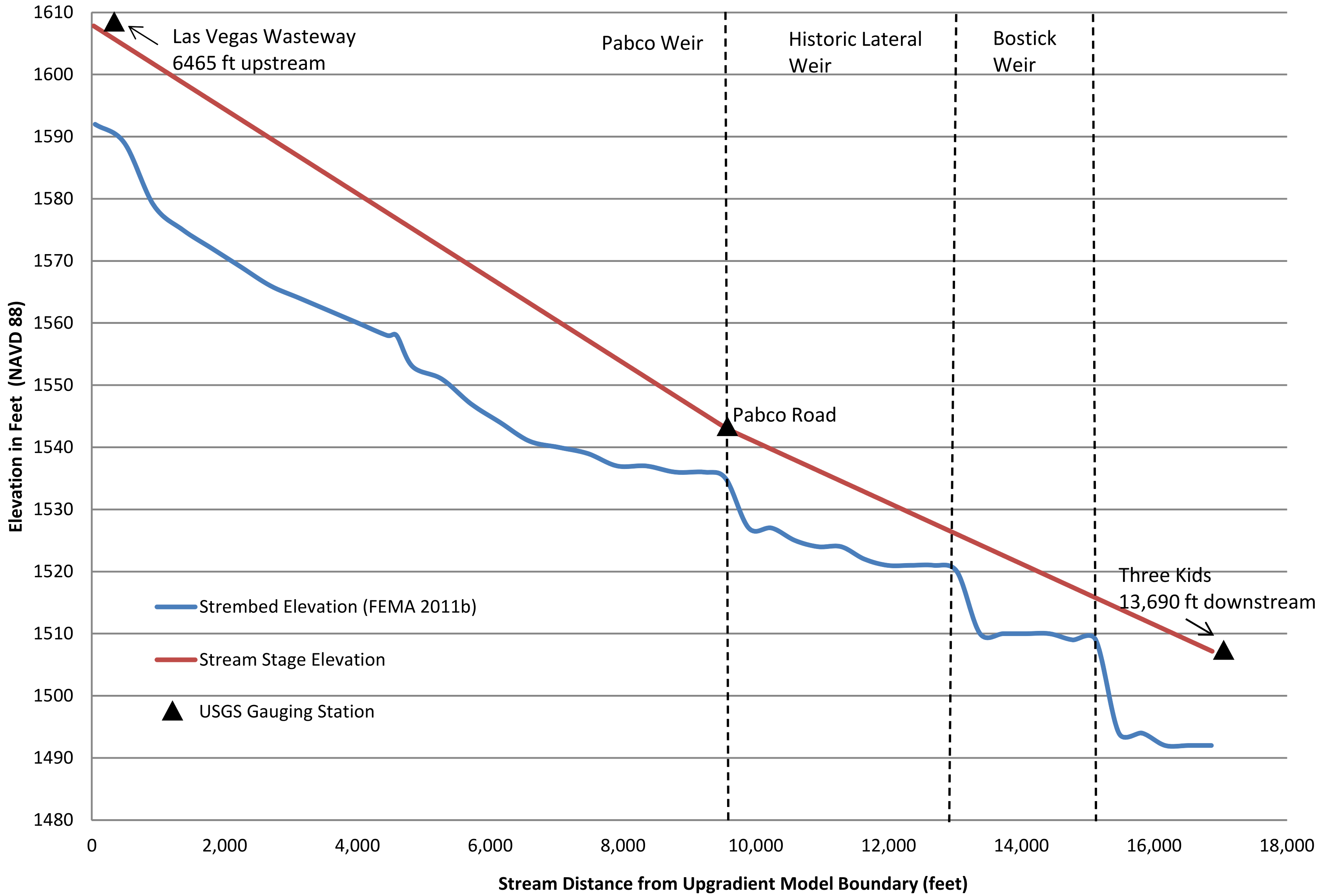
ENVIRON

MEASURED OUTFALL & STREAMFLOW LOCATIONS
Las Vegas Wash
Nevada Environmental Response Trust Site
Henderson, Nevada

Date: 2/28/2014	Contract Number: 21-34800H		Figure 5
Drafter: AS	Approved:	Revised:	

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 5-Las Vegas Wash Measured Outfall Locations.mxd

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 6- streamstage and streambed elevation.mxd

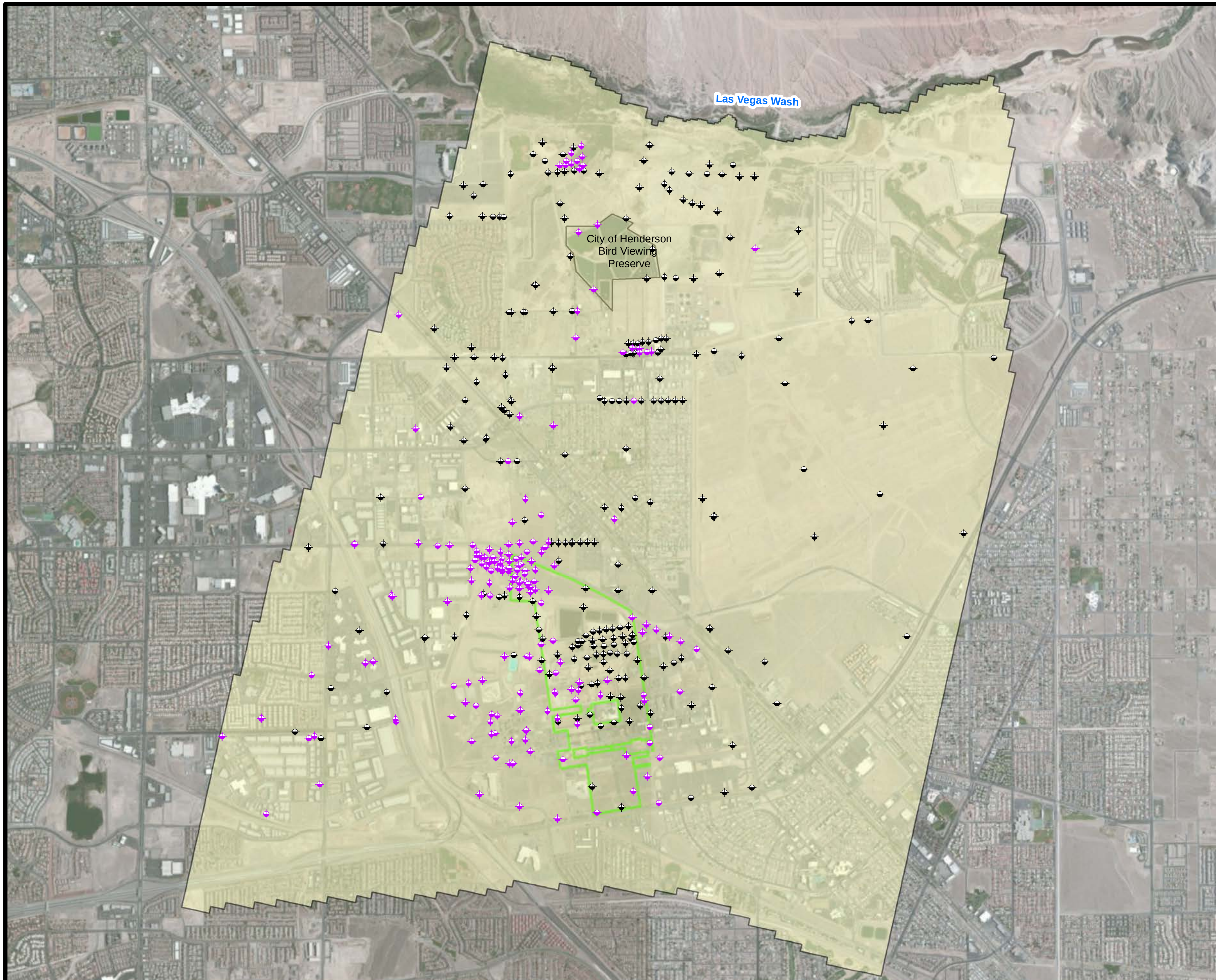


ENVIRON

Las Vegas Wash Stream Stage and Streambed Elevation
Nevada Environmental Response Trust Site
Henderson, Nevada

Figure
6

Drafter: RS | Date: 2/28/2014 | Contract Number: 21-34800H | Approved: | Revised:



EXPLANATION

Model Targets

- Existing Model
- Additional Locations
- NERT Property Boundary
- Revised Model Domain

N
W E
S

0 0.5 1
Miles

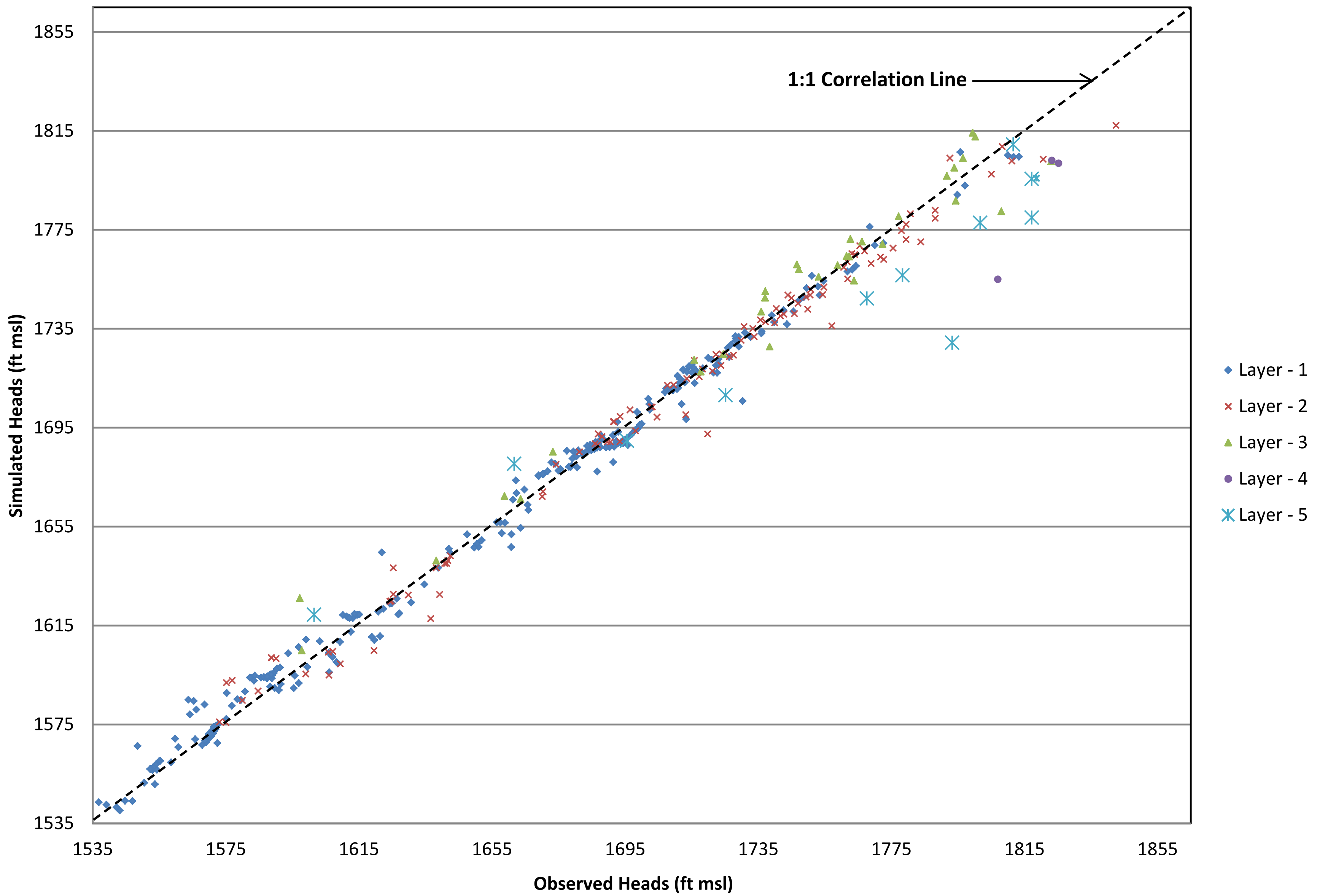
ENVIRON

MODEL TARGETS
Nevada Environmental Response Trust Site
Henderson, Nevada

Date: 2/28/2014	Contract Number: 21-34800H		Figure 7
Drafter: AS	Approved:	Revised:	

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 7-Model Targets.mxd

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 9- Model_Calibration.mxd

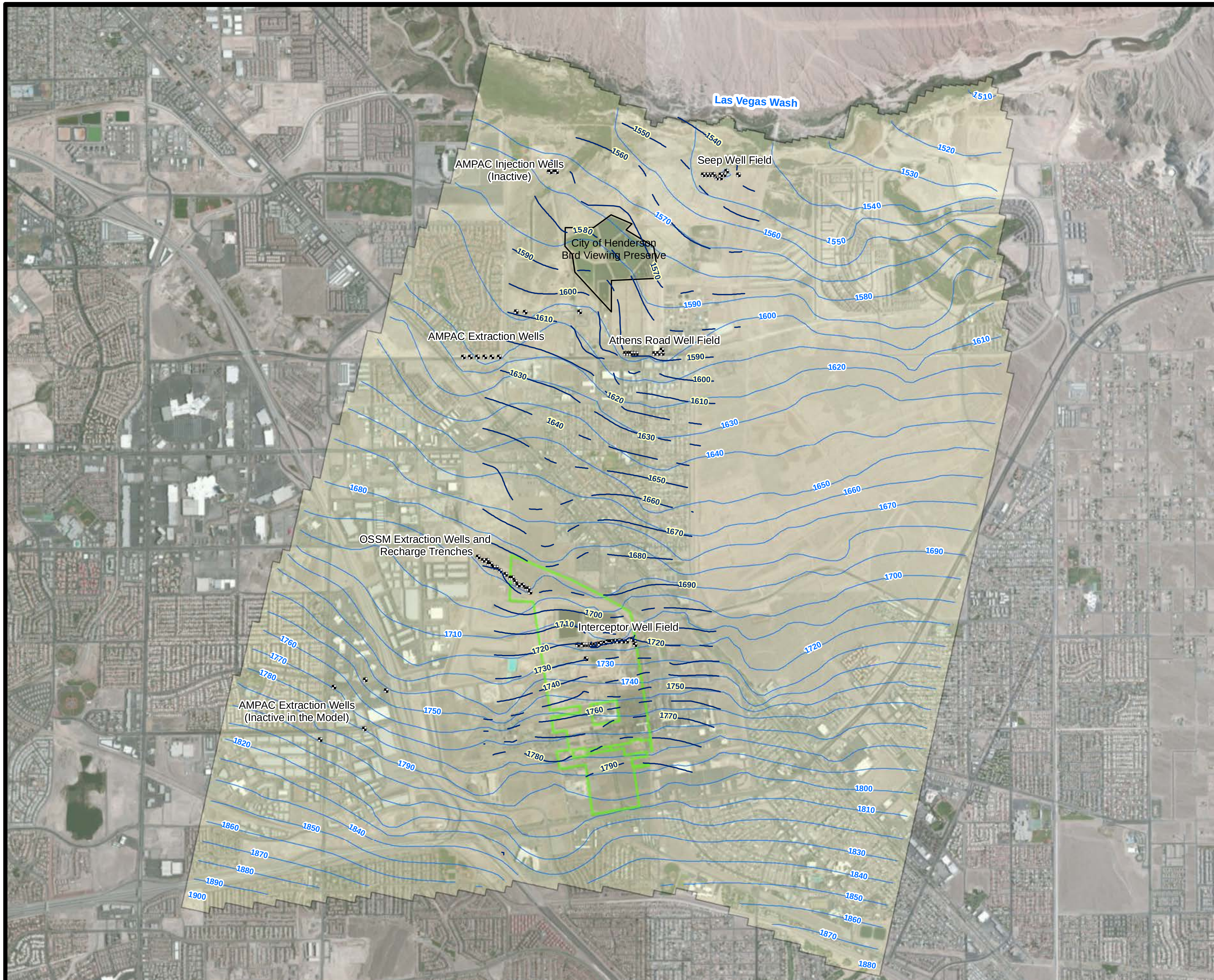


ENVIRON

Observed Versus Simulated Groundwater Elevation
Nevada Environmental Response Trust Site
Henderson, Nevada

Figure **8**

Drafter: RS | Date: 2/28/2014 | Contract Number: 21-34800H | Approved: | Revised:



EXPLANATION

- Extraction Wells
- Simulated Heads (ft amsl)
- Groundwater Elevations (ENVIRON 2012)
- NERT Property Boundary
- Revised Model Domain

NERT = Nevada Environmental Response Trust
AMPAC = American Pacific Corporation
OSSM = Olin/Stauffer/Syngenta/Montrose

N W E S

0 0.5 1 Miles

ENVIRON

SIMULATED GROUNDWATER ELEVATION
Nevada Environmental ResponseTrust Site
Henderson, Nevada

Date: 2/28/2014	Contract Number: 21-34800H		Figure 9
Drafter: AS	Approved:	Revised:	

Path: H:\LePetomane\NERT\Modeling\Semi-Annual Report 2013\Appendix - Modeling Report\Figures\GIS\Fig 9-Simulated Groundwater Elevations_v2.mxd

Appendix A

Model Target Groundwater Elevations

APPENDIX A: GROUNDWATER ELEVATIONS - SECOND QUARTER 2012

Nevada Environmental Response Trust Site

Henderson, Nevada

Observation Well Name	Easting	Northing	Target (ft amsl)	Mid-Screen Elevation (ft amsl)	Group
AA-01	830921.12	26720238.47	1,708.42	1,718.13	1
AA-08	827756.55	26733208.24	1,565.80	1,561.19	1
AA-09	831041.59	26723441.40	1,657.94	1,648.73	1
AA-10	825935.16	26730040.80	1,595.76	1,590.35	1
AA-13	833889.39	26722860.98	1,662.15	1,676.69	1
AA-18	836690.87	26727656.38	1,609.34	1,614.50	1
AA-20	831811.84	26728007.71	1,599.15	1,608.49	1
AA-21	826148.08	26734078.78	1,572.51	1,560.20	1
AA-22	833425.59	26731586.01	1,553.70	1,560.53	1
AA-27	832471.34	26719301.66	1,721.55	1,717.88	1
AA-BW-02A	826041.40	26720214.67	1,707.71	1,705.80	1
AA-BW-03A	825973.66	26720593.46	1,702.31	1,698.63	1
AA-BW-04A	825492.25	26721142.81	1,692.99	1,689.49	1
AA-BW-05A	825065.41	26721183.83	1,698.19	1,682.40	1
AA-BW-06A	824476.16	26721238.26	1,699.49	1,698.40	1
AA-BW-07A	823979.46	26720637.98	1,702.44	1,699.73	1
AA-BW-08A	825332.70	26719492.77	1,712.49	1,715.68	1
AA-MW-07	826126.54	26719344.40	1,726.29	1,713.72	1
AA-UW1	831427.20	26719624.99	1,722.32	1,714.63	1
AA-UW2	832819.54	26718117.11	1,754.38	1,756.38	1
AA-UW4	836517.02	26720029.40	1,757.14	1,754.88	1
AA-UW5	838134.66	26722958.50	1,719.85	1,721.51	1
AAX-15	823068.13	26728783.01	1,627.14	1,621.80	1
ACX-16	823946.00	26724229.00	1,670.10	1,659.10	1
ACY-15	821545.80	26723985.40	1,691.40	1,679.70	1
ADX-135	821150.50	26717438.90	1,808.06	1,665.15	1
AEX-35	821720.40	26718438.60	1,745.05	1,737.70	1
AGX-160	822790.37	26719978.45	1,738.45	1,580.40	1
AGX-50	822804.72	26719991.41	1,713.51	1,690.36	1
AMX-40	820936.20	26720195.70	1,729.87	1,711.20	1
APX-1-45	825255.70	26729255.10	1,609.43	1,573.70	1
APX-2-45	825650.90	26729263.00	1,606.05	1,571.10	1
APX-2-P1O1	825601.60	26729261.20	1,606.08	1,594.50	1
APX-4-20	826451.20	26729275.10	1,607.17	1,595.70	1
APX-5-16	827009.30	26729285.00	1,605.87	1,595.40	1
APX-5-7	826987.80	26729285.20	1,605.95	1,606.10	1
APX-7-14	825193.10	26729254.30	1,608.73	1,598.20	1
ARP-1	828593.16	26728365.51	1,588.55	1,584.32	1
ARP-2	828726.35	26728363.61	1,588.67	1,579.29	1
ARP-3	828860.77	26728364.89	1,587.66	1,583.17	1
ARP-4A	829167.89	26728411.81	1,585.61	1,590.27	1
ARP-5A	829375.01	26728458.43	1,582.78	1,590.90	1

APPENDIX A: GROUNDWATER ELEVATIONS - SECOND QUARTER 2012
Nevada Environmental Response Trust Site
Henderson, Nevada

Observation Well Name	Easting	Northing	Target (ft amsl)	Mid-Screen Elevation (ft amsl)	Group
ARP-6B	829520.52	26728499.92	1,582.72	1,580.36	1
ARP-7	829668.22	26728501.08	1,582.28	1,586.70	1
BEC-4	830699.33	26723946.72	1,651.96	1,648.84	1
BEC-9	833049.52	26727221.50	1,597.29	1,566.24	1
BRW-R1	831558.84	26716928.10	1,797.12	1,794.15	1
CLD3-R	829651.41	26720010.74	1,716.71	1,752.24	1
CLD4-R	829034.28	26718854.29	1,743.67	1,781.96	1
DBMW-14	838987.26	26727957.62	1,636.57	1,634.96	1
DBMW-19	831488.74	26731383.23	1,548.48	1,555.90	1
DBMW-2	830530.28	26728059.44	1,593.80	1,597.00	1
DBMW-3	831032.81	26728150.18	1,596.90	1,596.86	1
DBMW-5	833398.98	26729807.56	1,584.71	1,584.65	1
DBMW-8	835406.87	26729027.21	1,575.24	1,574.55	1
DX-30	819846.50	26717128.90	1,805.10	1,790.20	1
DX-75	819846.60	26717139.50	1,819.96	1,745.10	1
DY-26	820125.60	26718551.10	1,779.46	1,764.60	1
FX-25	820249.00	26721316.00	1,727.62	1,722.30	1
H-21R	824914.54	26721148.51	1,699.05	1,692.85	1
H-28	825871.32	26721021.82	1,693.57	1,688.95	1
H-55	823645.49	26720010.20	1,710.92	1,715.65	1
H-58A	825642.55	26723331.88	1,664.78	1,646.43	1
J2D1-R2	829885.78	26719274.00	1,729.08	1,741.88	1
J2D2-R2	830098.48	26719406.73	1,725.82	1,736.46	1
J2D4	829582.57	26719171.05	1,736.03	1,744.29	1
KX-18	823949.00	26726751.40	1,634.70	1,629.40	1
KY-23	824268.80	26727268.40	1,626.40	1,620.60	1
M-11	828617.03	26717608.56	1,772.72	1,772.38	1
M-111A	827447.19	26719134.86	1,733.84	1,734.07	1
M-115	827243.65	26718612.90	1,749.92	1,747.64	1
M-120	828387.79	26715162.90	1,800.27	1,788.58	1
M-126	826569.37	26719505.57	1,724.18	1,729.31	1
M-12A	828178.52	26717575.29	1,771.79	1,767.76	1
M-13	827806.03	26717477.66	1,768.51	1,776.89	1
M-131	827158.08	26719770.57	1,721.29	1,720.43	1
M-133	828698.61	26720067.29	1,715.80	1,678.92	1
M-135	827154.48	26719890.17	1,717.31	1,718.15	1
M-14A	827045.36	26719382.67	1,728.39	1,730.93	1
M-152	826973.49	26722690.63	1,673.33	1,563.50	1
M-153	828385.63	26718288.08	1,763.83	1,636.69	1
M-17A	828061.72	26719053.74	1,735.99	1,728.99	1
M-19	828846.19	26719350.03	1,731.02	1,742.27	1
M-22A	828270.11	26719531.63	1,728.28	1,733.46	1

APPENDIX A: GROUNDWATER ELEVATIONS - SECOND QUARTER 2012
Nevada Environmental Response Trust Site
Henderson, Nevada

Observation Well Name	Easting	Northing	Target (ft amsl)	Mid-Screen Elevation (ft amsl)	Group
M-23	827373.96	26721391.25	1,686.92	1,696.95	1
M-25	827677.80	26719503.57	1,726.32	1,728.43	1
M-31A	828368.37	26718289.58	1,750.64	1,751.87	1
M-34	828318.25	26718833.45	1,739.82	1,741.10	1
M-35	828509.37	26718840.13	1,739.99	1,740.28	1
M-36	828069.09	26719556.63	1,726.94	1,732.32	1
M-37	827414.22	26719422.01	1,728.97	1,733.56	1
M-38	827877.66	26719523.27	1,728.20	1,732.23	1
M-39	828548.82	26719525.34	1,729.20	1,728.73	1
M-44	827005.61	26722699.15	1,675.59	1,678.31	1
M-48	828303.85	26721337.52	1,692.41	1,699.68	1
M-50	828083.47	26718315.58	1,749.40	1,746.04	1
M-52	828394.48	26717985.39	1,761.94	1,762.42	1
M-57A	826993.31	26719716.74	1,723.81	1,723.44	1
M-61	828671.94	26719953.97	1,722.68	1,722.78	1
M-64	827601.30	26719748.40	1,719.97	1,724.76	1
M-65	827899.72	26719746.36	1,720.99	1,727.21	1
M-66	828183.64	26719787.47	1,722.29	1,724.34	1
M-67	828508.52	26719829.72	1,723.14	1,723.11	1
M-68	828751.00	26719864.47	1,722.91	1,724.73	1
M-69	827265.73	26719885.28	1,716.01	1,720.15	1
M-70	827567.35	26719904.69	1,712.53	1,720.60	1
M-71	827859.71	26719943.63	1,711.45	1,717.29	1
M-72	828172.13	26719977.14	1,714.20	1,724.04	1
M-73	828427.82	26720018.47	1,711.78	1,717.74	1
M-74	828713.65	26720062.18	1,713.59	1,720.38	1
M-75	827718.82	26718702.64	1,741.70	1,742.26	1
M-76	827550.73	26718659.92	1,745.89	1,743.27	1
M-77	828932.32	26718046.00	1,763.33	1,763.21	1
M-79	827382.10	26720048.92	1,710.78	1,719.43	1
M-83	827584.70	26720159.92	1,709.37	1,717.22	1
M-84	827766.70	26720189.13	1,715.94	1,718.08	1
M-85	827962.63	26720219.88	1,711.86	1,719.82	1
M-86	828141.82	26720238.99	1,710.62	1,718.13	1
M-87	828358.13	26720276.13	1,707.02	1,720.08	1
M-88	828588.75	26720313.96	1,707.27	1,717.30	1
M-89	827890.08	26719294.84	1,732.76	1,738.09	1
M-93	827143.44	26717685.92	1,761.75	1,757.14	1
M-94	827222.85	26722695.81	1,680.61	1,678.07	1
M-95	827426.74	26722701.69	1,678.64	1,677.09	1
M-96	827626.08	26722700.30	1,678.14	1,678.02	1
M-97	827492.47	26717795.18	1,760.72	1,760.85	1

APPENDIX A: GROUNDWATER ELEVATIONS - SECOND QUARTER 2012
Nevada Environmental Response Trust Site
Henderson, Nevada

Observation Well Name	Easting	Northing	Target (ft amsl)	Mid-Screen Elevation (ft amsl)	Group
M-99	827309.69	26720851.72	1,698.63	1,707.24	1
MCF-01B	830888.59	26720256.83	1,709.63	1,686.28	1
MCF-05	832871.21	26728512.84	1,601.51	1,401.37	1
MCF-06C	834945.84	26729004.59	1,576.94	1,581.62	1
MCF-09A	831024.27	26723427.11	1,661.63	1,415.87	1
MCF-09B	831019.19	26723449.62	1,658.74	1,580.77	1
MCF-10B	825951.40	26730022.81	1,597.80	1,521.86	1
MCF-16C	835846.38	26726030.18	1,625.37	1,628.98	1
MCF-32B	835753.14	26724074.91	1,663.59	1,582.70	1
MW-D2D	819110.50	26717312.60	1,823.05	1,772.30	1
MW-J	824962.00	26725010.00	1,658.89	1,650.50	1
MW-K	823523.00	26725991.00	1,651.01	1,648.60	1
MW-K1	827777.00	26726810.00	1,625.35	1,618.55	1
MW-K4	828994.00	26728410.00	1,586.45	1,585.95	1
MW-K5	829617.00	26730252.00	1,563.80	1,553.05	1
MW-R	825423.00	26725016.00	1,656.47	1,641.90	1
MW-S	826941.00	26730853.00	1,583.47	1,576.20	1
MW-T	826644.00	26732347.00	1,576.86	1,562.20	1
MW-U	826312.00	26733219.00	1,575.14	1,563.50	1
MW-V	825243.00	26733189.00	1,579.99	1,575.20	1
NX-17	823645.90	26727961.68	1,626.90	1,623.97	1
NY-15	823414.10	26727670.20	1,630.75	1,626.90	1
OX-16	824203.08	26727965.13	1,621.38	1,619.75	1
OY-8	824123.60	26728244.00	1,619.67	1,613.60	1
PC-101R	828711.72	26728107.74	1,588.20	1,583.12	1
PC-103	829110.87	26730205.73	1,575.31	1,580.49	1
PC-104	829277.08	26731049.70	1,566.14	1,574.18	1
PC-108	828526.96	26731913.05	1,571.95	1,557.61	1
PC-110	826778.31	26731928.11	1,579.55	1,572.77	1
PC-112	828898.31	26732800.69	1,560.73	1,548.15	1
PC-12	829430.43	26728102.92	1,587.41	1,594.07	1
PC-123	829485.04	26727358.44	1,603.26	1,598.94	1
PC-124	830132.95	26726741.58	1,610.23	1,607.93	1
PC-125	829925.95	26726739.82	1,611.34	1,608.86	1
PC-126	829724.72	26726737.84	1,611.74	1,607.33	1
PC-127	829316.65	26726735.62	1,613.20	1,607.42	1
PC-128	828953.97	26726732.39	1,614.48	1,608.56	1
PC-130	828538.19	26726729.31	1,613.70	1,600.91	1
PC-131	828123.28	26726725.41	1,622.37	1,608.78	1
PC-132	827913.94	26726723.10	1,624.95	1,610.04	1
PC-134	828776.17	26728126.42	1,590.12	1,552.31	1
PC-135	828765.25	26728123.18	1,588.87	1,582.55	1

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PC-136	829517.89	26728191.37	1,583.68	1,587.02	1
PC-17	828732.63	26728089.23	1,588.99	1,586.50	1
PC-18	828636.25	26728079.97	1,589.41	1,587.00	1
PC-2	830443.45	26730209.58	1,568.64	1,575.57	1
PC-21A	829269.53	26721332.72	1,692.65	1,700.52	1
PC-24	829524.18	26726729.82	1,612.27	1,610.98	1
PC-28	828530.65	26725375.67	1,638.86	1,636.10	1
PC-31	826781.65	26725195.83	1,647.54	1,625.86	1
PC-37	826612.10	26722172.24	1,679.01	1,678.42	1
PC-4	831171.80	26730353.42	1,564.25	1,570.22	1
PC-50	828326.94	26726722.30	1,620.87	1,606.66	1
PC-53	829941.58	26730225.29	1,565.41	1,572.28	1
PC-54	828296.34	26722067.79	1,682.42	1,682.43	1
PC-55	828530.49	26728056.66	1,590.41	1,583.18	1
PC-56	830645.29	26732289.43	1,553.02	1,538.45	1
PC-58	831123.78	26732118.20	1,552.53	1,547.71	1
PC-59	830150.30	26732452.69	1,554.06	1,548.12	1
PC-60	830405.14	26732358.75	1,553.32	1,546.38	1
PC-62	829764.28	26732733.52	1,554.94	1,545.23	1
PC-64	827916.52	26723702.44	1,665.71	1,663.79	1
PC-65	828386.90	26723682.74	1,665.93	1,663.81	1
PC-66	828779.40	26723966.95	1,660.87	1,656.63	1
PC-67	829207.80	26723846.87	1,660.79	1,650.52	1
PC-68	829616.96	26732906.82	1,555.32	1,534.57	1
PC-71	826805.90	26722687.72	1,675.00	1,677.83	1
PC-72	826604.72	26722688.82	1,670.57	1,674.43	1
PC-73	826404.90	26722694.93	1,669.08	1,667.00	1
PC-74	829203.52	26734003.52	1,552.65	1,520.84	1
PC-76	829183.79	26734006.74	1,552.24	1,547.60	1
PC-77	829031.63	26733568.07	1,558.60	1,532.40	1
PC-80	829823.82	26733250.46	1,554.30	1,539.68	1
PC-82	830316.93	26733194.96	1,550.54	1,507.15	1
PC-86	830826.99	26733185.76	1,547.01	1,531.35	1
PC-88	831259.41	26733178.42	1,543.14	1,506.01	1
PC-92	831749.30	26733109.85	1,539.18	1,535.55	1
PC-93	832179.60	26733117.81	1,536.82	1,516.26	1
PC-96	830896.56	26733450.83	1,544.75	1,518.57	1
PC-97	831565.69	26733441.54	1,542.20	1,520.53	1
POD8	833586.10	26724789.80	1,621.89	1,691.16	1
POU3	831329.98	26721664.71	1,689.38	NA	1
PX-40	824778.75	26727968.46	1,619.56	1,590.04	1
PY-14	825017.12	26727951.78	1,618.92	1,617.58	1

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SB-1-8	824928.20	26731968.90	1,588.35	1,592.20	1
SB-2-7	824742.70	26731972.20	1,591.53	1,594.20	1
SB-29-3	825052.30	26731965.60	1,589.70	1,595.10	1
SB-3-13	824433.70	26731978.50	1,599.05	1,594.70	1
SB-5-5	823505.90	26731993.00	1,608.27	1,605.60	1
SBMW-11-11	824459.80	26732893.90	1,590.96	1,589.00	1
SBMW-18-5	824190.70	26732562.50	1,596.98	1,596.10	1
SBMW-6-12	823897.80	26732861.90	1,595.43	1,588.90	1
TIMETMW-4	830973.92	26718582.87	1,748.75	1,752.61	1
TIMETMW-5	830385.81	26718063.61	1,761.85	1,762.47	1
TIMETMW-6R	829221.18	26717836.95	1,768.97	1,762.96	1
TMMW-102	830371.18	26715433.08	1,810.06	1,815.46	1
TMMW-103	831325.82	26715583.05	1,811.79	1,810.95	1
TMMW-104	832104.88	26715722.71	1,813.35	1,813.78	1
TR-10	827562.53	26715739.77	1,793.94	1,764.06	1
TR-2	826156.85	26719954.57	1,724.57	1,592.29	1
TR-3	826342.89	26718941.61	1,778.39	1,538.34	1
TR-4	826342.53	26718951.58	1,735.93	1,638.05	1
TR-5	826595.86	26717592.13	1,801.72	1,564.27	1
TR-9	827560.22	26715752.71	1,811.60	1,614.29	1
TWA-20	823910.40	26725603.50	1,650.55	1,645.90	1
TWB-21	825054.30	26726461.00	1,641.73	1,628.60	1
TWBX-21	825214.90	26726338.40	1,642.54	1,630.40	1
TWBY-21	824976.90	26726538.30	1,641.39	1,629.60	1
TWBY-36	824987.70	26726539.50	1,640.81	1,614.80	1
TWC-15	825243.90	26726761.20	1,638.28	1,630.00	1
TWC-48	825263.10	26726714.00	1,638.26	1,592.50	1
TWD1-17	824527.20	26725647.10	1,649.79	1,642.10	1
TWD4-15	824560.30	26725671.20	1,649.74	1,643.70	1
TWE-15	826426.20	26727676.60	1,624.35	1,616.90	1
TWE-18	826426.70	26727666.40	1,624.38	1,610.70	1
TWE-33	826427.00	26727656.30	1,624.70	1,594.20	1
TWH-14	825097.20	26727472.80	1,629.86	1,624.70	1
UC-1	825882.70	26733747.80	1,575.12	1,556.20	1
UC-3	826729.20	26733740.60	1,570.59	1,562.10	1
UC-4	827027.30	26733933.70	1,569.04	1,555.70	1
UD-2	826218.40	26733561.40	1,573.11	1,571.20	1
UWO-16	826575.50	26733241.60	1,572.67	1,555.90	1
UXO-16	826778.31	26733263.60	1,571.42	1,553.50	1
UYO-16	827047.00	26733277.70	1,570.74	1,551.60	1
UZO-17	827323.40	26733274.00	1,570.00	1,551.50	1
WS1-14	821616.20	26722663.10	1,704.59	1,694.00	1

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ZX-11	819494.20	26722564.50	1,730.32	1,717.20	1
AA-BW-01A	826112.39	26719802.79	1,715.50	1,711.56	2
AA-BW-09A	825703.31	26719455.90	1,715.03	1,720.12	2
AA-BW-12A	824440.21	26718772.36	1,728.59	1,719.54	2
AA-MW-05	824351.37	26715530.83	1,794.86	1,797.56	2
AA-MW-13R	825265.78	26717045.47	1,770.05	1,762.74	2
AA-MW-14	825660.68	26717082.46	1,772.63	1,768.31	2
AA-MW-16	826447.64	26719904.41	1,718.32	1,722.61	2
AA-MW-20	824824.72	26716567.82	1,779.45	1,760.23	2
AA-MW-24	825495.58	26715179.28	1,792.66	1,788.58	2
AA-MW-25	825508.33	26717917.91	1,747.44	1,749.87	2
ADY-36	821333.30	26719305.80	1,737.22	1,720.20	2
ADY-70	821323.00	26719305.80	1,737.05	1,691.20	2
ADYX-165	821116.31	26719273.57	1,807.06	1,587.41	2
ADYX-38	821103.55	26719268.39	1,740.46	1,720.07	2
AFX-30	821985.53	26717595.85	1,764.37	1,760.63	2
AFX-75	821964.11	26717675.40	1,762.74	1,714.16	2
AK-204	821851.29	26721204.59	1,793.28	1,521.53	2
AK-25	821872.05	26721155.18	1,711.98	1,701.70	2
AK-86	821868.13	26721163.69	1,717.72	1,640.45	2
B01	825676.63	26717341.36	1,767.03	1,757.64	2
B16	823953.15	26718137.87	1,742.68	1,735.20	2
BHE1-10	828193.10	26723364.50	1,670.35	1,660.70	2
CLD1-R	828993.72	26720138.24	1,712.98	1,745.19	2
CP-1	825287.67	26716403.47	1,794.36	1,707.62	2
DMC-MW-26	825692.03	26717360.62	1,817.20	1,530.96	2
DMC-MW-27R	825211.51	26716407.16	1,818.60	1,582.80	2
DMC-MW-28	825775.48	26719450.04	1,767.65	1,488.03	2
DPT-01	825680.22	26717349.85	1,772.37	1,686.07	2
DX-161C	819657.50	26717192.60	1,825.29	1,651.40	2
DX-24	819502.00	26717126.30	1,811.28	1,801.00	2
DZ-15	818150.03	26717687.40	1,820.66	1,811.66	2
DZ-152	818149.68	26717703.43	1,823.30	1,674.18	2
EC-10	823570.10	26717752.81	1,749.55	1,746.08	2
EC-12	824795.32	26717268.65	1,766.22	1,679.37	2
EC-13	824661.58	26717593.80	1,762.34	1,676.29	2
EC-14	824258.28	26718049.25	1,753.14	1,672.42	2
EC-2	825069.70	26719453.56	1,715.83	1,711.43	2
EC-3	824697.84	26717247.43	1,763.17	1,744.04	2
EC-4	824135.84	26717035.31	1,765.53	1,751.48	2
EC-7	824698.68	26717808.89	1,745.65	1,743.47	2
E-S	825485.40	26721390.81	1,687.75	1,687.36	2

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F3-27	819578.43	26718923.53	1,783.86	1,762.93	2
H-10A	825185.53	26722638.83	1,672.91	1,672.46	2
H-11	826574.18	26714839.94	1,795.78	1,868.47	2
H-14	823168.07	26722605.48	1,695.74	1,709.57	2
H-18A	824126.38	26721612.61	1,698.70	1,691.36	2
H-19	824407.06	26721202.71	1,699.96	1,688.14	2
H-25	824166.68	26722628.35	1,695.83	1,707.51	2
H-36	825183.10	26721873.34	1,687.50	1,682.55	2
H-43	824660.68	26721179.60	1,699.45	1,694.72	2
H-43	824660.68	26721179.60	1,699.52	1,694.72	2
H-48	825658.27	26723952.95	1,655.38	NA	2
H-49A	826110.29	26723485.40	1,662.36	1,649.96	2
H-53	824507.76	26722290.36	1,691.57	1,684.25	2
H-56A	825665.28	26723934.55	1,661.33	1,641.13	2
HM-2	832199.20	26731069.80	1,559.79	1,588.00	2
HMW13	827711.49	26731740.35	1,578.47	1,595.51	2
HMW14	827174.04	26731535.30	1,580.80	1,599.82	2
HMW15	827608.00	26729901.00	1,599.47	1,611.97	2
HMW16	827090.00	26728531.00	1,612.63	1,621.43	2
J2U2	830063.17	26718456.02	1,753.44	1,747.35	2
JX-11	825170.27	26725018.41	1,657.56	1,650.63	2
M-10	828536.18	26716636.63	1,788.19	1,783.21	2
M-103	828728.34	26715622.48	1,796.59	1,787.41	2
M-121	827694.57	26715011.24	1,799.47	1,788.63	2
M-123	826516.40	26718416.92	1,743.93	1,741.63	2
M-124	827092.23	26718226.14	1,750.85	1,746.16	2
M-125	826531.82	26718993.90	1,733.39	1,728.83	2
M-128	827171.63	26718501.70	1,746.97	1,736.30	2
M-137	829129.33	26716034.14	1,791.70	1,785.54	2
M-141	829044.45	26718195.34	1,754.74	1,754.66	2
M-142	827191.75	26718713.09	1,742.76	1,735.90	2
M-145	829205.27	26717451.15	1,775.53	1,759.68	2
M-146	829203.29	26716991.99	1,778.08	1,767.48	2
M-148A	829030.35	26718357.14	1,754.71	1,755.34	2
M-21	827792.86	26718359.30	1,751.10	1,764.07	2
M-2A	827984.75	26718769.56	1,739.08	1,746.16	2
M-7B	826106.50	26720979.66	1,696.54	1,694.83	2
M-92	827138.09	26717531.94	1,764.04	1,760.86	2
MC100	825791.43	26721421.10	1,686.93	1,679.94	2
MC102	825360.37	26721725.67	1,686.34	1,675.95	2
MC103	825009.31	26721975.65	1,691.72	1,682.92	2
MC105	824275.66	26722336.79	1,693.91	1,685.95	2

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MC109	825294.38	26721609.56	1,686.92	1,687.16	2
MC111	825942.13	26721355.46	1,687.97	1,694.50	2
MC113	825538.88	26722279.41	1,680.34	1,673.44	2
MC114	825835.01	26722158.53	1,679.22	1,675.48	2
MC-120	824999.35	26721888.67	1,690.46	1,693.57	2
MC-125	824944.69	26721928.06	1,690.45	1,688.74	2
MC-127	825805.48	26721281.42	1,688.30	1,696.55	2
MC-128	824642.14	26722133.70	1,690.37	1,688.04	2
MC21	824270.86	26722460.62	1,693.97	1,694.64	2
MC3	825209.50	26721410.01	1,691.36	1,725.73	2
MC3	825209.50	26721410.01	1,691.40	1,725.73	2
MC33	824104.02	26721968.11	1,696.93	1,694.72	2
MC35	824496.97	26722273.85	1,691.77	1,716.18	2
MC41	825520.41	26721583.32	1,686.38	1,681.24	2
MC45	825400.42	26722230.35	1,682.27	1,678.98	2
MC48	824952.84	26722431.11	1,679.50	1,681.90	2
MC49	825182.72	26722360.49	1,680.93	1,679.08	2
MC5	825192.38	26721968.59	1,687.14	1,717.47	2
MC50	825534.87	26722076.15	1,683.34	1,676.82	2
MC51	825647.67	26721900.05	1,684.47	1,679.38	2
MC53	825942.24	26721920.01	1,683.29	1,685.27	2
MC58	824989.32	26722230.58	1,684.52	1,687.17	2
MC6	825207.92	26722160.22	1,683.63	1,712.17	2
MC61	825702.25	26722433.39	1,673.99	1,669.36	2
MC62	825880.72	26722727.61	1,669.00	1,663.04	2
MC63	826321.93	26722717.05	1,669.05	1,660.83	2
MC65	826119.27	26722421.15	1,671.71	1,674.93	2
MC66	826221.26	26722558.00	1,670.24	1,665.41	2
MC71	824635.01	26722508.47	1,677.55	1,677.15	2
MC77	824228.29	26722198.17	1,695.08	1,682.54	2
MC78	824546.42	26722002.33	1,693.88	1,680.12	2
MC8	824684.03	26721897.09	1,694.06	1,719.65	2
MC81	824637.59	26721548.31	1,697.41	1,695.03	2
MC84	824413.48	26722287.11	1,692.78	1,680.61	2
MC87	824735.41	26722276.80	1,685.77	1,681.67	2
MC89	824948.93	26722120.35	1,689.25	1,685.49	2
MC92	825467.59	26722035.56	1,684.93	1,669.18	2
MC94	825912.02	26721595.27	1,686.14	1,685.78	2
MC95	825642.30	26721800.45	1,685.69	1,676.35	2
MC98	825696.66	26721567.14	1,686.42	1,682.42	2
MCF-BW-10A	823621.72	26718620.39	1,735.67	1,714.86	2
MCF-BW-11A	824044.54	26718693.95	1,730.75	1,713.88	2

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MC-MW-09	825794.59	26716752.37	1,777.23	1,709.98	2
MC-MW-10	825523.88	26717919.06	1,747.21	1,703.91	2
MC-MW-11	824860.15	26717766.00	1,746.64	1,694.50	2
MC-MW-12	826293.89	26717903.04	1,758.89	1,690.04	2
MC-MW-15	825513.65	26718415.14	1,737.17	1,698.75	2
MC-MW-17	826576.82	26717707.84	1,761.54	1,719.92	2
MC-MW-18	826495.85	26718439.15	1,743.27	1,680.60	2
MC-MW-29	825436.29	26721910.09	1,685.97	1,649.05	2
MC-MW-30	825000.22	26721948.80	1,690.56	1,676.73	2
MC-MW-31	824775.80	26722161.64	1,686.70	1,672.35	2
MC-MW-32	826314.47	26721325.15	1,691.74	1,670.25	2
MC-MW-32	826314.47	26721325.15	1,691.50	1,670.25	2
MC-MW-33	825490.04	26721551.65	1,688.08	1,646.20	2
MC-MW-34	824867.82	26721979.95	1,689.68	1,664.90	2
MC-MW-35	824348.73	26722329.67	1,693.46	1,653.66	2
MC-MW-36	825497.46	26722678.55	1,674.28	1,644.38	2
MC-MW-38	826484.48	26722040.65	1,681.30	1,656.41	2
MC-MW-39	826973.77	26718516.45	1,746.16	1,674.86	2
MC-MW-41	826067.64	26719059.20	1,728.85	1,661.23	2
MC-MW-42	826654.91	26719290.51	1,728.10	1,658.50	2
MW-08	841021.90	26734440.76	1,812.87	1,582.82	2
MW-16	826447.64	26719904.41	1,718.23	1,722.61	2
MW-AA	822059.00	26729177.00	1,639.24	1,632.75	2
MW-AB	822535.00	26725941.00	1,663.60	1,655.35	2
MW-AC	822686.00	26723991.00	1,686.64	1,681.80	2
MW-AHX	823443.00	26721020.30	1,703.14	1,678.10	2
MW-AHX	823443.00	26721020.30	1,702.78	1,678.10	2
MW-AJ	826455.00	26726030.00	1,642.01	1,629.30	2
MW-AX-72	818280.30	26714977.50	1,846.99	1,804.10	2
MW-C	819813.00	26715809.70	1,823.24	1,795.40	2
MW-F2	820057.00	26719757.00	1,752.96	1,752.60	2
MW-I	817038.00	26717185.00	1,842.59	1,817.20	2
PC-107	827136.50	26729287.58	1,607.09	1,604.24	2
PC-129	828747.28	26726730.81	1,615.18	1,608.59	2
PC-142	828436.04	26728106.76	1,591.35	1,592.94	2
PC-143	828698.71	26728238.64	1,588.66	1,572.00	2
PC-144	828903.75	26728223.86	1,587.48	1,583.93	2
PC-148	829249.33	26728124.42	1,588.77	1,583.46	2
PC-149	829117.97	26728122.90	1,588.73	1,584.43	2
PC-150	828915.29	26728104.18	1,588.73	1,589.59	2
PMW-4	826635.40	26733437.00	1,571.97	1,553.20	2
PMW-5	826814.80	26733442.70	1,571.47	1,547.30	2

APPENDIX A: GROUNDWATER ELEVATIONS - SECOND QUARTER 2012

Nevada Environmental Response Trust Site

Henderson, Nevada

Observation Well Name	Easting	Northing	Target (ft amsl)	Mid-Screen Elevation (ft amsl)	Group
PMW-6	826821.60	26733562.00	1,571.15	1,548.20	2
PMW-7	826962.14	26733788.63	1,569.82	1,549.57	2
PMW-8	827253.81	26733988.97	1,567.94	1,545.21	2
PW-1	825302.29	26716402.77	1,780.75	1,767.38	2
RIT-04	827202.85	26733337.57	1,569.87	1,545.57	2
RIT-06	827297.23	26733433.85	1,569.44	1,542.78	2
RIT-07	826964.16	26733478.96	1,570.31	1,543.00	2
RIT-08	827127.94	26733558.18	1,569.51	1,541.65	2
RIT-10	827280.22	26733679.40	1,568.80	1,543.65	2
SB-6-8	822827.90	26731997.40	1,613.58	1,608.70	2
TIMETMW-3R	829483.25	26716571.73	1,788.23	1,786.89	2
TMMW-101	829462.76	26715285.26	1,808.39	1,796.91	2
TMPZ-105	828703.77	26720557.27	1,701.99	1,707.68	2
TMPZ-106	829102.42	26720359.15	1,709.31	1,713.25	2
TMPZ-107	829386.70	26720209.59	1,711.53	1,716.60	2
TMPZ-108	829756.76	26720032.09	1,715.03	1,714.46	2
TMPZ-109	830082.66	26719874.25	1,718.42	1,720.59	2
TMPZ-110	830531.86	26719668.76	1,723.07	1,729.00	2
TMW-3	825730.52	26721507.20	1,686.57	1,684.51	2
TR-11	825422.57	26721918.29	1,725.20	1,496.55	2
TR-12	825286.37	26723271.82	1,695.54	1,414.06	2
TR-7	826724.99	26716525.47	1,817.22	1,554.03	2
TWI	825501.20	26726290.60	1,642.37	1,639.30	2
W-S	824421.01	26722094.11	1,694.20	1,682.94	2
WS2-15	822624.20	26722682.80	1,698.20	1,686.90	2
WS4-11	823505.99	26722616.08	1,694.63	1,689.84	2
WS5-10	820784.55	26722650.42	1,713.36	1,704.01	2
WS5-40	820799.59	26722650.60	1,713.26	1,678.56	2
WS5-80	820814.63	26722650.92	1,716.25	1,633.70	2

Notes:

ft amsl = feet above mean sea level

Group 1: Observation Wells are the same as those listed in the Northgate model (Northgate 2010)

Group 2: Additional observation wells data for second quarter 2012

Highlighted wells have groundwater elevations from Northgate model.

Easting and northing location data and mid screen elevations are compiled from All Well Database (McGinley 2012).