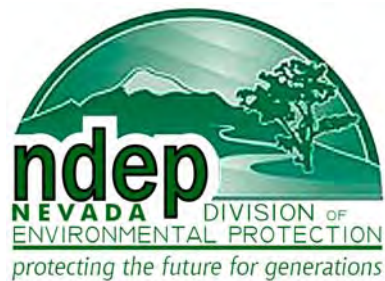


Evaluation of Arsenic Occurrence in the Western Hook Development Subarea Clark County, Nevada

April 13, 2010

Submitted to:



Prepared for:



Daniel B. Stephens & Associates, Inc.

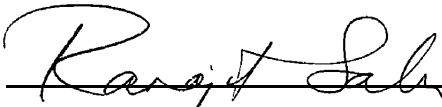
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1. Introduction and Objectives

The Western Hook Development subarea (Western Hook Subarea) is one of several subareas of the BMI Common Areas (Site) located in Clark County, Nevada (Figure 1) and encompasses approximately 227 acres (Figure 1). The Western Hook Subarea formerly included unexcavated ponds, previously excavated ponds, three ditches, and areas that were not used for any known waste disposal (BRC et al., 2007).

This report summarizes the methods and results of an evaluation of Western Hook Subarea arsenic concentrations detected in shallow soil and the conclusions based on the assessment. This report also incorporates comments received from the State of Nevada Division of Environmental Protection (NDEP) dated March 4, 2010, regarding the draft Western Hook Subarea report dated February 8, 2010 (Appendix A).

In August 2008, Basic Remediation Company (BRC) prepared a *Sampling and Analysis Plan* (SAP) for the Western Hook Subarea. The purpose of the SAP was to evaluate soil and soil vapor that may have been impacted at the Western Hook Subarea from former activities and adjoining lands. As described in the SAP, planned clearing activities were completed prior to collecting soil samples throughout the Western Hook Subarea on a systematic sampling basis. Samples were collected over a regular grid across the property from a randomly placed location within each grid cell. Additional biased sampling locations were selected within or near small-scale contamination points of interests, including but not limited to previous debris locations, ponds, berm walls near previously excavated ponds, and conveyance ditches.

This sampling procedure was planned to provide enough samples for completion of a statistically robust assessment of potential contaminant distribution and to provide a robust data set upon which to perform a human health risk assessment in support a no further action determination (NFAD) for this area (BRC, 2008). The scope of the SAP was limited to soil and soil vapor flux sampling in an effort to assess issues that might directly impact the Western Hook Subarea development potential consistent with the *Closure Plan* (BRC et al., 2007).



The soil samples were analyzed for a broad suite of analytes, including metals. This report addresses the detected concentrations of arsenic (As), which was detected in several Western Hook Subarea surface and subsurface soil samples (and in the adjoining Open Space Subarea) above the shallow soil background arsenic concentration of 7.2 milligrams per kilogram (mg/kg) (BRC and ERM, 2010a, 2010b, 2010c) (Figures 2 and 3). (For reference only, the data were also compared to the upper Tertiary Muddy Creek formation (UMCf) background arsenic concentration of 24.8 mg/kg. Three surface soil samples and four subsurface soil samples exceeded 24.8 mg/kg.)

As discussed in Section 3.1, arsenic occurs naturally throughout the environment, and elevated arsenic concentrations are widespread in the Western United States in nonthermal water that is unaffected by mining (Welch et al., 1988). Arsenic is regulated in drinking water. The federal maximum contaminant level (MCL) is 10 micrograms per liter ($\mu\text{g/L}$).

Daniel B. Stephens & Associates, Inc. reviewed the Western Hook Subarea arsenic data along with historical and current Western Hook Subarea conditions to determine if the arsenic detections are anthropogenic or naturally occurring. To accomplish the objective of this reporting effort, the following tasks were completed:

- Geology was evaluated and summarized (including pedogenic, hydrogeologic and geochemical site conditions).
- Western Hook Subarea use history was evaluated and summarized (including potential anthropogenic sources and potential arsenic mobilization and/or accumulation mechanisms).
- Supplementary laboratory analyses were completed.



2. Supplemental Western Hook Subarea Investigation

As described in the August 7, 2009 work plan (DBS&A, 2009) (work plan), DBS&A conducted document research and a supplemental field investigation to investigate the arsenic detections in Western Hook Subarea soils. These tasks are described in Section 2.1 and 2.2.

2.1 Document Research

DBS&A reviewed available geologic maps of the area to evaluate natural geologic sources of arsenic such as the presence of arsenic-bearing rocks, minerals, or formations. Soil type maps and pedogenic information from the Natural Resources Conservation Service (NRCS) were also obtained and reviewed along with logs for Western Hook Subarea borings and wells. Arsenic in regional groundwater was also mapped as part of this task using available data from the upgradient Plants Area reports (Figure 4).

DBS&A also reviewed historical aerial photographs for the Site area (Section 3.2.4) to identify past site uses in the area, including buildings, roads, pits, ponds, wetlands, streams, mining pits, and surface water bodies. Available reports were also obtained and reviewed to further evaluate the occurrence and fate of arsenic in the environment (Section 3).

2.2 Field Investigation

A supplemental field investigation was conducted by GES Nevada (GES) in August and September 2009 that included soil sampling, water sampling, and tamarisk plant tissue sampling according to the work plan (GES, 2009a; 2009b).

2.2.1 Methods

As described in the GES field reports (GES 2009a; 2009b), surface soil samples were collected from the following locations (Figure 2):

- WHD-As-BP04



- WHD-As-BP08
- WHD-As-P-14
- WHD-As-BL03
- WHD-As-BN10
- WHD-As-BG05

GES also obtained deeper soil samples from 4 to 12 feet below ground surface (ft bgs) from the following locations (Figure 3):

- WHD-As-BP03
- WHD-As-BP08
- WHD-As-BN01
- WHD-As-BK03
- WHD-As-BH04
- WHD-As-BG05

The soil samples were submitted for the following analyses:

- Grain size
- pH
- Total arsenic
- Arsenate
- Arsenite
- Phosphate
- Orthophosphate
- Total organic carbon
- Sulfide
- Sulfate
- Monosodium-methylarsonate ($\text{CH}_3\text{AsO}_3\text{HNa}$)
- Sodium-dimethylarsinate ($(\text{CH}_3)_2\text{AsO}_2\text{Na}$)



BRC also completed electron dot mapping for arsenic on the mineral grains from soil sample WHD-As-BN-10-0 to determine if arsenic-bearing minerals are present. Electron dot mapping is a technique that uses scanning electron microscopy (SEM) and energy-dispersive x-ray (EDX) spectrometry to identify the presence of arsenic in a particulate sample.

In addition, BRC retained the following soil samples from the first round of soil sampling at the Site (BRC, 2008) and submitted them for grain size testing:

- WHC1-BG05-0
- WHC1-BM06-0
- WHC1-BO10-0
- WHC1-BP04-0
- WHC1-D11-0
- WHC1-P14-0
- WHC1-BH05-10
- WHC1-BK03-12
- WHC1-BN01-12
- WHC1-BO10-10
- WHC1-BP03-11
- WHC1-P10-10

As discussed in the work plan, BRC recognized that tamarisk leaf litter was also potentially a source of relatively high arsenic detected in soil. A tamarisk plant tissue field sampling task was therefore conducted to evaluate if arsenic could potentially be bioaccumulated in tamarisk leaves and redistributed onto soil through leaf litter deposition. BRC identified existing live tamarisk stands near the Western Hook Subarea (Figure 5), and GES collected one sample of live leaves, a separate sample of leaf litter, and shallow soil samples from each stand to evaluate potential arsenic concentrations in soil. The shallow soil samples were collected from the following depths (GES, 2009a):

- 0 to 1 inch
- 3 to 4 inches



- 6 to 7 inches
- 9 to 10 inches

GES also collected two surface water samples from the western side of the Western Hook Subarea (Figure 2). One sample (WHD-As-SW01) was collected from the concrete-lined drainage ditch exiting the east side of the South Valley Ranch development, and the other sample (WHD-As-SW-02) was collected northeast of WHD-As-SW01 where the drainage ditch discharges to unpaved grade.

2.2.2 Results

The results of the tamarisk sampling and associated shallow soil sampling and analysis are presented in Table 1. The results of the laboratory analyses of the soil and surface water samples collected in the Western Hook Subarea supplemental investigation are presented in Figures 2 and 3 and Table 2. The results of the sampling efforts are discussed in Section 2.3. Grain size data, presented for reference, are included in Appendix B. In addition, Table 3 summarizes the grain size data and presents the interpreted Unified Soil Classification System (USCS) symbol for each soil sample submitted for grain size analysis.

2.3 Current Arsenic Distribution

2.3.1 Tamarisk Sampling Results

As shown in Table 1, total arsenic was not detected in live tamarisk leaf samples from any of the stand locations and only at relatively low concentrations (0.98 to 9.6 mg/kg) in the leaf litter samples (Figure 5). Arsenic was detected, however, in the soil samples collected at the tamarisk stand locations from 3.8 to 29.8 mg/kg. These soil results are broadly comparable to the results of prior soil sampling for arsenic in the Western Hook Subarea.



2.3.2 Surface Water Sampling Results

Arsenic was detected in both surface water samples collected from the drainage ditch exiting the east side of the South Valley Ranch development. Arsenic was detected at 35.1 $\mu\text{g/L}$ in sample WD-As-SW01 collected from the lined portion of the ditch. In sample WHD-As-SW02, collected where the ditch water discharges to unpaved grade, arsenic was detected at 42.8 $\mu\text{g/L}$.

2.3.3 Soil Sampling Results

As shown in Figure 5 and Table 2, total arsenic was detected in each of the Western Hook Subarea soil samples collected for this investigation. The detected total arsenic concentrations ranged from 5.4 mg/kg (WHD-BG05-0) to 24.3 mg/kg (WHD-AS-BN10-0) and are consistent with prior results. Arsenic was also speciated in each sample to obtain a result for arsenic III (As (III)) and arsenic V (As (V)). As shown in the data, As (III) was detected only in relatively low concentrations (all <0.3 mg/kg); most of the total arsenic detections are due to the presence of As (V). Organic species of arsenic (dimethylarsinic acids [DMAs] and methylarsenates [MMAs]) were not detected.

SEM/EDX analysis was conducted in an effort to try and determine if arsenopyrite (FeAsS), a common arsenic mineral, is present in Western Hook Subarea soils. The report of the SEM/EDX analysis is included in Appendix C. The main minerals detected were common silicates, ilmenite, celestite, barite, and iron oxide. Arsenopyrite was not detected. As discussed in the laboratory report (Appendix C), if arsenic were present in the sample (WHD-AS-BN10-0) as FeAsS in the size range of 1 to 100 micrometers (μm), the particles should have been detected. Because no such particles were detected, the arsenic is interpreted to be likely present in one or more of the following forms:

- Particles larger than 110 μm that were screened out for the analysis or were present within the interior of other particles that are beyond the range of method detection
- Particles smaller than 0.5 μm or colloidal particles not individually detectable



- Water-soluble particles that dissolved during density preparation and sample preparation (rinsing)
- Trace element (< 2 weight percent) dispersed in minerals or rocks
- Mineral species in the light fraction separated out for the analysis.

2.3.4 Arsenic in Regional Groundwater

A map of regional detections of arsenic in shallow groundwater was constructed using BRC data from the 2006 groundwater sampling event and historical data from sampling in the upgradient Plants Area (Olin, Montrose, Stauffer, Syngenta, Tronox and Timet) and AMPAC wells. BRC's 2006 data were used because the data were roughly contemporaneous with the available off-site data. BRC does have more recent data from its 2009 sampling event and will update the map with a 2009 data set when validated, contemporaneous shallow groundwater data are available from all of the upgradient Plants Area and AMPAC wells. Nonetheless, BRC believes that the conclusions that can be drawn from the 2006 data set are unlikely to be different.

As shown in Figure 4, the highest arsenic detection in the region is located in the Plants Area at well EC-09 (1,000 µg/L). Wells near EC-09 are also impacted with relatively high arsenic ranging up to 530 µg/L (at well EC-06). An arsenic contour line of 200 µg/L has been drawn around the approximate center of the Plants Area to delineate the reported arsenic detections. Contour lines for 150 µg/L and 100 µg/L extend from the Plants Area to the north-northeast into the Pittman residential area. The 50-µg/L contour is broader and extends north and northeast from the Plants Area to the Las Vegas Wash. Some concentrations higher than 200 µg/L are also detectable to the north at wells PC-28 (210 µg/L) and MW-S (240 µg/L). Lower concentrations are evident near the former City of Henderson (COH) Northern and Southern rapid infiltration basins (RIBs).



3. Arsenic Sources

3.1 Geologic

Naturally occurring arsenic is commonly found in a variety of solid phases. Arsenic can be a component of volcanic glass in volcanic rocks of rhyolitic to intermediate composition, adsorbed to and co-precipitated with metal oxides (especially iron oxides), adsorbed to clay-mineral surfaces, and associated with sulfide minerals and organic carbon (Hinkle and Polette, 1999).

Welch et al. (1988) state that high concentrations of arsenic are common throughout much of the western United States and are generally associated with one of four geochemical environments: (1) basin-fill deposits of alluvial-lacustrine origin, particularly in semiarid areas, (2) volcanic deposits, (3) geothermal systems, and (4) uranium- and gold-mining areas.

Two of the environments cited by Welch et al. (1988) as sources of arsenic (basin-fill deposits and volcanic deposits) clearly exist in the vicinity of the Western Hook Subarea. A third, geothermal systems, may also be relevant in the Site vicinity. Warm wells ($\sim 37^{\circ}\text{C}$) are located approximately 2.3 miles west-northwest of the Site, and hot wells ($>37^{\circ}\text{C}$) are located approximately 10 miles east of the Site within the basin (Shevenell et al., 2000).

Welch et al. (1988) discuss that, within alluvial basins in the Western United States, the source of the arsenic is possibly weathering of volcanic rocks, and elevated arsenic concentrations in groundwater may be a result of reactions occurring within volcanically derived sediments. The proposed mechanism is the concentration of arsenic onto phases such as ferric oxyhydroxide that are deposited within the sediments. Subsequent dissolution by chemically reduced groundwater of the phases containing arsenic could then generate elevated dissolved (more mobile than the sorbed phase) arsenic concentrations.

3.1.1 McCullough Mountains

The local surface topography slopes in a northerly to northeasterly direction from the McCullough Range, a north-south trending range that extends from the California-Nevada state



line to just south of Henderson. The northern part of the range in the Henderson area is predominantly Tertiary volcanic rock (Bell and Smith, 1980). The volcanic rocks of the McCullough Range are comprised of numerous flows of gray to dark-gray dacite with plagioclase, biotite, and hornblende phenocrysts (Bell and Smith, 1980).

Cycling of arsenic between sulfides and iron oxides (and weathered biotite) in response to changes in geochemical environments caused by cycles of erosion and burial was discussed as a source of arsenic by Thomas et al. (2005). Other potential sources of arsenic from geologic materials are thought to be weathering of arsenic-rich coatings on the surface of quartz and biotite grains, impurity within biotite, and dissolution of arsenic-containing iron oxides under anaerobic conditions.

3.1.2 River Mountains

The land surface slopes from east to northwest from the River Mountains toward the Site. The River Mountain range is located to the northwest of Hoover Dam between Las Vegas Valley and Lake Mead. The bedrock consists of a thick pile of dacite flows and mudflow breccia and pyroclastic deposits (Bell and Smith, 1980). Near Lake Mead Drive, this sequence is interbedded with basalt and andesite flows (Bell and Smith, 1980). The exposed rocks are mapped as grayish red to red dacite flows with plagioclase, biotite, and hornblende as phenocrysts (Bell and Smith, 1980).

As with the McCullough Range, the volcanic origin of the River Range indicates that it is a natural source of arsenic in the Western Hook Subarea vicinity.

The Three Kids Mine is located in the River Range, approximately 5 miles east of the Western Hook Subarea. The manganese-bearing sedimentary rocks in this location are gray to black tuffaceous sandstone and siltstone, moderately to well bedded. They are dominantly of pyroclastic origin and have been variably reworked by water. These deposits underlie the Tertiary Muddy Creek formation (TMCf) in this location and are likely older than the TMCf (Bell and Smith, 1980). CH2M Hill (2006) report that sampling conducted by the University of Nevada, Las Vegas (UNLV) at and in the vicinity of the Three Kids Mine indicated that naturally



occurring arsenic may exist at concentrations ranging from below 70 to greater than 500 milligrams per kilogram (mg/kg) (Sims, 1997; Naugle, 1997). (CH2M Hill noted that the UNLV data were not obtained from an EPA-approved laboratory, but were included for informational purposes.)

CH2M Hill (2006) also noted that volcanic intrusions that exist on-site at the Henderson Landfill are composed of basalt flows containing phenocrysts of plagioclase and augite that are commonly brecciated and that the intrusions with flows containing phenocrysts of plagioclase, biotite, and hornblendes are commonly flow-banded and may be equivalent to River Mountain formations found to the south of Lake Mead Drive bordering the Three Kids Mine. BRC notes that its Open Space subarea lies to the west of the COH Landfill.

Volcanic intrusions that subcrop in other areas of the Site, including the Western Hook Subarea, may also be equivalent to either the River Mountain or the McCullough Mountain volcanic formations.

3.1.3 Quaternary Alluvium

The soils in the Western Hook Subarea are forming in Quaternary alluvium (Qal) derived from pediment and alluvial fan deposits (Bell and Smith, 1980). These deposits are generally characterized by silty, sandy pebble gravel composed dominantly of volcanic clasts derived from the volcanic rocks of the McCullough Range (Bell and Smith, 1980). The deposits are branching and recombining channels deposits of undifferentiated alluvium, occurring in non-indurated low wash terraces and modern wash deposits (Bell and Smith, 1980).

Since these deposits were derived from the volcanic McCullough Range and possibly the volcanic River Range, the sediments within these deposits are also of volcanic origin and, representing a more advanced stage of weathering of the volcanic rocks, could similarly be a source of arsenic.



3.1.4 Muddy Creek Formation

The TMCf unconformably underlies the Qal in the Western Hook Subarea. The TMCf is comprised of extensive basin-fill sediments of lacustrine and subaerial origin (Bell and Smith, 1980). The coarse-grained facies (TMCc) occur primarily in upslope positions, for example in the Plants Area. However, coarse-grained lenses, which are sporadically encountered during drilling, at depth are also interpreted to be equivalent to the TMCc. When encountered, these lenses of TMCc are generally coarser in texture. Wells have been completed in these lenses to monitor the Middle and Deep water-bearing zones at the site because of the increased possibility of water yield from these lenses, indicating a higher permeability than the fine-grained facies.

The TMCc typically consists of yellowish to reddish brown fanglomerate, well cemented coarse sandy to pebbly to cobbly gravel. The TMCc locally contains interbedded gypsiferous silt and pebbly sand. The upper portion of the TMCc is described as well bedded and containing volcanic pebbles (Bell and Smith, 1980).

The fine-grained facies of the TMCf consists of dominantly gypsiferous pink to red siltstone, sandy siltstone, and claystone. The upper portion of this facies is described as containing massive beds of white to light pink gypsum, locally manganese-rich (Bell and Smith, 1980).

The TMCf sediments are of the same general age as the volcanic source-area mountains from which they are derived. The sediments within these deposits are also of volcanic origin and, representing a more advanced stage of weathering of the volcanic rocks, could similarly be a source of arsenic.

3.1.5 Previous Regional and Local Arsenic Investigations

Arsenic is ubiquitous in the Western Hook (and adjacent Open Space) Subarea vicinity, and several investigations have been conducted to determine the source of arsenic in water and industrial waste. Four of these studies focused on the occurrence of arsenic in the Site vicinity, two on the source of arsenic in water, and two on arsenic levels in soils. The two water quality



investigations were conducted across the western United States and in the Las Vegas Valley, respectively. The soil investigations were conducted on sites in the Henderson area south of the Las Vegas Wash.

Two of the four geochemical environments identified by Welch et al. (1988) (Section 3.1) as associated with arsenic in groundwater are found in the McCullough Range and River Mountains (volcanic deposits) and the TMCf (basin-fill sedimentary deposits of alluvial-lacustrine origin). Arsenic concentrates in certain minerals because it can substitute for silicon, ferric iron, and aluminum in silicates. Biotite and hornblende are both iron magnesium silicate minerals that may contain high concentrations of arsenic. Welch et al. (1988) provides a range for arsenic in basalt of 0.18 to 113 milligrams per kilogram (mg/kg).

The United States Geological Survey (USGS) investigated the water quality in the Las Vegas Valley as part of the National Water-Quality Assessment Program (Bevans et al., 1998). The report concluded that arsenic in the Las Vegas Wash came from natural volcanic rocks. The authors identify the source of arsenic as volcanic rocks. These volcanic rocks are found south of the Las Vegas Wash and correspond to the McCullough Range and River Mountains. The volcanic rocks are shown in a figure, but no more specific information is provided.

Local investigations of arsenic in soil have been conducted at the Three Kids Mine and the COH Landfill. At Three Kids Mine, the investigation focused on contamination impacting off-site water quality (Sims and Bottenberg, 2008). The Henderson Landfill investigation focused on obtaining the information needed to demonstrate that arsenic in landfill soils was of natural origin and that no remediation would be necessary (CH2M Hill, 2006).

The Three Kids Mine is located in the River Mountains on the east side of Henderson. Manganese extraction activities at the mine produced waste containing arsenic as well as other contaminants. The mine's waste management practices allowed sediments with arsenic to get into washes that conduct flow to the Las Vegas Wash. One aspect of the investigation included the collection and analysis of four background soil samples collected in locations not impacted by mining. The background samples were collected near outcrops of bedrock volcanics from



depths not exceeding 3 inches (Sims, 1997). The background concentration of arsenic was reported as 25 mg/kg (Sims and Bottenberg, 2008).

The Henderson Landfill is located south of the Las Vegas Wash approximately 2.5 miles east of the Western Hook Subarea. In 2003, CH2M Hill conducted an investigation focused on characterizing soils in areas that were candidates for use as borrow material. In 2006, supplemental samples were collected within three geologic-based areas on the Henderson Landfill site (Western Area, Central Area, and North-Central Area). The supplemental samples were collected to create appropriate sample populations for comparing arsenic concentrations in background samples and samples potentially impacted by waste. Shallow supplemental samples were collected from depths of 6 to 12 inches. Deep supplemental samples were collected from 18 inches to 5 feet at each location. Samples were collected from either undisturbed soils or soils associated with the waste.

The comprehensive data sets were evaluated to demonstrate that arsenic found in the soils represents naturally occurring arsenic, and as such, arsenic could be removed from the site's contaminants of potential concern list. The Western and Central Areas were located over alluvial sediments and the North-Central Area was located by volcanic deposits. Western Area soil samples from undisturbed areas had arsenic concentrations between 3.7 mg/kg and 20.5 mg/kg. Central Area soil samples from undisturbed areas had arsenic concentrations between 8.8 mg/kg and 34 mg/kg.

The average arsenic concentrations from undisturbed samples were not statistically different from samples associated with the waste. In the Central Area, shallow samples had an average arsenic concentration of 20.4 mg/kg and deep samples had an average arsenic concentration of 22.0 mg/kg. In the North-Central Area, the undisturbed samples had arsenic concentrations between 40 mg/kg and 910 mg/kg with a mean concentration of 346 mg/kg. These relatively high concentrations are reported to be natural for soils associated with volcanic rock outcrops in the vicinity. The report concluded that all of the arsenic on the site was of natural origin.

Borings advanced by BRC and others in the Western Hook Subarea have penetrated the Qal and identified its contact with the underlying TMCf. Figure 6 presents a cross section oriented



northwest to southeast through the Western Hook Subarea. The minimum thickness of the Qal in this area is 39 feet at wells AA-21 and MCF-08B-R. The maximum Qal thickness measured is 68 feet at well AA-08.

Figure 6 also shows the horizontal extent and estimated depth of the CoH infiltration basin (birding ponds) in this area. Although the exact depths of the ponds are not known, they are not anticipated to be deeper than the minimum thickness of Qal in this area (39 feet). As a result, it is considered unlikely that soil samples for arsenic collected in the Western Hook Subarea were collected from the TMCf formation or that the CoH pond berms were constructed with TMCf soils brought to the surface from depth.

3.2 Plants Area Sources

3.2.1 POSSM Companies

NDEP has noted that it is their understanding that the Pioneer-Olin-Stauffer-Syngenta-Montrose (POSSM) companies did not use arsenic in their pesticide production. However, NDEP stated that there may have been a tenant at the Tronox facility that did (NDEP, 2009).

In a Conceptual Site Model (CSM) report that was prepared on behalf of Montrose, Stauffer Management Company, LLC/Syngenta Crop Protection, Inc. (SMC/Syngenta) and Pioneer (collectively known as "The Companies"), Hargis (2008a) reported that, based on data collected in August 2006, arsenic was detected in each of the wells in the extraction well network of the groundwater extraction and treatment system (GWETS) located just north of the northern BRC Corrective Action Management Unit (CAMU) boundary. The arsenic concentrations in the GWETS extraction wells ranged from 92 $\mu\text{g/L}$ to 270 $\mu\text{g/L}$. Hargis reported that arsenic was prevalent throughout the downgradient area wells at levels exceeding the MCL of 10 $\mu\text{g/L}$ in 16 of the 22 monitoring wells sampled (Hargis, 2008a). Though the GWETS system is designed to extract, treat, and re-inject treated water downgradient, arsenic is not treated by the GWETS system.



DBS&A (2007) observed that all of the chemicals found historically in any of the wells located downgradient or cross-gradient from the CAMU site were also found in upgradient wells and that historical isoconcentration plots indicated that significant groundwater sources exist for these chemicals at off-site, upgradient locations. The most current groundwater arsenic concentration data (as presented on Figure 4) are consistent with and support this interpretation. The groundwater data indicate that one or more significant sources of arsenic is present at locations upgradient of the CAMU, most likely emanating from the properties owned by the POSSM Companies. This groundwater impacted by arsenic is flowing beneath the CAMU where it is, in part, captured by the GWETS. The captured groundwater is run through the treatment system (which does not include treatment for arsenic) and re-injected downgradient where it proceeds to flow and disperse generally northward. As indicated in Figure 4, the data indicate that this arsenic plume is impacting groundwater in the Western Hook Subarea.

3.2.2 AMPAC

Limited data are available regarding arsenic concentrations in AMPAC groundwater monitoring wells. It is known, however, that AMPAC has impacted groundwater with perchlorate and is actively pursuing its remediation. The AMPAC perchlorate plume map as depicted on the NDEP website (<http://ndep.nv.gov/BCA/perchlorate05.htm>) clearly depicts migration of the AMPAC plume onto the Western Hook Subarea. For the purposes of this evaluation, perchlorate serves as a conservative tracer in that unremediated perchlorate travels essentially unretarded and at the approximate speed of groundwater. The fact that the AMPAC perchlorate groundwater plume is impacting the Western Hook Subarea indicates that chemical impacts to groundwater from the AMPAC plant have the potential to travel downgradient in groundwater and impact the Western Hook Subarea.

NDEP has published data on their web site (http://ndep.nv.gov/bmi/docs/table_downgradient07.pdf) that includes arsenic concentrations from AMPAC wells MW-APX-5-16, MW-K1, MW-K5, MW-R, and MW-S. Published arsenic concentrations in these wells range from 87 to 190 µg/L, with all published arsenic detections above the MCL of 10 µg/L.



It cannot be determined from this limited data set whether arsenic releases from AMPAC are impacting groundwater in the Western Hook Subarea. However, the data do indicate that groundwater has been impacted by arsenic at these monitoring well locations. The potential that arsenic has followed the same flow path indicated by the path of the AMPAC perchlorate plume cannot be ruled out at this time. Further investigation should be conducted to determine whether AMPAC operations have impacted groundwater with arsenic in the Western Hook Subarea.

3.2.3 Tronox

No data could be identified and located upon which to base an evaluation of distribution of arsenic in groundwater at the Tronox facility as an indicator of a potential source of arsenic to groundwater. The isoconcentration plot of arsenic concentrations in Shallow Zone groundwater indicates that an arsenic plume is migrating across the Tronox plant property and that Tronox is possibly a source of arsenic and possibly contributing to the larger plume that is migrating northward across the Site vicinity. Additional data are needed to evaluate this possibility.

NDEP has noted that it is their understanding that Tronox did not use arsenic in their pesticide production, but that there may have been a tenant at the Tronox facility that did (NDEP, 2009).

In the report of the Conceptual Site Model of the Tronox facility (ENSR, 2005), previously known as Kerr-McGee, it was noted that arsenic, as arsenic trioxide (As_2O_3), constituted 0.01 percent by weight of the analytical composition of the manganese dioxide ore used at the Tronox facility. Arsenic trioxides are moderately soluble in water (O'Day, 2006).

3.2.4 Aerial Photograph Review

In 1941, approximately 5,000 acres of empty desert in the southeastern quadrant of the Las Vegas Valley was deeded by the United States for use as the site of what was to become the world's largest magnesium plant, which played a critical role in World War II. Construction on the project began on September 15, 1941 (BRC et al., 2007).



Since that time, various parts of the original site have remained industrialized, been used for the disposal of a variety of industrial wastes, been abandoned, been converted to other uses, or remained virgin desert (BRC et al., 2007).

A review of historical aerial photographs was conducted in order to identify if any anthropogenic and/or natural features potentially played a role in the transport of arsenic to the Western Hook Subarea. However, as discussed in Section 3.2.5, no additional arsenic sources were identified. The aerial photographs reviewed are presented in Appendix D.

3.2.5 Ditch Soil Sampling

Soil sampling for arsenic in the former Western Ditch (W. Ditch) at the CAMU was reported in 2007 (DBS&A, 2007). Between 2003 and 2005, a total of 43 soil samples were collected for arsenic analysis at depths between 0 and 130 ft bgs in the Western W. Ditch and the Eastern W. Ditch.

In the Eastern W. Ditch samples, detected arsenic ranged from 2.4 to 6.7 mg/kg from 0 to 15 ft bgs (4 samples). (In deeper samples well below the ditch between 18 and 50 ft bgs [9 samples], detected arsenic ranged from 3.7 to 10.9 mg/kg. Also, detected arsenic in 3 soil samples from 73 to 130 ft bgs [UMCf samples below the Qal] ranged from 10.8 to 16.7 mg/kg.)

In the Western W. Ditch samples, detected arsenic ranged from 2.2 to 3.9 mg/kg from 0 to 10 ft bgs (10 samples). Arsenic was not detected (<5 mg/kg) in 5 of the samples collected between 0 and 10 ft bgs. From 15 to 35 ft bgs (20 samples), arsenic was detected between 3.4 and 19 mg/kg. The maximum detected concentration (19 mg/kg) was measured in a sample from 35 ft bgs. In addition, arsenic was not detected (<5 or <5.3 mg/kg) in 5 of the samples from 15 to 35 ft bgs (DBS&A, 2007).

The Northwestern Ditch was also sampled for arsenic in 2007 (BEC and ERM, 2008). The sample (JB-NW DITCH) was collected along the south side of Warm Springs Road, northeast of the CAMU, in the trace of the former ditch. Arsenic was detected at 3.1 mg/kg in the JB-NW



DITCH sample reported to be collected from 0 ft bgs. Arsenic was also detected at 6.3 mg/kg in the JB-NW DITCH sample reported from 10 ft bgs.

Soil pH was also measured in the Eastern W. Ditch soil samples (DBS&A, 2007). In 2 surface soil samples (0 ft bgs), pH was measured at 6.8 and 8.3. In the remaining 6 soil samples between 18 and 49 feet bgs, pH ranged from 8 to 9.2. (Below the Qal, pH was measured between 8.5 and 9.1 in samples from the UMCf).

The ditch sampling data indicate that total arsenic was not present at significant concentrations in the former soils. In fact, these concentrations are generally consistent with background levels of arsenic. It is expected that if the Western or Northwestern Ditches (the Ditches) had conveyed significant concentrations of arsenic in the liquid effluent, a fingerprint of significant concentrations of total arsenic would have been present in the soil profile beneath the Ditches. Since the soil profiles beneath the Western and Northwestern Ditches are low in total arsenic concentrations at all sampled depths, it can be concluded that significant arsenic was not conveyed by the Ditches.

In addition, the pH data indicate that soil conditions were not acidic in the former Western Ditch soils and indicate that soil redox and Eh/pH conditions favorable for arsenic reduction, mobilization, and leaching beneath ditch soil were not present.



4. Arsenic Transport

4.1 Soils

4.1.1 Review of Western Hook Subarea Monitoring Well Boring Logs

Boring logs from three wells in the Western Hook Subarea were examined. The presence of volcanic rocks, moisture, and depth to water were noted. Gleying or mottling is not noted in the boring log notes.

Well PC-108 is located on the southern edge of the eastern arm of the Site, just north of a pond in the COH Birding Preserve. The sediments to the depth of 19 ft bgs were described as dark yellowish brown sands and volcanic gravels with some silt. Water was encountered at 9 ft bgs.

Well AA-08 is located along the northern boundary of the Site. The soil was described as silty sand with some volcanic gravel and cobbles to a depth of 44 ft bgs. The color was light gray at the surface, changed to very dark grayish brown at 5 ft bgs, and lightened to dark grayish brown at 20 ft bgs with no further changes to 44 ft bgs. The top 5 feet were dry and water was first encountered at 9.5 ft bgs.

Well AA-10 is located in the south-central part of the Western Hook Subarea along a channel. The soil was described as silty sand to a depth of 32 ft bgs with the variable presence of volcanic cobbles to a depth of 10 ft bgs. The color was yellowish brown at the surface and changed to brown at 5 ft bgs, to dark grayish brown at 10 ft bgs, and to grayish brown at 30 ft bgs. The only moisture information provided was that the surface soils were wet from rain infiltration. Water was not encountered during the boring process.

4.1.2 Pedogenic Information

Soil type data were downloaded from the NCRS database (NCRS, 2009). The Western Hook Subarea is comprised of four described soil types. Soils in the northern arm are described as slickens which is further defined as a fine layer of silt. The soil type described in the northwest



corner of the Western Hook Subarea is a McCarran very fine sandy loam. The McCarran series consists of deep, well drained soils that formed in gypsiferous and calcareous alluvium with low slopes and mean annual precipitation of about 5 inches (NRCS, 2003). The soil type of the western arm of the Western Hook Subarea is Caliza extremely cobbly fine sandy loam. The soil type of the southeastern corner of the Western Hook Subarea is Caliza extremely very gravelly sandy loam. The Caliza series consists of deep well drained soils that formed in gravelly alluvium of alluvial fans or river deposits of Pleistocene age. Caliza series soils have slopes between 1 percent and 50 percent and a mean annual precipitation of about 8 inches (NRCS, 2008).

A review of boring logs from the Western Hook Subarea shows that Unified Soil Classification System (USCS) soils that were observed in the surface to 20 ft bgs depth interval during drilling and sampling are laterally and vertically heterogeneous and comprised of gravelly sands (GP), gravelly silts (GM), clays (CL), silty sands (SM), well graded sands (SW), poorly graded sands (SP), and variants of the above. The logs typically contain documented observations of subangular to rounded volcanic gravel and cobbles within the top 20 feet of the soil profile. The degree of weathering (edge-rounding) on these coarse fragments is an indication that the soils were transported and emplaced by a combination of water-borne and gravitational processes. The volcanic nature of the coarse fragments indicates that they are likely sourced in either the McCullough Range or River Mountains.

4.1.3 Arsenic Speciation in Soils

Arsenic is commonly found throughout the environment in a variety of chemical species that vary in toxicity and mobility. The chemical variability of arsenic stems from its electronic structure and bonding properties, which give rise to a variety of forms in the solid, aqueous, and gas states (O'Day, 2006). Arsenic chemical species can be transformed due to biological activity or a change in oxidation-reduction potential and pH (Melamed, 2004).

In a review of arsenic geochemistry, EPA (Melamed, 2004) reported that the main species of arsenic found in the environment are the As (III) and As (V) oxyacids. In aqueous solutions, arsenic forms the ox anions arsenite, $\text{H}_3\text{As}^{3+}\text{O}_3$ [or commonly written $\text{As}^{3+}(\text{OH})_3$] and arsenate,



$\text{H}_3\text{As}^{5+}\text{O}_4$ (O'Day, 2006). In many environments, the As (V) is often de-protonated as an As (V) or arsenate anion. In contrast, the As (III) oxyacid remains in its neutral form as arsenite. In contaminated soils, inorganic arsenate is the predominant species (Melamed, 2004). In general, the arsenate and other As (V) species are immobilized on geologically available surfaces, usually as iron oxides. The redox potential of arsenic ox-anions is such that arsenite is expected to be the stable aqueous form under moderately reducing conditions, roughly from oxidation potentials (Eh) of about +300 mV at pH 4 to –200 mV at pH 9, while arsenate is stable in oxidized aqueous solutions (O'Day, 2006).

As (III) commonly partitions to the aqueous phase in anoxic environments, and would be more mobile. As (V) usually remains bound to minerals, such as ferrihydrite and alumina, limiting its mobility and bioavailability (U.S. Department of Health and Human Services, 2007). As (III) is moderately unstable in the presence of oxygen; however, it can be found under aerobic conditions as well (U.S. Department of Health and Human Services, 2007). While As (V) is strongly sorbed by soils under aerobic conditions, it is rapidly desorbed as the system becomes anaerobic. Once it is desorbed, As (V) can be reduced to As (III), which exhibits greater mobility in soils (U.S. Department of Health and Human Services, 2007). Transformations between the various oxidation states and species of arsenic occur as a result of biotic or abiotic processes (U.S. Department of Health and Human Services, 2007).

Table 2 and Figures 2 and 3 present the results of field sampling conducted to speciate arsenic and evaluate the predominant form in which arsenic is present. Sample collection points were distributed from the southern end of the Western Hook Subarea to the north in an attempt to sample the range of conditions that might impact the speciation of arsenic.

In the Western Hook Subarea surface soils, the predominant species of arsenic present was As (V). In the seven surface soil samples collected for the specific purpose of speciating arsenic, the As (V) ranged in concentration from 3.33 to 23.2 mg/kg with a mean As (V) concentration of 9.73 mg/kg, while the As (III) ranged from nondetected (< 0.057 mg/kg) to 0.249 mg/kg. The organic forms of arsenic, DMA and MMA, were both below the detection limits (which ranged from 0.268 to 0.490 mg/kg) in all surface soil samples.



In the Western Hook Subarea subsurface soils, the predominant species of arsenic present was also As (V). In the seven surface soil samples collected for the specific purpose of speciating arsenic, the As (V) ranged in concentration from 3.82 to 21.1 mg/kg with a mean As (V) concentration of 13.10 mg/kg, while the As (III) ranged from 0.63 to 0.294 mg/kg. As in the surface soil samples, the organic forms of arsenic, DMA and MMA, were both nondetect for all subsurface soil samples. The sample detection limit ranged from <0.130 to <0.467 mg/kg.

The data indicate that, under the present redox conditions, the less-mobile and less toxic (U.S. Department of Health and Human Services, 2007) As (V) is the predominant form of arsenic present in the Western Hook Subarea.

4.2 Groundwater

Figure 4 presents isoconcentration contours of total arsenic concentrations in groundwater. The figure presents an interpretation and illustration of the distribution of total arsenic in groundwater from Lake Mead Parkway on the south to Las Vegas Wash on the north, from approximately Interstate 515 on the southwest to the COH Landfill on the northeast. The basis of the interpretation is a compilation of multiple data sets collected at various times between 2006 and 2008. While it is recognized that the interpretation is not based on precisely contemporaneous data, the interpretation is nonetheless useful in understanding the distribution of arsenic in the BMI Complex region, including the Western Hook Subarea.

The data indicate that a significant groundwater source concentration of total arsenic in groundwater beneath the POSSM plants area feeds an arsenic groundwater plume that is moving northward towards the Western Hook Subarea and northeasterly across the BMI Eastside Evaporation Pond area. It appears that infiltration from operation of the COH Northern and Southern RIBs has provided a hydraulic barrier to the easterly migration of arsenic and perhaps flushed some arsenic mass to Las Vegas Wash, thus preventing significant expansion of the arsenic groundwater plume to the east. Smaller secondary sources are potentially indicated by a localized area of elevated arsenic groundwater concentrations in the approximate vicinity of (1) East Merlayne Road and Melton Street in the Pittman residential area, (2) immediately adjacent to the western edge of the COH Birding Preserve Ponds, and (3) beneath



the approximate northern boundary of the COH Landfill. An off-site arsenic source may be indicated east of the Tuscany Village area, east of Lake Mead Parkway, in the direction of the Three Kids Mine.

Hydrographs were plotted for wells in which water elevations have been measured in the Western Hook Subarea and vicinity, including groundwater monitoring wells PZ-13, HMW-16, AA-08, AA-10, AA-21, PC-103, PC-104, PC-106, and PC-108 (Figure 7). No groundwater elevation data exist for PC-107. The hydrographs are provided in Appendix E.

Depth to groundwater in the Western Hook Subarea is generally shallow. During the period of record (2004 through 2009), monitoring wells on the west side of COH Birding Preserve Ponds (PZ-13, HMW-16, AA-08, AA-10, AA-21, PC-106 [Figure 7]) had the shallowest recorded depths to water ranging from less than 5 ft bgs (PC-106) to approximately 20 ft bgs (AA-10). Monitoring wells to the east side (PC-103, PC-104, PC-108 [Figure 7]) have had somewhat deeper recorded depths to water, ranging from approximately 10 to 13 ft bgs (PC-108) to 30 to 32 ft bgs (PC-104).

The hydrographs for monitoring wells AA-08 and AA-10 along with the original boring logs (BRC-SB-08-B and BRC-SB-10-B, respectively [BRC et al., 2007]) indicate that shallow groundwater at depths less than 20 ft bgs has been measured in the Western Hook Subarea since 2004.

In areas where the groundwater is shallow and evapotranspiration exceeds precipitation, as occurs in the Site vicinity, upward capillary water flow occurs from shallow groundwater. The soils become wetted above the water table, and evapotranspiration depletes the applied water but leaves solutes behind, leading to increased solute concentrations in the vadose zone and shallow ground water (Hendrickx and Buchanan, 2009). Figure 8 depicts the process of water table rise, capillary rise, and soil salination.

The amount of water and salts that move with capillary rise from a shallow ground water table into the root zone depends on the soil texture, the depth and type of the root zone, and the groundwater table. Hendrickx and Buchanan (2009) compiled published investigations that



have evaluated the height to which capillary rise from groundwater can affect the solute concentration in overlying soils. Table 4 illustrates the maximum height of capillary rise for ten example upward flux rates. The data presented in the table show that, at low flux rates over long periods of time, upward solute transport from the water table through capillary rise can be significant. The data demonstrate that, for finer-textured soils such as loamy sands and clay loams (as described by the United States Department of Agriculture [USDA] Soil Taxonomy system), the capillary rise influence can be over 5 to 6 meters (over 16 to 20 feet).

As discussed in Section 4.1.1, boring logs from the Western Hook Subarea indicate that USCS soils that were observed in surface to 20 ft bgs depth interval during drilling and sampling are laterally and vertically heterogeneous and comprised of gravelly sands (GP), gravelly silts (GM), clays (CL), silty sands (SM), well graded sands (SW), poorly graded sands (SP), and variants of the above. Figure 9 presents a side-by-side comparison of the of the USDA and USCS systems of soil classification (Dragun, 1988). From this comparison, it can be concluded that significant capillary rise and upward solute transport could have occurred over the relevant time frame in the soil types that have been observed in the Western Hook Subarea.

4.3 Surface Water

4.3.1 Effluent Ditches

The Western Ditch Extension and the Northwest Ditch historically carried effluent northward to ultimately the Lower Ponds area and the Las Vegas Wash. Effluent ditch soil sampling results (Section 3.2.5) indicate that these streams did not transport significant levels of arsenic to the Western Hook Subarea.

4.3.2 Runoff

In the 1961 aerial photograph, it is evident that the Western Ditch Extension was not channelized and flowed overland as braided stream runoff that covered a wide swath of desert, at times exceeding 2,000 feet in width. The general pattern of flow was to the northeast. The



Western Ditch Extension merged with the Northwest Ditch, and they flowed in a braided stream regime over what is now the Western Hook Subarea.

Currently subsurface water is draining from the South Valley Ranch residential development immediately west of the Western Hook Subarea. French drains are removing the subsurface water, and that water is mixing with surface storm drain water and flowing in a channelized ditch that traverses the Western Hook Subarea on its way northward to Las Vegas Wash. Before it reaches the wash, the channel broadens and the drainage water flows across open ground.

As part of the Western Hook Subarea evaluation two drain water samples were collected to evaluate arsenic concentrations (Table 2, Figure 5). Sample WHD-As-SW01 contained 35.1 $\mu\text{g/L}$ of arsenic and sample WHD-As-SW02 contained 42.8 $\mu\text{g/L}$. These concentrations indicate that groundwater beneath the residential area is likely impacted by arsenic above the MCL. The drainage water arsenic concentrations are consistent with concentrations observed in the regional arsenic groundwater plume. Any of this arsenic-impacted drainage water that infiltrated from the bottom of the channelized drainage ditch could have resulted in leaching of arsenic into soil, and possibly into groundwater, in the Western Hook Subarea.

4.3.3 Wastewater Sources

Wastewater in the form of industrial effluent from operational activities in Plants area was historically conveyed northward to the Western Hook Subarea, to the Lower Ponds Area, and to the Las Vegas Wash (Sections 4.3.1 and 4.3.2).

Two sewage holding ponds were constructed and can be first observed in the aerial photograph record in 1961. These ponds were located southeast of the Western Hook Subarea and west of the current COH water reclamation facility. It is unknown whether the holding ponds were designed and constructed with low permeability liners. Also unknown is the precise chemical constituency of the liquids placed in the holding ponds.

The regional map of arsenic in Shallow Zone groundwater shows that an elevated concentration of arsenic of 240 $\mu\text{g/L}$ was detected in monitoring well MW-S (Hargis, 2008b). This well is



situated on the east side of the Western Hook Area, at the current location of the COH wastewater ponds, where the Lower Ponds and the terminus of the former Northwest Ditch were formerly located. Data regarding the construction of the pond liners and the arsenic content of the wastewater in the COH ponds are not available. As a result, it is not possible to evaluate whether the COH wastewater ponds could be acting as a current source of arsenic to groundwater or as a source of low redox water infiltrating into surrounding soil and mobilizing arsenic.

It is noted, however, that these ponds were operated by the CoH as RIBs. RIB water quality data—such as pH, total dissolved solids (TDS), oxidation-reduction potential (ORP), total organic carbon (TOC), and other parameters—would be useful in the evaluation of detected Western Hook Subarea arsenic concentrations in soil; however, no such data are available from the CoH.

4.4 Vegetative Plant Material

Arsenic is a nonessential element for plants. At higher concentrations, arsenic interferes with plant metabolic processes and can inhibit growth, often leading to death (Tu and Ma, 2002). Nonetheless, terrestrial plants may accumulate arsenic by root uptake (U.S. Department of Health and Human Services, 2007). However, even when grown on highly polluted soil or soil naturally high in arsenic, the arsenic level taken up by the plants is comparatively low (U.S. Department of Health and Human Services, 2007).

Uptake of four arsenic species (arsenite, arsenate, MMA, and DMA) by turnips grown under soilless culture conditions showed that while uptake increased with increasing arsenic concentration in the nutrient, the organic arsenicals showed higher upward translocation than the inorganic arsenical (Carbonell-Barrachina et al. 1999). The total amount of arsenic taken up by the turnip plants (roots and shoots) was highest for MMA, sequentially less for DMA and arsenite, and least for arsenate. In a similar experiment, conducted with tomato plants, the total amount of arsenic taken up by the tomato plants was highest for DMA, sequentially less for MMA, and least for arsenate and arsenite (U.S. Department of Health and Human Services,



2007). Arsenic was mainly accumulated in the root system (85 percent), with smaller amounts (1 percent) translocating to the fruit, (U.S. Department of Health and Human Services, 2007).

Consistent with previous research indicating that arsenic uptake by plants is limited, total arsenic was not detected in the tamarisk leaf samples collected in the Western Hook Subarea (Table 1). The relatively low concentrations of arsenic detected in the leaf litter samples are likely indicative of plant materials mixing with soil and sediment near the surface. Though no analytic data were collected from tamarisk roots, the Tu and Ma (2002) and U.S. Department of Health and Human Services (2007) research described above indicates that it is likely that arsenic taken up by tamarisk would be primarily located below ground surface in the root mass.

The primary effect that tamarisk would have on transport of arsenic in the Western Hook Subarea is related to its characteristic high consumptive use of water, high evapotranspiration rates, deep rooting, and the maintenance of an upward gradient for water to move upward from a shallow water table, through the capillary fringe, and into the vadose zone. Tamarisk is a phreatophyte (a deep rooted plant able to secure a portion of its water requirement from groundwater sources) and a halophyte (a plant that is able to thrive in a saline environment), (Devitt, 2006 [copy included in Appendix F]) and is capable of sending roots 25 to 30 ft bgs (Devitt, 2006). Given that the arsenic level taken up by the plants is comparatively low (U.S. Department of Health and Human Services, 2007), tamarisk that historically existed in the Western Hook Subarea would act to preferentially take up water and mostly exclude the uptake of dissolved arsenic. The result would be an increase in arsenic concentration in soils where tamarisk grew over relatively shallow groundwater impacted by arsenic.



5. Findings

Arsenic occurs naturally in many geologic settings in the western United States. The local geology in the Western Hook Subarea contains volcanic rocks and basin-fill sedimentary deposits of alluvial-lacustrine origin, both of which are sources of arsenic. Geologic maps show that the Western Hook Subarea soils are formed in alluvial fan sediments originating from volcanic rocks. These volcanic rocks contain silicates and iron-bearing minerals that often contain arsenic. Site investigations east of the Western Hook Subarea found background arsenic concentrations above 20 mg/kg. At the Henderson Landfill near volcanic rock outcrops, background soil concentrations of arsenic between 40 mg/kg and 910 mg/kg were measured. Boring logs for three wells at the Western Hook Subarea contain gravel and cobbles of volcanic origin.

There is a significant groundwater plume of arsenic that extends from the Plants Area northward to beneath the Western Hook Subarea and then to Las Vegas Wash. The groundwater in the vicinity of the Western Hook Subarea is relatively shallow and a mechanism, tamarisk evapotranspiration and capillary rise, has been identified that can potentially explain upward movement of arsenic into the vadose zone beneath the Western Hook Subarea.

Transport of historical effluent through the Western and Northwestern Ditches is not a likely source of arsenic transport to the Western Hook Subarea.

The weight of evidence indicates that natural concentrations of arsenic in the Western Hook Subarea are elevated due to the chemical characteristics of the geologic source material that formed the soils. Other information and data, however, indicate that anthropogenic sources (i.e., a Shallow Zone groundwater plume that is currently present) could have also impacted soils in the Western Hook and adjacent Open Space Subareas.



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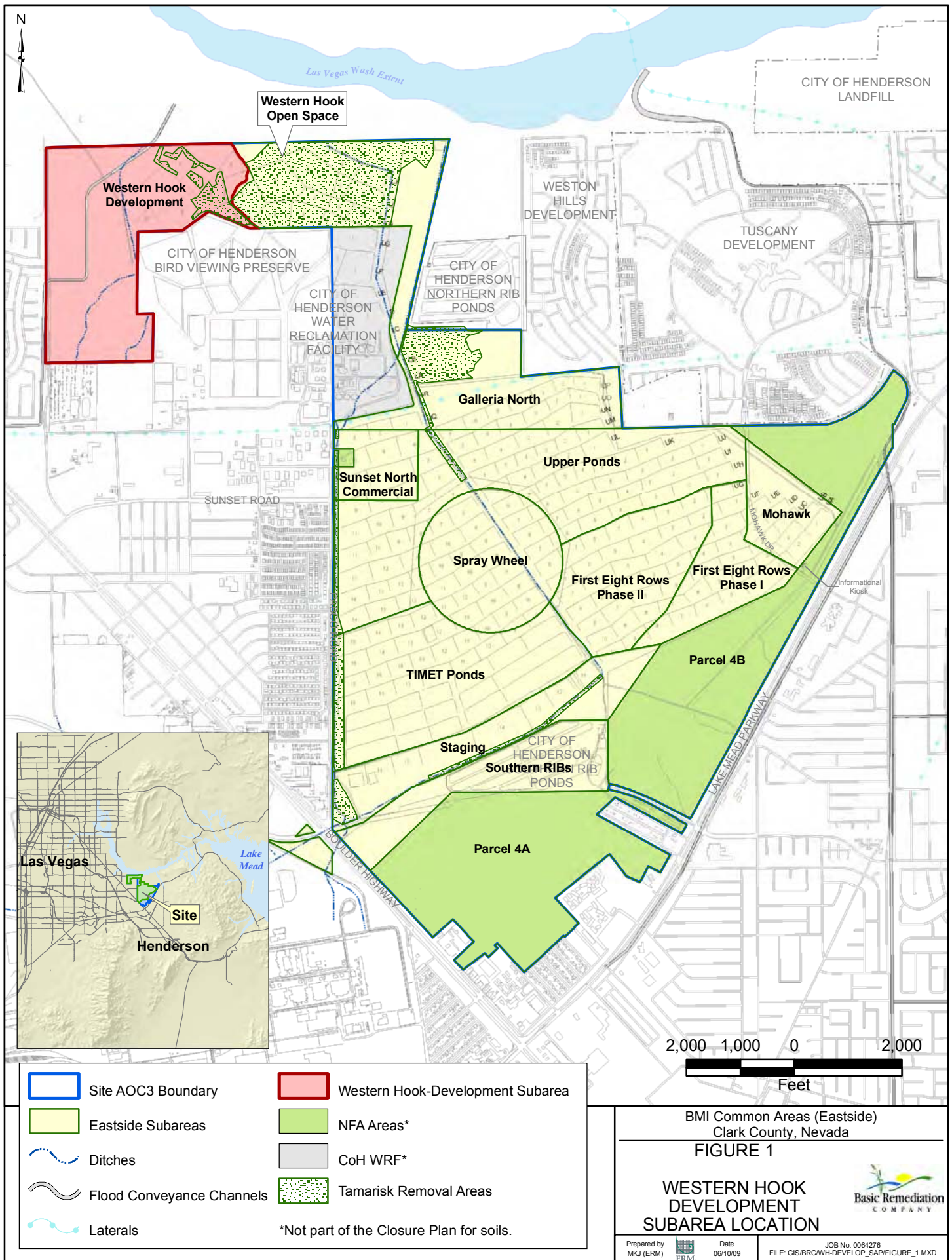


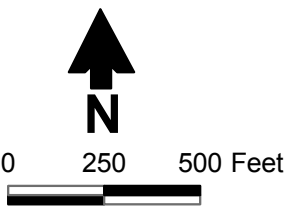
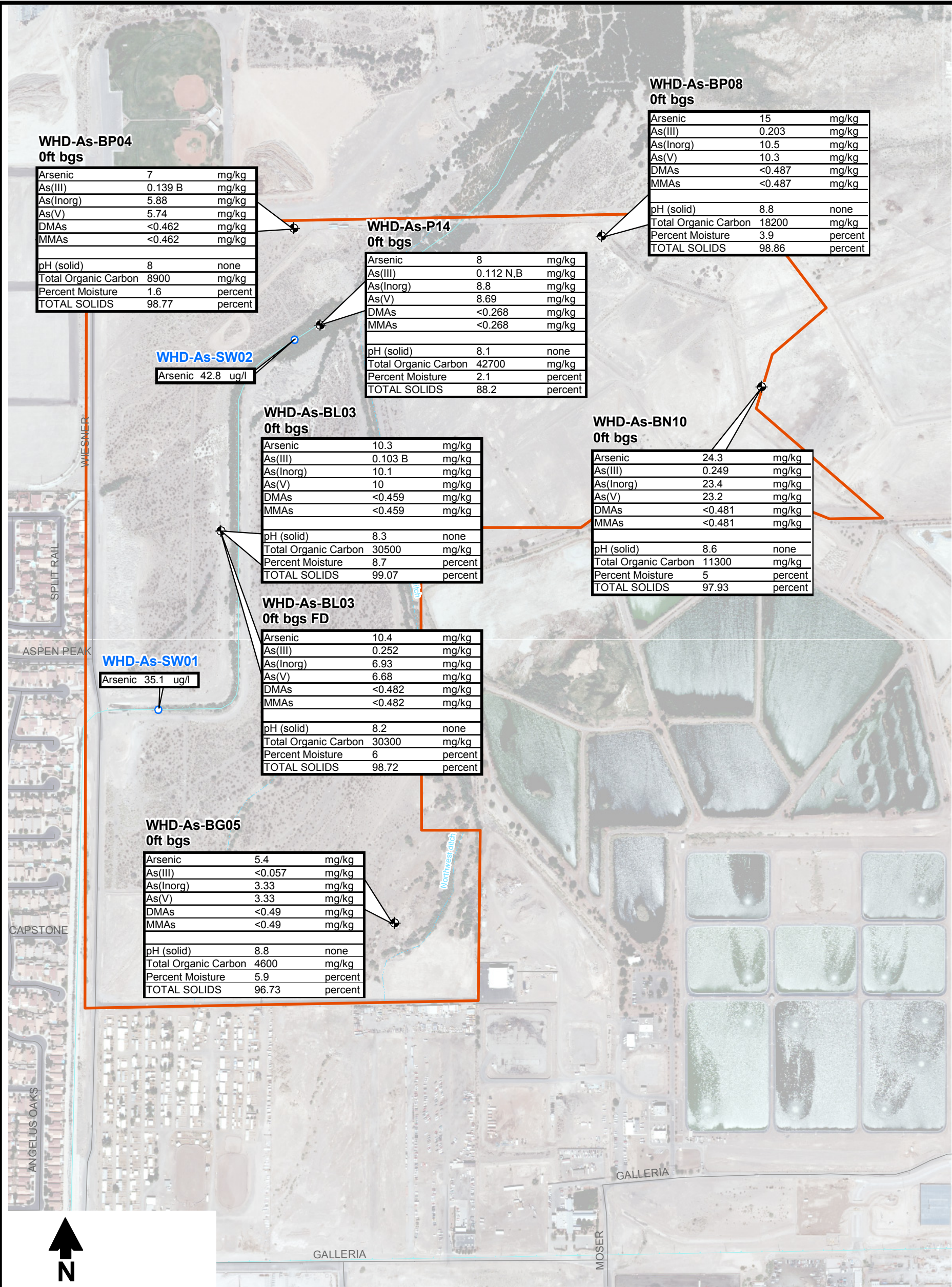
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Figures





Base Map Source: Originator: U.S. Geological Survey, Publication Date: 20090202

Explanation

- Soil sample location
- Surface water sample location
- Western Hook Development Subarea
- ft bgs Feet below ground surface

Note: Samples collected September 2009

BMI Common Areas (Eastside)
Henderson, Nevada

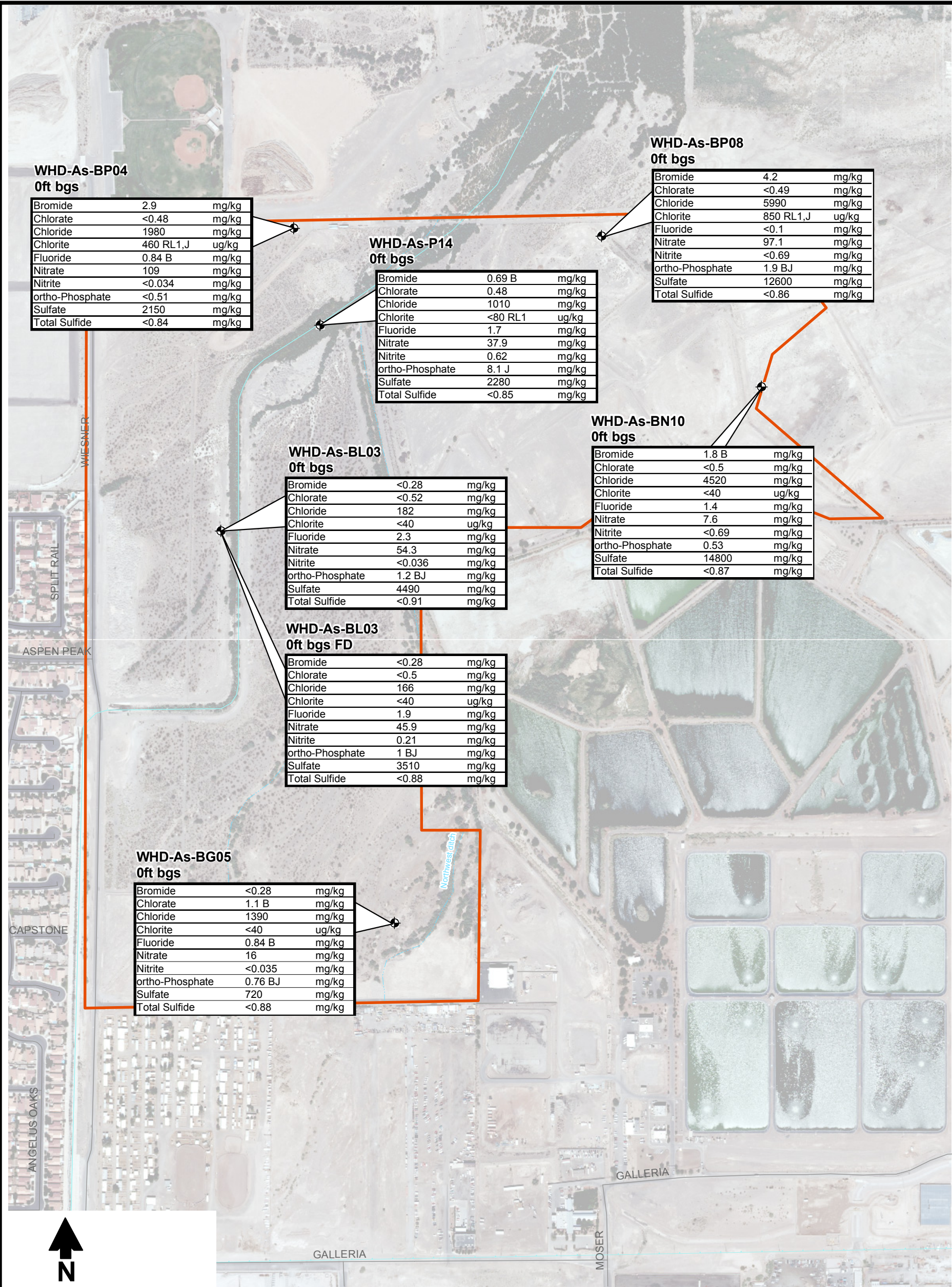
FIGURE 2
Western Hook Subarea
Surface Samples

Basic Remediation
COMPANY

Prepared by:
DBS&A CRS

Date
1-15-10

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GIS/MXDS/CHEMISTRY/
WESTERN_HOOK_0_FT_BGS_P1.MXD 906011



Explanation

- Soil sample location
- Western Hook Development Subarea
- ft bgs Feet below ground surface

Note: Samples collected September 2009



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BMI Common Areas (Eastside)
Henderson, Nevada

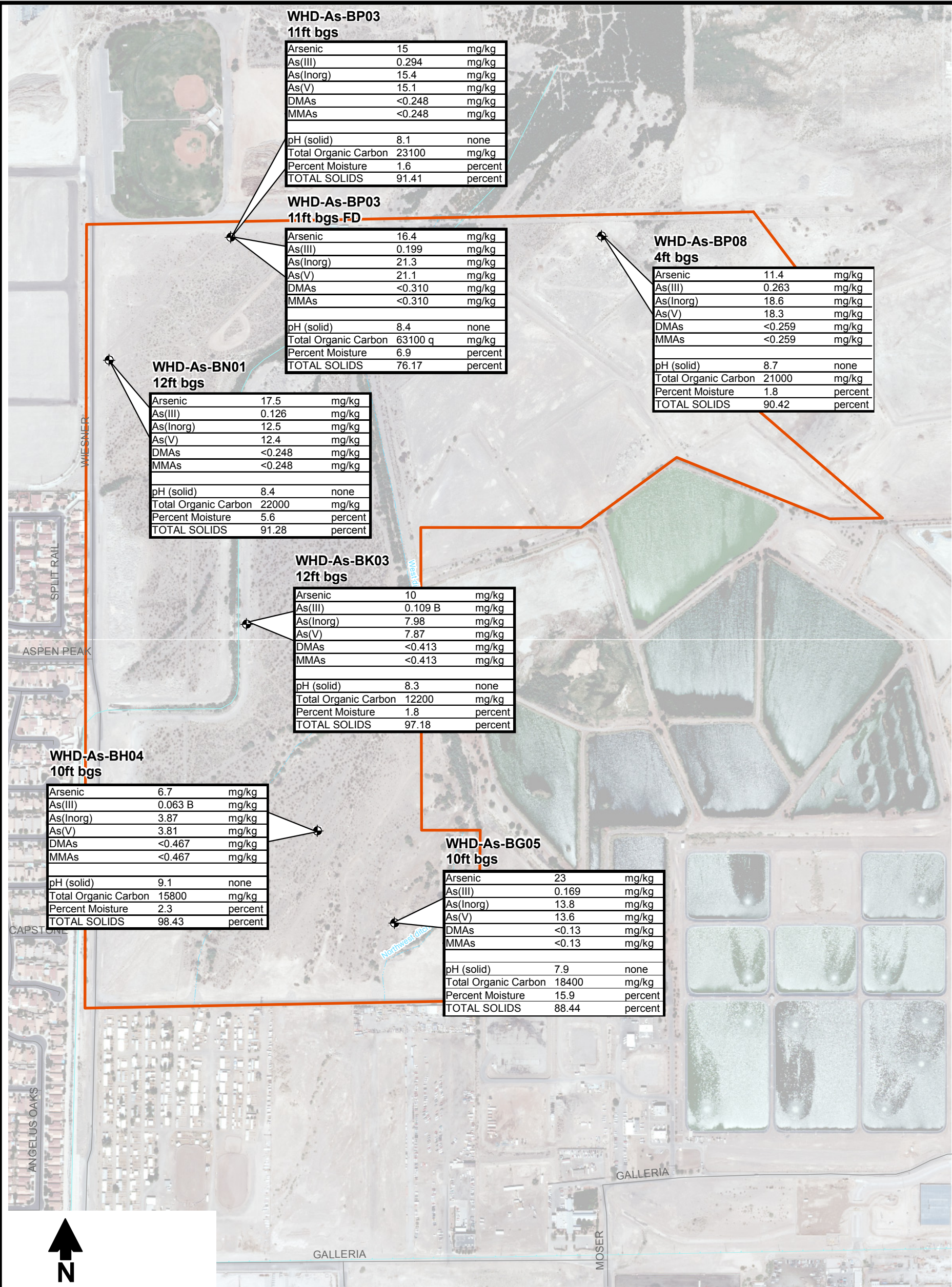
FIGURE 2
Western Hook Subarea
Surface Samples



Prepared by:
DBS&A CRS

Date
1-15-10

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GIS/MXDS/CHEMISTRY/
WESTERN_HOOK_0_FT_BGS_P2.MXD 906011



Base Map Source: Originator: U.S. Geological Survey, Publication Date: 20090202

Explanation

- Soil sample location
- Western Hook Development Subarea
- ft bgs Feet below ground surface

Note: Samples collected September 2009



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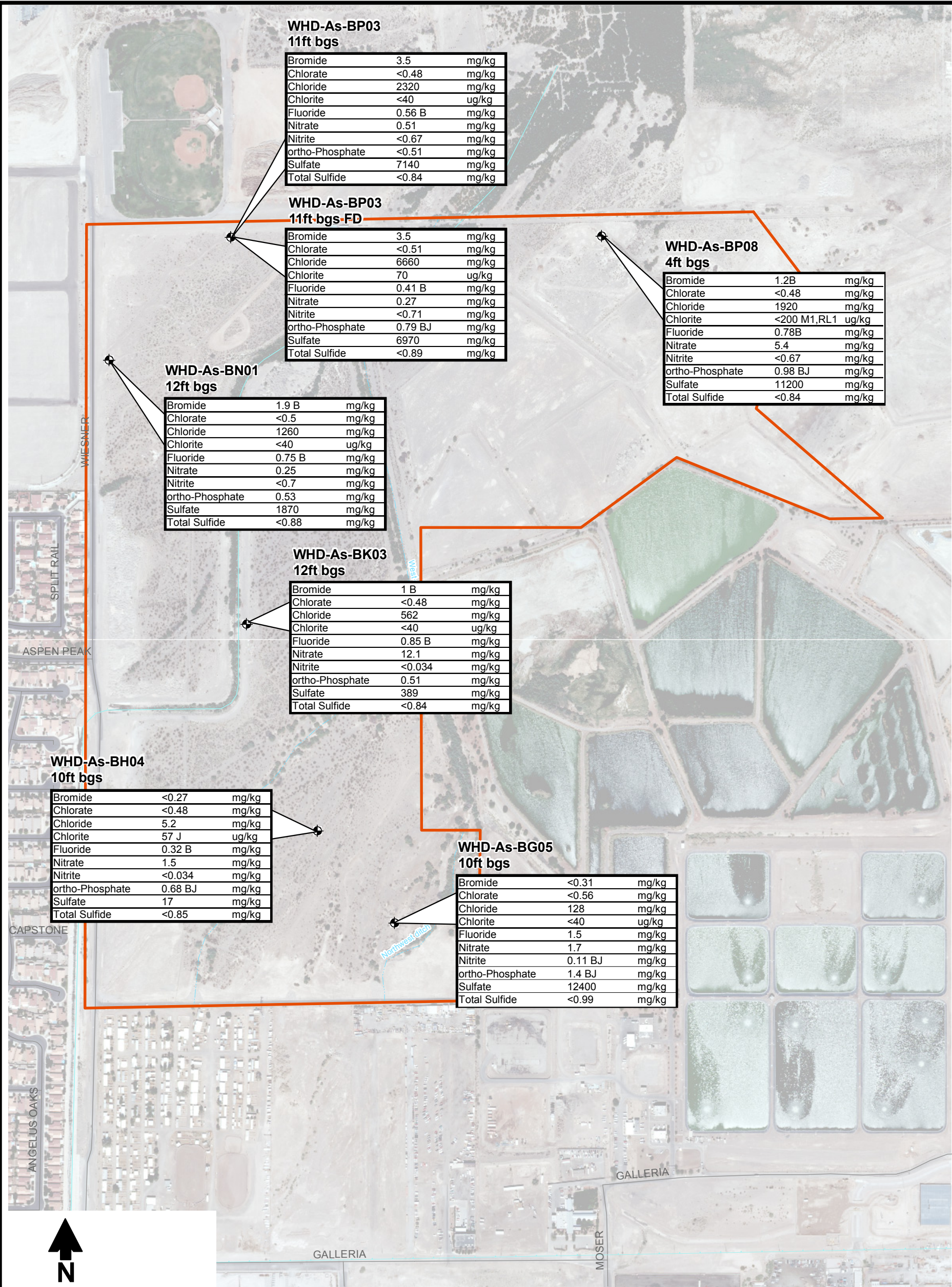
BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE 3
Western Hook Subarea
Subsurface Samples

Basic Remediation
COMPANY

Prepared by: DBS&A CRS Date: 1-15-10

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Base Map Source: Originator: U.S. Geological Survey, Publication Date: 20090202

Explanation

- Soil sample location
- Western Hook Development Subarea
- ft bgs Feet below ground surface

Note: Samples collected September 2009



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BMI Common Areas (Eastside)
Henderson, Nevada

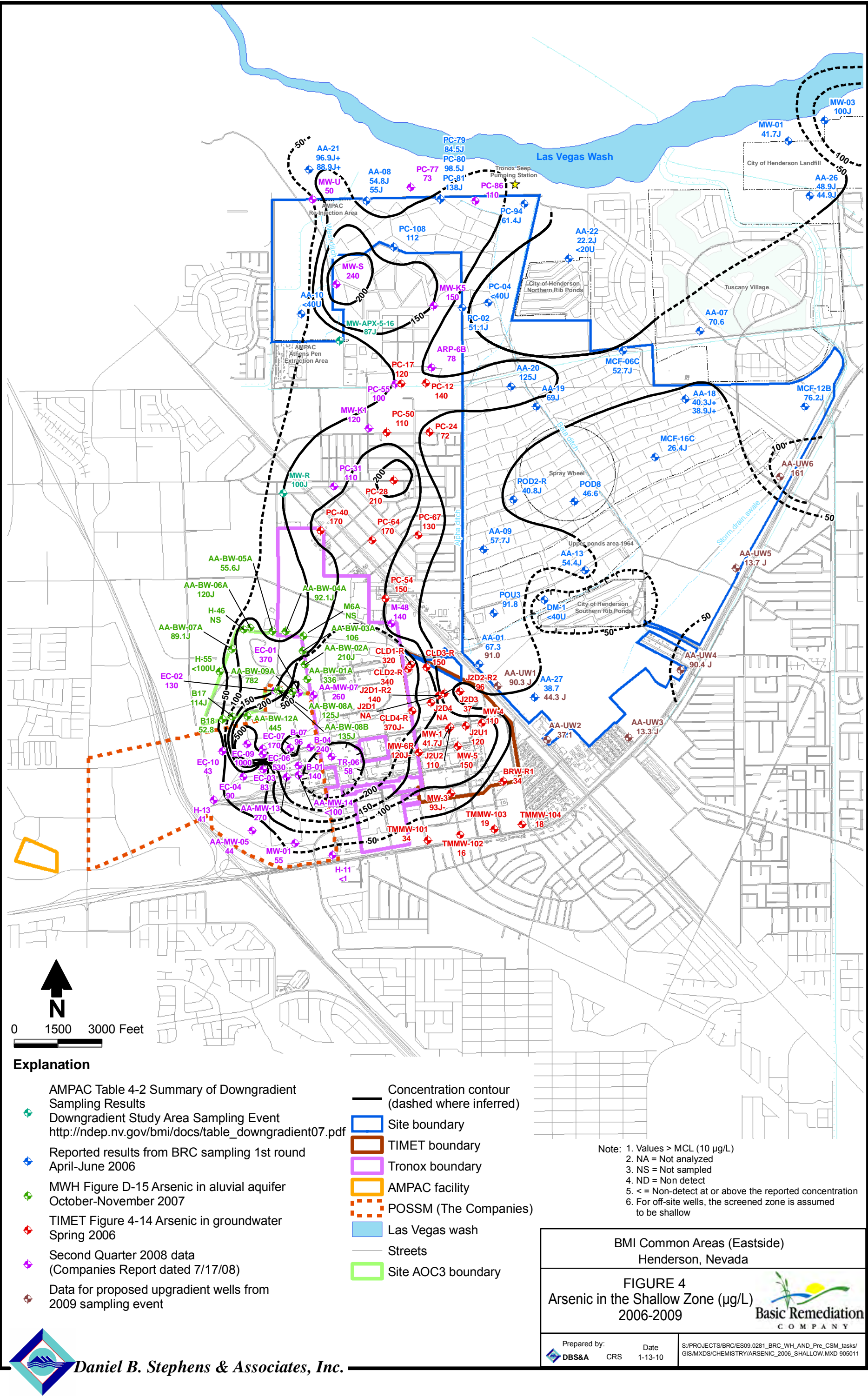
FIGURE 3
Western Hook Subarea
Subsurface Samples

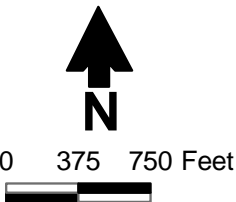
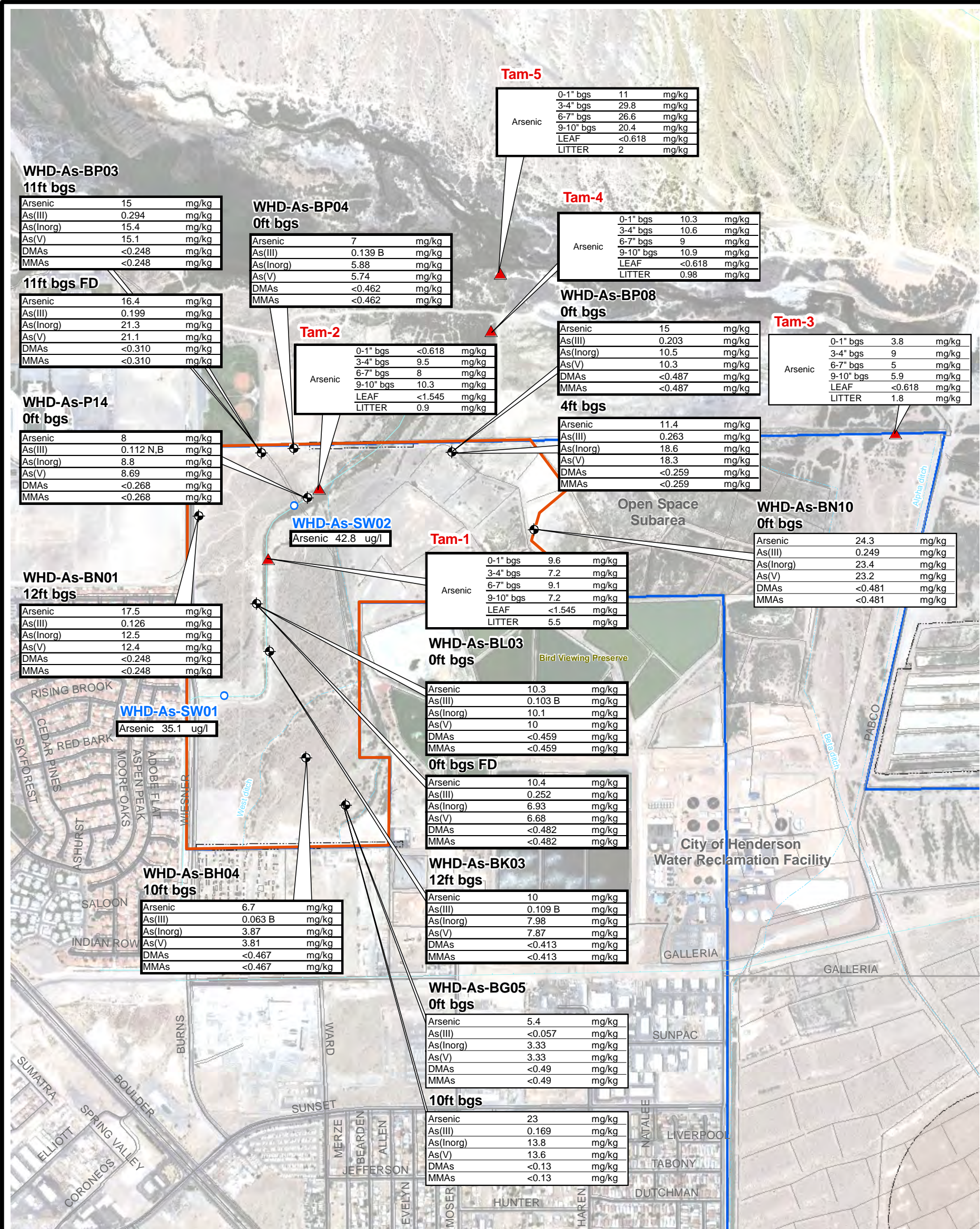


Prepared by:
DBS&A

Date
1-15-10

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Explanation

- Soil sample location
- Surface water sample location
- Tamarisk and shallow soil sampling location
- Western Hook Development Subarea
- Site boundary
- ft bgs Feet below ground surface

Base Map Source: Originator: U.S. Geological Survey, Publication Date: 20090202
Source: GES Nevada (GES), 2009a, BRC Tamarisk Sampling in Western Hook Area, Henderson, Nevada, August 31.
Note: Samples collected September 2009

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE 5
Western Hook Subarea
Arsenic Data

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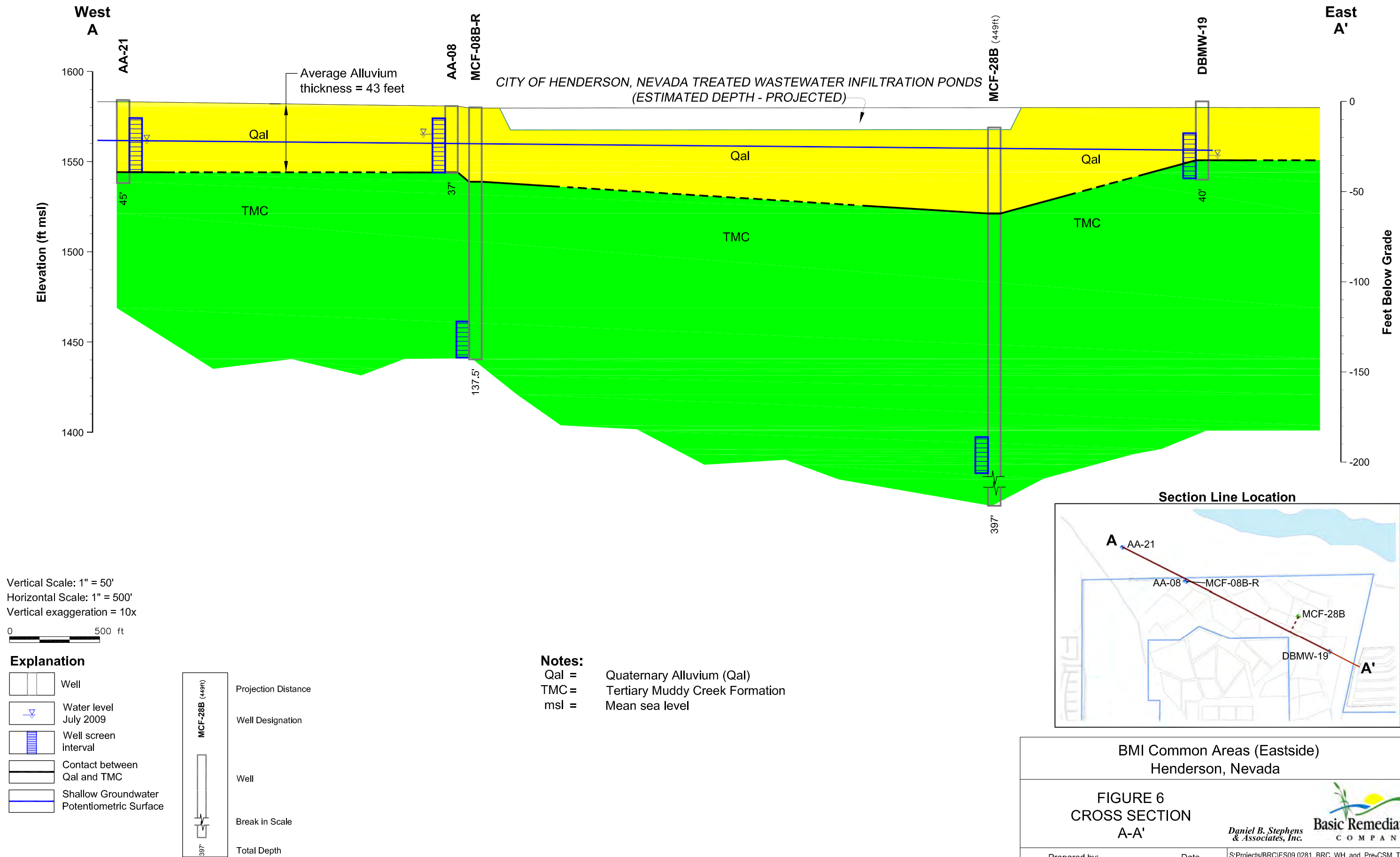
Date
04-09-10

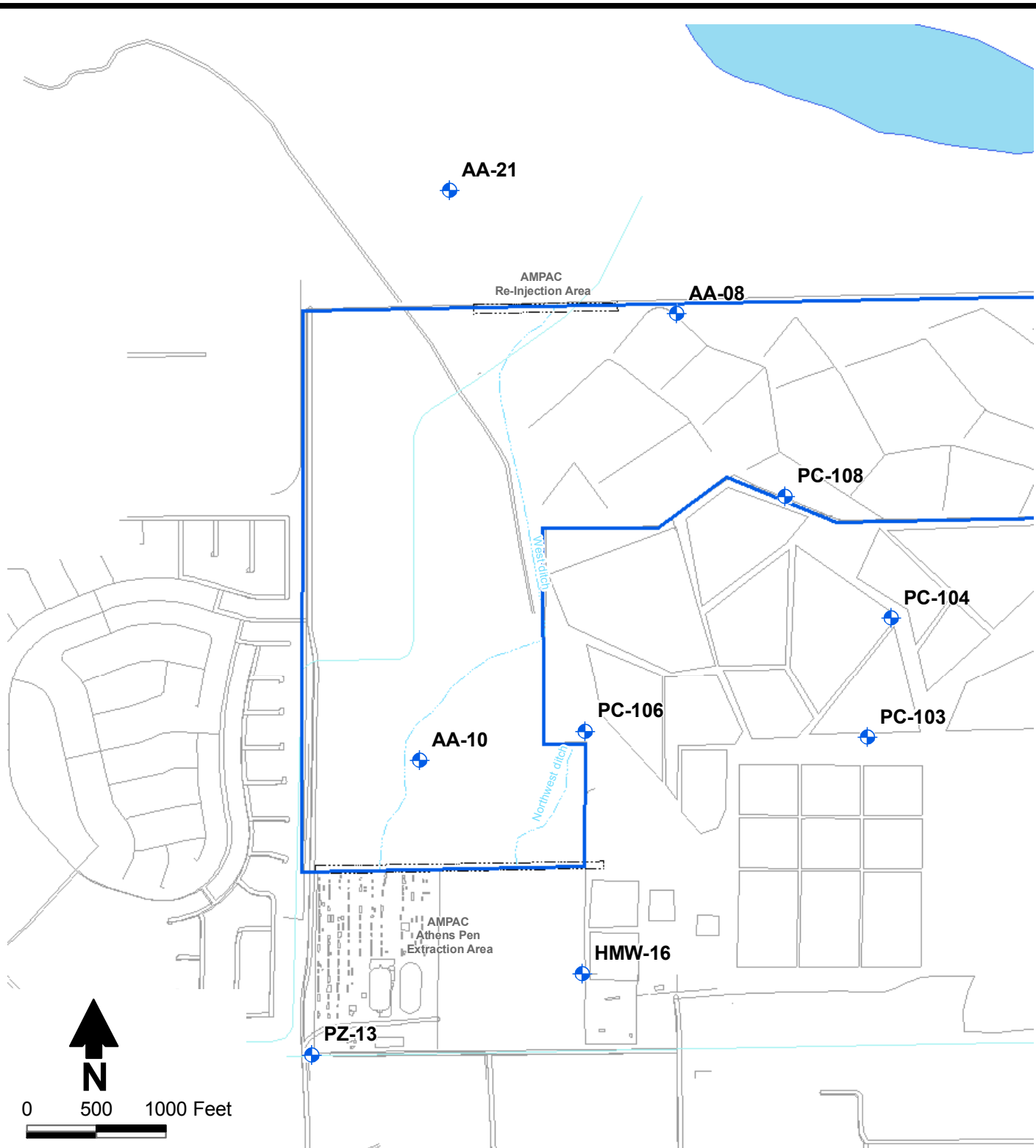
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Basic Remediation
COMPANY

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Explanation

- | | | | |
|---|------------------------------|---|---------|
|  | Shallow Zone Monitoring well |  | Streets |
|  | Site boundary |  | Canals |
|  | Las Vegas wash |  | Ditches |




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BMI Common Areas (Eastside)
Henderson, Nevada

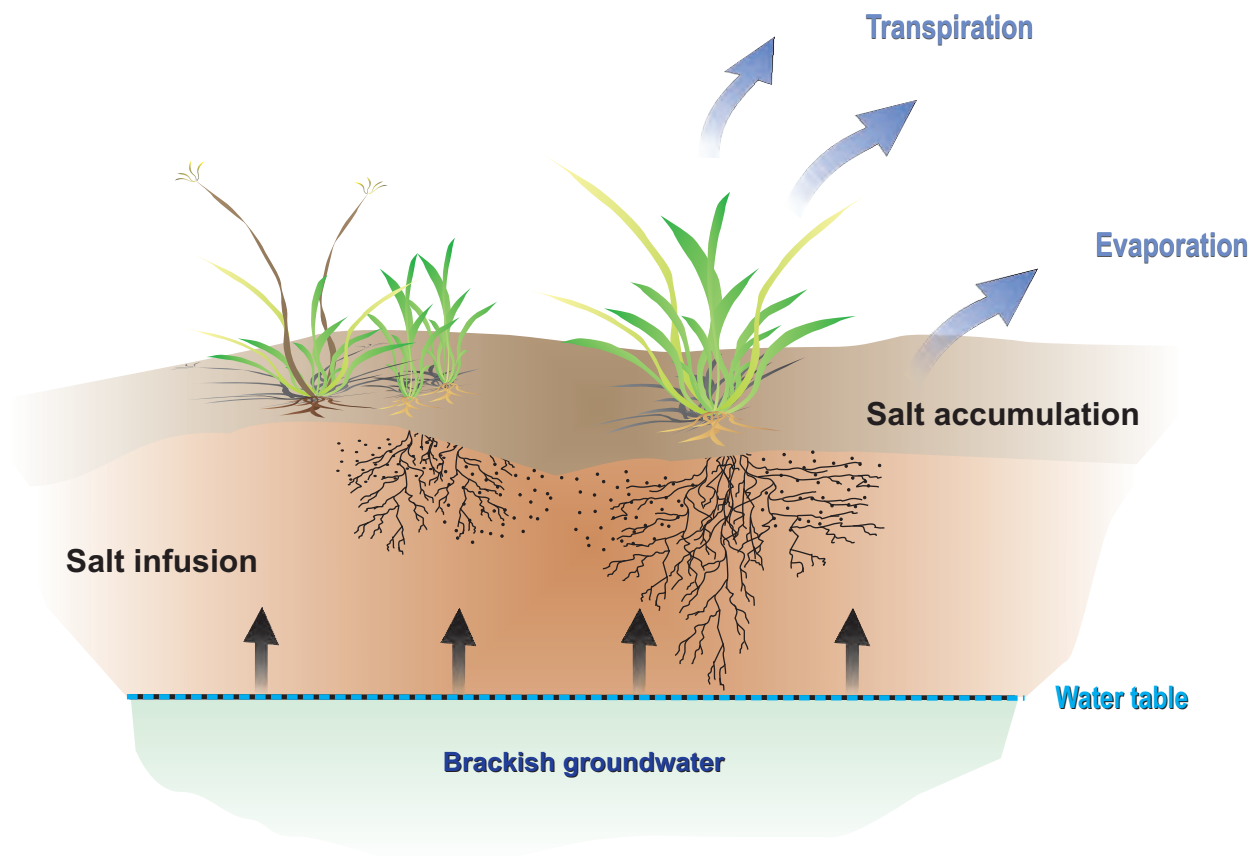
FIGURE 7
Western Hook
Monitoring Wells





Prepared by:
 **DBS&A** CRS

Date
01-13-10

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GIS/MXDS/BASE_MAPS/
WESTERN_HOOK_MONITORING_WELLS.MXD 013110



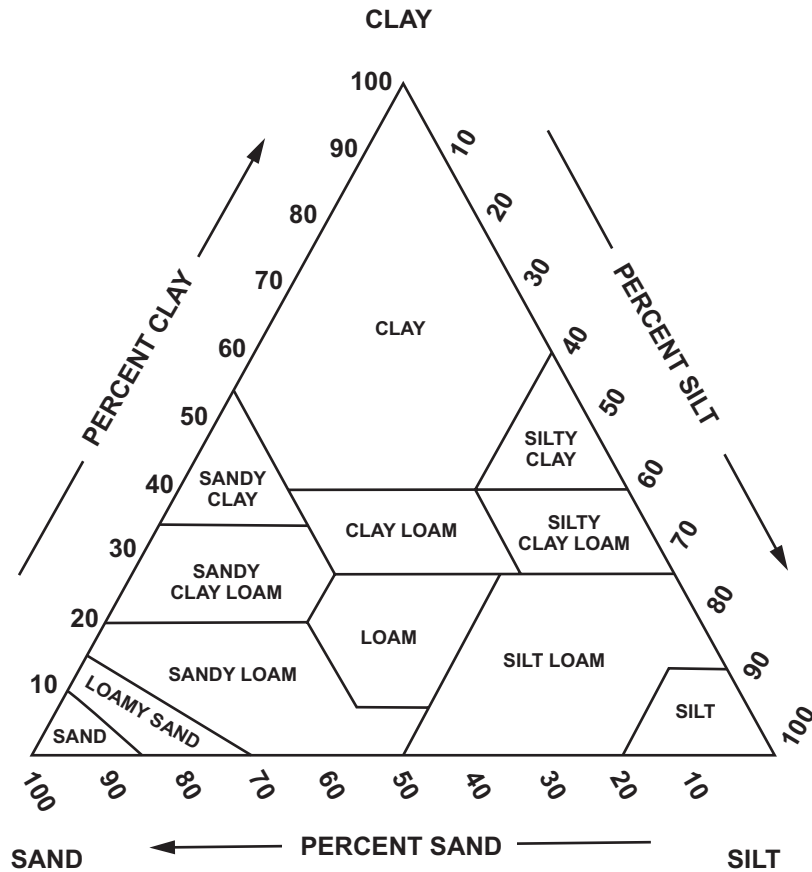
Source: The process of water table rise, capillary rise, and salination (Hillel, 1998).

| | | |
|---|----------------------|--|
| BMI Common Areas (Eastside) Henderson, Nevada | | |
| FIGURE 8 Capillary Rise and Salt Accumulation | |  |
| Prepared by:  DBS&A | Date: CRS 1-14-10 | S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/ VDR_DRAWINGS/Capillary_rise.cdr |

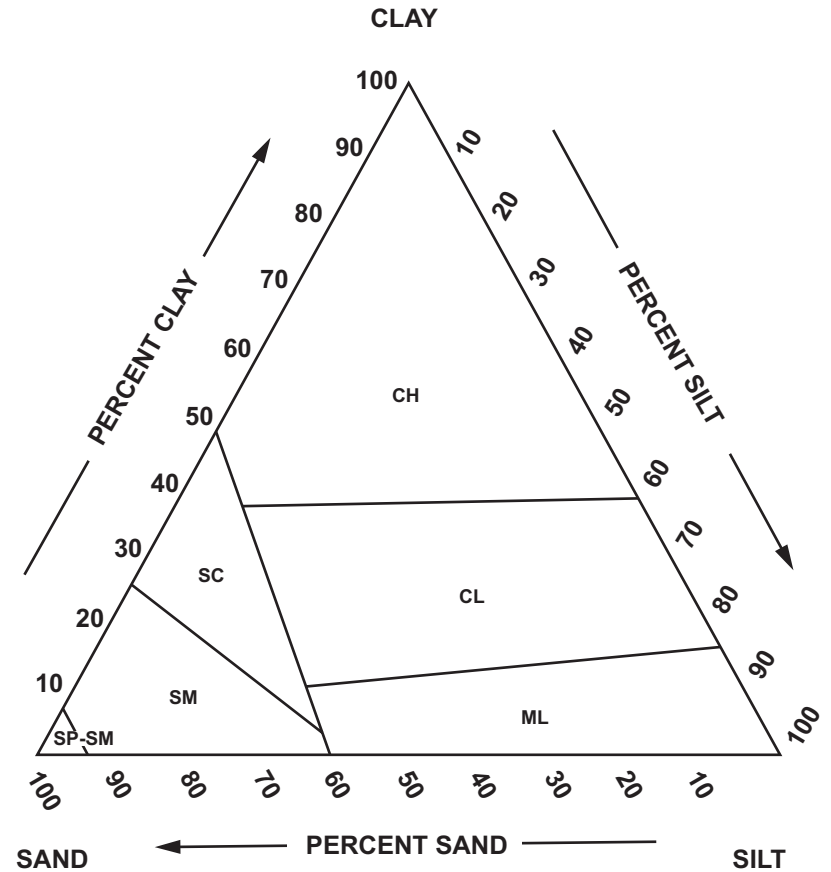


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USDA



USCS



Source: Dragun, 1988



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BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE 9
Comparison of
USDA and USCS Systems



Prepared by:
DBS&A CRS

Date
1-15-10

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Tables



**Table 1. Analytical Sample Results for Shallow Soil,
Live Tamarisk Leaves, and Tamarisk Leaf Litter
Western Hook Area**

| Tamarisk Stand | Sample | Arsenic Concentration (mg/kg) | Percent Moisture (%) |
|------------------------|-------------|-------------------------------|----------------------|
| <i>Detection limit</i> | | 0.618 ^a | NA |
| 1 | TAM1-0-1" | 9.6 ^b | 0.92 |
| | TAM1-3-4" | 7.2 ^b | 0.93 |
| | TAM1-6-7" | 9.1 ^b | 1.6 |
| | TAM1-9-10" | 7.2 ^b | 1.8 |
| | TAM1-LEAF | <1.545 ^b | 53.1 |
| | TAM1-LITTER | 5.5 ^b | 6.9 |
| 2 | TAM2-0-1" | <1.618 | 1 |
| | TAM2-3-4" | 9.5 | 1.7 |
| | TAM2-6-7" | 8 | 1.7 |
| | TAM2-9-10" | 10.3 | 2.5 |
| | TAM2-LEAF | <1.545 ^b | 66.1 |
| | TAM2-LITTER | 0.9 | 1.8 |
| 3 | TAM3-0-1" | 3.8 | 4.2 |
| | TAM3-3-4" | 9 ^c | 4.7 |
| | TAM3-6-7" | 5 | 4.2 |
| | TAM3-9-10" | 5.9 | 5.7 |
| | TAM3-LEAF | <1.618 | 54.6 |
| | TAM3-LITTER | 1.8 | 6 |
| 4 | TAM4-0-1" | 10.3 | 3 |
| | TAM4-3-4" | 10.6 | 2 |
| | TAM4-6-7" | 9 | 1.1 |
| | TAM4-9-10" | 10.9 | 5.2 |
| | TAM4-LEAF | <1.618 | 57.5 |
| | TAM4-LITTER | 0.98 | 6.8 |
| 5 | TAM5-0-1" | 11 | 3.7 |
| | TAM5-3-4" | 29.8 | 8.2 |
| | TAM5-6-7" | 26.6 | 5.8 |
| | TAM5-9-10" | 20.4 | 11.5 |
| | TAM5-LEAF | <1.618 | 51.3 |
| | TAM5-LITTER | 2 | 7.2 |

^a Unless otherwise noted

^b Detection limit = 1.545 mg/kg

mg/kg = Milligrams per kilogram

NA = Not applicable



Table 2. Analytical Sample Results for Soil and Surface Water Samples
Western Hook Area

| Sample | Concentration (mg/kg ^a) | | | | | | | | | | | | | | | | | | | | |
|------------------------------------|-------------------------------------|---------|----------------|-------|---------|----------|----------|-----------------|------|-------|----------|-------|---------|---------|-----------------|----------------------|-------------------|---------|----------------------|------------------|---------------|
| | Arsenic | As(III) | As (Inorganic) | As(V) | Bromide | Chlorate | Chloride | Chlorite (µg/L) | DCA | DMAs | Fluoride | MMAs | Nitrate | Nitrite | ortho-Phosphate | Percent Moisture (%) | pH (solid) (s.u.) | Sulfate | Total Organic Carbon | Total Solids (%) | Total Sulfide |
| <i>Method^b</i> | SW6020 | E1632 | E1632 | E1632 | E300 | E300 | E300 | E300 | E300 | E1632 | E300 | E1632 | E300 | E300 | E300 | E160.3 | SW9045 | E300 | SW9060 | SM2540G | E376.1 |
| <i>Detection limit^c</i> | 0.618 ^a | 0.057 | 0.435 | 0.435 | 0.28 | 0.5 | 42.5 | 40 | None | 0.49 | 0.11 | 0.49 | 1.1 | 0.035 | 0.53 | None | None | 10.6 | 210 | 0.1 | 0.88 |
| <i>Soil</i> | | | | | | | | | | | | | | | | | | | | | |
| WHD-AS-BG05-10 | 23 | 0.169 | 13.8 | 13.6 | — | — | 128 | — | 104 | — | 1.5 | — | 1.7 | 0.11 | 1.4 | 15.9 | 7.9 | 12,400 | 18,400 | 88.44 | — |
| WHD-AS-BH04-10 | 6.7 | 0.063 | 3.87 | 3.81 | — | — | 5.2 | 57 | 111 | — | 0.32 | — | 1.5 | — | 0.68 | 2.3 | 9.1 | 17 | 15,800 | 98.43 | — |
| WHD-AS-BK03-12 | 10 | 0.109 | 7.98 | 7.87 | 1 | — | 562 | — | 106 | — | 0.85 | — | 12.1 | — | — | 1.8 | 8.3 | 389 | 12,200 | 97.18 | — |
| WHD-AS-BL03-0 | 10.3 | 0.103 | 10.1 | 10.0 | — | — | 182 | — | 107 | — | 2.3 | — | 54.3 | — | 1.2 | 8.7 | 8.3 | 4,490 | 30,500 | 99.07 | — |
| WHD-AS-BL03-0-FD | 10.4 | 0.252 | 6.93 | 6.68 | — | — | 166 | — | 107 | — | 1.9 | — | 45.9 | 0.21 | 1 | 6 | 8.2 | 3,510 | 30,300 | 98.72 | — |
| WHD-AS-BN01-12 | 17.5 | 0.126 | 12.5 | 12.4 | 1.9 | — | 1,260 | — | 107 | — | 0.75 | — | 0.25 | — | — | 5.6 | 8.4 | 1,870 | 22,000 | 91.28 | — |
| WHD-AS-BN10-0 | 24.3 | 0.249 | 23.4 | 23.2 | 1.8 | — | 4,520 | — | 106 | — | 1.4 | — | 7.6 | — | — | 5 | 8.6 | 14,800 | 11,300 | 97.93 | — |
| WHD-AS-BG05-0 | 5.4 | — | 3.33 | 3.33 | — | 1.1 | 1,390 | — | — | — | 0.84 | — | 16 | — | 0.76 | 5.9 | 8.8 | 720 | 4,600 | 96.73 | — |
| WHD-AS-BP03-11 | 15 | 0.294 | 15.4 | 15.1 | 3.5 | — | 2,320 | — | 107 | — | 0.56 | — | 0.51 | — | — | 1.6 | 8.1 | 7,140 | 23,100 | 91.41 | — |
| WHD-AS-BP03-11-FD | 16.4 | 0.199 | 21.3 | 21.1 | 3.5 | — | 6,660 | 70 | 104 | — | 0.41 | — | 0.27 | — | 0.79 | 6.9 | 8.4 | 6,970 | 63,100 | 76.17 | — |
| WHD-AS-BP04-0 | 7 | 0.139 | 5.88 | 5.74 | 2.9 | — | 1,980 | 460 | 106 | — | 0.84 | — | 109 | — | — | 1.6 | 8 | 2,150 | 8,900 | 98.77 | — |
| WHD-AS-BP08-0 | 15 | 0.203 | 10.5 | 10.3 | 4.2 | — | 5,990 | 850 | 108 | — | — | — | 97.1 | — | 1.9 | 3.9 | 8.8 | 12,600 | 18,200 | 98.86 | — |
| WHD-AS-BP08-4 | 11.4 | 0.263 | 18.6 | 18.3 | 1.2 | — | 1,920 | — | 103 | — | 0.78 | — | 5.4 | — | 0.98 | 1.8 | 8.7 | 11,200 | 21,000 | 90.42 | — |
| WHD-AS-P14-0 | 8 | 0.112 | 8.80 | 8.69 | 0.69 | — | 1,010 | — | 109 | — | 1.7 | — | 37.9 | 0.62 | 8.1 | 2.1 | 8.1 | 2,280 | 42,700 | 88.20 | — |
| <i>Surface water</i> | | | | | | | | | | | | | | | | | | | | | |
| WHD-AS-SW01 | 35.1 ^c | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| WHD-AS-SW02 | 42.8 ^c | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

^a Unless otherwise noted

^b E = EPA method; SW = Surface water

^c Units in µg/L; detection limit = 0.52

mg/kg= Milligrams per kilogram

AS = Arsenic

µg/L = Micrograms per liter

DCA = Dichloroacetate

DMAs = Dimethylarsinic acids

MMAs = Methylarsenates

s.u. = Standard units

— = Not detected above applicable detection limit

NA = Not analyzed



Table 3. Summary of Grain Size Data and USCS Symbols

| Sample | Percentage of Total Sample | | | | | | | USCS Classification | |
|------------------|----------------------------|-------|--------|--------|------|------|------|---------------------|---------------------------------------|
| | Gravel | Sand | | | | Silt | Clay | | |
| | | Total | Coarse | Medium | Fine | | | Symbol | Description |
| WHD-AS-BP08-4 | 1.8 | 69.6 | 2.5 | 11.8 | 55.3 | 19.7 | 8.9 | SM | Silty sand |
| WHD-AS-BL03-3 | 18.5 | 61.0 | 11.0 | 21.3 | 28.7 | 17.5 | 3.0 | SM | Silty sand with gravel |
| WHD-AS-BL03-0-FD | 21.2 | 59.4 | 13.6 | 20.3 | 25.5 | 17.2 | 2.2 | SM | Silty sand with gravel |
| WHD-AS-BG05-10 | 13.0 | 74.6 | 11.1 | 22.8 | 40.8 | 11.2 | 1.2 | SW-SM | Well graded sand with silt |
| WHD-AS-BH04-10 | 27.2 | 48.1 | 9.2 | 16.4 | 22.5 | 18.6 | 6.0 | SM | Silty sand with gravel |
| WHD-AS-BH04-0 | 22.3 | 64.3 | 15.21 | 15.2 | 33.9 | 7.0 | 6.3 | SW-SM | Well graded sand with silt and gravel |
| WHD-AS-BH08-0 | 4.8 | 70.2 | 6.2 | 18.0 | 46.1 | 19.5 | 5.5 | SM | Silty sand |
| WHD-AS-BN10-0 | 12.0 | 52.8 | 6.4 | 23.9 | 22.5 | 32.8 | 2.5 | SM | Silty sand |



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Table 4. Maximum Height of Capillary Rise in Homogeneous Soil Profiles of Various Textures

| Texture | Maximum Capillary Rise (cm) | | | | | | | | | |
|-------------------------|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Capillary flux (cm/d) | 3 | 2 | 1 | 0.8 | 0.6 | 0.4 | 0.2 | 0.1 | 0.1 | 0.01 |
| Sand ^a | 14 | 15 | 17 | 18 | 19 | 20 | 23 | 26 | 29 | 37 |
| Sand ^b | 35 | 40 | 48 | 51 | 55 | 61 | 73 | 87 | 103 | 152 |
| Loamy sand ^a | 16 | 17 | 20 | 21 | 22 | 24 | 28 | 32 | 37 | 51 |
| Loamy sand ^c | 133 | 151 | 185 | 197 | 213 | 237 | 282 | 334 | 394 | 572 |
| Sandy loam ^a | 20 | 23 | 28 | 30 | 32 | 36 | 43 | 51 | 61 | 91 |
| Sandy loam ^b | 37 | 44 | 59 | 64 | 72 | 84 | 107 | 135 | 169 | 277 |
| Loam ^a | 21 | 26 | 35 | 38 | 43 | 50 | 65 | 82 | 103 | 171 |
| Loam ^a | 32 | 41 | 60 | 66 | 78 | 95 | 130 | 176 | 234 | 425 |
| Clay loam ^a | 10 | 14 | 23 | 27 | 32 | 40 | 58 | 82 | 112 | 219 |
| Clay loam ^c | 106 | 126 | 165 | 179 | 197 | 226 | 279 | 342 | 415 | 639 |

Source: Hendrickx et al., 2003 as reported by Hendrickx and Buchanan, 2009
Individual sources cited by Hendrickx et al., 2003:

^a Carsel and Parrish, 1988

^b Wösten and van Genuchten, 1988

^c Van Genuchten, 1978

cm = Centimeters

cm/d = Centimeters per day

Appendix A
Response to Comments

Response to Nevada Division of Environmental Protection (NDEP) Comments, dated March 4, 2010, to *Evaluation of Arsenic Occurrence in the Western Hook Development Subarea*, dated February 8, 2010, NDEP Facility ID# H-000688

1. Section 2.2.2, page (pg) 6, last sentence of section, soil physical properties and USCS classification should be summarized in a Table.

Response: Table 3 has been included in the revised report to present these data based on the grain size analyses.

2. Section 2.3.1, pg 6, it would be helpful to have a Figure which presents the arsenic results within the areas of former Tamarisk versus areas outside the Tamarisk stands. This would help to complete the discussion in this section. This comment also applies to Section 4.4.

Response: Figure 5 has been revised to include these data.

3. Section 3.1.2, pg 11, last paragraph of the section, BRC states “Currently, such subcropping has not been identified, nor identified as associated with the River Mountains, by the limited number of deep boreholes advanced in the Western Hook Subarea.” The latter sentence appears to be speculation. Please re-word or remove from the report.

Response: The referenced sentence has been omitted.

4. Section 3.1.5, pages 12 and 13, BRC needs to expand the discussion to explain why BRC believes that the deep background data is applicable to shallow soils in the Western Hook sub-area.

Response: This section has been revised to discuss the thickness of Qal in the Western Hook Subarea. As discussed in the revised report, since the Qal is a minimum of 39 feet thick in the area, it is considered unlikely that Western Hook Subarea soil samples for arsenic analysis were collected from the TMCf or TMCf-bearing soils consistent with the deep background data set.

5. Section 3.2.2, pg 16, 1st full paragraph on page, BRC states “NDEP has published data on their web site...that includes arsenic concentrations from AMPAC wells MW-APX-5-16, MW-K1, MW-K5, MW-R, and MW-S. Published arsenic concentrations in these wells range from 87 to 190 µg/L, with all published arsenic detections above the MCL of 10 µg/L.” Please include these wells and concentrations on Figure 4; then re-contour. In addition, please insure that the sampling methodology employed by AMPAC is consistent and usable with BRC’s low-flow sampling methodology.

Response: Data for the wells listed above were already included on the map. Available AMPAC data from the website http://ndep.neptuneinc.org/ndep_gisdt/home/index.xml were reviewed and compared to the AMPAC data posted on the map. However, the website data are dated 2004, so they were not added to the map because the existing AMPAC data are for 2007 and 2008. No information was obtained regarding AMPAC's groundwater sampling methodology.

6. Section 4.2, pages (pp) 22–24, the conceptual model presented herein has definite implications to the unsaturated zone modeling being completed by BRC and should be considered.

Response: Comment noted. BRC will consider this conceptual model during upcoming unsaturated zone modeling.

7. Section 4.3.2, pg 25, last paragraph of the section, BRC states “Laboratory analyses of two drain water samples indicate that total arsenic concentrations in the drainage water are in the mid-30s to low-40s- $\mu\text{g/L}$ range. Please provide the analytical results in lieu of the general range referenced here.

Response: The analytical results have been added to the revised text as requested.

8. Section 4.3.3, pg 25, last paragraph of the section, NDEP has the following comments:
- Please note that the ponds referenced in this paragraph were rapid infiltration basins (RIBs).

Response: Text has been added to this section of the revised report to mention that the CoH used these ponds as RIBs.

- BRC states “As a result, it is not possible to evaluate whether the COH wastewater treatment ponds could be acting as a current source of arsenic to groundwater or as a source of low redox water infiltrating into surrounding soil and mobilizing arsenic.” The RIB water interaction in this area is expected and should have been evaluated in this investigation. For example, water chemical parameters such as: TDS, pH, ORP, TOC, arsenic, etc. The revised Deliverable should address this data gap.

Response: The report text has been edited to state, *RIB water quality data—such as pH, total dissolved solids (TDS), oxidation-reduction potential (ORP), total organic carbon (TOC), and other parameters—would be useful in the evaluation of detected Western Hook Subarea arsenic concentrations in soil; however, no such data are available from the CoH.*

Appendix B

Grain Size Data

TestAmerica
South Burlington, VT
Extended Data Package

91190128

TestAmerica Laboratories, Inc.

October 1, 2009

Mr. Jerry Everett
TestAmerica, Inc.
13715 Rider Trail North
Earth City, MO 63045

Re: Laboratory Project No. 29014
Case: BRCWHOOK; SDG: 9I190128

Dear Mr. Everett:

Enclosed are the analytical results for the samples that were received by TestAmerica Burlington on September 22nd, 2009. Laboratory identification numbers were assigned, and designated as follows:

| <u>Lab ID</u> | <u>Client Sample ID</u> | <u>Sample Date</u> | <u>Sample Matrix</u> |
|-----------------------------------|-----------------------------|------------------------|--------------------------|
| Received: 09/22/09 ETR No: 133685 | | | |
| 807089 | WHD-AS-BG05-10 | 09/18/09 | SOIL |
| 807090 | WHD-AS-BH04-10 | 09/18/09 | SOIL |
| 807091 | WHD-AS-BP04-0 | 09/18/09 | SOIL |
| 807092 | WHD-AS-BP08-0 | 09/18/09 | SOIL |
| 807093 | WHD-AS-BN10-0 | 09/18/09 | SOIL |

Documentation of the condition of the samples at the time of their receipt and any exception to the laboratory's Sample Acceptance Policy is documented in the Sample Handling section of this submittal.

Particle Size Analysis by ASTM D422

There were no exceptions to the method quality control criteria during the analyses of these samples.

Any reference within this report to Severn Trent Laboratories, Inc. or STL, should be understood to refer to TestAmerica Laboratories, Inc. (formerly known as Severn Trent Laboratories, Inc.) The analytical results associated with the samples presented in this test report were generated under a quality system that adheres to requirements specified in the NELAC standard. Release of the data in this test report and any associated electronic deliverables is authorized by the Laboratory Director's designee as verified by the following signature.



If there are any questions regarding this submittal, please contact me at 802 660-1990.

Sincerely,

A handwritten signature in black ink, reading 'Rayburn J. Lavigne'. The signature is written in a cursive style with a large, stylized 'R' and 'L'.

Rayburn Lavigne
Project Manager

RJL/hsf
Enclosure

| | |
|------------------------------------|-----------|
| Chain of Custody | 1 |
| Particle Size Results | 3 |
| Sample Handling | 12 |



Chain of Custody

F9I190128**INTER-COMPANY LOG****COMMENTS:**

Project Manager:

Project:

Report Type: W

Client: 445691 - Basic Remediation Company

WESTERN HOOK

Date Received: 2009-09-19

Analytical Due Date: 2009-09-29

Report Due Date: 2009-10-05

WORK LOCATION: H2 TestAmerica Burlington

SMP#: 2 CLIENT ID: WHD-AS-BG05-10 DATE SAMPLED: 20090918 MATRIX: A SOLID
SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive
EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET
WORKORDER LK5D71AP METAL: XX

SMP#: 3 CLIENT ID: WHD-AS-BH04-10 DATE SAMPLED: 20090918 MATRIX: A SOLID
SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive
EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET
WORKORDER LK5D91AP METAL: XX

SMP#: 4 CLIENT ID: WHD-AS-BP04-0 DATE SAMPLED: 20090918 MATRIX: A SOLID
SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive
EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET
WORKORDER LK5EA1AP METAL: XX

SMP#: 5 CLIENT ID: WHD-AS-BP08-0 DATE SAMPLED: 20090918 MATRIX: A SOLID
SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive
EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET
WORKORDER LK5EC1AP METAL: XX

SMP#: 6 CLIENT ID: WHD-AS-BN10-0 DATE SAMPLED: 20090918 MATRIX: A SOLID
SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive
EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET
WORKORDER LK5ED1AP METAL: XX

The sample(s) listed on this form are being sent to your location for the specified analysis. If you have any questions, please contact the Project Manager listed above. PLEASE RETURN THE ORIGINAL SIGNED FORM WITH THE REPORT AT THE COMPLETION OF ANALYSIS.

Thank You

TA- St. Louis
Sample Receiving

RELINQUISHED BY:

DATE: 9.21.09 1700

RECEIVED FOR LAB BY:

DATE: 9/22/09 1030



Particle Size Results

Particle Size of Soils by ASTM D422

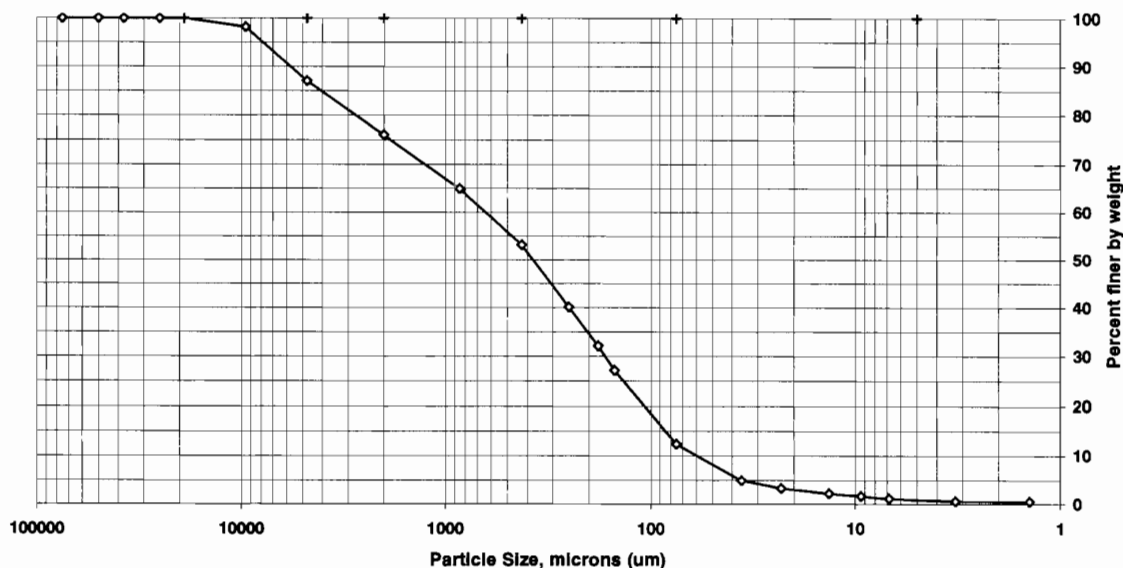
Client Code: STLMOS
 Sample ID: WHD-AS-BG05-10
 Lab ID: 807089

SDG: 9I190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 89.7%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 98.2 | 1.8 |
| #4 | 4750 | 87.0 | 11.2 |
| #10 | 2000 | 76.0 | 11.1 |
| #20 | 850 | 65.0 | 11.0 |
| #40 | 425 | 53.2 | 11.8 |
| #60 | 250 | 40.1 | 13.1 |
| #80 | 180 | 32.1 | 8.0 |
| #100 | 150 | 27.1 | 5.0 |
| #200 | 75 | 12.4 | 14.7 |
| Hydrometer | 36.0 | 4.9 | 7.5 |
| | 23.1 | 3.3 | 1.6 |
| | 13.4 | 2.2 | 1.1 |
| | 9.4 | 1.7 | 0.5 |
| | 6.8 | 1.2 | 0.5 |
| | 3.2 | 0.6 | 0.5 |
| V | 1.4 | 0.5 | 0.1 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 13.0 |
| Sand | 74.6 |
| Coarse Sand | 11.1 |
| Medium Sand | 22.8 |
| Fine Sand | 40.8 |
| Silt | 11.2 |
| Clay | 1.2 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

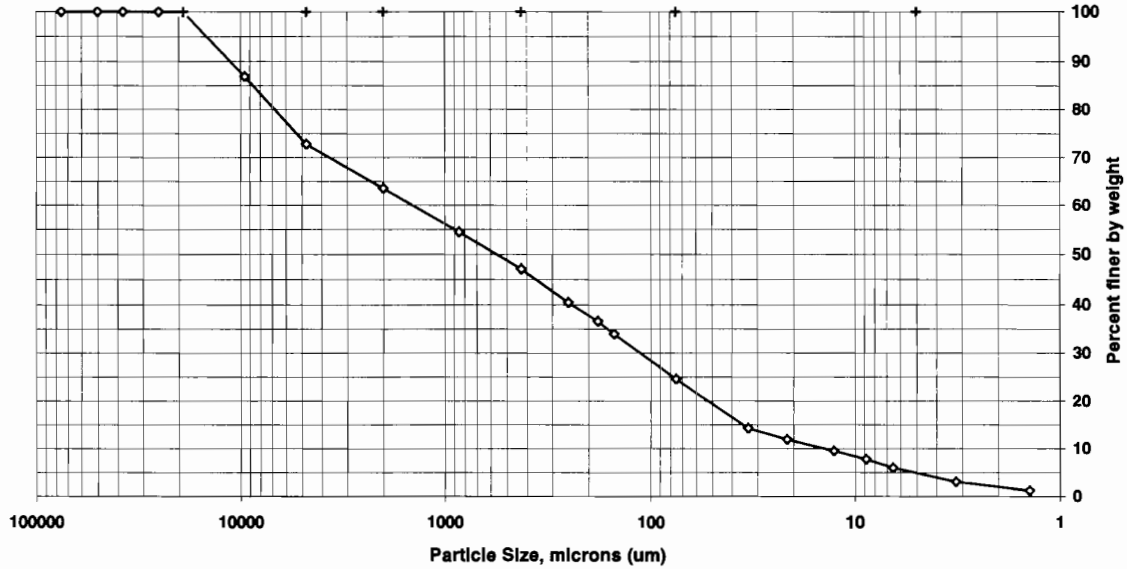
Client Code: STLMOS
 Sample ID: WHD-AS-BH04-10
 Lab ID: 807090

SDG: 9I190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 91.0%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 86.9 | 13.1 |
| #4 | 4750 | 72.8 | 14.2 |
| #10 | 2000 | 63.6 | 9.2 |
| #20 | 850 | 54.5 | 9.1 |
| #40 | 425 | 47.1 | 7.4 |
| #60 | 250 | 40.5 | 6.7 |
| #80 | 180 | 36.6 | 3.8 |
| #100 | 150 | 34.0 | 2.7 |
| #200 | 75 | 24.6 | 9.3 |
| Hydrometer | 33.3 | 14.3 | 10.4 |
| | 21.5 | 11.9 | 2.4 |
| | 12.7 | 9.6 | 2.4 |
| | 8.8 | 7.8 | 1.8 |
| | 6.5 | 6.0 | 1.8 |
| | 3.2 | 3.1 | 3.0 |
| V | 1.4 | 1.2 | 1.9 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 27.2 |
| Sand | 48.1 |
| Coarse Sand | 9.2 |
| Medium Sand | 16.4 |
| Fine Sand | 22.5 |
| Silt | 18.6 |
| Clay | 6.0 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

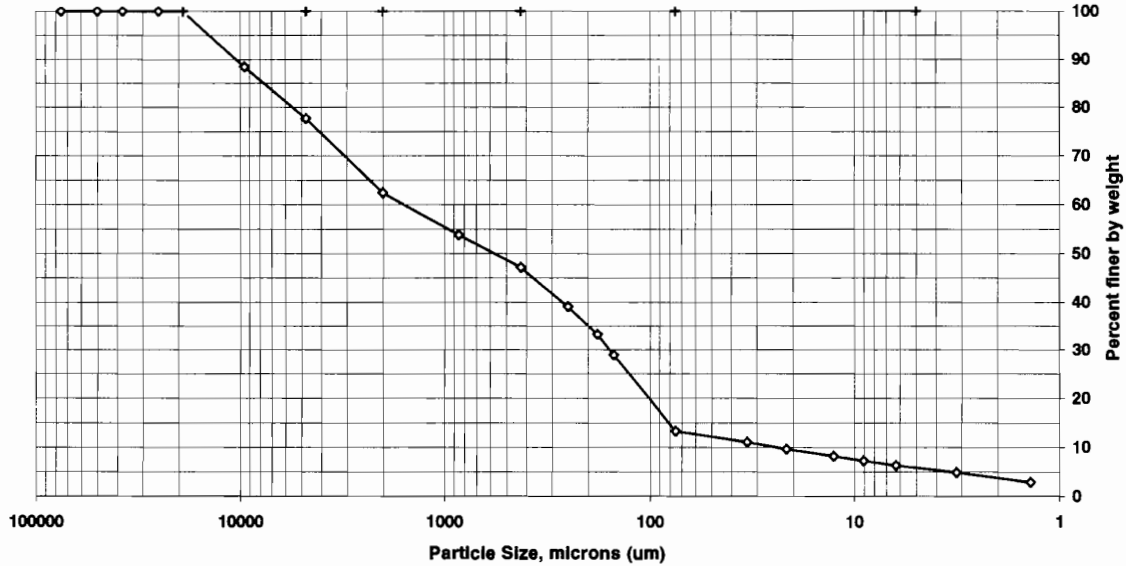
Client Code: STLMOS
 Sample ID: WHD-AS-BP04-0
 Lab ID: 807091

SDG: 9I190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 98.3%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 88.4 | 11.6 |
| #4 | 4750 | 77.7 | 10.8 |
| #10 | 2000 | 62.4 | 15.2 |
| #20 | 850 | 53.8 | 8.6 |
| #40 | 425 | 47.2 | 6.6 |
| #60 | 250 | 39.1 | 8.1 |
| #80 | 180 | 33.3 | 5.8 |
| #100 | 150 | 28.9 | 4.3 |
| #200 | 75 | 13.3 | 15.6 |
| Hydrometer | 33.5 | 11.1 | 2.2 |
| | 21.5 | 9.7 | 1.4 |
| | 12.6 | 8.2 | 1.4 |
| | 9.0 | 7.3 | 1.0 |
| | 6.3 | 6.3 | 1.0 |
| | 3.2 | 4.9 | 1.4 |
| V | 1.4 | 2.9 | 2.0 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 22.3 |
| Sand | 64.3 |
| Coarse Sand | 15.2 |
| Medium Sand | 15.2 |
| Fine Sand | 33.9 |
| Silt | 7.0 |
| Clay | 6.3 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

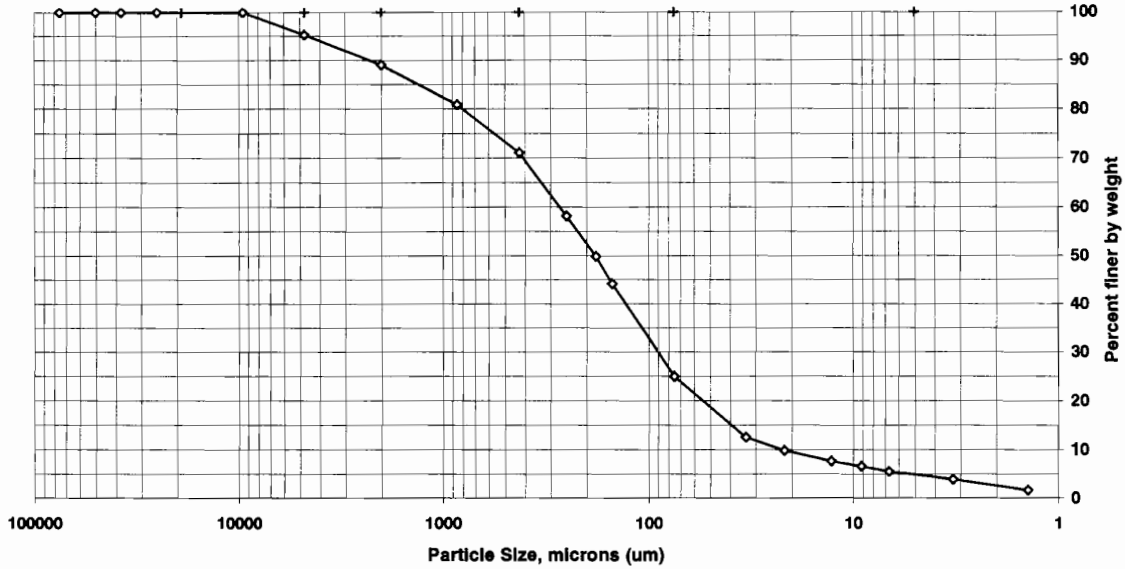
Client Code: STLMOS
 Sample ID: WHD-AS-BP08-0
 Lab ID: 807092

SDG: 9I190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 96.9%
 Specific Gravity: 2.650
 Maximum Particle Size: 9.5 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 100.0 | 0.0 |
| #4 | 4750 | 95.2 | 4.8 |
| #10 | 2000 | 89.0 | 6.2 |
| #20 | 850 | 80.8 | 8.2 |
| #40 | 425 | 71.1 | 9.8 |
| #60 | 250 | 58.1 | 12.9 |
| #80 | 180 | 49.8 | 8.3 |
| #100 | 150 | 44.1 | 5.7 |
| #200 | 75 | 25.0 | 19.2 |
| Hydrometer | 33.5 | 12.6 | 12.4 |
| | 21.8 | 9.8 | 2.7 |
| | 12.8 | 7.7 | 2.2 |
| | 9.2 | 6.6 | 1.1 |
| | 6.7 | 5.5 | 1.1 |
| | 3.3 | 3.9 | 1.6 |
| V | 1.4 | 1.6 | 2.3 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 4.8 |
| Sand | 70.2 |
| Coarse Sand | 6.2 |
| Medium Sand | 18.0 |
| Fine Sand | 46.1 |
| Silt | 19.5 |
| Clay | 5.5 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

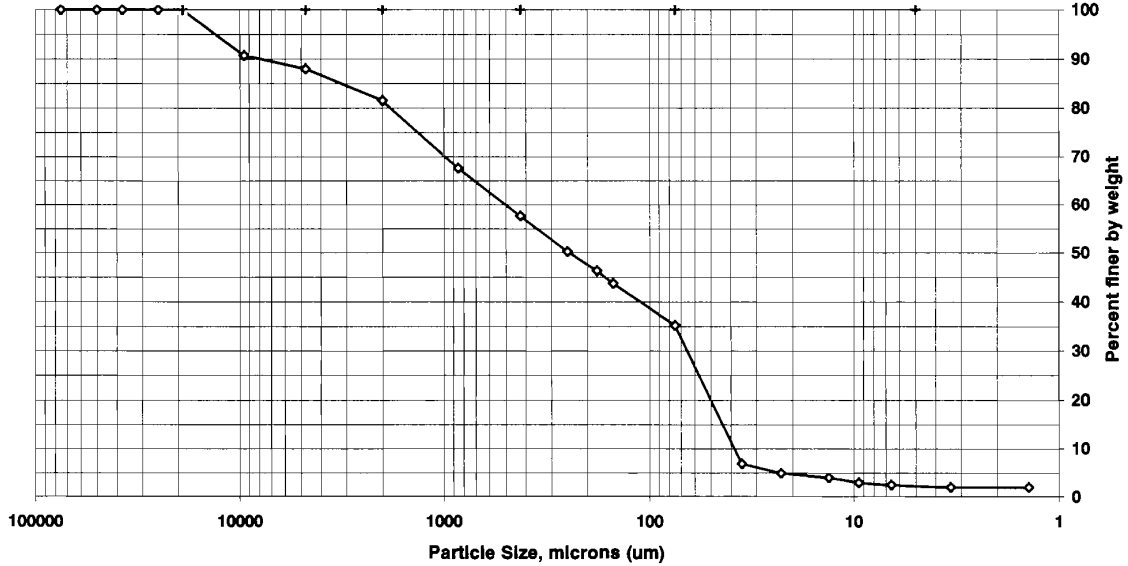
Client Code: STLMOS
 Sample ID: WHD-AS-BN10-0
 Lab ID: 807093

SDG: 9I190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 97.6%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: plant
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 90.7 | 9.3 |
| #4 | 4750 | 88.0 | 2.7 |
| #10 | 2000 | 81.6 | 6.4 |
| #20 | 850 | 67.7 | 13.9 |
| #40 | 425 | 57.7 | 10.0 |
| #60 | 250 | 50.2 | 7.5 |
| #80 | 180 | 46.3 | 3.9 |
| #100 | 150 | 43.8 | 2.6 |
| #200 | 75 | 35.2 | 8.6 |
| Hydrometer | 35.3 | 6.9 | 28.3 |
| | 22.8 | 4.9 | 2.0 |
| | 13.3 | 3.9 | 1.0 |
| | 9.5 | 3.0 | 1.0 |
| | 6.6 | 2.5 | 0.5 |
| | 3.4 | 2.0 | 0.5 |
| V | 1.4 | 2.0 | 0.0 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 12.0 |
| Sand | 52.8 |
| Coarse Sand | 6.4 |
| Medium Sand | 23.9 |
| Fine Sand | 22.5 |
| Silt | 32.8 |
| Clay | 2.5 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

Particle Size Analysis of Soils
By ASTM D422
Hydrometer Data

Set Number
91190128

Client Code: **STLMOS**
 SDG: **91190128**
 ETR(s): **133685**

Date Received: **22-Sep-09**
 Start Date: **22-Sep-09**
 End Date: **1-Oct-09**

Date and Analyst

| Percent Solids | Weighed | Mixed | Hydrometer | Large sieves | Small sieves |
|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| <u>MAP 9/25/09</u> | <u>MAP 9/25/09</u> | <u>MNT 9/26/09</u> | <u>MAP 9/29/09</u> | <u>MNT 9/26/09</u> | <u>MAP 9/30/09</u> |
| <u>DJP 9/28/09</u> | | | <u>DPS 9/30/09</u> | <u>DJP 10/1/09</u> | <u>DJP 10/1/09</u> |

| | | | | | | | | | | | | |
|-------------------|------|------|------|------|------|------|---------------|---------------|---------------|---------------|---------------|------|
| Test number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lab number | | | | | | | 807089 | 807090 | 807091 | 807092 | 807093 | |
| Time, min. (2) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Reading | | | | | | | 1.0085 | 1.0160 | 1.0155 | 1.0155 | 1.0110 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (5) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Reading | | | | | | | 1.0070 | 1.0140 | 1.0140 | 1.0130 | 1.0090 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (15) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Reading | | | | | | | 1.0060 | 1.0120 | 1.0125 | 1.0110 | 1.0080 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (30) | 30 | 30 | 29 | 29 | 31 | 31 | 31 | 32 | 30 | 30 | 30 | 31 |
| Reading | | | | | | | 1.0055 | 1.0105 | 1.0115 | 1.0100 | 1.0070 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (60) | 59 | 58 | 58 | 63 | 60 | 59 | 59 | 60 | 63 | 57 | 63 | 57 |
| Reading | | | | | | | 1.0050 | 1.0090 | 1.0105 | 1.0090 | 1.0065 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (250) | 256 | 256 | 250 | 250 | 240 | 234 | 265 | 259 | 253 | 247 | 241 | 235 |
| Reading | | | | | | | 1.0045 | 1.0065 | 1.0090 | 1.0075 | 1.0060 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (1440) | 1440 | 1440 | 1434 | 1434 | 1424 | 1418 | 1412 | 1406 | 1400 | 1394 | 1388 | 1382 |
| Reading | | | | | | | 1.0045 | 1.0050 | 1.0070 | 1.0055 | 1.0060 | |
| Temperature, C | | | | | | | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | |

Hydrometer used: 741402 Model #: ASTM 151H
 Calibrations: L temp, C L read H Temp, C H read
 17.0 1.0045 23.0 1.0035

Manufacturer: Chase
 Cal. Date: 01/06/09

Hydrometer start time: 17:27
 Hydrometer data entered: DJP 10/1/09

Particle Size Analysis of Soils
By ASTM D422
Hydrometer Data

Set Number
91190128

Client Code: STLMOS
SDG: 91190128
ETR(s): 133685

Date Received: 22-Sep-09
Start Date: 22-Sep-09
End Date: 10-1-09

Date and Analyst

| Percent Solids | Weighed | Mixed | Hydrometer | Large sieves | Small sieves |
|--------------------------|------------|------------|----------------------------|--------------------------|--------------------------|
| MR 9.25.09 DJ 9.28.09 | MR 9.25.09 | MR 9/26/09 | MR 9.29.09 DPS 09/30/09 | MR 9/26/09 DJ 10.1.09 | MR 9.30.09 DJ 10.1.09 |

| Test number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------------------|------|------|------|------|------|------|--------|--------|--------|--------|--------|------|
| Lab number | | | | | | | 807089 | 807090 | 807091 | 807092 | 807093 | |
| Time, min. (2) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Reading | | | | | | | 1.0085 | 1.0160 | 1.0155 | 1.0155 | 1.0110 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (5) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Reading | | | | | | | 1.0070 | 1.0140 | 1.0140 | 1.0130 | 1.0090 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (15) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Reading | | | | | | | 1.0060 | 1.0120 | 1.0125 | 1.0110 | 1.0080 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (30) | 30 | 30 | 29 | 29 | 31 | 31 | 31 | 32 | 30 | 30 | 30 | 31 |
| Reading | | | | | | | 1.0055 | 1.0105 | 1.0115 | 1.0100 | 1.0070 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (60) | 59 | 58 | 58 | 63 | 60 | 59 | 59 | 60 | 63 | 57 | 63 | 57 |
| Reading | | | | | | | 1.0050 | 1.0090 | 1.0105 | 1.0090 | 1.0065 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (250) | 256 | 256 | 250 | 250 | 240 | 234 | 265 | 259 | 253 | 247 | 241 | 235 |
| Reading | | | | | | | 1.0045 | 1.0065 | 1.0090 | 1.0075 | 1.0060 | |
| Temperature, C | | | | | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.0 | |
| Time, min. (1440) | 1440 | 1440 | 1434 | 1434 | 1424 | 1418 | 1412 | 1406 | 1400 | 1394 | 1388 | 1382 |
| Reading | | | | | | | 1.0045 | 1.0050 | 1.0070 | 1.0055 | 1.0060 | |
| Temperature, C | | | | | | | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | |

Hydrometer used: 74142 Model #: ASTM 151H
Calibrations: L temp, C L read H Temp, C H read
17.0 23.0

Manufacturer: Cal. Date:

Hydrometer start time: 1727
Hydrometer data entered: DJ 10.1.09

Particle Size Analysis of
Soils By ASTM D422
Sieve Data

Client Code: **STLMQS**

ETR(s): **133685**
SDG: **9I190128**

Date Rec: **22-Sep-09** Start Date: **22-Sep-09**
End Date: **1-Oct-09**

SET: **9I190128**

Dry prep = D421
Wet prep = D2217

| Standard Values | |
|-----------------|-------------|
| Sieve | Opening, um |
| 3 inch | 75000 |
| 2 inch | 50000 |
| 1.5 inch | 37500 |
| 1 inch | 25000 |
| 3/4 inch | 19000 |
| 3/8 inch | 9500 |
| #4 | 4750 |
| #10 | 2000 |
| #20 | 850 |
| #40 | 425 |
| #60 | 250 |
| #80 | 180 |
| #100 | 150 |
| #200 | 75 |

| Sieve (tares) | |
|---------------|---------|
| Size | Mass, g |
| 3 inch | |
| 2 inch | |
| 1.5 inch | |
| 1 inch | |
| 3/4 inch | |
| 3/8 inch | 447.55 |
| #4 | 488.28 |
| #10 | 469.09 |
| #20 | 391.24 |
| #40 | 356.15 |
| #60 | 326.07 |
| #80 | 335.93 |
| #100 | 329.82 |
| #200 | 326.67 |

| Test | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|---|---|---|---|---|---|-------------|------------|------------|------------|------------|----|
| Laboratory No | | | | | | | 807088 | 807090 | 807091 | 807092 | 807093 | |
| Sample ID | | | | | | | WHD-AS-BQ05 | HD-AS-BH04 | HD-AS-BP04 | HD-AS-BP08 | HD-AS-BN10 | 0 |

| | | | | | | | | | | | | |
|-------------------|--|--|--|--|--|--|--------|--------|--------|--------|--------|--|
| Sample Prep | | | | | | | D2217 | D2217 | D2217 | D2217 | D2217 | |
| Pan, g | | | | | | | | | | | | |
| Pan/sample, g | | | | | | | 167.56 | 149.30 | 170.34 | 152.97 | 166.88 | |
| Pan/dry sample, g | | | | | | | | | | | | |

Hygroscopic Moisture correction factor (HMCf) for dry prep / Percent Solids for dry and wet prep

| | | | | | | | | | | | | |
|-------------------|--|--|--|--|--|--|--------|--------|--------|--------|--------|--|
| Pan, g | | | | | | | 0.99 | 1.00 | 0.99 | 0.96 | 0.96 | |
| Pan/sample, g | | | | | | | 16.83 | 33.93 | 27.84 | 24.66 | 34.99 | |
| Pan/dry sample, g | | | | | | | 17.60 | 30.97 | 27.20 | 23.82 | 34.18 | |
| HMCf | | | | | | | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | |

Description of >#10 particles

| | | | | | | | | | | | | |
|-------------------|--|--|--|--|--|--|---------|---------|---------|---------|---------|--|
| Non-soil material | | | | | | | na | na | na | na | plant | |
| Shape | | | | | | | angular | angular | angular | angular | angular | |
| Hardness | | | | | | | hard | hard | hard | hard | hard | |

| | | | | | | | | | | | | |
|-----------------|--|--|--|--|--|--|-------|-------|-------|-------|-------|--|
| Sample % Solids | | | | | | | 89.7% | 91.0% | 98.3% | 96.9% | 97.6% | |
|-----------------|--|--|--|--|--|--|-------|-------|-------|-------|-------|--|

| | | | | | | | | | | | | |
|------------------|--|--|--|--|--|--|--------|--------|--------|--------|--------|--|
| Dry sample wt, g | | | | | | | 150.37 | 135.88 | 167.53 | 148.17 | 162.91 | |
|------------------|--|--|--|--|--|--|--------|--------|--------|--------|--------|--|

Sieve + Sample Weights

| Size | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g |
|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 3 inch | | | | | | | | | | | | |
| 2 inch | | | | | | | | | | | | |
| 1.5 inch | | | | | | | | | | | | |
| 1 inch | | | | | | | | | | | | |
| 3/4 inch | | | | | | | | | | | | |
| 3/8 inch | | | | | | | 450.28 | 465.31 | 466.94 | | 462.68 | |
| #4 | | | | | | | 505.05 | 507.52 | 506.31 | 495.33 | 492.74 | |
| #10 | | | | | | | 479.72 | 475.60 | 488.61 | 472.26 | 473.53 | |
| #20 | | | | | | | 408.38 | 404.16 | 406.25 | 404.00 | 414.49 | |
| #40 | | | | | | | 373.91 | 368.18 | 367.26 | 370.62 | 372.98 | |
| #60 | | | | | | | 345.74 | 335.11 | 339.65 | 345.23 | 338.33 | |
| #80 | | | | | | | 347.89 | 341.13 | 345.70 | 348.23 | 342.27 | |
| #100 | | | | | | | 337.35 | 333.45 | 337.08 | 338.25 | 334.02 | |
| #200 | | | | | | | 349.81 | 339.34 | 352.81 | 355.05 | 340.80 | |

Maximum Particle size

| | | | | | | | | | | | | |
|--|--|--|--|--|--|--|-------|-------|-------|--------|-------|--|
| | | | | | | | 19 mm | 19 mm | 19 mm | 9.5 mm | 19 mm | |
|--|--|--|--|--|--|--|-------|-------|-------|--------|-------|--|

| | | | | | | | | | | | | |
|------------|------|------------------|--|--|--|--|-------|-------|-------|-------|-------|--|
| Default SG | 2.65 | Specific gravity | | | | | 2.650 | 2.650 | 2.650 | 2.650 | 2.650 | |
|------------|------|------------------|--|--|--|--|-------|-------|-------|-------|-------|--|

Sample Mass Parameters

| | | | | | | | | | | | | |
|---------------------|---------|---------|---------|---------|---------|---------|--------|-------|--------|--------|--------|---------|
| Sample Mass >#10, g | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 36.13 | 49.51 | 62.94 | 16.24 | 30.03 | 0.00 |
| Sample mass <#10, g | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | 114.24 | 86.37 | 104.59 | 131.93 | 132.88 | #VALUE! |



Sample Handling

IMPER
IDENT
APE

ORIGIN ID: ALNA (314) 298-8566
BRIAN DANIELS
TEST AMERICA
13715 RIDER TRAIL N

Ship Date: 21SEP09
ActWgt: 18.0 LB
System#: 486221/CAFE2361
Account: S *****

EARTH CITY, MO 63045
UNITED STATES US

TO **RON PENTKOWSKI**
TEST AMERICA BURLINGTON
30 COMMUNITY DR STE 11

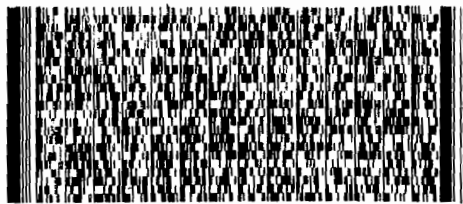
(802) 660-1990

FedEx
Express



SOUTH BURLINGTON, VT 05403

Ref: I190128



Delivery Address
Barcode

BILL RECIPIENT

PRIORITY OVERNIGHT

TUE

Deliver By:

TRK# 4029 5259 5890

Form
0201

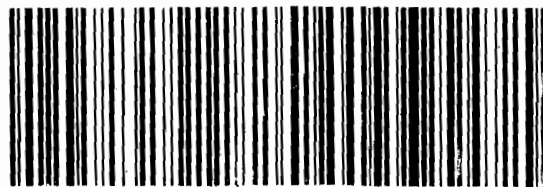
BTU

22SEP09

AA

05403 -VT-US

XH BTVA



Press Here. Press Here. Press Here.

Press Here. Press Here.

1 296 19



E

| TestAmerica Burlington | | | |
|--|--------------------------|---------------------------|--|
| SAMPLE RECEIPT & LOG IN CHECKLIST | | | |
| Client: STCMOS | Date Received: 09/22/09 | Log In Date: 09/22/09 | |
| ETR: 133685 | Time Received: 1830 | By: [Signature] | |
| SDG: 97156123 | Received By: [Signature] | Signature: [Signature] | |
| Project: 29014 | # Coolers Received: 1 | PM Signature: [Signature] | |
| Samples Delivered By: <input checked="" type="checkbox"/> Shipping Service <input type="checkbox"/> Courier <input type="checkbox"/> Hand <input type="checkbox"/> Other (specify) | | Date: 09/23/09 | |
| List Air bill Number(s) or Attach a photocopy of the Air Bill: | | | |

If yes, list custody seal numbers:

Unless otherwise documented, the recorded temperature readings are adjusted readings to account for the CF of the IR Gun

EPA Criteria: 0-6°C, except for air and geo samples which should be at ambient temperature and tissue samples, which may be frozen.

Some clients require thermal preservation criteria of 2-4°C or other such criteria. The PM must notify SM when alternate criteria is specified.

COC is present and includes the following information for each container:

| Sample ID / Sample Description | | | | |
|--------------------------------|--|--|--|--|
| | | | | |

| SAMPLE INTEGRITY/USABILITY | YES | NO | NA | COMMENTS |
|----------------------------|-----|----|----|----------|
|----------------------------|-----|----|----|----------|

ANOMALY / NCR SUMMARY[illegible]

TestAmerica
South Burlington, VT

Sample Data Summary
Package

9I190128

TestAmerica Laboratories, Inc.

October 1, 2009

Mr. Jerry Everett
TestAmerica, Inc.
13715 Rider Trail North
Earth City, MO 63045

Re: Laboratory Project No. 29014
Case: BRCWHOOK; SDG: 9I190128

Dear Mr. Everett:

Enclosed are the analytical results for the samples that were received by TestAmerica Burlington on September 22nd, 2009. Laboratory identification numbers were assigned, and designated as follows:

| <u>Lab ID</u> | <u>Client Sample ID</u> | <u>Sample Date</u> | <u>Sample Matrix</u> |
|-----------------------------------|-----------------------------|------------------------|--------------------------|
| Received: 09/22/09 ETR No: 133685 | | | |
| 807089 | WHD-AS-BG05-10 | 09/18/09 | SOIL |
| 807090 | WHD-AS-BH04-10 | 09/18/09 | SOIL |
| 807091 | WHD-AS-BP04-0 | 09/18/09 | SOIL |
| 807092 | WHD-AS-BP08-0 | 09/18/09 | SOIL |
| 807093 | WHD-AS-BN10-0 | 09/18/09 | SOIL |

Documentation of the condition of the samples at the time of their receipt and any exception to the laboratory's Sample Acceptance Policy is documented in the Sample Handling section of this submittal.

Particle Size Analysis by ASTM D422

There were no exceptions to the method quality control criteria during the analyses of these samples.

Any reference within this report to Severn Trent Laboratories, Inc. or STL, should be understood to refer to TestAmerica Laboratories, Inc. (formerly known as Severn Trent Laboratories, Inc.) The analytical results associated with the samples presented in this test report were generated under a quality system that adheres to requirements specified in the NELAC standard. Release of the data in this test report and any associated electronic deliverables is authorized by the Laboratory Director's designee as verified by the following signature.



If there are any questions regarding this submittal, please contact me at 802 660-1990.

Sincerely,

A handwritten signature in black ink, reading "Rayburn J. Lavigne". The signature is written in a cursive style with a large, stylized initial 'R'.

Rayburn Lavigne
Project Manager

RJL/hsf
Enclosure

COMMENTS:

Project Manager:

Project:

Report Type: W

Client: 445691 - Basic Remediation Company

Date Received: 2009-09-19

Analytical Due Date: 2009-09-29

Report Due Date: 2009-10-05

WESTERN HOOK

WORK LOCATION: H2 TestAmerica Burlington

SMP#: 2 CLIENT ID: WHD-AS-BG05-10 DATE SAMPLED: 20090918 MATRIX: A SOLID

SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive

EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET

WORKORDER LK5D71AP

METAL: XX

SMP#: 3 CLIENT ID: WHD-AS-BH04-10 DATE SAMPLED: 20090918 MATRIX: A SOLID

SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive

EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET

WORKORDER LK5D91AP

METAL: XX

SMP#: 4 CLIENT ID: WHD-AS-BP04-0 DATE SAMPLED: 20090918 MATRIX: A SOLID

SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive

EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET

WORKORDER LK5EA1AP

METAL: XX

SMP#: 5 CLIENT ID: WHD-AS-BP08-0 DATE SAMPLED: 20090918 MATRIX: A SOLID

SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive

EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET

WORKORDER LK5EC1AP

METAL: XX

SMP#: 6 CLIENT ID: WHD-AS-BN10-0 DATE SAMPLED: 20090918 MATRIX: A SOLID

SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive

EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET

WORKORDER LK5ED1AP

METAL: XX

The sample(s) listed on this form are being sent to your location for the specified analysis. If you have any questions, please contact the Project Manager listed above. PLEASE RETURN THE ORIGINAL SIGNED FORM WITH THE REPORT AT THE COMPLETION OF ANALYSIS.

Thank You

TA- St. Louis
Sample Receiving

RELINQUISHED BY:

DATE:

RECEIVED FOR LAB BY:

DATE:



Sample Data Summary – Geotechnical

Particle Size of Soils by ASTM D422

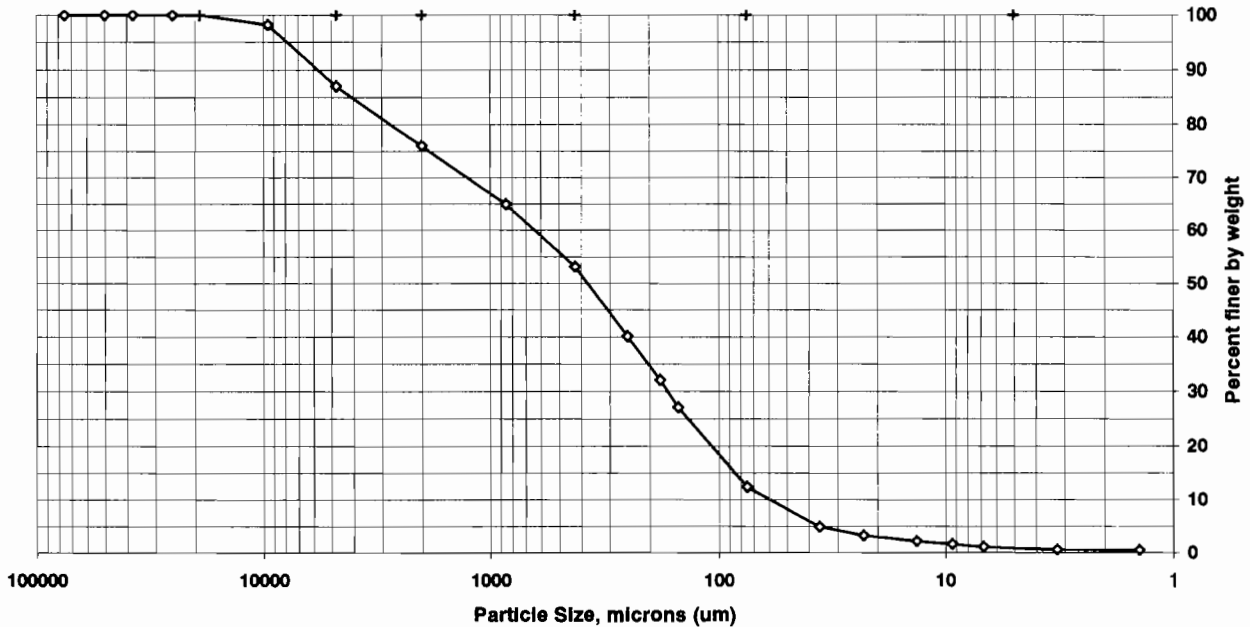
Client Code: STLMOS
 Sample ID: WHD-AS-BG05-10
 Lab ID: 807089

SDG: 91190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 89.7%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 98.2 | 1.8 |
| #4 | 4750 | 87.0 | 11.2 |
| #10 | 2000 | 76.0 | 11.1 |
| #20 | 850 | 65.0 | 11.0 |
| #40 | 425 | 53.2 | 11.8 |
| #60 | 250 | 40.1 | 13.1 |
| #80 | 180 | 32.1 | 8.0 |
| #100 | 150 | 27.1 | 5.0 |
| #200 | 75 | 12.4 | 14.7 |
| Hydrometer | 36.0 | 4.9 | 7.5 |
| | 23.1 | 3.3 | 1.6 |
| | 13.4 | 2.2 | 1.1 |
| | 9.4 | 1.7 | 0.5 |
| | 6.8 | 1.2 | 0.5 |
| | 3.2 | 0.6 | 0.5 |
| V | 1.4 | 0.5 | 0.1 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 13.0 |
| Sand | 74.6 |
| Coarse Sand | 11.1 |
| Medium Sand | 22.8 |
| Fine Sand | 40.8 |
| Silt | 11.2 |
| Clay | 1.2 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

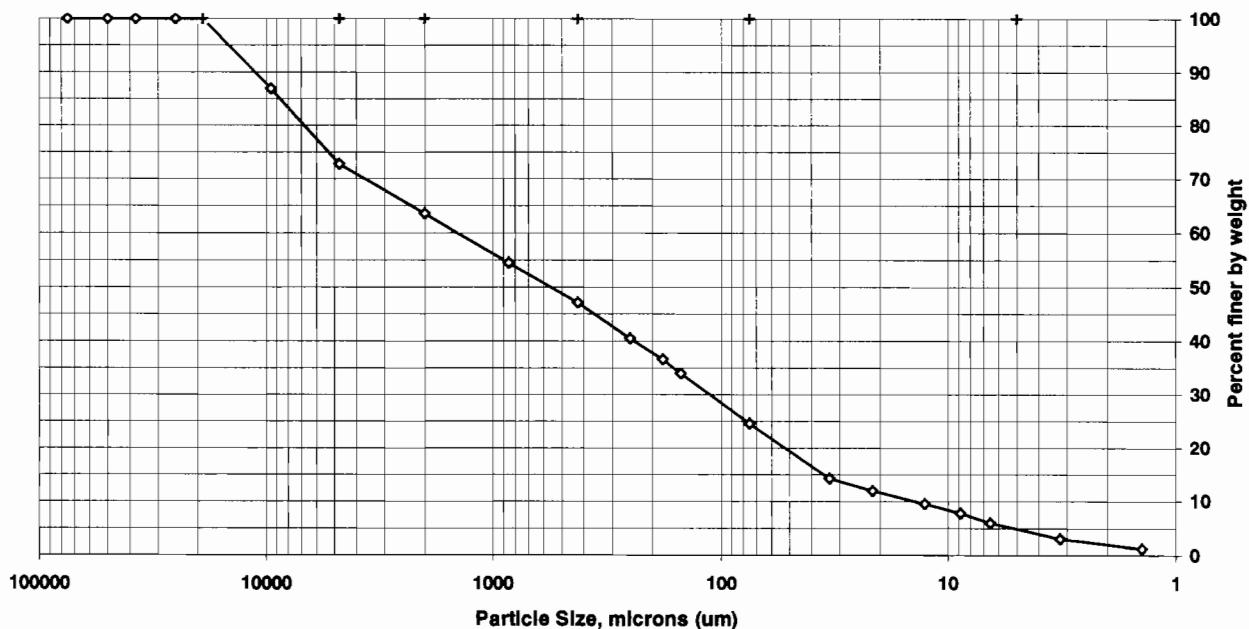
Client Code: STLMOS
 Sample ID: WHD-AS-BH04-10
 Lab ID: 807090

SDG: 91190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 91.0%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 86.9 | 13.1 |
| #4 | 4750 | 72.8 | 14.2 |
| #10 | 2000 | 63.6 | 9.2 |
| #20 | 850 | 54.5 | 9.1 |
| #40 | 425 | 47.1 | 7.4 |
| #60 | 250 | 40.5 | 6.7 |
| #80 | 180 | 36.6 | 3.8 |
| #100 | 150 | 34.0 | 2.7 |
| #200 | 75 | 24.6 | 9.3 |
| Hydrometer | 33.3 | 14.3 | 10.4 |
| | 21.5 | 11.9 | 2.4 |
| | 12.7 | 9.6 | 2.4 |
| | 8.8 | 7.8 | 1.8 |
| | 6.5 | 6.0 | 1.8 |
| | 3.2 | 3.1 | 3.0 |
| V | 1.4 | 1.2 | 1.9 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 27.2 |
| Sand | 48.1 |
| Coarse Sand | 9.2 |
| Medium Sand | 16.4 |
| Fine Sand | 22.5 |
| Silt | 18.6 |
| Clay | 6.0 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

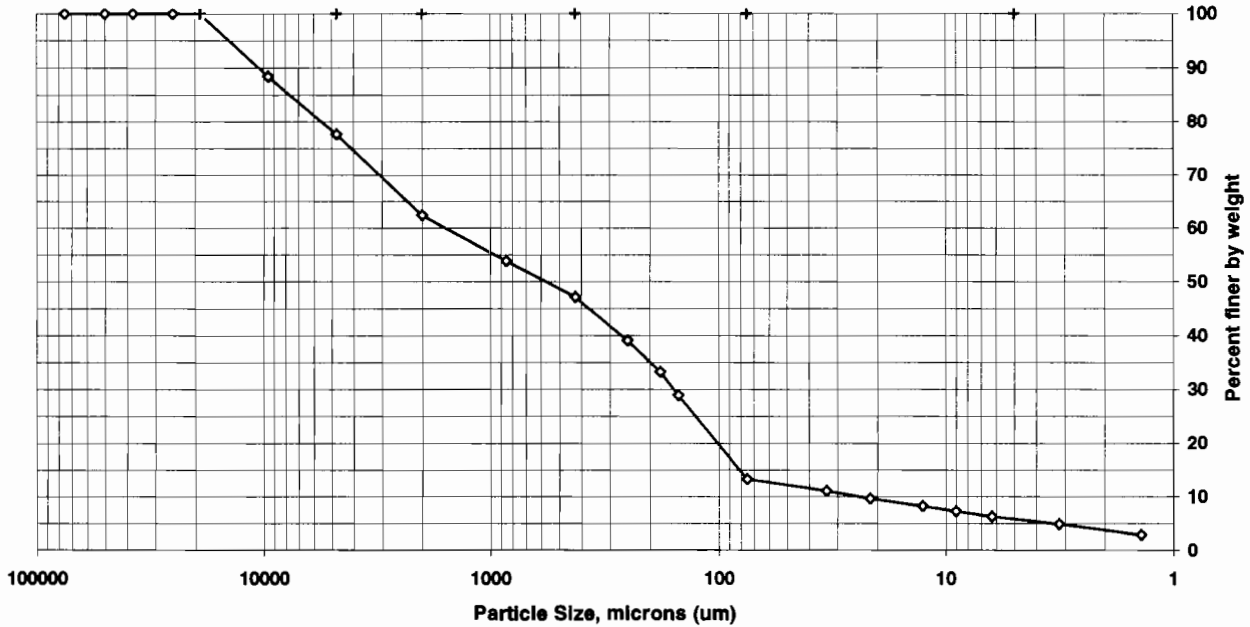
Client Code: STLMOS
 Sample ID: WHD-AS-BP04-0
 Lab ID: 807091

SDG: 91190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 98.3%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 88.4 | 11.6 |
| #4 | 4750 | 77.7 | 10.8 |
| #10 | 2000 | 62.4 | 15.2 |
| #20 | 850 | 53.8 | 8.6 |
| #40 | 425 | 47.2 | 6.6 |
| #60 | 250 | 39.1 | 8.1 |
| #80 | 180 | 33.3 | 5.8 |
| #100 | 150 | 28.9 | 4.3 |
| #200 | 75 | 13.3 | 15.6 |
| Hydrometer | 33.5 | 11.1 | 2.2 |
| | 21.5 | 9.7 | 1.4 |
| | 12.6 | 8.2 | 1.4 |
| | 9.0 | 7.3 | 1.0 |
| | 6.3 | 6.3 | 1.0 |
| | 3.2 | 4.9 | 1.4 |
| V | 1.4 | 2.9 | 2.0 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 22.3 |
| Sand | 64.3 |
| Coarse Sand | 15.2 |
| Medium Sand | 15.2 |
| Fine Sand | 33.9 |
| Silt | 7.0 |
| Clay | 6.3 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

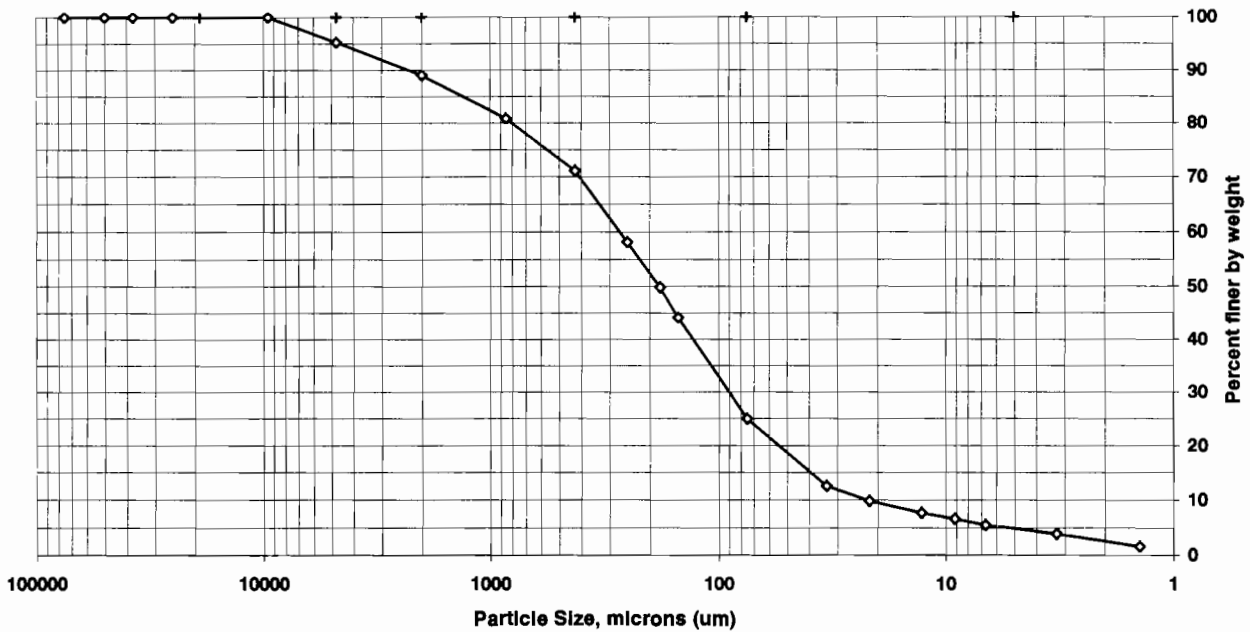
Client Code: STLMOS
 Sample ID: WHD-AS-BP08-0
 Lab ID: 807092

SDG: 91190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 96.9%
 Specific Gravity: 2.650
 Maximum Particle Size: 9.5 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 100.0 | 0.0 |
| #4 | 4750 | 95.2 | 4.8 |
| #10 | 2000 | 89.0 | 6.2 |
| #20 | 850 | 80.8 | 8.2 |
| #40 | 425 | 71.1 | 9.8 |
| #60 | 250 | 58.1 | 12.9 |
| #80 | 180 | 49.8 | 8.3 |
| #100 | 150 | 44.1 | 5.7 |
| #200 | 75 | 25.0 | 19.2 |
| Hydrometer | 33.5 | 12.6 | 12.4 |
| | 21.8 | 9.8 | 2.7 |
| | 12.8 | 7.7 | 2.2 |
| | 9.2 | 6.6 | 1.1 |
| | 6.7 | 5.5 | 1.1 |
| | 3.3 | 3.9 | 1.6 |
| V | 1.4 | 1.6 | 2.3 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 4.8 |
| Sand | 70.2 |
| Coarse Sand | 6.2 |
| Medium Sand | 18.0 |
| Fine Sand | 46.1 |
| Silt | 19.5 |
| Clay | 5.5 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

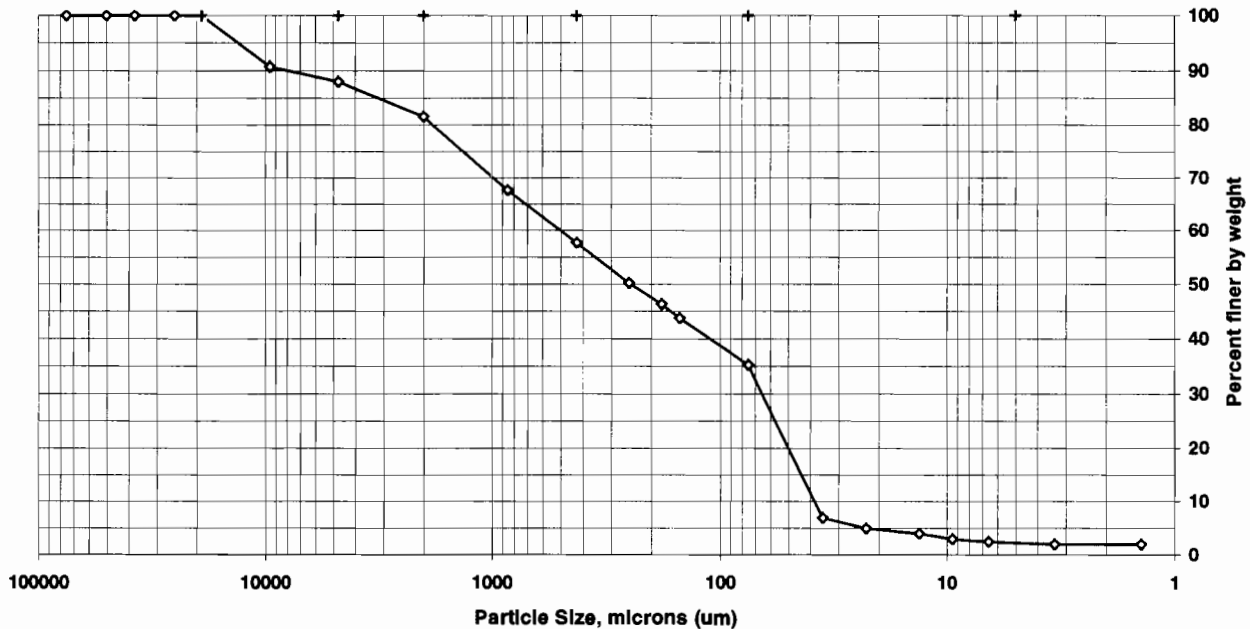
Client Code: STLMOS
 Sample ID: WHD-AS-BN10-0
 Lab ID: 807093

SDG: 91190128
 ETR(s): 133685

Date Received: 9/22/2009
 Start Date: 9/22/2009
 End Date: 10/1/2009

Percent Solids: 97.6%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: plant
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 90.7 | 9.3 |
| #4 | 4750 | 88.0 | 2.7 |
| #10 | 2000 | 81.6 | 6.4 |
| #20 | 850 | 67.7 | 13.9 |
| #40 | 425 | 57.7 | 10.0 |
| #60 | 250 | 50.2 | 7.5 |
| #80 | 180 | 46.3 | 3.9 |
| #100 | 150 | 43.8 | 2.6 |
| #200 | 75 | 35.2 | 8.6 |
| Hydrometer | 35.3 | 6.9 | 28.3 |
| | 22.8 | 4.9 | 2.0 |
| | 13.3 | 3.9 | 1.0 |
| | 9.5 | 3.0 | 1.0 |
| | 6.6 | 2.5 | 0.5 |
| | 3.4 | 2.0 | 0.5 |
| V | 1.4 | 2.0 | 0.0 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 12.0 |
| Sand | 52.8 |
| Coarse Sand | 6.4 |
| Medium Sand | 23.9 |
| Fine Sand | 22.5 |
| Silt | 32.8 |
| Clay | 2.5 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

TestAmerica
South Burlington, VT
Extended Data Package

91230183

TestAmerica Laboratories, Inc.

October 1, 2009

Mr. Jerry Everett
TestAmerica, Inc.
13715 Rider Trail North
Earth City, MO 63045

Re: Laboratory Project No. 29014
Case: BRCWHOOK; SDG: 9I230183

Dear Mr. Everett:

Enclosed are the analytical results for the samples that were received by TestAmerica Burlington on September 24th, 2009. Laboratory identification numbers were assigned, and designated as follows:

| <u>Lab ID</u> | <u>Client Sample ID</u> | <u>Sample Date</u> | <u>Sample Matrix</u> |
|-----------------------------------|-----------------------------|------------------------|--------------------------|
| Received: 09/24/09 ETR No: 133736 | | | |
| 807466 | WHD-AS-BP08-4 | 09/21/09 | SOIL |
| 807467 | WHD-AS-BL03-0 | 09/21/09 | SOIL |
| 807468 | WHD-AS-BL03-0-FD | 09/21/09 | SOIL |

Documentation of the condition of the samples at the time of their receipt and any exception to the laboratory's Sample Acceptance Policy is documented in the Sample Handling section of this submittal.

Particle Size Analysis by ASTM D422

There were no exceptions to the method quality control criteria during the analyses of these samples.

Any reference within this report to Severn Trent Laboratories, Inc. or STL, should be understood to refer to TestAmerica Laboratories, Inc. (formerly known as Severn Trent Laboratories, Inc.) The analytical results associated with the samples presented in this test report were generated under a quality system that adheres to requirements specified in the NELAC standard. Release of the data in this test report and any associated electronic deliverables is authorized by the Laboratory Director's designee as verified by the following signature.



If there are any questions regarding this submittal, please contact me at 802 660-1990.

Sincerely,

A handwritten signature in black ink, reading "Rayburn J. Lavigne". The signature is written in a cursive style with a large, stylized initial 'R'.

Rayburn Lavigne
Project Manager

RJL/hsf
Enclosure

| | |
|------------------------------------|-----------|
| Chain of Custody | 1 |
| Particle Size Results | 3 |
| Sample Handling | 10 |



Chain of Custody

F9I230183

INTER-COMPANY LOG

COMMENTS:

Project Manager:

Project:

Report Type:

Client:

W

WESTERN HOOK

445691 - Basic Remediation Company

Date Received: 2009-09-23

Analytical Due Date: 2009-10-02

Report Due Date: 2009-10-06

WORK LOCATION: H2 TestAmerica Burlington

SMP#: 1 CLIENT ID: WHD-AS-BP08-4 DATE SAMPLED: 20090921 MATRIX: A SOLID
SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive
EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET
WORKORDER LLAKM1AP METAL: XX
WORKORDER LLAKM1AN METAL: XX

SMP#: 6 CLIENT ID: WHD-AS-BL03-0 DATE SAMPLED: 20090921 MATRIX: A SOLID
SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive
EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET
WORKORDER LLAK71AQ METAL: XX
WORKORDER LLAK71AR METAL: XX

SMP#: 7 CLIENT ID: WHD-AS-BL03-0-FD DATE SAMPLED: 20090921 MATRIX: A SOLID
SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive
EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET
WORKORDER LLAK91AN METAL: XX
WORKORDER LLAK91AP METAL: XX

The sample(s) listed on this form are being sent to your location for the specified analysis. If you have any questions, please contact the Project Manager listed above. PLEASE RETURN THE ORIGINAL SIGNED FORM WITH THE REPORT AT THE COMPLETION OF ANALYSIS.

Thank You

TA-St. Louis
Sample Receiving

RELINQUISHED BY:

DATE:

RECEIVED FOR LAB BY:

DATE:



Particle Size Results

Particle Size of Soils by ASTM D422

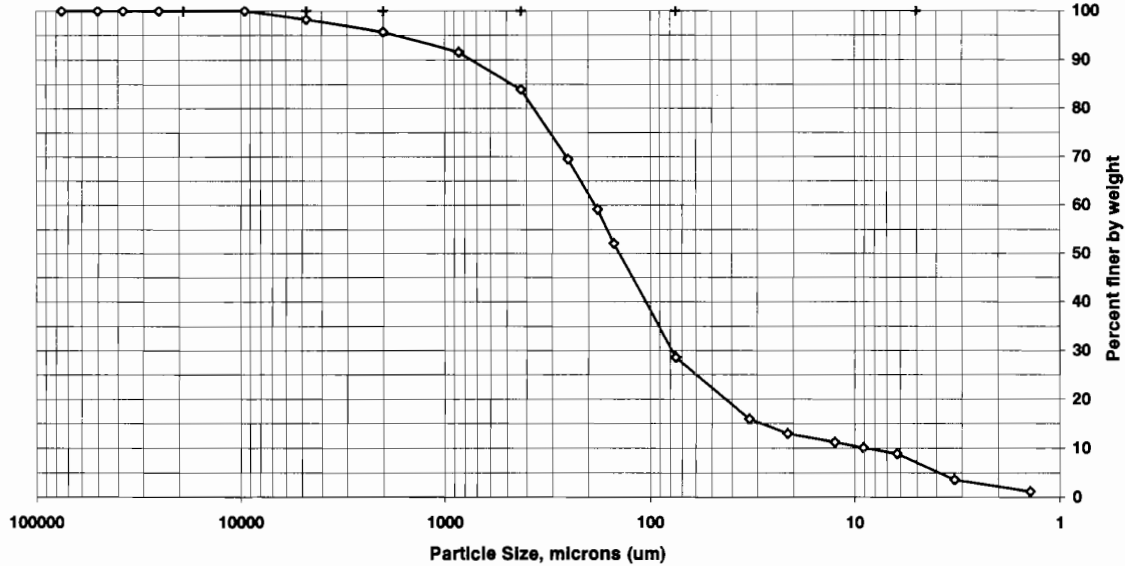
Client Code: STLMOS
 Sample ID: WHD-AS-BP08-4
 Lab ID: 807466

SDG: 9I230183
 ETR(s): 133736

Date Received: 9/24/2009
 Start Date: 9/24/2009
 End Date: 10/1/2009

Percent Solids: 90.3%
 Specific Gravity: 2.650
 Maximum Particle Size: 9.5 mm

Non-soil material: na
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 100.0 | 0.0 |
| #4 | 4750 | 98.2 | 1.8 |
| #10 | 2000 | 95.7 | 2.5 |
| #20 | 850 | 91.6 | 4.1 |
| #40 | 425 | 83.9 | 7.7 |
| #60 | 250 | 69.5 | 14.4 |
| #80 | 180 | 59.1 | 10.4 |
| #100 | 150 | 52.1 | 7.0 |
| #200 | 75 | 28.6 | 23.5 |
| Hydrometer | 32.8 | 15.9 | 12.7 |
| | 21.3 | 13.0 | 2.9 |
| | 12.5 | 11.2 | 1.8 |
| | 9.1 | 10.1 | 1.2 |
| | 6.2 | 8.9 | 1.2 |
| | 3.3 | 3.6 | 5.3 |
| V | 1.4 | 1.2 | 2.4 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 1.8 |
| Sand | 69.6 |
| Coarse Sand | 2.5 |
| Medium Sand | 11.8 |
| Fine Sand | 55.3 |
| Silt | 19.7 |
| Clay | 8.9 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

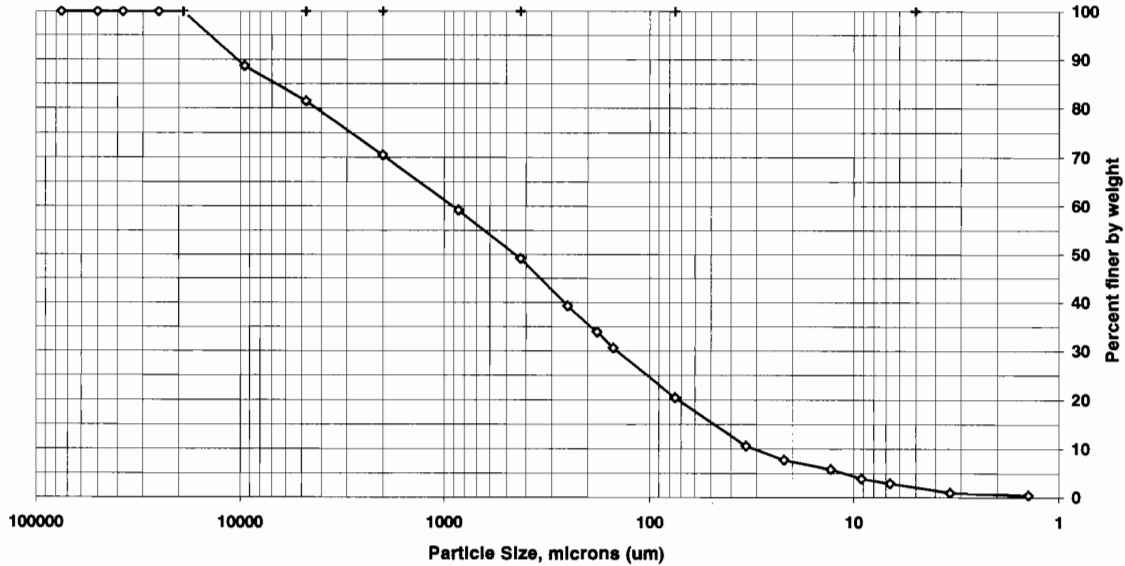
Client Code: STLMOS
 Sample ID: WHD-AS-BL03-0
 Lab ID: 807467

SDG: 9I230183
 ETR(s): 133736

Date Received: 9/24/2009
 Start Date: 9/24/2009
 End Date: 10/1/2009

Percent Solids: 98.5%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: plant
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 88.7 | 11.3 |
| #4 | 4750 | 81.5 | 7.2 |
| #10 | 2000 | 70.4 | 11.0 |
| #20 | 850 | 59.2 | 11.2 |
| #40 | 425 | 49.2 | 10.0 |
| #60 | 250 | 39.3 | 9.9 |
| #80 | 180 | 33.9 | 5.4 |
| #100 | 150 | 30.6 | 3.3 |
| #200 | 75 | 20.5 | 10.1 |
| Hydrometer | 33.7 | 10.6 | 9.9 |
| | 22.0 | 7.7 | 2.9 |
| | 12.9 | 5.8 | 1.9 |
| | 9.2 | 3.9 | 1.9 |
| | 6.7 | 3.0 | 1.0 |
| | 3.4 | 1.0 | 1.9 |
| V | 1.4 | 0.5 | 0.6 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 18.5 |
| Sand | 61.0 |
| Coarse Sand | 11.0 |
| Medium Sand | 21.3 |
| Fine Sand | 28.7 |
| Silt | 17.5 |
| Clay | 3.0 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

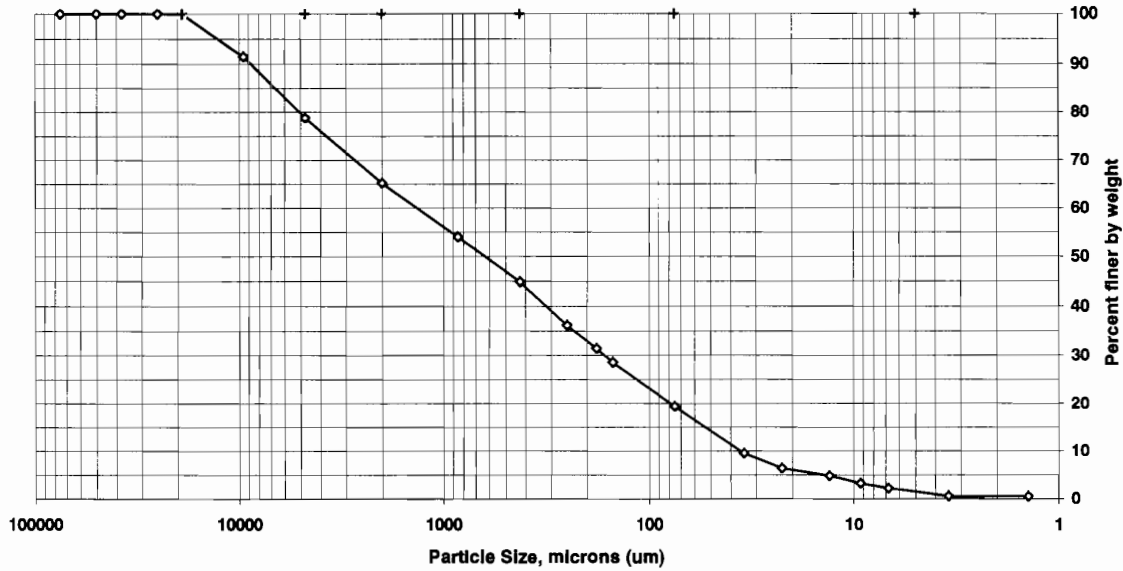
Client Code: STLMOS
 Sample ID: WHD-AS-BL03-0-FD
 Lab ID: 807468

SDG: 9I230183
 ETR(s): 133736

Date Received: 9/24/2009
 Start Date: 9/24/2009
 End Date: 10/1/2009

Percent Solids: 98.6%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: plant
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 91.5 | 8.5 |
| #4 | 4750 | 78.8 | 12.7 |
| #10 | 2000 | 65.2 | 13.6 |
| #20 | 850 | 54.0 | 11.2 |
| #40 | 425 | 44.9 | 9.1 |
| #60 | 250 | 36.2 | 8.7 |
| #80 | 180 | 31.5 | 4.7 |
| #100 | 150 | 28.5 | 2.9 |
| #200 | 75 | 19.4 | 9.1 |
| Hydrometer | 34.4 | 9.6 | 9.8 |
| | 22.4 | 6.4 | 3.2 |
| | 13.1 | 4.8 | 1.6 |
| | 9.3 | 3.2 | 1.6 |
| | 6.8 | 2.2 | 1.1 |
| | 3.4 | 0.6 | 1.6 |
| V | 1.4 | 0.5 | 0.1 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 21.2 |
| Sand | 59.4 |
| Coarse Sand | 13.6 |
| Medium Sand | 20.3 |
| Fine Sand | 25.5 |
| Silt | 17.2 |
| Clay | 2.2 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with
 a metal paddle.
 Dispersion Period: 1 minute

Particle Size Analysis of Soils
By ASTM D422
Hydrometer Data

Set Number
9I230183

Client Code: STLMOS
SDG: 9I230183
ETR(s): 133736

Date Received: 24-Sep-09
Start Date: 24-Sep-09
End Date: 1-Oct-09

Date and Analyst

| Percent Solids | Weighed | Mixed | Hydrometer | Large sieves | Small sieves |
|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| <u>MAP 9/25/09</u> | <u>MAP 9/25/09</u> | <u>MNT 9/26/09</u> | <u>MAP 9/29/09</u> | <u>MNT 9/26/09</u> | <u>MAP 9/30/09</u> |
| <u>DJP 9/28/09</u> | | | <u>DPS 9/30/09</u> | <u>DJP 10/1/09</u> | <u>DJP 10/1/09</u> |

| | | | | | | | | | | | | |
|-------------------|------|------|------|---------------|---------------|---------------|------|------|------|------|------|------|
| Test number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Lab number | | | | 807466 | 807467 | 807468 | | | | | | |
| Time, min. (2) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Reading | | | | 1.0175 | 1.0150 | 1.0130 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (5) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Reading | | | | 1.0150 | 1.0120 | 1.0100 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (15) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Reading | | | | 1.0135 | 1.0100 | 1.0085 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (30) | 30 | 30 | 29 | 29 | 31 | 31 | 31 | 32 | 30 | 30 | 30 | 31 |
| Reading | | | | 1.0125 | 1.0080 | 1.0070 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (60) | 59 | 58 | 58 | 63 | 60 | 59 | 59 | 60 | 63 | 57 | 63 | 57 |
| Reading | | | | 1.0115 | 1.0070 | 1.0060 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (250) | 256 | 256 | 250 | 250 | 240 | 234 | 265 | 259 | 253 | 247 | 241 | 235 |
| Reading | | | | 1.0070 | 1.0050 | 1.0045 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (1440) | 1440 | 1440 | 1434 | 1434 | 1424 | 1418 | 1412 | 1406 | 1400 | 1394 | 1388 | 1382 |
| Reading | | | | 1.0050 | 1.0045 | 1.0045 | | | | | | |
| Temperature, C | | | | 20.0 | 20.0 | 20.0 | | | | | | |

| | | | |
|------------------|-----------|----------|-----------|
| Hydrometer used: | 741402 | Model #: | ASTM 151H |
| Calibrations: | L temp, C | L read | H Temp, C |
| | 17.0 | 1.0045 | 23.0 |
| | | | 1.0035 |

Manufacturer: Chase
Cal. Date: 01/06/09
Hydrometer start time: 17:27
Hydrometer data entered: DJP 10/1/09

Particle Size Analysis of Solis
By ASTM D422
Hydrometer Data

Set Number
9I230183

Client Code: STLMO5
SDG: 9I230183
ETR(s): 133736

Date Received: 24-Sep-09
Start Date: 24-Sep-09
End Date: 10-1-09

Date and Analyst

| Percent Solids | Weighted | Mixed | Hydrometer | Large sieves | Small sieves |
|--------------------------|------------|------------|----------------------------|---------------------------|--------------------------|
| MM 9-25-09 DJ 9-28-09 | MM 9-25-09 | MM 9/26/09 | MM 9-29-09 DPS 09/30/09 | MM 09/26/09 DJ 10-1-09 | MM 9-28-09 DJ 10-1-09 |

| Test number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------------------|------|------|------|--------|--------|--------|------|------|------|------|------|------|
| Lab number | | | | 807466 | 807467 | 807468 | | | | | | |
| Time, min. (2) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Reading | | | | 1.0175 | 1.0150 | 1.0130 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (5) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Reading | | | | 1.0150 | 1.0120 | 1.0100 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (15) | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Reading | | | | 1.0135 | 1.0100 | 1.0085 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (30) | 30 | 30 | 29 | 29 | 31 | 31 | 31 | 32 | 30 | 30 | 30 | 31 |
| Reading | | | | 1.0125 | 1.0080 | 1.0070 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (60) | 59 | 58 | 58 | 63 | 60 | 59 | 59 | 60 | 63 | 57 | 63 | 57 |
| Reading | | | | 1.0115 | 1.0070 | 1.0060 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (250) | 256 | 256 | 250 | 250 | 240 | 234 | 265 | 259 | 253 | 247 | 241 | 235 |
| Reading | | | | 1.0070 | 1.0050 | 1.0045 | | | | | | |
| Temperature, C | | | | 20.5 | 20.5 | 20.5 | | | | | | |
| Time, min. (1440) | 1440 | 1440 | 1434 | 1434 | 1424 | 1418 | 1412 | 1406 | 1400 | 1394 | 1388 | 1382 |
| Reading | | | | 1.0050 | 1.0045 | 1.0040 | | | | | | |
| Temperature, C | | | | 20.0 | 20.0 | 20.0 | | | | | | |

| | | | | |
|------------------|---------------------------|--------|-----------|--------|
| Hydrometer used: | 741402 Model #: ASTM 151H | | | |
| Calibrations: | L temp, C | L read | H Temp, C | H read |
| | 17.0 | | 23.0 | |

Manufacturer:
Cal. Date:

Hydrometer start time: 1727
Hydrometer data entered: DJ 10-1-09

Particle Size Analysis of
Soils By ASTM D422
Sieve Data

Client Code: **STUMOS**

ETR(s): **133736**
SDG: **9I230183**

Date Rec: **24-Sep-09** Start Date: **24-Sep-09**
End Date: **1-Oct-09**

SET: **9I230183**

| Test | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---------------|---------------------------------------|---|---|--------|--------|--------|---|---|---|----|----|----|
| Laboratory No | | | | 807488 | 807487 | 807486 | | | | | | |
| Sample ID | WHD-AS-BP084-D-AS-BL03-D-AS-BL03-O-FD | | | | | | | | | | | |

Dry prep = D421
Wet prep = D2217

Sample Prep

| | | | | | | | | | | | | |
|-------------------|--|--|--|---------------|---------------|---------------|--|--|--|--|--|--|
| Pan, g | | | | | | | | | | | | |
| Pan/sample, g | | | | 151.79 | 170.15 | 154.64 | | | | | | |
| Pan/dry sample, g | | | | | | | | | | | | |

| Standard Values | |
|-----------------|-------------|
| Sieve | Opening, um |
| 3 inch | 75000 |
| 2 inch | 50000 |
| 1.5 inch | 37500 |
| 1 inch | 25000 |
| 3/4 inch | 19000 |
| 3/8 inch | 9500 |
| #4 | 4750 |
| #10 | 2000 |
| #20 | 850 |
| #40 | 425 |
| #60 | 250 |
| #80 | 180 |
| #100 | 150 |
| #200 | 75 |

Hygroscopic Moisture correction factor (HMCf) for dry prep / Percent Solids for dry and wet prep

| | | | |
|-------------------|---------------|---------------|---------------|
| Pan, g | 0.98 | 0.98 | 0.98 |
| Pan/sample, g | 17.78 | 30.88 | 27.11 |
| Pan/dry sample, g | 16.15 | 30.21 | 26.74 |
| HMCf | 100.0% | 100.0% | 100.0% |

Description of >#10 particles

| | | | |
|-------------------|----------------|----------------|----------------|
| Non-soil material | na | plant | plant |
| Shape | angular | angular | angular |
| Hardness | hard | hard | hard |

Sample % Solids

| | | |
|--------------|--------------|--------------|
| 90.3% | 98.5% | 98.6% |
|--------------|--------------|--------------|

Dry sample wt, g

| | | |
|---------------|---------------|---------------|
| 137.05 | 167.57 | 152.45 |
|---------------|---------------|---------------|

Sieve + Sample Weights

| Sieve (tares) | | Mass, g | | | | | | | | | | | |
|---------------|---------------|----------|---------|---------|---------------|---------------|---------------|---------|---------|---------|---------|---------|---------|
| Size | Mass, g | Size | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g | Mass, g |
| 3 inch | | 3 inch | | | | | | | | | | | |
| 2 inch | | 2 inch | | | | | | | | | | | |
| 1.5 inch | | 1.5 inch | | | | | | | | | | | |
| 1 inch | | 1 inch | | | | | | | | | | | |
| 3/4 inch | | 3/4 inch | | | | | | | | | | | |
| 3/8 inch | 447.55 | 3/8 inch | | | | 466.55 | 460.51 | | | | | | |
| #4 | 488.28 | #4 | | | 490.76 | 500.34 | 507.59 | | | | | | |
| #10 | 463.69 | #10 | | | 460.57 | 481.59 | 483.83 | | | | | | |
| #20 | 391.84 | #20 | | | 397.46 | 410.87 | 408.96 | | | | | | |
| #40 | 356.15 | #40 | | | 366.65 | 372.85 | 379.01 | | | | | | |
| #60 | 326.07 | #60 | | | 345.83 | 342.68 | 339.36 | | | | | | |
| #80 | 335.93 | #80 | | | 350.13 | 344.91 | 343.12 | | | | | | |
| #100 | 329.82 | #100 | | | 339.43 | 338.36 | 334.30 | | | | | | |
| #200 | 326.67 | #200 | | | 358.85 | 349.63 | 340.61 | | | | | | |

Maximum Particle size

| | | |
|---------------|--------------|--------------|
| 9.5 mm | 19 mm | 19 mm |
|---------------|--------------|--------------|

Default SG **2.65**

Specific gravity

| | | |
|--------------|--------------|--------------|
| 2.650 | 2.650 | 2.650 |
|--------------|--------------|--------------|

Sample Mass Parameters

| | | | | | | | | | | | | |
|---------------------|----------------|----------------|----------------|---------------|---------------|--------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Sample Mass >#10, g | 0.00 | 0.00 | 0.00 | 5.96 | 49.53 | 53.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sample mass <#10, g | #VALUE! | #VALUE! | #VALUE! | 131.09 | 118.04 | 99.44 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |



Sample Handling



ORIGIN ID: ALNA (314) 298-8566
BRIAN DANIELS
TEST AMERICA
13715 RIDER TRAIL N

EARTH CITY, MO 63045
UNITED STATES US

Ship Date: 23SEP09
ActWgt: 8.2 LB
System#: 486221/CAFE2361
Account: S *****

TO **RON PENTKOWSKI**
TEST AMERICA BURLINGTON
30 COMMUNITY DR STE 11

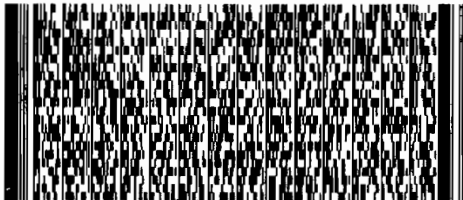
SOUTH BURLINGTON, VT 05403

(802) 660-1990

FedEx
Express



Ref: I230183



Delivery Address
Barcode

BILL RECIPIENT

PRIORITY OVERNIGHT

TRK# 4029 6269 6006

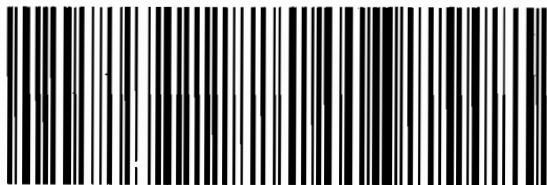
Form
0201

BTV

THU
Deliver By:
24SEP09
AA

05403 -VT-US

XH BTVA



| TestAmerica Burlington SAMPLE RECEIPT & LOG IN CHECKLIST | | | | | |
|--|-------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|------------------|
| Client: <u>STLMUS</u> | | Date Received: <u>09/24/09</u> | | Log In Date: <u>09/24/09</u> | |
| ETR: <u>133936</u> | | Time Received: <u>1015</u> | | By: <u>[Signature]</u> | |
| SDG: <u>97230163</u> | | Received By: <u>CK</u> | | Signature: <u>[Signature]</u> | |
| Project: <u>24014</u> | | # Coolers Received: <u>1</u> | | PM Signature: <u>[Signature]</u> | |
| Samples Delivered By: <input checked="" type="checkbox"/> Shipping Service <input type="checkbox"/> Courier <input type="checkbox"/> Hand <input type="checkbox"/> Other (specify) | | | | Date: <u>09/25/09</u> | |
| List Air bill Number(s) or Attach a photocopy of the Air Bill: | | | | | |
| | | | | | |
| | | YES | NO | NA | COMMENTS |
| There is no evidence to indicate tampering | | <input checked="" type="checkbox"/> | | | |
| Custody seals are present and intact | | <input checked="" type="checkbox"/> | | | |
| Custody seal numbers are present | | | <input checked="" type="checkbox"/> | | |
| If yes, list custody seal numbers: | | | | | |
| | | | | | |
| Thermal Preservation Type: <input type="checkbox"/> Wet Ice <input type="checkbox"/> Blue Ice <input checked="" type="checkbox"/> None <input type="checkbox"/> Other (specify) | | | | | |
| IR Gun ID: <u>96</u> | | Correction Factor (CF) = <u>0</u> °C | | | |
| Cooler 1: <u>21.6</u> °C | Cooler 6 | °C | Cooler 11 | °C | Cooler 16 |
| Cooler 2: °C | Cooler 7 | °C | Cooler 12 | °C | Cooler 17 |
| Cooler 3: °C | Cooler 8 | °C | Cooler 13 | °C | Cooler 18 |
| Cooler 4: °C | Cooler 9 | °C | Cooler 14 | °C | Cooler 19 |
| Cooler 5: °C | Cooler 10 | °C | Cooler 15 | °C | Cooler 20 |
| Unless otherwise documented, the recorded temperature readings are adjusted readings to account for the CF of the IR Gun | | | | | |
| EPA Criteria: 0-6°C, except for air and geo samples which should be at ambient temperature and tissue samples, which may be frozen. | | | | | |
| Some clients require thermal preservation criteria of 2-4°C or other such criteria. The PM must notify SM when alternate criteria is specified. | | | | | |
| | | YES | NO | NA | COMMENTS |
| Sample containers were received intact | | <input checked="" type="checkbox"/> | | | |
| Legible sample labels are affixed to each container | | <input checked="" type="checkbox"/> | | | |
| | | YES | NO | NA | COMMENTS |
| COC is present and includes the following information for each container: | | | | | |
| • Sample ID / Sample Description | <input checked="" type="checkbox"/> | | | | |
| • Date of Sample Collection | <input checked="" type="checkbox"/> | | | | |
| • Time of Sample Collection | <input checked="" type="checkbox"/> | | | | |
| • Identification of the Sampler | | <input checked="" type="checkbox"/> | | | |
| • Preservation Type | | | <input checked="" type="checkbox"/> | | |
| • Requested Tests Method(s) | | <input checked="" type="checkbox"/> | | | |
| • Necessary Signatures | <input checked="" type="checkbox"/> | | | | |
| Internal Chain of Custody (ICOC) Required | | | | | |
| If yes to above, ICOC Record Initiated for every Worksheet | | | | | |
| | | YES | NO | NA | COMMENTS |
| The sample container matches the COC | | | <input checked="" type="checkbox"/> | | <u>See below</u> |
| Appropriate sample containers were received for the tests requested | | <input checked="" type="checkbox"/> | | | |
| Samples were received within holding time | | <input checked="" type="checkbox"/> | | | |
| Sufficient amount of sample is provided for requested analyses | | <input checked="" type="checkbox"/> | | | |
| VOA vials do not have headspace or a bubble >6mm (1/4" diameter) | | | | <input checked="" type="checkbox"/> | |
| Appropriate preservatives were used for the tests requested | | | | <input checked="" type="checkbox"/> | |
| pH of inorganic samples checked and is within method specification | | | | <input checked="" type="checkbox"/> | |
| If no, attach Inorganic Sample pH Adjustment Form | | | | <input checked="" type="checkbox"/> | |
| ANOMALY / NCR SUMMARY | | | | | |
| <u>Sample labels list Hg, COC does not, in this used R 1g/L. COC lists nitrate of SAZD, WSA lists SAZL, 1g/L and 5 SAZL R WSA.</u> | | | | | |

TestAmerica
South Burlington, VT

Sample Data Summary
Package

9I230183

TestAmerica Laboratories, Inc.

October 1, 2009

Mr. Jerry Everett
TestAmerica, Inc.
13715 Rider Trail North
Earth City, MO 63045

Re: Laboratory Project No. 29014
Case: BRCWHOOK; SDG: 9I230183

Dear Mr. Everett:

Enclosed are the analytical results for the samples that were received by TestAmerica Burlington on September 24th, 2009. Laboratory identification numbers were assigned, and designated as follows:

| <u>Lab ID</u> | <u>Client Sample ID</u> | <u>Sample Date</u> | <u>Sample Matrix</u> |
|-----------------------------------|-----------------------------|------------------------|--------------------------|
| Received: 09/24/09 ETR No: 133736 | | | |
| 807466 | WHD-AS-BP08-4 | 09/21/09 | SOIL |
| 807467 | WHD-AS-BL03-0 | 09/21/09 | SOIL |
| 807468 | WHD-AS-BL03-0-FD | 09/21/09 | SOIL |

Documentation of the condition of the samples at the time of their receipt and any exception to the laboratory's Sample Acceptance Policy is documented in the Sample Handling section of this submittal.

Particle Size Analysis by ASTM D422

There were no exceptions to the method quality control criteria during the analyses of these samples.

Any reference within this report to Severn Trent Laboratories, Inc. or STL, should be understood to refer to TestAmerica Laboratories, Inc. (formerly known as Severn Trent Laboratories, Inc.) The analytical results associated with the samples presented in this test report were generated under a quality system that adheres to requirements specified in the NELAC standard. Release of the data in this test report and any associated electronic deliverables is authorized by the Laboratory Director's designee as verified by the following signature.



If there are any questions regarding this submittal, please contact me at 802 660-1990.

Sincerely,

A handwritten signature in black ink that reads 'Rayburn J. Lavigne'. The script is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

Rayburn Lavigne
Project Manager

RJL/hsf
Enclosure

F9I230183

INTER-COMPANY LOG

COMMENTS:

Project Manager:

Project:

Report Type:

Client: 445691 - Basic Remediation Company

WESTERN HOOK

Date Received: 2009-09-23

Analytical Due Date: 2009-10-02

Report Due Date: 2009-10-06

WORK LOCATION: H2 TestAmerica Burlington

SMP#: 1 CLIENT ID: WHD-AS-BP08-4 DATE SAMPLED: 20090921 MATRIX: A SOLID

SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive

EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET

WORKORDER LLAQM1AP

METAL: XX

WORKORDER LLAQM1AN

METAL: XX

SMP#: 6 CLIENT ID: WHD-AS-BL03-0 DATE SAMPLED: 20090921 MATRIX: A SOLID

SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive

EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET

WORKORDER LLAQ71AQ

METAL: XX

WORKORDER LLAQ71AR

METAL: XX

SMP#: 7 CLIENT ID: WHD-AS-BL03-0-FD DATE SAMPLED: 20090921 MATRIX: A SOLID

SAMPLE COMMENTS:

METHOD: ZZ NONE NONE Archive

EXTRACTION: 88 NO SAMPLE PREPARATION PERFORMED / QC TYPE: 01 STANDARD TEST SET

WORKORDER LLAQ91AN

METAL: XX

WORKORDER LLAQ91AP

METAL: XX

The sample(s) listed on this form are being sent to your location for the specified analysis. If you have any questions, please contact the Project Manager listed above. PLEASE RETURN THE ORIGINAL SIGNED FORM WITH THE REPORT AT THE COMPLETION OF ANALYSIS.

Thank You

TA- St. Louis
Sample Receiving

RELINQUISHED BY:

DATE:

RECEIVED FOR LAB BY:

DATE:



Sample Data Summary – Geotechnical

Particle Size of Soils by ASTM D422

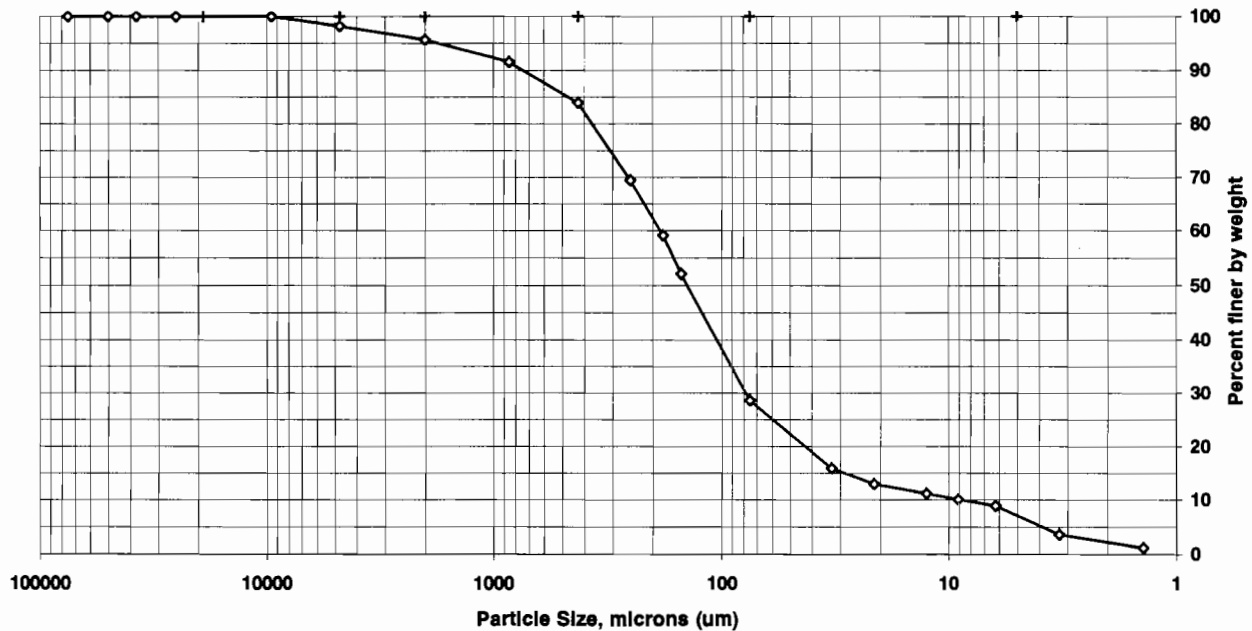
| | |
|--------------|---------------|
| Client Code: | STLMOS |
| Sample ID: | WHD-AS-BP08-4 |
| Lab ID: | 807466 |

SDG: 9|230183
ETR(s): 133736

Date Received: 9/24/2009
Start Date: 9/24/2009
End Date: 10/1/2009

| | |
|-------------------------------|--------|
| Percent Solids: | 90.3% |
| Specific Gravity: | 2.650 |
| Maximum Particle Size: | 9.5 mm |

| | |
|--------------------|---------|
| Non-soli material: | na |
| Shape (> #10): | angular |
| Hardness (> #10): | hard |



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 100.0 | 0.0 |
| #4 | 4750 | 98.2 | 1.8 |
| #10 | 2000 | 95.7 | 2.5 |
| #20 | 850 | 91.6 | 4.1 |
| #40 | 425 | 83.9 | 7.7 |
| #60 | 250 | 69.5 | 14.4 |
| #80 | 180 | 59.1 | 10.4 |
| #100 | 150 | 52.1 | 7.0 |
| #200 | 75 | 28.6 | 23.5 |
| Hydrometer | 32.8 | 15.9 | 12.7 |
| | 21.3 | 13.0 | 2.9 |
| | 12.5 | 11.2 | 1.8 |
| | 9.1 | 10.1 | 1.2 |
| | 6.2 | 8.9 | 1.2 |
| | 3.3 | 3.6 | 5.3 |
| V | 1.4 | 1.2 | 2.4 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 1.8 |
| Sand | 69.6 |
| Coarse Sand | 2.5 |
| Medium Sand | 11.8 |
| Fine Sand | 55.3 |
| Silt | 19.7 |
| Clay | 8.9 |

Preparation Method: **D2217**
Dispersion Device: Mechanical mixer with
a metal paddle.
Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

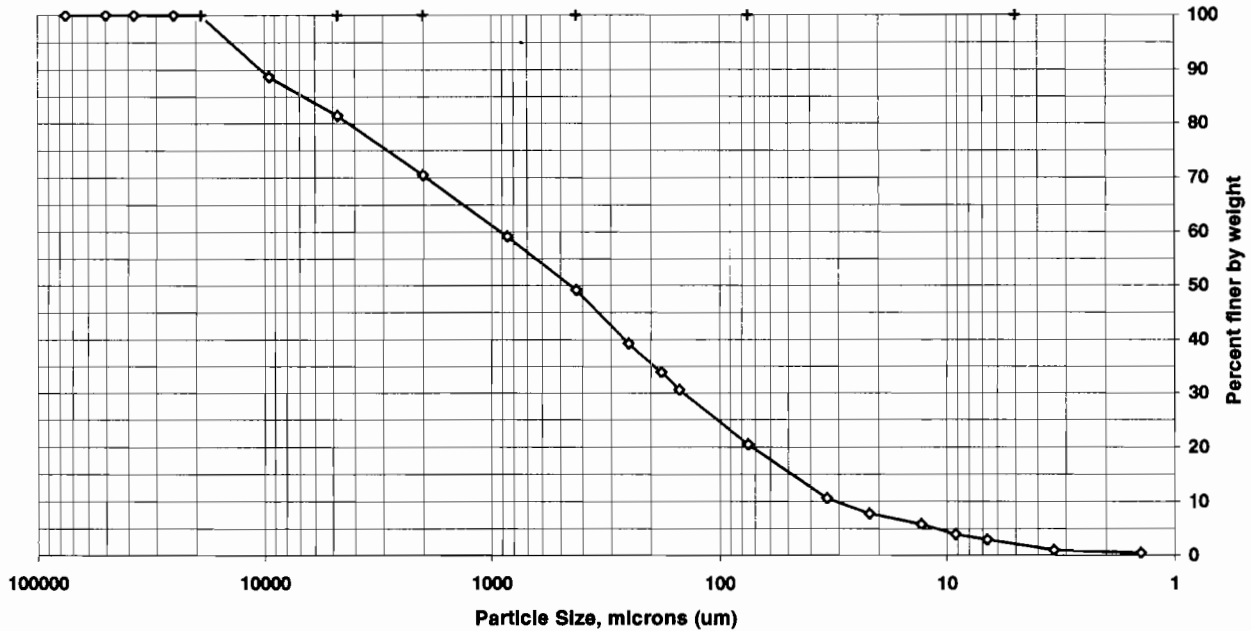
Client Code: STLMOS
 Sample ID: WHD-AS-BL03-0
 Lab ID: 807467

SDG: 91230183
 ETR(s): 133736

Date Received: 9/24/2009
 Start Date: 9/24/2009
 End Date: 10/1/2009

Percent Solids: 98.5%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: plant
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 88.7 | 11.3 |
| #4 | 4750 | 81.5 | 7.2 |
| #10 | 2000 | 70.4 | 11.0 |
| #20 | 850 | 59.2 | 11.2 |
| #40 | 425 | 49.2 | 10.0 |
| #60 | 250 | 39.3 | 9.9 |
| #80 | 180 | 33.9 | 5.4 |
| #100 | 150 | 30.6 | 3.3 |
| #200 | 75 | 20.5 | 10.1 |
| Hydrometer | 33.7 | 10.6 | 9.9 |
| | 22.0 | 7.7 | 2.9 |
| | 12.9 | 5.8 | 1.9 |
| | 9.2 | 3.9 | 1.9 |
| | 6.7 | 3.0 | 1.0 |
| | 3.4 | 1.0 | 1.9 |
| V | 1.4 | 0.5 | 0.6 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 18.5 |
| Sand | 61.0 |
| Coarse Sand | 11.0 |
| Medium Sand | 21.3 |
| Fine Sand | 28.7 |
| Silt | 17.5 |
| Clay | 3.0 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with a metal paddle.
 Dispersion Period: 1 minute

Particle Size of Soils by ASTM D422

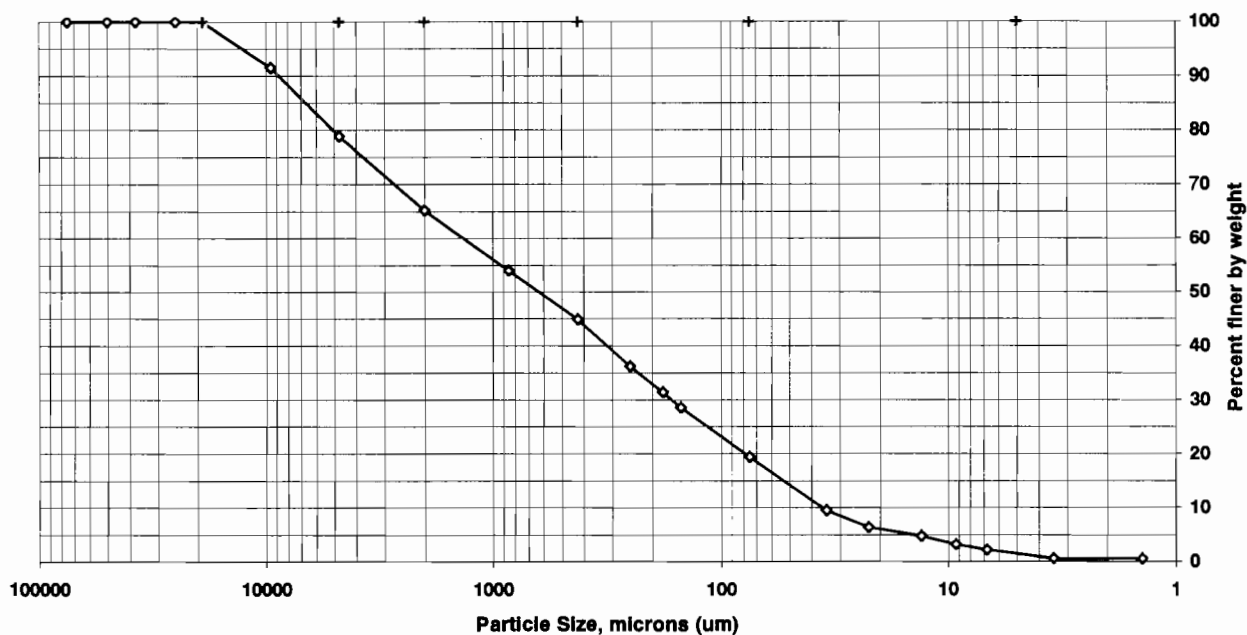
Client Code: STLMOS
 Sample ID: WHD-AS-BL03-0-FD
 Lab ID: 807468

SDG: 91230183
 ETR(s): 133736

Date Received: 9/24/2009
 Start Date: 9/24/2009
 End Date: 10/1/2009

Percent Solids: 98.6%
 Specific Gravity: 2.650
 Maximum Particle Size: 19 mm

Non-soil material: plant
 Shape (> #10): angular
 Hardness (> #10): hard



| Sieve size | Particle size, um | Percent finer | Incremental percent |
|------------|-------------------|---------------|---------------------|
| 3 inch | 75000 | 100.0 | 0.0 |
| 2 inch | 50000 | 100.0 | 0.0 |
| 1.5 inch | 37500 | 100.0 | 0.0 |
| 1 inch | 25000 | 100.0 | 0.0 |
| 3/4 inch | 19000 | 100.0 | 0.0 |
| 3/8 inch | 9500 | 91.5 | 8.5 |
| #4 | 4750 | 78.8 | 12.7 |
| #10 | 2000 | 65.2 | 13.6 |
| #20 | 850 | 54.0 | 11.2 |
| #40 | 425 | 44.9 | 9.1 |
| #60 | 250 | 36.2 | 8.7 |
| #80 | 180 | 31.5 | 4.7 |
| #100 | 150 | 28.5 | 2.9 |
| #200 | 75 | 19.4 | 9.1 |
| Hydrometer | 34.4 | 9.6 | 9.8 |
| | 22.4 | 6.4 | 3.2 |
| | 13.1 | 4.8 | 1.6 |
| | 9.3 | 3.2 | 1.6 |
| | 6.8 | 2.2 | 1.1 |
| | 3.4 | 0.6 | 1.6 |
| V | 1.4 | 0.5 | 0.1 |

| Soil Classification | Percent of Total Sample |
|---------------------|-------------------------|
| Gravel | 21.2 |
| Sand | 59.4 |
| Coarse Sand | 13.6 |
| Medium Sand | 20.3 |
| Fine Sand | 25.5 |
| Silt | 17.2 |
| Clay | 2.2 |

Preparation Method: **D2217**
 Dispersion Device: Mechanical mixer with a metal paddle.
 Dispersion Period: 1 minute

Appendix C
Electron Dot Mapping Report



850 Pasquinelli Drive • Westmont, Illinois 60559-5539
630-887-7100 • Fax: 630-887-7417

14 January 2010

Mr. Mark Jones
Project Manager
ERM
2525 Natomas Park Dr., Suite 350
Sacramento, Ca. 95833

Subject: ASPEX analysis of Soil Sample WHD-AS-BN10-0
Re: McCrone Associates Project MA48807

Dear Mr. Jones:

This report summarizes the ASPEX analyses conducted on your soil sample WHD-AS-BN10-0. This work was performed under your authorization and the cost will be applied to the credit card number you provided.

SAMPLE RECEIPT

On 10 November 2009, we received a package from Geotechnical and Environmental Services containing soil sample WHD-AS-BN10-0. The sample was received in a cooler, and was placed in our sample refrigerator. The sample consisted of a glass jar filled to the top with 220.58 g of dry, reddish-gray, gravelly soil, including one large gray rock approximately 5 cm across and weighing 46.23 g.

The analytical request in the Sample Submission Form requested that we perform elemental analysis using scanning electron microscopy with energy dispersive x-ray spectroscopy (SEM/EDS) to help evaluate the origin of arsenic (As) detected in soil sample WHD-AS-BN10-0. A density separation was requested in an attempt to concentrate arsenic-bearing materials. If arsenic was determined to be present, we were to identify the arsenic bearing material. We were also instructed to document the presence of other elements identified while searching for As spectra and to classify them as common mineral species. The analysis plan was developed based on conversations with Maria Barajas of ERM and John Dodge of Daniel B. Stephens and Associates.

PREPARATION

The sample was stored in our sample refrigerator until analysis was started. The sample was first emptied into a clean pan and any clumps were manually broken up. A size separation was subsequently performed by passing the soil through a 140 mesh

The results and conclusions, herein, have been peer-reviewed and are considered thorough and complete by McCrone Associates, Inc. The results apply exclusively to the samples analyzed and documented in this report. No further revisions will be made unless a corrective action is deemed warranted by McCrone Associates, Inc. Dissemination, interpretation, and/or reproduction, except in whole, are not recommended as doing so may alter and/or nullify the results.

Mr. Mark Jones
MA48807

soil sieve (110 μm openings). This step was performed to remove large particulate that cannot be analyzed by SEM/EDS. The material allowed to pass through the sieve was reweighed (17.99 g) and divided into ten, 50 ml centrifuge tubes. The weight of soil in each tube was measured.

Once the sample was divided into the centrifuge tubes, a density separation was performed to remove the less dense materials from our sample in an attempt to concentrate any arsenic-bearing minerals. This was performed by adding Low Viscosity Polytungstate (LVP; density=2.82 g/L; Geosciences, Prospect Heights, IL) to each tube and sonicating the soil in the LVP for 30 minutes. Subsequently, the tubes were centrifuged at 2000 RPM for ten minutes, and the light fraction of the sample was removed and retained. The heavy fraction of the sample was then washed with particle-free water and centrifuged to remove LVP. This heavy fraction was then prepared for automated SEM/EDS analysis using an ASPEX 3025 Personal Scanning Electron Microscope (P-SEM).

In order to prepare particle dispersions for automated SEM/EDS analysis, a 1:100 diluted portion of the heavy fraction was pipetted through a pre-weighed 1.0 μm pore size polycarbonate (PC) membrane filter using vacuum. The filter was rinsed with particle-free water and subsequently dried and reweighed. This was performed for 16 separate filters. The 16 filters were mounted on aluminum stubs, coated with a conductive layer of carbon, and submitted for analysis in our ASPEX instrument. The total amount of material loaded on these filters amounted to 0.1136 g (see Table 1 for details).

ANALYSIS

All samples were analyzed with our ASPEX 3025 low-vacuum P-SEM using the automated feature analysis program. Particles were analyzed for elemental composition using EDS. Morphological information was also collected.

Samples were analyzed with a magnification of between 350x and 500x using a 25 kV, 0.62 nA electron beam. Image thresholds, based on the backscattered electron image (BEI), were set to detect particles from 0.5 to 200 μm in size on the PC filters. Samples were analyzed for 10 to 20 hours.

After the samples were analyzed in the ASPEX P-SEM, the data were processed using Graf elemental processing software (available from NIST). All particles were checked for the presence of arsenic, and were subsequently classified using a rule-based classification scheme.

The results and conclusions, herein, have been peer-reviewed and are considered thorough and complete by McCrone Associates, Inc. The results apply exclusively to the samples analyzed and documented in this report. No further revisions will be made unless a corrective action is deemed warranted by McCrone Associates, Inc. Dissemination, interpretation, and/or reproduction, except in whole, are not recommended as doing so may alter and/or nullify the results.

Mr. Mark Jones
MA48807

CONCLUSION

The automated SEM/EDS analyses resulted in the identification and classification of over 223,000 particles. Of these, only two particles were found to contain detectable levels of arsenic, at an estimated level of <15 wt%. A discrete, As phase could not be identified in these two particles by BEI. Both particles in which As was identified were silica-rich particles and appeared to be composed of multiple phases, including monazite, xenotime, and iron-silicate. No sulfur was identified in either of the particles, which would be expected for an arsenopyrite.

The main materials identified during this analysis were common silicates, ilmenite, celestite, barite, and iron oxide. Table 2 contains all of the materials identified during the automated SEM/EDS analyses, and Table 3 provides the calculations for the estimated detection limit of As by our analysis.

During our discussions on this project, Mr. Dodge reported that sample WHD-AS-BN10-0 had a bulk As content of 24-25 mg/kg. If all the As were to occur as 1-100 μm particles of FeAsS or similar compounds, we should have detected thousands of these particles by automated SEM/EDS. The fact that we did not detect As compounds or minerals suggests that the arsenic in the soil sample is present in one or more of the following forms:

1. Present in large rocks or particles ($>110\ \mu\text{m}$), or buried in particles beyond the analysis range of SEM/EDS (a few micrometers)
2. Sub- $0.5\ \mu\text{m}$ or colloidal particles, which could not be individually detected by automated SEM/EDS
3. Water-soluble compounds that dissolved during density separation and rinsing
4. Present as a trace element ($<2\ \text{wt}\%$) dispersed in minerals or rocks
5. Present in mineral species that ended up in the light fraction after density separation

Further analysis of separate size and density fractions of the soil may be able to further identify the form of arsenic. However, additional work with a fresh sample would be needed to perform this study.

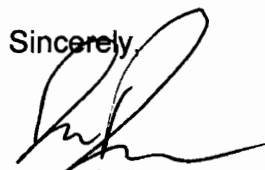
This testing was conducted in a Good Manufacturing Practices compliant laboratory.

The results and conclusions, herein, have been peer-reviewed and are considered thorough and complete by McCrone Associates, Inc. The results apply exclusively to the samples analyzed and documented in this report. No further revisions will be made unless a corrective action is deemed warranted by McCrone Associates, Inc. Dissemination, interpretation, and/or reproduction, except in whole, are not recommended as doing so may alter and/or nullify the results.

Mr. Mark Jones
MA48807

Thank you for consulting McCrone Associates. Your sample will be retained for a minimum of 30 days, after which it may be disposed of by McCrone Associates, unless you direct otherwise. If you have any questions, please do not hesitate to contact me (bbierman@mccrone.com).

Sincerely,

A handwritten signature in black ink, appearing to read 'Brian J. Bierman', with a stylized flourish at the end.

Brian J. Bierman
Senior Research Scientist

BJB:rd
Enclosures
Ref: MA48807; Credit Card

The results and conclusions, herein, have been peer-reviewed and are considered thorough and complete by McCrone Associates, Inc. The results apply exclusively to the samples analyzed and documented in this report. No further revisions will be made unless a corrective action is deemed warranted by McCrone Associates, Inc. Dissemination, interpretation, and/or reproduction, except in whole, are not recommended as doing so may alter and/or nullify the results.

Table 1. WHD-AS-BN10-0 Soil Analysis Worksheet

| Description | Weight | % |
|---|-----------------------|----------|
| Soil in jar | 220.58 g | |
| Soil passed through 140 mesh soil sieve | 17.99 g | 8.2 |
| Soil in heavy fraction of sample | 1.06 g | 5.9 |
| Amount of soil loaded on filters | 0.1136 g | 10.7 |
| Amount of material analyzed at ASPEX | 0.0164 g | 14.4 |
| ASPEX Estimated As Detection Limit | 90 parts per trillion | |

Table 2: ASPEX Gross Screening Report

Project Number: MA48807

Total Particles = 223,628

| Material | Number of Particles | Minimum Size (µm) | Maximum Size (µm) |
|----------------------------|---------------------|-------------------|-------------------|
| Iron Silicate | 58,006 | 0.3 | 155.8 |
| Aluminum Silicate | 32,217 | 0.4 | 140.9 |
| Magnesium Silicate | 23,872 | 0.3 | 130.7 |
| Ilmenite | 21,935 | 0.5 | 120.0 |
| Celestite | 18,352 | 0.5 | 105.7 |
| Calcium Silicate | 17,591 | 0.4 | 158.3 |
| Misc. Silicates | 6,244 | 0.4 | 132.8 |
| Barite | 5,948 | 0.5 | 81.9 |
| Iron-rich | 5,457 | 0.5 | 153.8 |
| Augite | 5,255 | 1.0 | 134.0 |
| Apatite | 5,136 | 0.8 | 93.1 |
| Quartz | 4,389 | 0.4 | 124.8 |
| Potassium Feldspar | 3,717 | 0.4 | 118.7 |
| Titanium Silicate | 2,932 | 0.5 | 124.3 |
| Non-Al Silicate | 1,841 | 0.5 | 99.2 |
| Tungsten-rich | 1,397 | 0.6 | 26.4 |
| Epidote | 1,232 | 1.4 | 85.2 |
| Calcium-rich | 1,181 | 1.4 | 73.2 |
| Lepidolite | 1,039 | 1.0 | 111.7 |
| Calcium Carbonate | 932 | 1.1 | 71.2 |
| Titanium-rich | 849 | 1.1 | 41.2 |
| Calcium-Magnesium Silicate | 680 | 1.2 | 117.0 |
| Zircon | 483 | 1.0 | 87.5 |
| Manganese Silicate | 305 | 0.8 | 38.9 |
| Calcium-Titanium Silicate | 297 | 1.5 | 76.0 |
| Biotite | 250 | 4.5 | 133.7 |
| Low Alloy Steel | 222 | 1.0 | 24.7 |
| Monazite | 199 | 0.6 | 70.0 |
| Albite | 170 | 1.9 | 30.6 |
| Zirconium-Titanium-Iron | 150 | 0.8 | 11.4 |
| 300 Series S.S. | 123 | 0.9 | 19.0 |
| #Unclassified# | 116 | 1.3 | 46.2 |
| Manganese-rich | 105 | 1.2 | 61.5 |
| Iron-Calcium rich | 103 | 1.9 | 32.4 |
| Rare Earth Element Rich | 81 | 0.7 | 45.6 |
| Bronze | 79 | 0.8 | 24.1 |
| Aluminum-rich | 65 | 1.1 | 26.4 |
| Hornblende | 65 | 1.4 | 65.8 |
| Labradorite | 64 | 1.7 | 23.9 |
| Steel corrosion | 61 | 1.3 | 31.0 |
| Tin-rich | 48 | 0.8 | 19.9 |
| 400 Series S.S. | 47 | 1.7 | 19.1 |
| Iron-Sulfur | 47 | 1.2 | 18.9 |
| Tremolite | 43 | 2.1 | 56.4 |
| Carbon Steel | 39 | 1.3 | 15.9 |
| Copper-rich | 39 | 2.7 | 23.3 |
| Brass | 37 | 1.3 | 27.4 |
| Anorthite | 32 | 2.8 | 11.7 |
| Zirconium-rich | 28 | 1.0 | 7.9 |
| Mischmetal | 27 | 2.2 | 17.2 |
| Chlorine-rich | 13 | 6.8 | 34.1 |

Monday, January 11, 2010

Page 1 of 2

Table 2: ASPEX Gross Screening Report

Project Number: MA48807

Total Particles = 223,628

| Material | Number of Particles | Minimum Size (µm) | Maximum Size (µm) |
|-------------------------------|--------------------------------|------------------------------|------------------------------|
| Xenotime | 13 | 1.6 | 68.8 |
| Zinc-rich | 9 | 2.5 | 12.6 |
| Galvanized Steel | 7 | 3.4 | 7.9 |
| Gold | 7 | 0.8 | 4.9 |
| Cerium-Vanadium | 6 | 2.8 | 18.9 |
| Potassium Silicate | 6 | 1.5 | 5.4 |
| Chromium-rich | 4 | 1.2 | 2.6 |
| Thorite | 4 | 1.1 | 4.4 |
| Bismuth Chloride | 3 | 1.3 | 5.2 |
| REE mineral | 3 | 2.6 | 7.1 |
| Aluminum-Strontium-Phosphorus | 2 | 2.5 | 5.5 |
| Arsenic containing | 2 | 4.0 | 5.5 |
| Barite with Zinc | 2 | 2.0 | 2.1 |
| Fluorine-rich | 2 | 4.2 | 13.4 |
| Iron-Tin | 2 | 3.9 | 24.9 |
| Magnesium Fluoride | 2 | 15.5 | 18.7 |
| Solder | 2 | 9.3 | 17.6 |
| Cerium-rich | 1 | 2.4 | 2.4 |
| Gold-Iron | 1 | 3.5 | 3.5 |
| Iron-Copper | 1 | 2.9 | 2.9 |
| Lead-rich | 1 | 7.0 | 7.0 |
| Magnesium-rich | 1 | 8.8 | 8.8 |
| Manganese-Iron | 1 | 16.4 | 16.4 |
| Molybdenum | 1 | 20.8 | 20.8 |
| Nickel-Chromium | 1 | 3.1 | 3.1 |
| Sulfur-rich | 1 | 1.8 | 1.8 |
| Titanium-Calcium | 1 | 8.9 | 8.9 |
| Vanadium with REE | 1 | 3.0 | 3.0 |
| Vanadium-rich | 1 | 4.9 | 4.9 |

Table 3. ASPEX As Detection Limit Estimate**Arsenopyrite mineral (FeAsS)**

Molecular weight – 162.83g/mol

Density – 6.1g/cm³For a 1µm spherical particle the volume will be 5.236x10⁻¹³cm³

$$\begin{aligned}
 \text{Volume} &= 4/3\pi r^3 \\
 &= 4/3\pi(0.00005\text{cm})^3 \\
 &= 4/3\pi(1.25\times 10^{-13}\text{cm}^3) \\
 &= \mathbf{5.236\times 10^{-13}\text{cm}^3}
 \end{aligned}$$

The mass of a 1µm sphere of arsenopyrite equals 3.194x10⁻¹²g

$$\begin{aligned}
 \text{Mass} &= \text{Density} \times \text{Volume} \\
 &= 6.1\text{g/cm}^3 \times 5.236\times 10^{-13}\text{cm}^3 \\
 &= \mathbf{3.194\times 10^{-12}\text{g}}
 \end{aligned}$$

Amount of arsenic in 1µm of arsenopyrite

= Molecular weight of As / Molecular weight of arsenopyrite

$$\begin{aligned}
 &= 74.92\text{g/mol} / 162.83\text{g/mol} \\
 &= 0.4601
 \end{aligned}$$

$$= 0.4601 \times 3.194\times 10^{-12}\text{g}$$

$$= \mathbf{1.470\times 10^{-12}\text{g As}}$$

Estimated ASPEX Detection Limit: one, 1 µm FeAsS sphere in the analyzed fraction of soil

D.L. ≈ As in 1µm of arsenopyrite / amount of material analyzed

$$\begin{aligned}
 &= 1.470\times 10^{-12}\text{g} / 0.0164\text{g} \\
 &= \mathbf{8.963\times 10^{-11} \text{ or } 89.6 \text{ parts per trillion}}
 \end{aligned}$$

Appendix D

**Historical
Aerial Photographs**



Base Map Source: 1943 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1943



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1943.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1950.MXD 014110



Base Map Source: 1950 Aerial photograph



0 2500 5000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

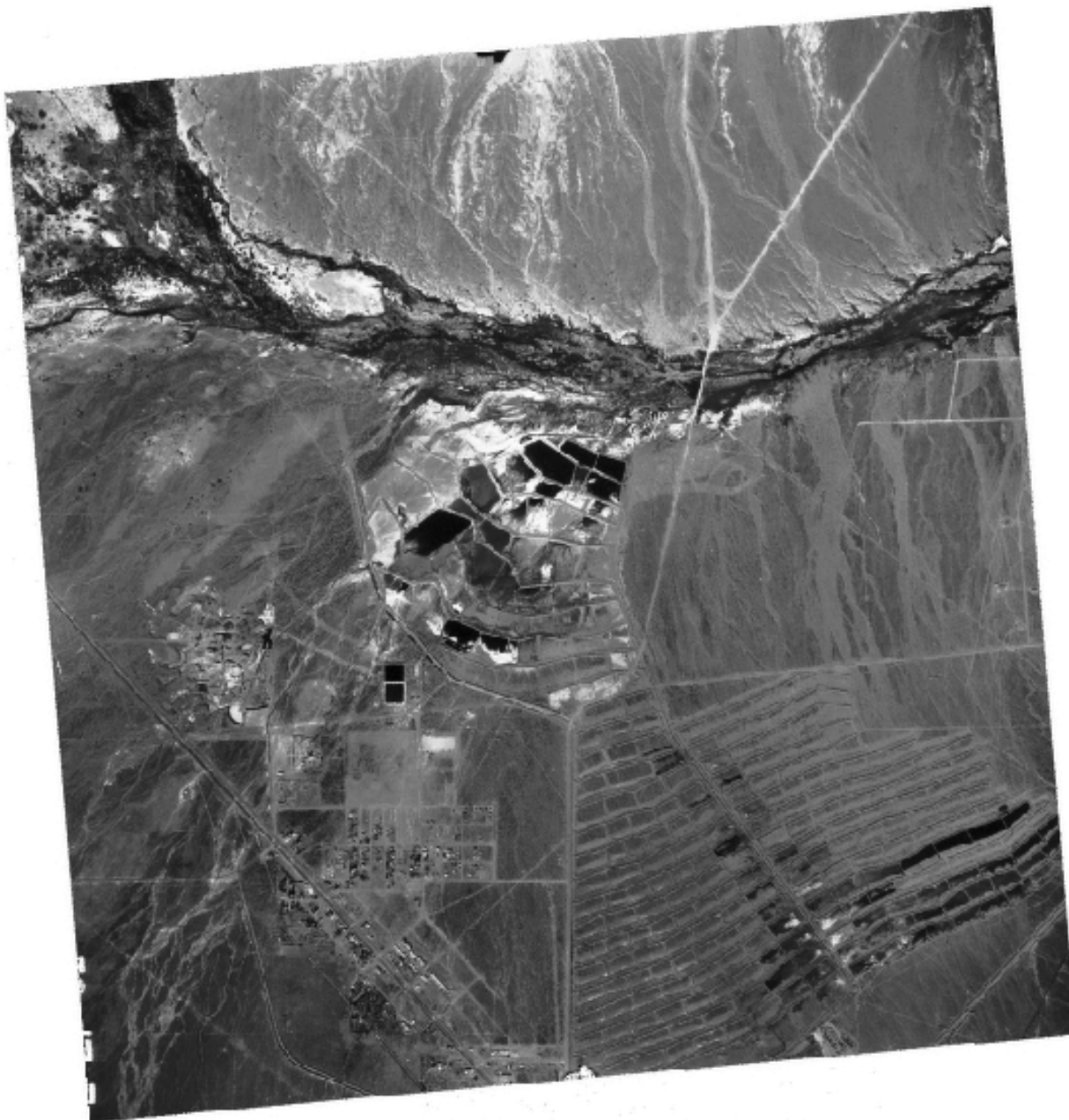
FIGURE
Aerial Photograph 1950



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1950.MXD 014110

S:/PROJECTS/BROES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1961.MXD 014110



Base Map Source: 1961 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1961



Prepared by:
DBS&A

CRS

Date
01-13-10

S:/PROJECTS/BROES09.0281_BRC_WH_AND_PRE-CSM_TASKS/
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AERIAL_PHOTO_1961.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1967.MXD 014110



Base Map Source: 1967 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1967



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1967.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXD/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1968.MXD 014110



Base Map Source: 1968 Aerial photograph



0 2000 4000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1968



Prepared by: DBS&A CRS
Date: 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/
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AERIAL_PHOTO_1968.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1969.MXD 014110



Base Map Source: 1969 Aerial photograph



0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1969



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S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1969.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1972.MXD 014110



0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

Base Map Source: 1972 Aerial photograph

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1972



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1972.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXD/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1973.MXD 014110



Base Map Source: 1973 Aerial photograph

0 2000 4000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1973



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXD/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1973.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1974.MXD 014110



Base Map Source: 1974 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1974



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1974.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1975.MXD 014110



Base Map Source: 1975 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1975



Prepared by: DBS&A CRS
Date: 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1975.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1967.MXD 014110



Base Map Source: 1976 Aerial photograph

0 2000 4000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1976



Prepared by: DBS&A CRS
Date: 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/
GIS/MXDS/AERIAL_PHOTOS/8X11/
AERIAL_PHOTO_1976.MXD 014110



Base Map Source: 1980 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1980



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1980.MXD 014110



Base Map Source: 1987 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1987



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1987.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXD/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1988.MXD 014110



Base Map Source: 1988 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1988



Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXD/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1988.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1990.MXD 014110



Base Map Source: 1990 Aerial photograph

0 1500 3000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1990



Prepared by:
DBS&A CRS

Date
01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/
GIS/MXDS/AERIAL_PHOTOS/8X11/
AERIAL_PHOTO_1990.MXD 014110

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1999.MXD 014110



Base Map Source: 1999 Aerial photograph

0 2000 4000 Feet



Daniel B. Stephens & Associates, Inc.

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
Aerial Photograph 1999



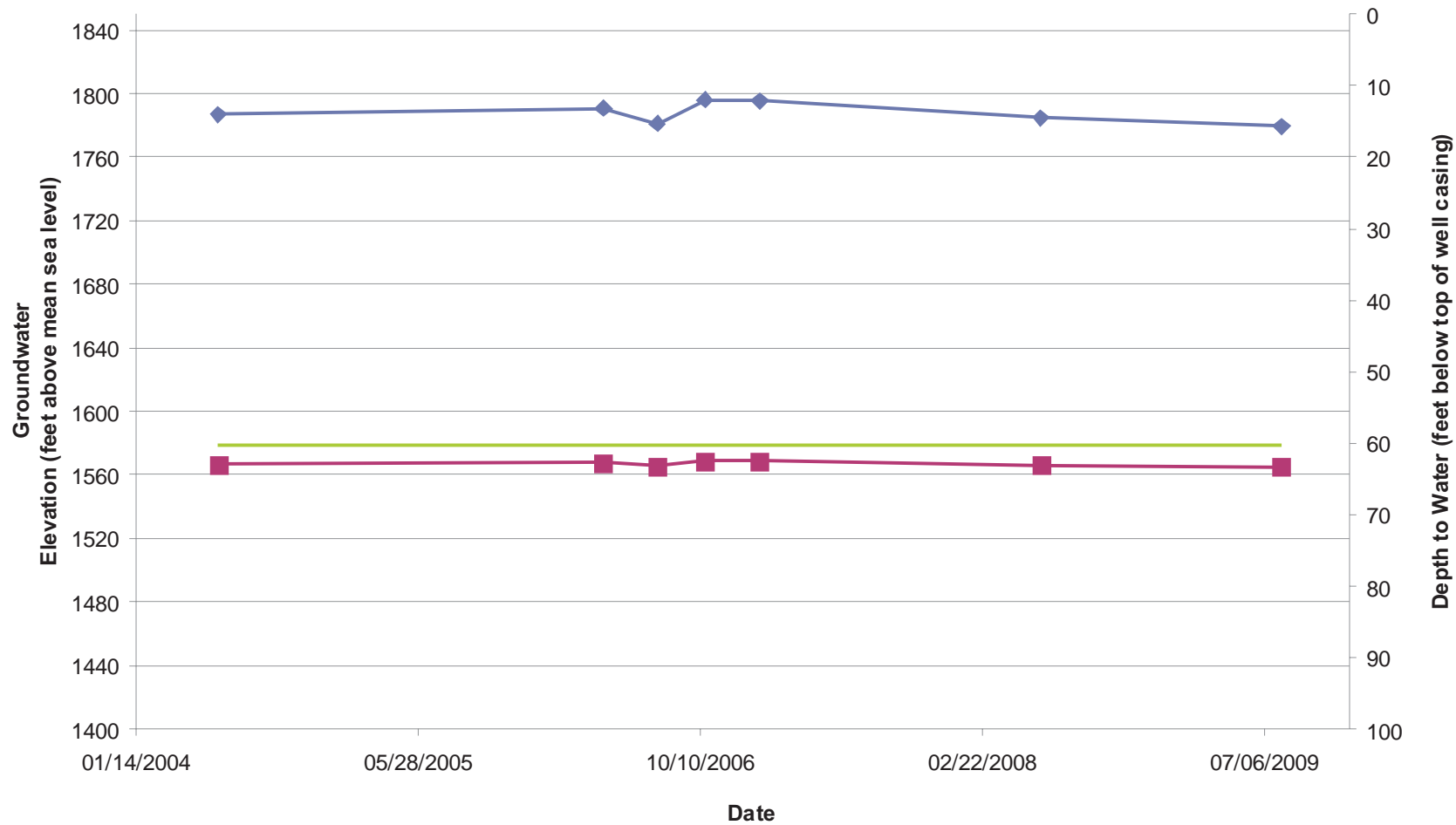
Prepared by: DBS&A CRS Date 01-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/GIS/MXDS/AERIAL_PHOTOS/8X11/AERIAL_PHOTO_1999.MXD 014110

Appendix E

Hydrographs

AA-08



■ Groundwater Elevation (ft.-amsl)
 — Surface Elevation (ft.-amsl)
 ◆ Depth to Water (ft.-btoc)

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
AA-08 Hydrograph



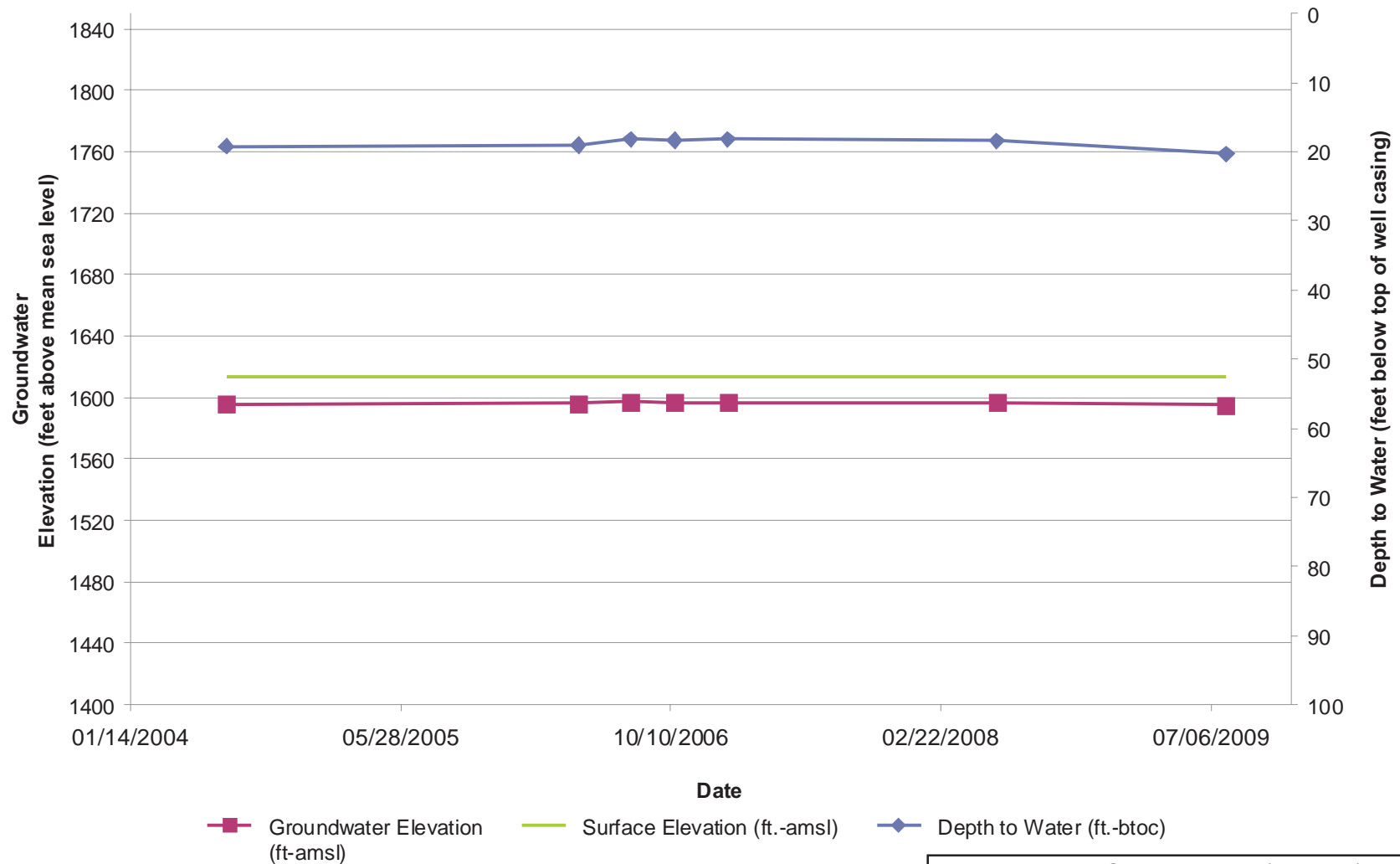
Prepared by: DBS&A CRS Date: 1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

AA-10



BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
AA-10 Hydrograph



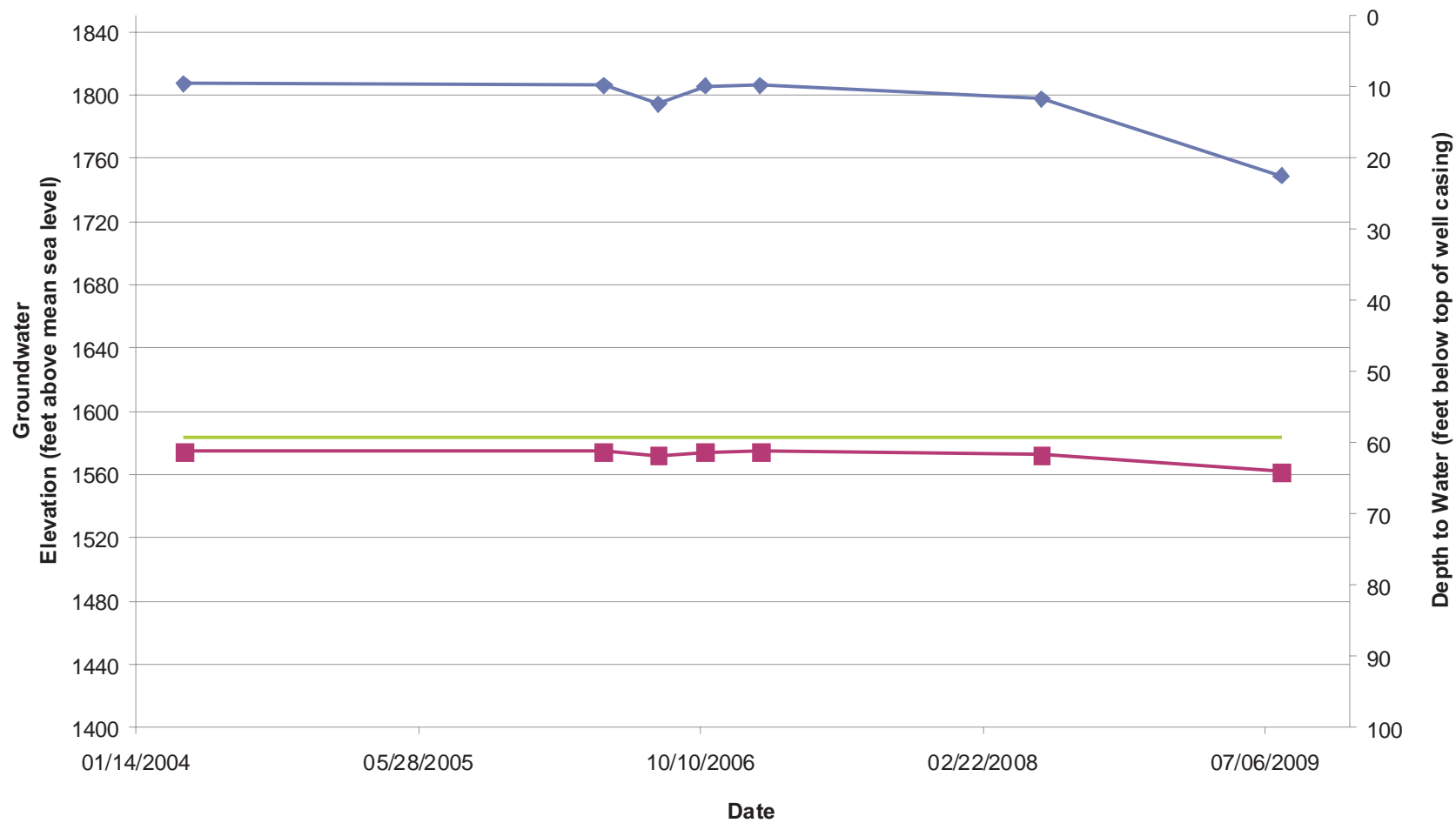
Prepared by:
DBS&A CRS Date
1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/
VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

AA-21



■ Groundwater Elevation (ft.-amsl)
 — Surface Elevation (ft.-amsl)
 ◆ Depth to Water (ft.-btoc)

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
AA-21 Hydrograph



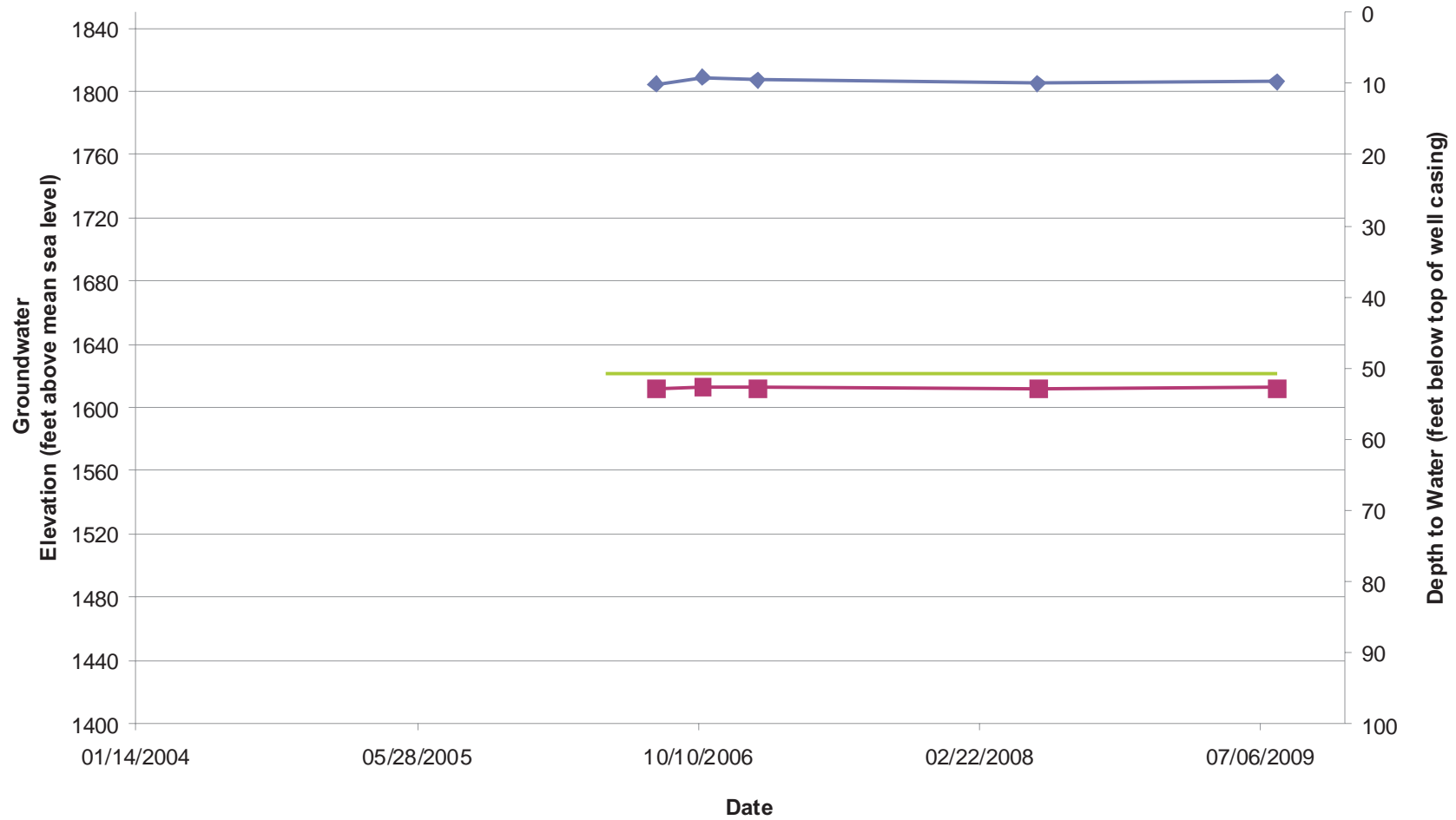
Prepared by: DBS&A CRS Date: 1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

HMW-16



■ Groundwater Elevation (ft.-amsl)
 — Surface Elevation (ft.-amsl)
 ◆ Depth to Water (ft.-btoc)

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
HMW-16 Hydrograph



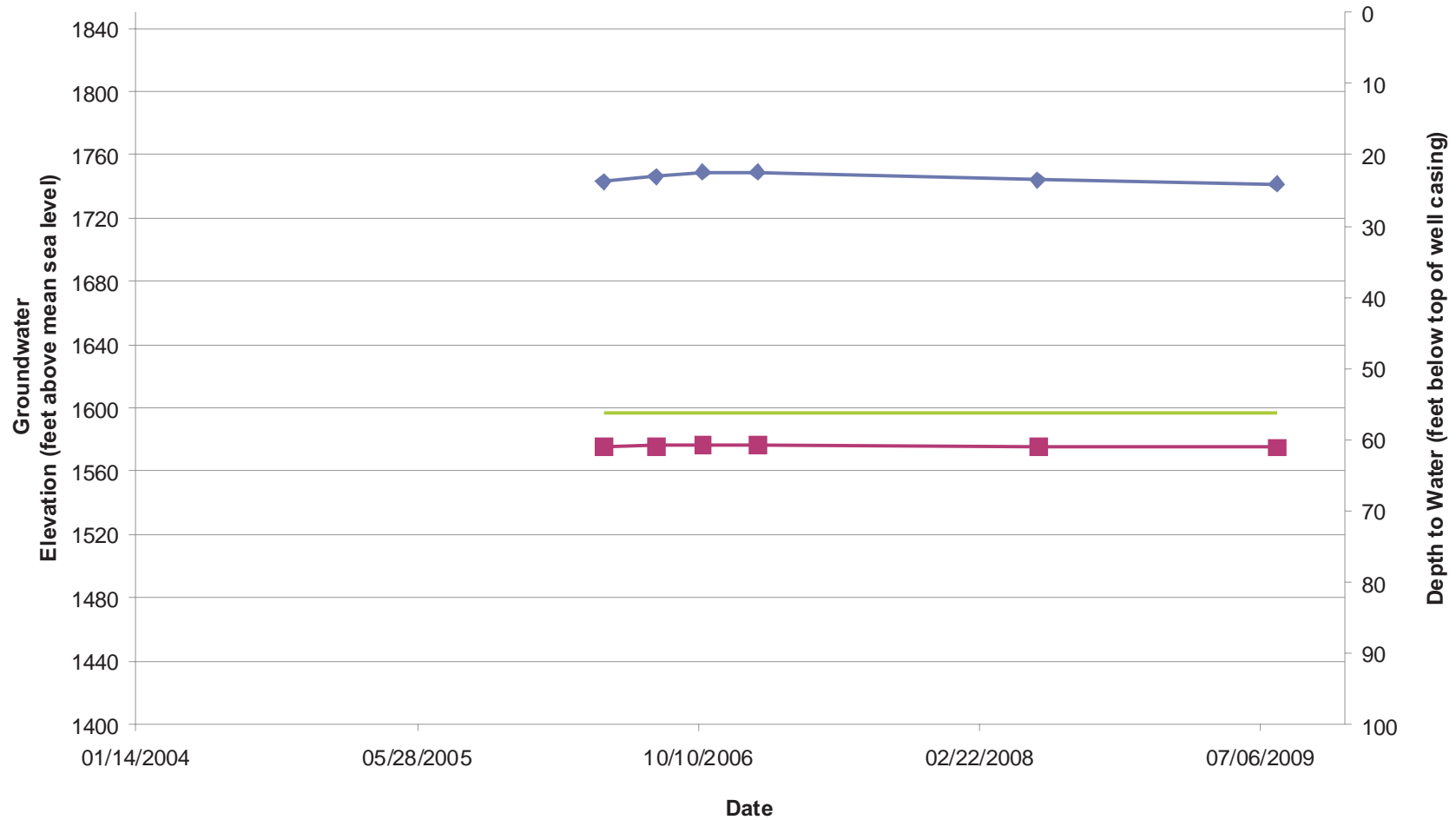
Prepared by: DBS&A CRS Date: 1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

PC-103



■ Groundwater Elevation (ft-amsl)
 — Surface Elevation (ft.-amsl)
 ◆ Depth to Water (ft.-btoc)

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
PC-103 Hydrograph



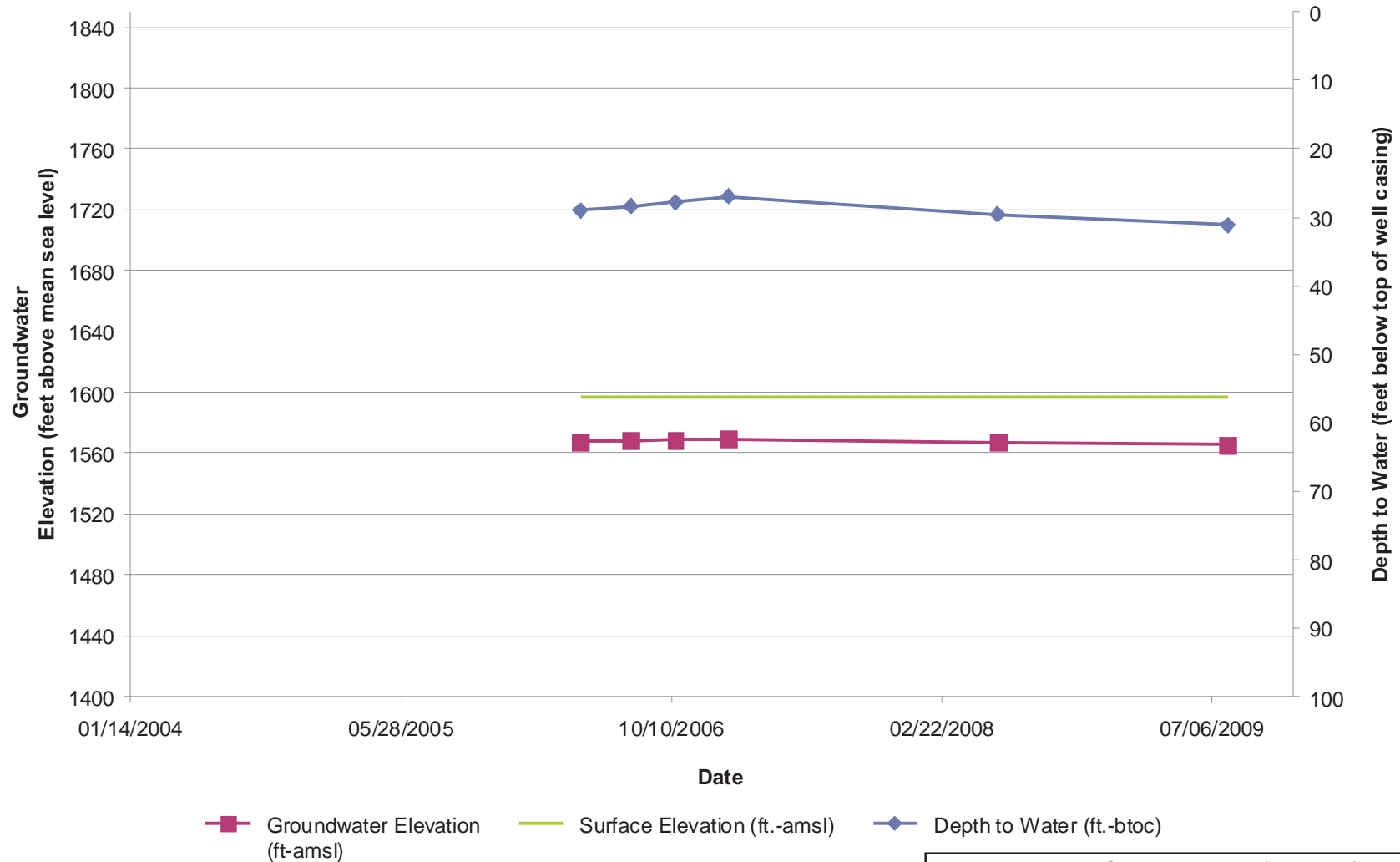
Prepared by: DBS&A CRS Date: 1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

PC-104



BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
PC-104 Hydrograph



Prepared by:
DBS&A CRS

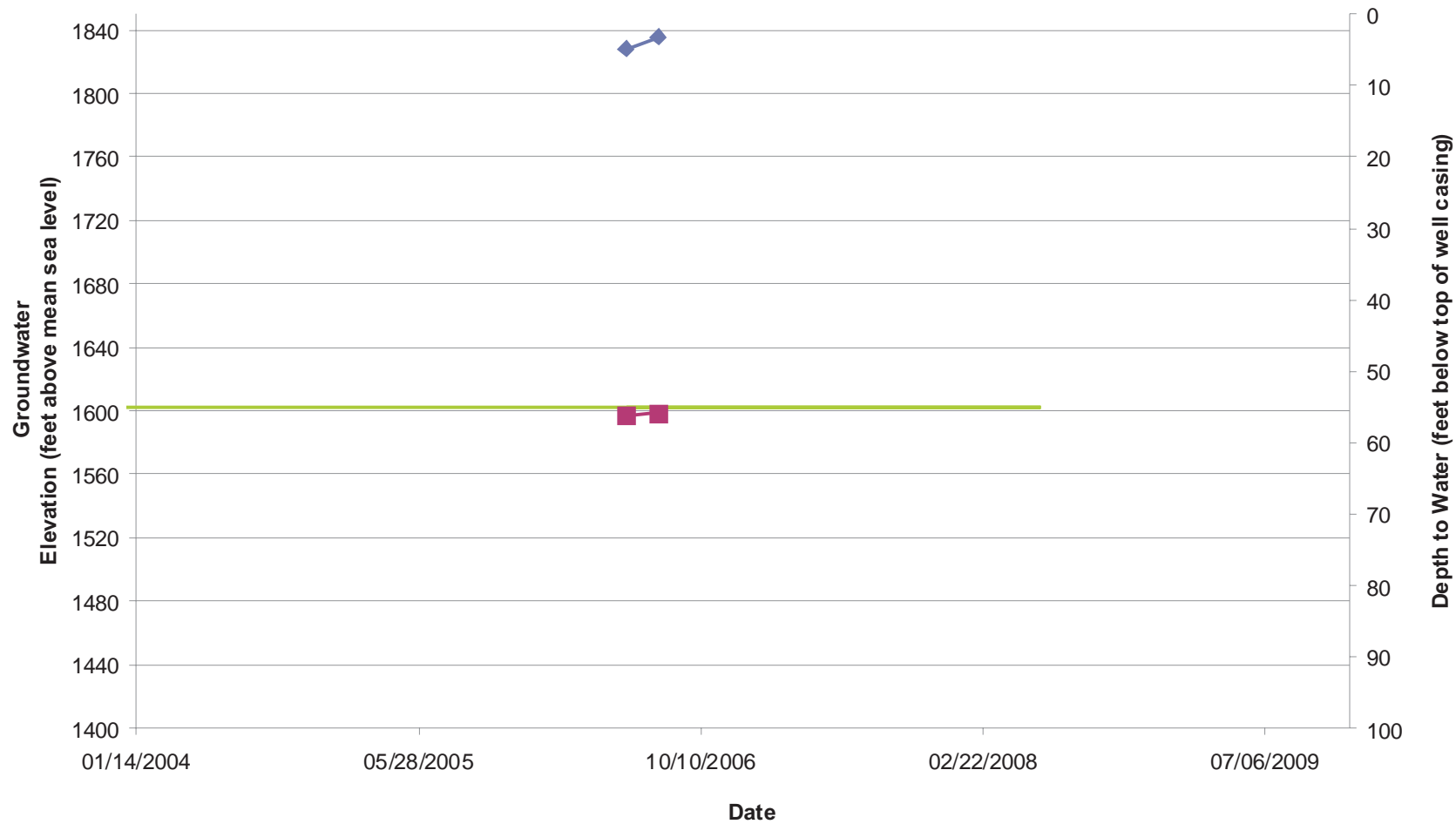
Date
1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/
VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

PC-106



Groundwater Elevation (ft.-amsl)

Surface Elevation (ft.-amsl)

Depth to Water (ft.-btoc)

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
PC-106 Hydrograph



Prepared by:
DBS&A CRS

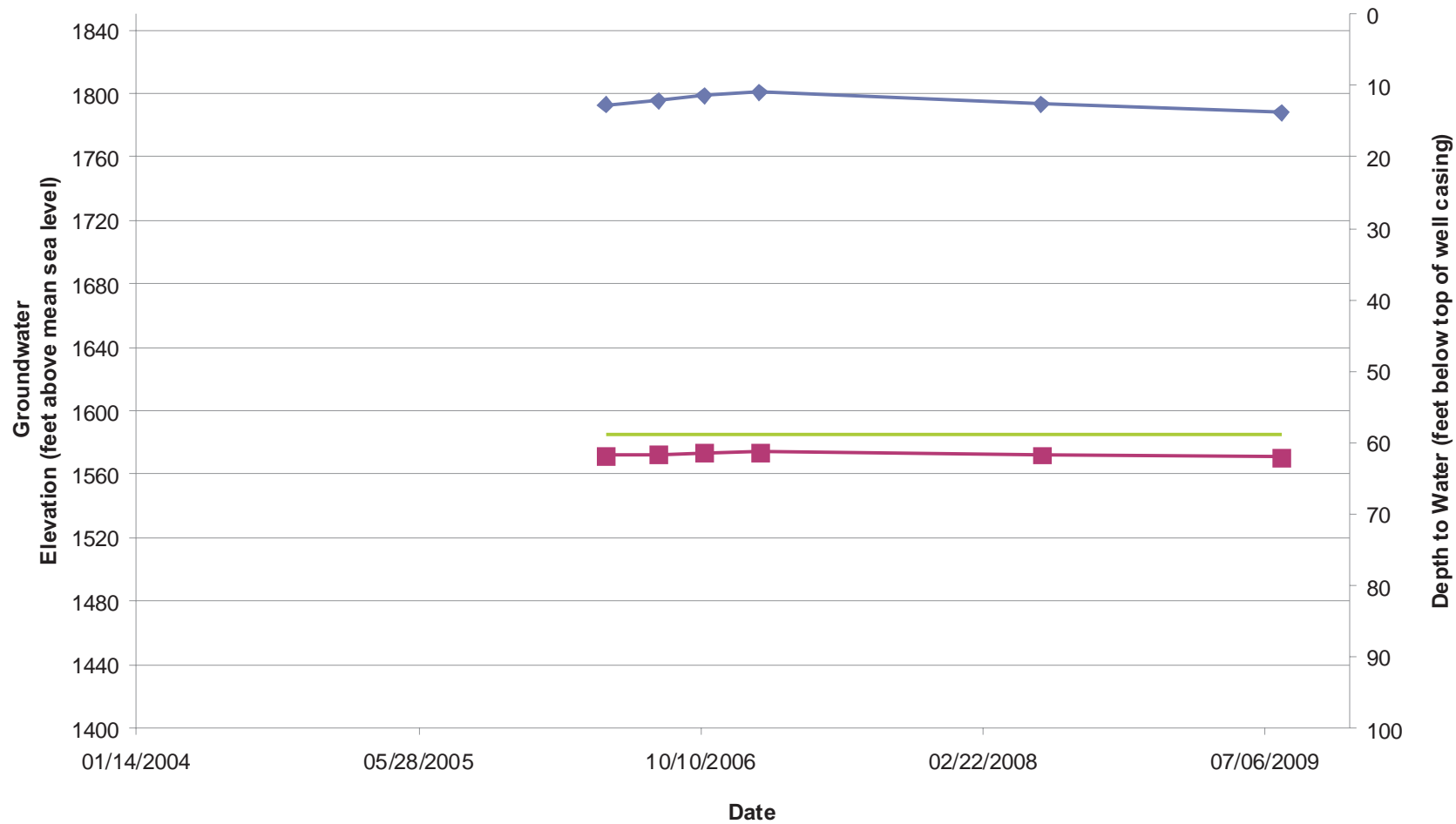
Date
1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/
VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

PC-108



■ Groundwater Elevation (ft.-amsl)
 — Surface Elevation (ft.-amsl)
 ◆ Depth to Water (ft.-btoc)

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
PC-108 Hydrograph



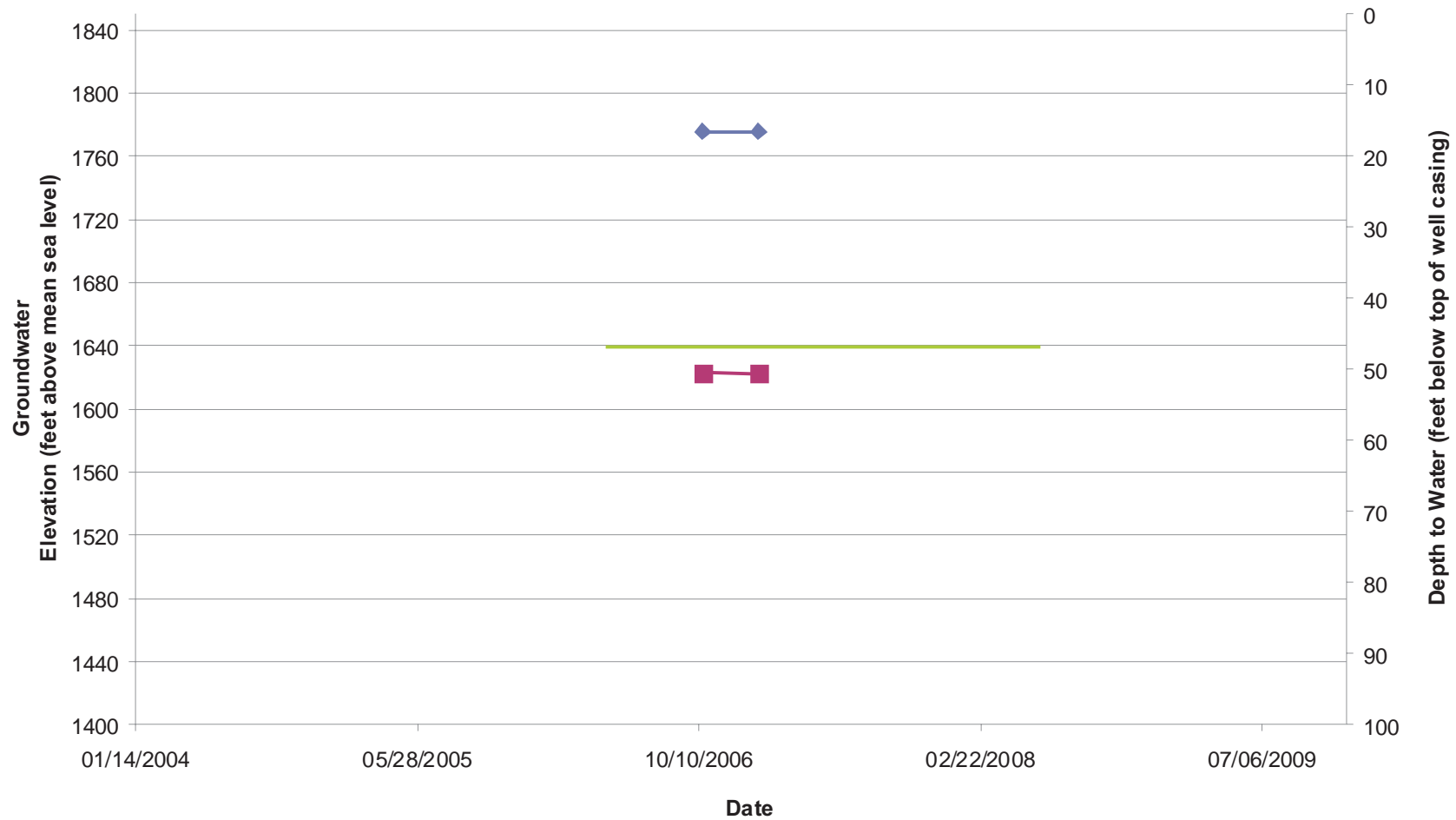
Prepared by: DBS&A CRS Date: 1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

PZ-13



■ Groundwater Elevation (ft.-amsl)
 — Surface Elevation (ft.-amsl)
 ◆ Depth to Water (ft.-btoc)

BMI Common Areas (Eastside)
Henderson, Nevada

FIGURE
PZ-13 Hydrograph



Prepared by: DBS&A CRS Date: 1-13-10

S:/PROJECTS/BRC/ES09.0281_BRC_WH_AND_PRE-CSM_TASKS/VDR_DRAWINGS/Report_figs_12-09/hydrographs_wester_hook.cdr



Daniel B. Stephens & Associates, Inc.

Appendix F

Tamarisk Evapotranspiration Estimates (Devitt, 2006)

**Evapotranspiration Estimates of Saltcedar
on LandWell Property in Henderson NV**

**D.A. Devitt, Soil and Water Scientist,
Las Vegas NV**

August 7, 2006

Evapotranspiration Estimates of Saltcedar on LandWell Property in Henderson NV

D.A. Devitt, Soil and Water Scientist, Las Vegas NV

General Introduction

Saltcedar (*Tamarsik ramosissima* Ledeb.) is a loosely branched tree or shrub which grows to a height of 1-6 meters. Saltcedar is non native to North America, with a probable Eurasian and/or North African origin. Saltcedar was introduced by the Department of Agriculture in the late 1800's to control wind erosion and stream bank erosion. Unfortunately, saltcedar is an invasive species that has spread throughout the southwestern United States (especially riparian habitats) and is now considered by many ecologists to be a naturalized species.

Saltcedar possesses many physiological and morphological characteristics that have led to large scale displacement of native species. Perhaps the most important characteristics are that saltcedar is a phreatophyte (a deep rooted plant that is able to secure a significant portion of its water requirement from groundwater sources) and a halophyte (a plant that is able to thrive in a saline environment). However, it is classified as facultative not obligate in terms of being phreatophytic and halophytic, thus it is able to invade and establish in a wider range of hydrologic and edaphic conditions. In addition, saltcedar is known for its large seed production, rapid germination and seedling establishment, high growth rates, high evapotranspiration rates, high leaf area index, drought tolerance, flood tolerance and ability to quickly recover after a fire.

Site Evaluation

On July 19, 2006 saltcedar stands were evaluated on the LandWell property in Henderson, NV. Visual observations of health, tree height, canopy temperature, leaf xylem water potential, leaf area index and distance between individual plants were assessed at multiple sites and are reported in Table 1.

Alpha Ditch

A well established stand of saltcedar occupies the inner area of the Alpha ditch with an additional area just east of the ditch. Based on aerial photos (Figures 2-4) and GIS processing, the stand exists over a 1.11 mile stretch of the ditch, comprising approximately 7.54 acres of trees in an area of 11.46 acres. The stand is monospecific and appears to be primarily of one age. Based on trunk diameters, the trees would appear to be 30 to 40 years old. The plants are healthy but showed signs of heat stress (average midday canopy temperature of 41.8 °C). Depth to groundwater (see contour lines on Figures 1-3) in the general area of the alpha ditch is estimated to be approximately 25-30 feet. Although saltcedar is capable of sending roots to this depth, if groundwater were the sole source of water for these plants they would be more shrub like in architecture not tree like. Based on the size and general health of the saltcedar in the alpha ditch, I believe these trees must be receiving surface water (runoff) periodically to supplement groundwater uptake. At the northern most end of the alpha ditch, additional saltcedar stands exist, comprising 5.34 acres of trees in 13.44 acres, with groundwater at a similar depth as noted for the alpha ditch.

Beta Ditch

Saltcedar growing in the Beta ditch lacks uniformity in size and density compared to the Alpha ditch. The Beta ditch was partially destroyed at some point in the past and has not been capable of receiving any runoff water for some time. The saltcedar exists only in the inner area of the ditch, over a scattered length of approximately 0.70 miles, comprising 2.73 acres of trees in 4.48 acres. Although many of the trees appeared stressed, with observed mortalities, a few trees appeared rather healthy, suggesting water has been made available via infiltration basins to the south. Depth to groundwater near the Beta ditch ranges from 40 to 55 feet, the deepest for all saltcedar stands evaluated.

Saltcedar “Islands” East of the Henderson Treatment Plant

Saltcedar was observed growing in well defined isolated “islands” with clear open paths between adjacent “islands” near the Henderson treatment plant. These trees were healthy, tall and extremely dense (closed canopy) within the islands. The trees averaged 3.1 meters in height (tallest), had a leaf area index of 1.55 but were under the greatest stress based on estimates of plant water status. Canopy temperatures averaged 44.5°C and leaf xylem water potentials averaged -3.8 MPa (midday). The larger islands comprised approximately 9.14 acres of trees in 15.36 acres, whereas smaller islands to the north (narrow corridor just east of the Henderson Treatment plant) comprised an additional 1.81 acres of trees in 3.55 acres. Depth to groundwater in this area is estimated at 20 to 25 feet.

Saltcedar stands south of the Las Vegas Wash

Saltcedar growing north of the Henderson treatment plant and south of the Las Vegas Wash was subjected to fire approximately three years ago. Most of the plants have resprouted and established new canopy cover. However, the stand is shorter in height (2.89 m) and more open (1.1 meters between individual plants) than the stands associated with the “islands”. Canopy temperatures were significantly lower at this site compared to the other sites monitored (40.5 °C) and had more positive leaf xylem water potentials (-3.3 MPa, midday). Depth to groundwater in this area is 5 to 10 feet. The larger stands of saltcedar in this area comprised approximately 4.21 acres of trees in 8.26 acres. (note: acreage was estimated from aerial photos, additional ground validation is recommended, as the area near the wash was located within a fenced area. Additional acres of saltcedar may have been overlooked in this area based on photo identification).

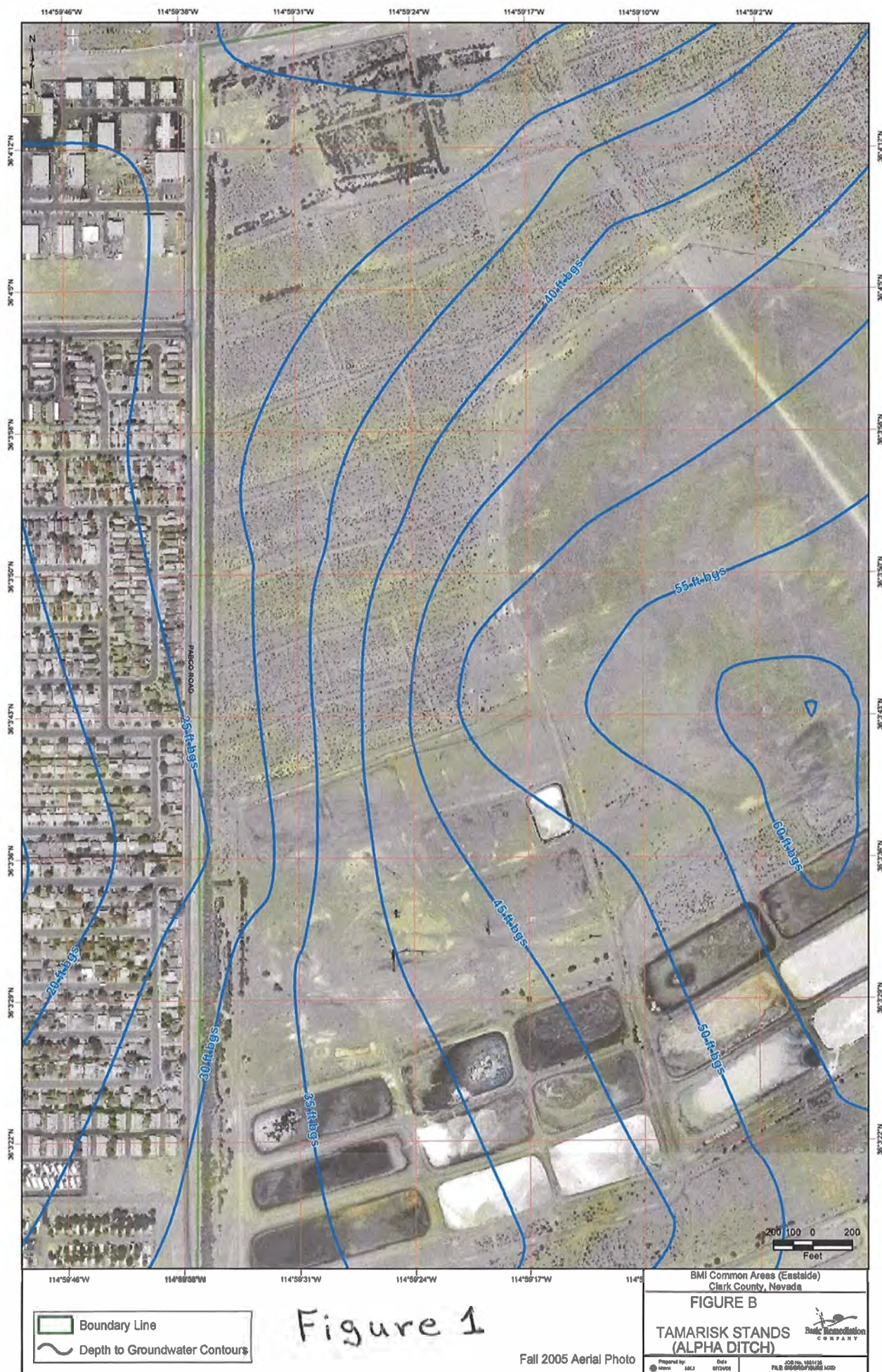
Table 1. Physiological and morphological characteristics of saltcedar growing on the LandWell property. Measurements taken on July 19, 2006 between 11:00 AM and 1:00 PM.

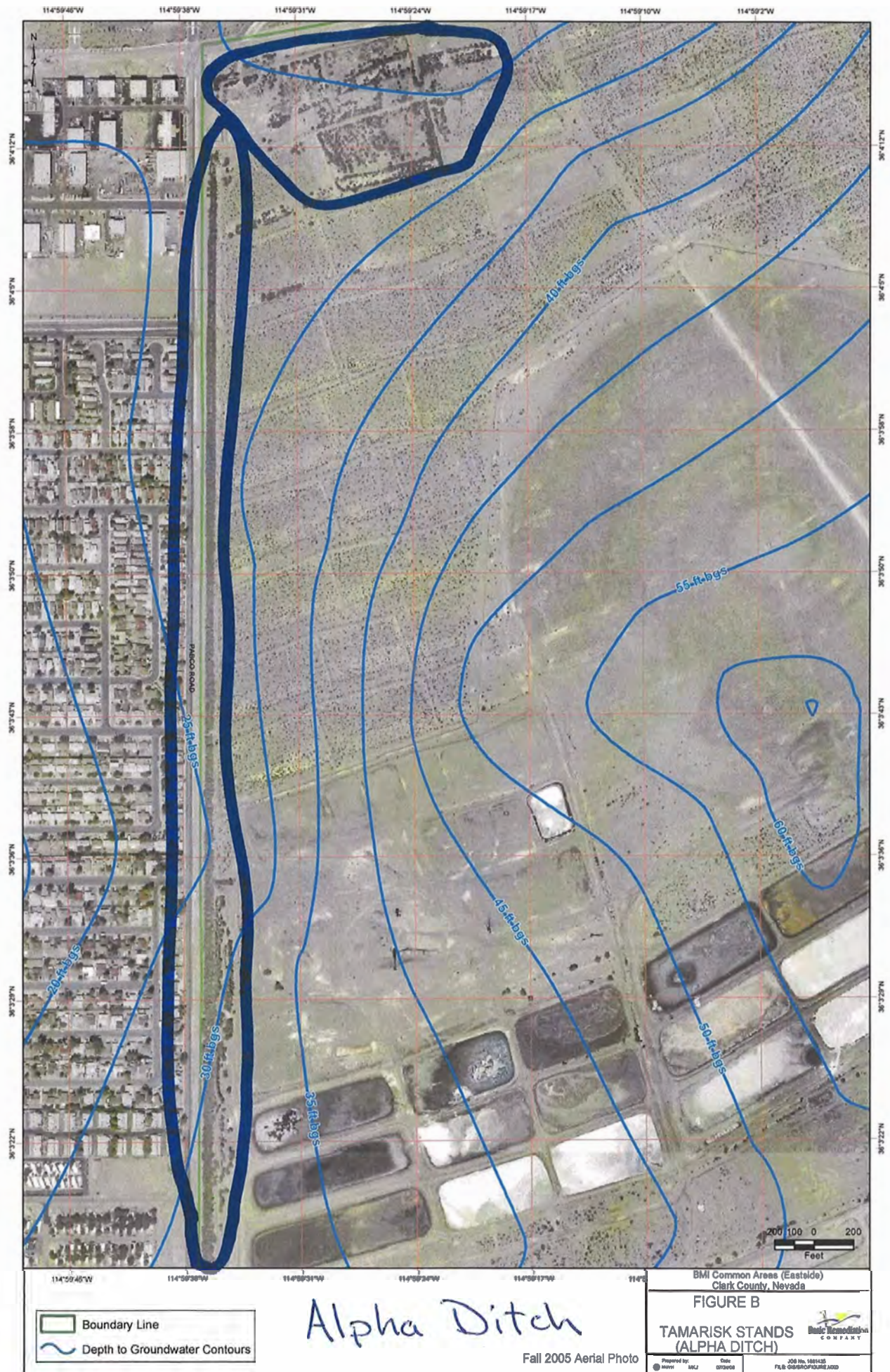
| Site* | Height (m) | Leaf Temperature (°C) | Leaf Water Potential (MPa) | LAI** | Distance*** (m) |
|-------|-----------------|--------------------------|-------------------------------|-----------------|--------------------|
| A | 2.89 ± 0.88 | 40.5 ± 0.8 | -3.3 ± 0.1 | 2.04 ± 0.23 | 1.1 ± 0.8 |
| B | 3.10 ± 0.52 | 44.5 ± 2.6 | -3.8 ± 0.4 | 1.55 ± 0.26 | closed canopy |
| C | | 41.8 ± 1.1 | | | closed canopy |

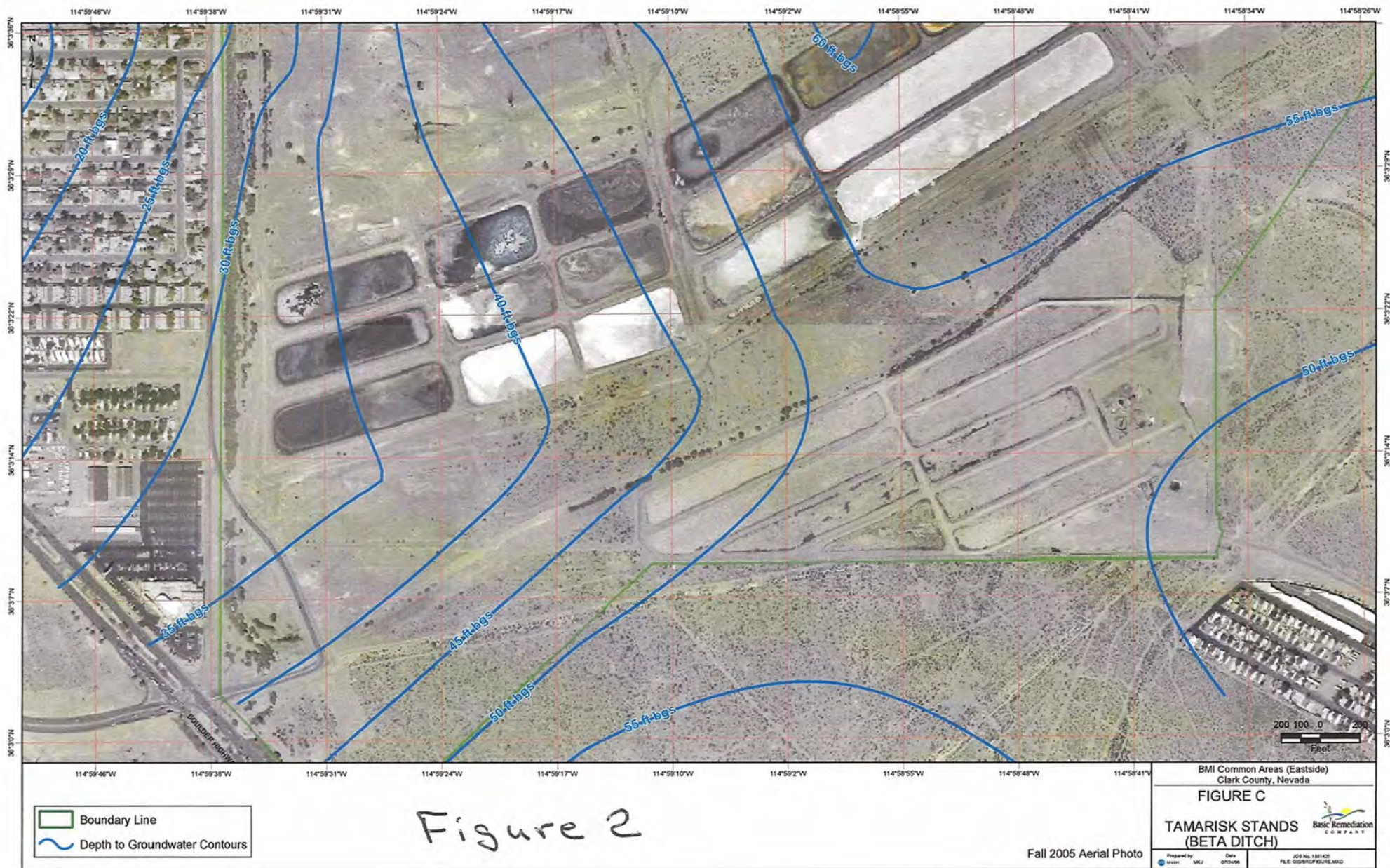
* Site A: located south of the LV Wash, Site B: islands east of treatment plant, Site C: Alpha Ditch

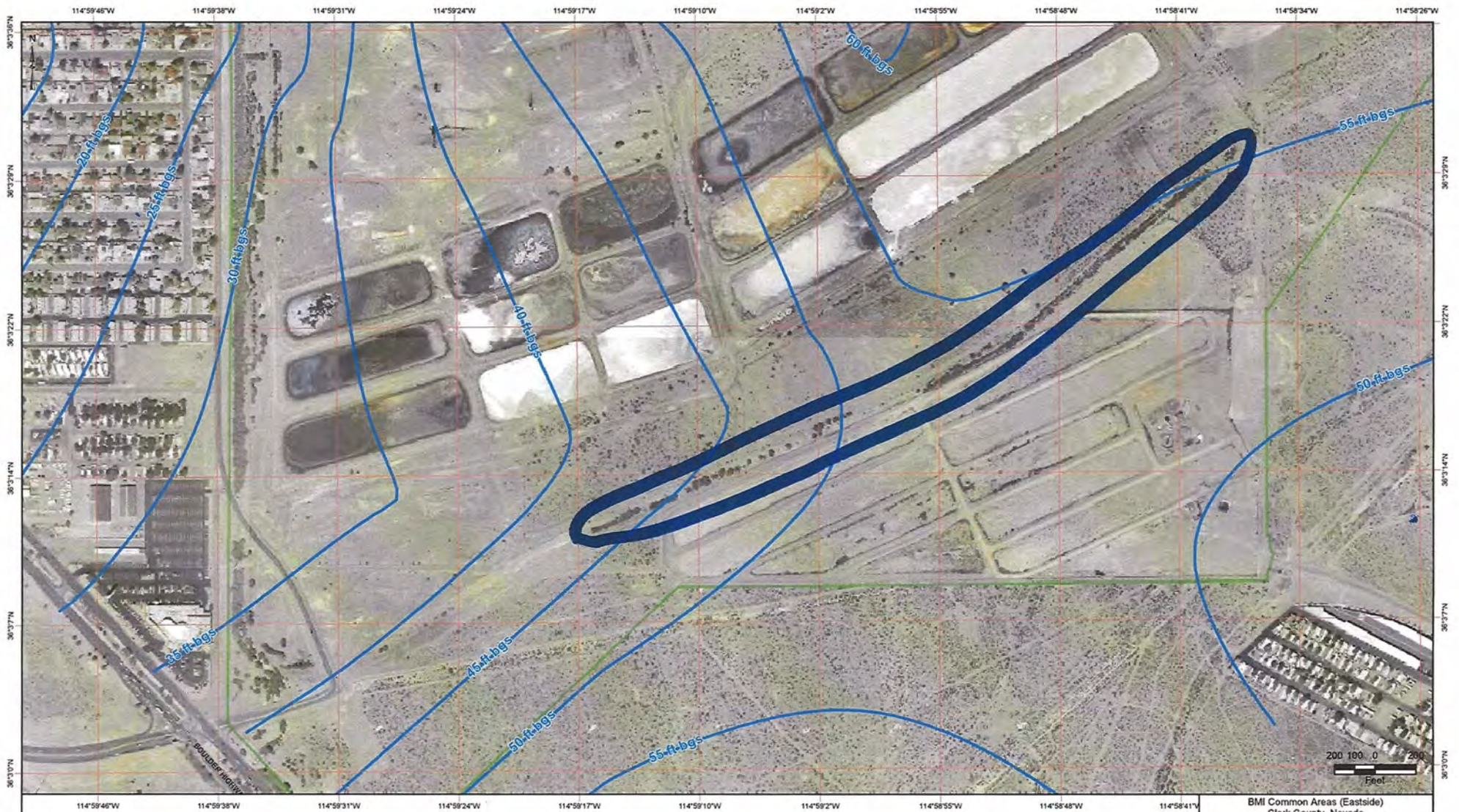
** LAI : Leaf Area Index

*** Distance between adjacent plants









Beta Ditch

Sattcedar

Boundary Line
Depth to Groundwater Contours

Fall 2005 Aerial Photo

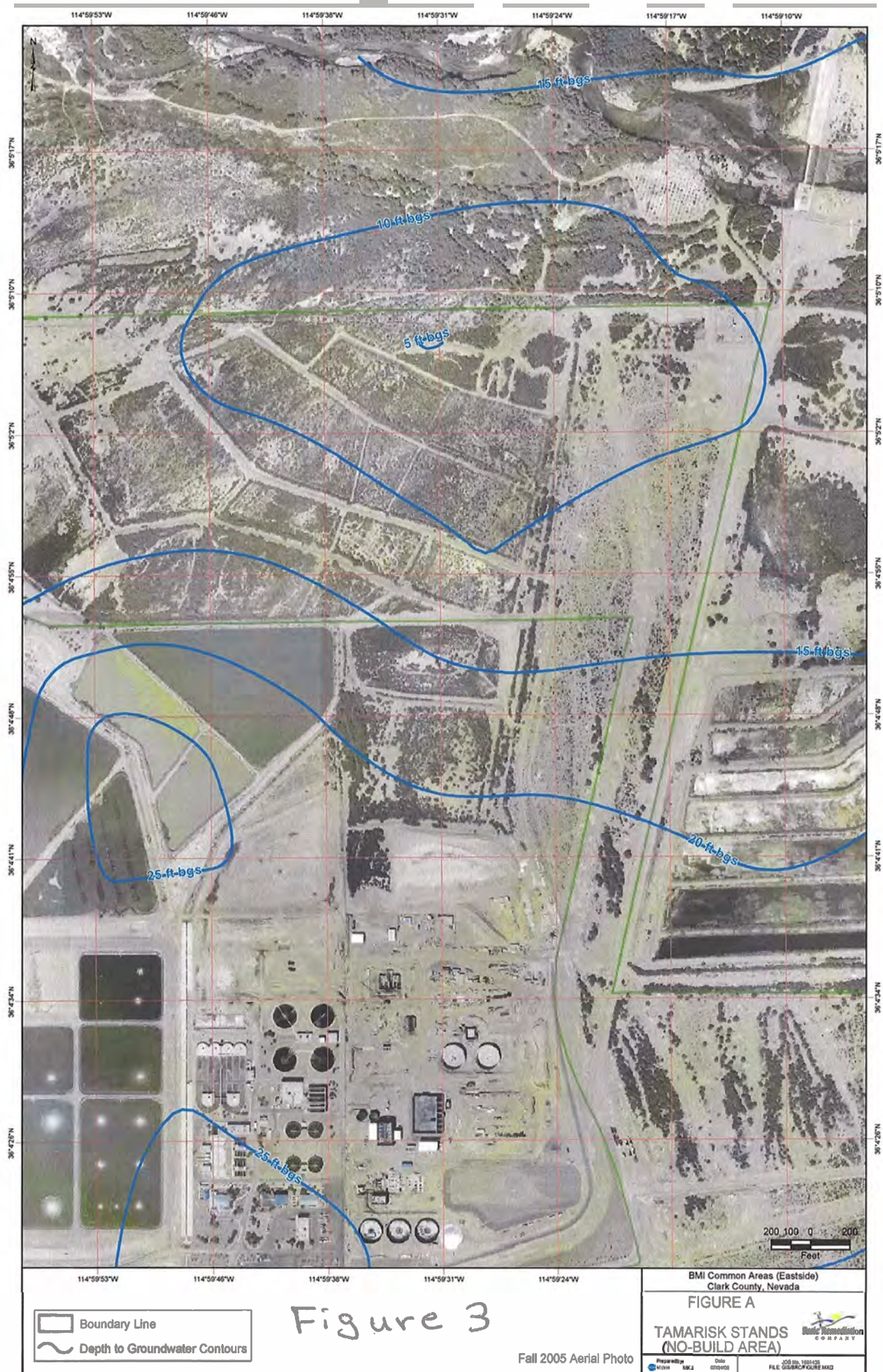
BMI Common Areas (Eastside)
Clark County, Nevada

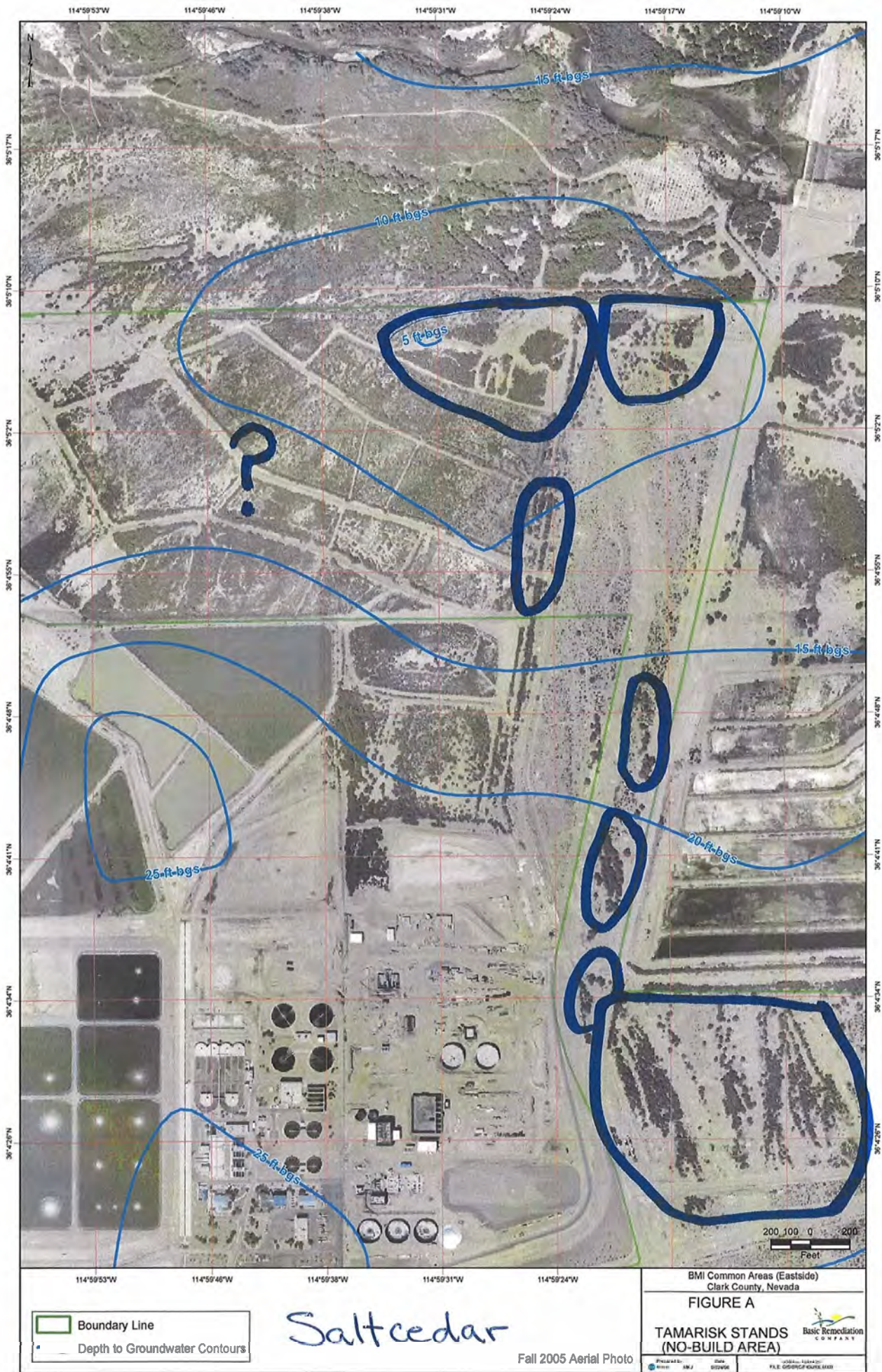
FIGURE C

TAMARISK STANDS
(BETA DITCH)



Prepared by: Date: 10/20/05
Map: MCA 10/20/05
Scale: 1:50,000
File: BDRM050904E.MXD





Saltcedar

Las Vegas Wash

"Islands"

Evapotranspiration

Evapotranspiration is the combined loss of water from a given area, and during a specified period of time, by evaporation from the soil surface and by transpiration from plants. Evapotranspiration varies by plant density, species composition, environmental demand, depth to groundwater, rainfall, nutrient availability and by any factors that can influence biomass and leaf surface area. In arid environments, where plant communities are surrounded by large expanses of dry desert terrain, energy known as advective energy can dominate the energy balance of these plant communities. This advection can occur on a localized basis (openings within a plant community) but also on a regional basis, when the horizontal flow of air transfers heat from one region to another.

Potential evapotranspiration for the greater Las Vegas area is presented on a monthly basis in Figure 4. These estimates are based on the Penman Monteith equation which typically represents the maximum rate plant cover will lose water through the process of evapotranspiration. Although some plants can transpire beyond this rate, such as tall fescue, a C-3 cool season turfgrass (especially when grown in an arid environment), many other plants are better adapted at regulating water loss and lose water at significantly lower rates.

Actual evapotranspiration rates of plants are obtained via lysimetry, energy balance approaches (eddy covariance or Bowen ratio), stem flow gauges or indirectly through spectral reflectance in the visible, near infrared and thermal bands. Unfortunately, no actual evapotranspiration estimates for saltcedar have been made for the Henderson site in question or for any saltcedar stands in the Las Vegas Valley.

Therefore any evapotranspiration estimates assigned to the existing saltcedar stands must be based on published data collected under conditions similar to the bioclimatic and hydrologic conditions of the Henderson site. I have put together a collection of seven published peer reviewed scientific journal articles relevant to the estimate of water use by saltcedar growing in southern Nevada (see attached articles). In the following section I summarize the results from these articles and then conclude with a best estimate of evapotranspiration for saltcedar stands growing on the LandWell property in Henderson NV.

ET_O - LAS VEGAS, NV

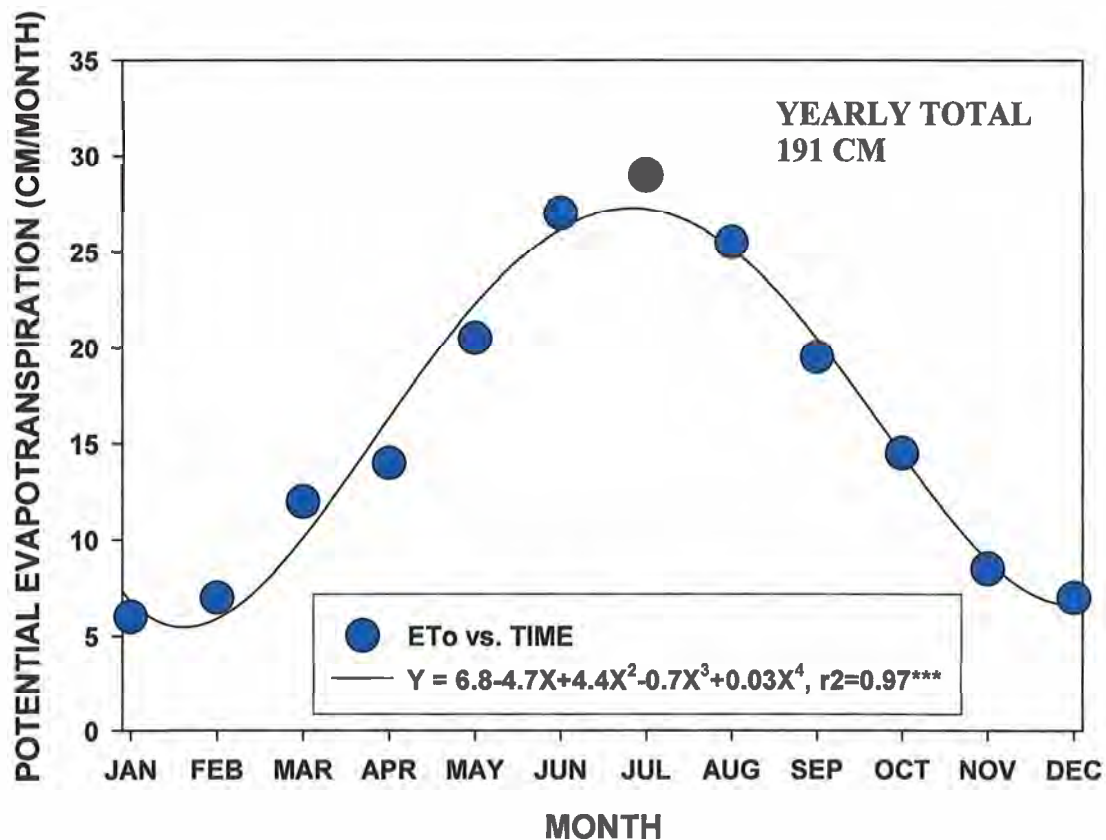


FIGURE 4

Case Studies

1) Sala A. S.D. Smith and D.A. Devitt. 1996. Water use by *Tamarix ramosissima* and associated phreatophytes in a Mojave Desert floodplain. Ecological Application 6(3);888-898.

- Water use by saltcedar and three co-occurring native phreatophytes were estimated via stem flow gauges.
- Leaf area based sap flow rates were comparable in the four species despite large differences in individual leaf area and total water loss.
- Daily water use of saltcedar weighted by the daily potential evapotranspiration increased linearly with the total leaf area per plant.
- Under high potential evapotranspiration maximum sapflow rates of saltcedar on a leaf area basis were significantly higher at locations where saltcedar leaf area index was lower, indicating that highly transpiring saltcedar stands may reduce leaf level evaporative demand.
- 90% of the variability in daily water use normalized by potential evapotranspiration could be accounted for based on leaf area.

2) Devitt D.A., J.M. Piorkowski, S.D. Smith, J.R. Cleverly and A. Sala. 1997. Plant water relations of *Tamarix ramosissima* in response to the imposition and alleviation of soil moisture stress. Journal of Arid Environments 36: 527-540.

- Saltcedar seedlings were grown in lysimeters along the Virgin River and subjected to a 29 day dry down (loss of water table) and an 18 day wet-up period to reestablish water table depths.

- Sapflow decreased significantly as water table and stored soil water declined.

As sapflow approached zero, a significant decrease in the time in which daily sapflow stopped occurred, rather than a delayed sapflow start time.

- Upon application of water, all plants responded by increasing sapflow within 24 hours.
- Stomatal conductance, leaf xylem water potential and sapflow measured during the drydown and wet up stages were all linearly correlated with relative soil water in storage, with no parameters showing any signs of hysteresis.
- Longer periods of drydown without groundwater access would be required to cause catastrophic cavitation in saltcedar.

3) Devitt D.A., A. Sala, K.A. Mace and S.D. Smith. 1997. The effect of applied water on the water use of saltcedar in a desert riparian environment. *Journal of Hydrology*. 192:233-246.

- Saltcedar plots along the Virgin River were irrigated for a 6 week period during a hot dry summer period (0, 50 or 100% of potential evapotranspiration).
- Results indicated that at least 4 weeks of irrigations were required before a significant increase in water use by saltcedar would occur.
- Any attempt to characterize evapotranspiration of mature stands of saltcedar will require a detailed spatial assessment of stand density and an evaluation of water availability relative to atmospheric water demand over time.
- It is doubtful under typical hot dry summer conditions that saltcedar would effectively utilize water from most summer rainfall events.

- Although saltcedar does have a deep root system, it does not guarantee that saltcedar will be able to draw groundwater from a declining water table at a rate similar to when the water table was higher.

4) Devitt, D.A. A. Sala, S.D. Smith, J. Cleverly, L.K. Shaulis and R. Hammett. 1997. Bowen ratio estimates of evapotranspiration for *Tamaris ramosissima* stands on the Virgin River. Water Resources Research. Vol 34:2407-2414.

- A two year evapotranspiration study was conducted over a saltcedar stand growing on the Virgin River. Evapotranspiration was estimated via the Bowen ratio energy balance approach.
- In a drought year evapotranspiration was estimated at 75 cm and in a high stream flow year, evapotranspiration was estimated at 145 cm.
- Results suggest that saltcedar has the potential to be both a low water user and a high water user, depending on moisture availability, canopy development and atmospheric demand.
- The annual water use rates for saltcedar reported in this study are in the same range (77-107 cm) as those reported by Weeks et al. (1989).
- A more open canopy allows greater energy transfer to occur from the soil surface to the boundary layer and to allow the flow of horizontal energy from open areas to move deeper into the plant stand, potentially fuelling greater water loss via transpiration.

5) Cleverly, J.R., S. D. Smith, A. Sala and D.A. Devitt. 1997. Invasive capacity of *Tamarix ramosissima* in a Mojave Desert floodplain: the role of drought.

Oecologia 111:12-18.

- Saltcedar possessed a similar leaf level transpiration rate and sap flow as did co-occurring native phreatophytes.
- Saltcedar operated at lower plant water potentials
- Saltcedar is able to maintain higher leaf area per unit sapwood area and invest much less biomass and energy in non photosynthetic stems under non stress conditions.
- Because saltcedar is the most stress tolerant of the species studied; reduction in stream flow rates could further promote the invasion of desert floodplains by saltcedar.
- Saltcedar is able to maintain a high leaf area under the extreme evaporative conditions that typify desert climates.

6) Smith S.D., D.A. Devitt, A. Sala, J.R. Cleverly and D. E. Busch. 1998. Water relations of riparian plants from warm Desert regions. Wetlands 18:687-696.

- Analysis of water loss rates indicate that saltcedar dominated stands can have extremely high evapotranspiration rates when water tables are high but not necessarily when water tables are lower.
- Saltcedar has leaf level transpiration rates that are comparable to native species but has the ability to maintain higher leaf areas probably due to its greater water stress tolerance.
- The ability to function as a facultative phreatophyte in arid floodplains such as the Colorado River may favor saltcedar over native trees that are dependent on a perennial ground water source.

7) Devitt D.A., D.J. Donovan, T. Katzer, and M. Johnson. 2002. A reevaluation of the groundwater budget for Las Vegas Valley, Nevada, with emphasis on groundwater discharge. Journal of American Water Resources Association. 38:1735-1751.

- Errors have been made in the past in predicting evapotranspiration of plant communities growing in the Las Vegas Valley because significant attention was not given to the proper selection of data sets that were obtained under similar climatic conditions.

Evapotranspiration estimates from nearby locations can be transferable if certain adjustments are made.

- Area estimates for plant communities should not be adjusted downward based on area densities, as Van Hycklama (1974) found that reducing the density of a saltcedar stand from 100 to 50 percent reduced water use by only about 10 percent. Research by Devitt et al. (1998) on the Virgin River in southern Nevada also does not support the approach of using an area density adjustment