Hydrogeologic Assessment for the Anaconda-Yerington Copper Mine

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INTRODUCTION

On December 29, 2008, CH2M HILL was retained by the U.S. Environmental Protection Agency (USEPA) under Contract # EP-S9-08-04, Task Order 0006-RICO-09GU to provide technical and scientific consulting services related to environmental remediation activities underway at the Anaconda Yerington Copper Mine, Nevada. This technical memorandum presents the results of a Hydrogeologic Assessment conducted for the Anaconda Yerington Copper Mine as described in Task FI.01 of the Work Plan for RI/FS Task Order (CH2M HILL, 2008).

The primary objective the Hydrogeologic Assessment is to identify potential data gaps in the conceptual site model (CSM) with particular emphasis on determining if any of the heap leach pads (HLPs) or ponds at the site are contributing contaminants to groundwater at unacceptable levels. A secondary objective of the Hydrogeologic Assessment is to support supplemental remedial investigation (RI) decisions about optimal placement of additional monitoring wells.

Subsequent to review of the Hydrogeologic Framework Assessment (HFA) (Brown and Caldwell, 2005), the Second Step Hydrogeologic Framework Assessment Work Plan (Brown and Caldwell, 2007), the Site-Wide Groundwater Work Plan (OU-1) (Brown and Caldwell, 2007b), the Remedial Investigation Work Plan for the Yerington Pit Lake (OU-2) (Brown and Caldwell, 2007c), the Second-Step HFA Data Evaluation Report (Brown and Caldwell, 2008b), and the Conceptual Site Model (Brown and Caldwell, 2009), CH2M HILL has identified several data gaps in the existing CSM and proposes installation of five new groundwater monitoring wells to begin addressing these data gaps. Groundwater monitoring well locations are proposed to assess the movement and quality of groundwater beneath the Arimetco HLPs and former process areas so that influences on localized groundwater can be evaluated.

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SITE LOCATION AND HISTORY

The Anaconda Copper Mine site covers more than 3,400 acres in the Mason Valley, 1.5 miles west of the city of Yerington, in Lyon County, central Nevada, approximately 65 miles southeast of Reno (Attachment 1, Figure 1). The Singatse Range and the town of Weed Heights lie to the west, open agricultural fields and homes to the north, U.S. Bureau of Land Management (BLM) managed public land to the south, and the Walker River and city of Yerington to the east.

Copper was discovered in the Yerington District in 1865, and operations at this mine site began in 1918 as the Nevada Empire Mine. Anaconda purchased the Mine in 1941, and from approximately 1952 to 1978 conducted mining and milling operations at the open-pit, low-grade copper mine. They removed the overburden, and excavated the ore from the pit, requiring extensive dewatering to access the ore. Anaconda processed both copper oxide and copper sulfide ores. The oxide ore was crushed and leached in vats with dilute sulfuric acid solution produced at an on-site acid plant. The sulfide ore was finely crushed and copper sulfides were recovered using a flotation process. The ore processing generated solid and liquid wastes including, waste rock areas, tailing piles, HLPs, liquid waste ponds, and evaporation ponds. Anaconda mining operations generated approximately 360 million tons of ore and debris from the open pit and 15 million tons of overburden resulting in 400 acres of waste rock placed south of the Pit, 3,000 acres of contaminated tailings, and 1,377 acres of disposal ponds. In 1977, Atlantic Richfield Company (ARC) purchased Anaconda. A decrease in copper prices, lower priced foreign imports, and declining grade and amount of ore available forced the closure of Anaconda's copper mining operations in 1978. When Anaconda operations ceased, groundwater pumping was discontinued, resulting in formation of the Pit Lake. Final dimensions of the mined pit were 6,200 feet long, 2,500 feet wide and 800 feet deep. The current depth of water is nearly 500 feet totaling an estimated 40,000 acre-feet of water.

Following site closure, portions of the site were used for metal salvage and as a transformer recycling facility. In 1982, the property was sold to Mr. Don Tibbals, who refurbished Weed Heights, conducted a small leaching operation, and leased portions of the site to various companies. Arizona Metals Company, Inc. (Arimetco) purchased the property from Mr. Tibbals in 1988 and pursued leaching operations on the site, expanding the existing electrowinning and solvent extraction process area, and constructing five lined HLPs. Arimetco filed for bankruptcy in 1997 and abandoned the site in 2000.

The Nevada Department of Environmental Protection (NDEP) and the United States Environmental Protection Agency (USEPA) have taken several emergency removal actions at the site to address immediate concerns after Arimetco abandoned the site. Furthermore, NDEP and USEPA have required ARC to begin remedial investigations and feasibility studies to determine the extent of contamination and potential cleanup options for the site. USEPA has initiated remedial investigation of the Arimetco portions of the site, namely Operable Unit 8, as shown in Figure 2 (Attachment 1).

NATURE AND EXTENT OF CONTAMINATION

The major environmental threats at the site come from contaminated groundwater and contaminated fugitive dust that could impact human health. Additional concerns include

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contaminated surface water which could impact wildlife, physical hazards associated with abandoned buildings and debris, and the unstable materials such as the waste rock areas, heap leach pads, tailings piles, and Pit Lake slopes.

Although remedial investigations are on-going at the site, the initial list of contaminants of potential concern (COPCs) includes:

- *Metals*-Aluminum, Arsenic, Beryllium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Selenium, Zinc
- *Radioisotopes* -Uranium-234, Uranium-235, Uranium-238, Thorium-230, Thorium-232, Radium-226, Radium-228, and
- *Others*-Chloride, Sulfates/Sulfides, low pH (acidic) conditions, particulate matter

There also are indications that solvents such as kerosene were used as part of the mining/milling process and these types of hydrocarbons may still be present in media at the site.

HYDROGEOLOGIC ASSESSMENT

GEOLOGY

Uplifted mineralized bedrock composed primarily of granitic, metamorphic and volcanic rocks is overlain by unconsolidated alluvial deposits derived by erosion of the uplifted mountain block of the Singatse Range and alluvial materials deposited by the Walker River fill the structural basin occupied by Mason Valley in the vicinity of the Site. The thickness of alluvium at the Site increases from south to north and from west to east. This geometry is consistent with the alluvial fan, transitional, and flood-plain/lacustrine depositional environments that developed east and north of the Singatse Range. Bedrock outcrops associated with a structural spur of the Singatse Range borders the Site along the eastern margin of the Sulfide Tailings area. The alluvial deposits consist of clastic sediments ranging in size from clay to cobbles. Relatively coarse-grained alluvial fan (fine sand) and fluvial (coarse sand to cobble) deposits comprise the major aquifer materials and serve as the principal sources of water for domestic wells and high-capacity irrigation wells in the area.

HYDROGEOLOGY

Recharge to bedrock groundwater beneath the Site from the Singatse Range results from the percolation of precipitation and runoff through the fractured bedrock. Recharge to alluvial groundwater beneath the Site occurs as a result of direct percolation of meteoric water (as precipitation and runoff) through the alluvial fan materials. Recharge from direct precipitation on the valley floor is considered to be negligible (Huxel, 1969 and Seitz et. al., 1982). Huxel estimated the following recharge percentages to the Mason Valley hydrographic basin: 1) 3 percent from precipitation that falls on the surrounding mountain ranges; 2) 97 percent from the Walker River and associated agricultural diversions; and 3) less than 0.1 percent from direct precipitation on the valley floor.

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Along the southern margin of the Site, recharge to the alluvium and bedrock groundwater flow systems occurs predominantly from the adjacent Walker River. As the river flows to the northeast, past the City of Yerington, a spur of the Singatse Range likely impedes recharge from the Walker River to the alluvium underlying the northern half of the mine site. This hydraulic boundary condition is inferred from the observed alluvial aquifer head elevations on either side of the spur, although there is insufficient data to quantify this condition. Recharge from the Campbell Ditch immediately east of the "Singatse Spur" to the alluvial aquifer is also likely impeded by the occurrence of the observed bedrock outcrops (i.e., the "Groundhog Hills"). Anticipated effects are different head elevations on either side of the "Singatse Spur", and the influence of fracture flow through the bedrock on groundwater chemical conditions in the alluvial aquifer.

Beneath the mine, groundwater generally flows toward the northwest. However, local variations in the groundwater flow direction are likely. For example, a groundwater divide trending roughly north-northeast is suspected in the general vicinity of the Process Area. This divide may be reflective of the area where influences from the Pit Lake to the Southeast are no longer observed. Additionally, the groundwater flow direction in the alluvial aquifer near the Walker River is likely to be more westerly due to influences from the river. A general lack of groundwater monitoring wells in these areas makes interpretation of groundwater flow directions uncertain (see Figure 1-3 [Brown and Caldwell, 2008b], Attachment 2).

An active groundwater pumpback system comprising 11 wells is located near the north perimeter of the Site. The pumpback system is designed to extract shallow groundwater from approximately 40 to 60 feet below ground surface. Mine-related groundwater in the capture zone areas of the 11 wells is pumped and conveyed to a 23-acre lined evaporation pond system. Operation of the pumpback well system locally affects the groundwater flow regime. Groundwater flows in this area are also affected by a mound of water that is generated six months of the year during the irrigation season when surface water diverted from the Walker River and pumped groundwater is applied to the agricultural farm located south of Luzier Lane and east of the pumpback ponds. This seasonal application of groundwater results in complex distribution patterns affecting groundwater flow directions, chemical quality, and the geochemical conditions within the aquifer along the northern margin of the site. The hydraulic relationship between the pumpback system wells and the nearby irrigation well are to be evaluated as part of the "Draft Site-Wide Groundwater RI Work Plan" (Brown and Caldwell and Integral 2007b).

The hydraulic relationship between the shallow, intermediate and deep hydrostratigraphic zones in the alluvial aquifer north of the mine site is affected locally by: 1) agricultural practices involving extraction of groundwater, presumably from the deep hydrostratigraphic zone, and application of irrigation water on agricultural fields resulting in a groundwater mound; 2) extraction of shallow groundwater by the pumpback well system; and 3) low-permeability layers, where present. Head differences in shallow, intermediate, and deep wells located immediately north of the mine indicate a downward vertical gradient. The magnitude of the vertical gradient is conceptualized to vary seasonally in response to climate conditions, agricultural practices, pumpback well operations, and regional groundwater conditions.

Potential migration paths for mine-related groundwater are hypothesized to be: 1) along an approximately 5,000-foot wide flow path between the irrigation mound and the potential

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boundary condition imposed by the bedrock of the Singatse Range, and 2) vertical redistribution and mixing resulting from agricultural operations within the mound area. Although some degree of resistance to vertical flow exists within the alluvial aquifer, created by the depositional layering of sedimentary deposits and the occurrence of low-permeability layers, some downward migration of mine-related groundwater is likely to have occurred as a result of historic operations at the Site and the influence of agricultural irrigation practices immediately north of the Site.

Variations in reported pre-mining groundwater elevations (80 to 125 feet), proximal to the Pit Lake, are not uncommon in fractured bedrock flow systems where clay-filled faults can compartmentalize groundwater flow into discrete hydrogeologic blocks. Although the fractured granitic bedrock can transmit groundwater as an effective porous media, discrete structural elements in the Yerington Pit will likely influence groundwater inflows. The concept of groundwater being locally compartmentalized is supported by geologic maps (Proffett and Dilles, 1984) and the map of pit structural elements (Figure 5-2, Brown and Caldwell, 2007c [see Attachment 2]). Perched groundwater is common in many of the pit slopes. The alluvium increases in thickness on the western side of the pit due to both an increase in elevation of the alluvial fan surface (4400 ft east edge vs. 4600 feet west edge) and a decrease in elevation of the alluvium/bedrock contact (Hershey, 2002) (Figure 3-10, Brown and Caldwell, 2007c [see Attachment 2).

The Yerington Pit Lake continues to act as a terminal sink, as the Pit Lake surface is below the potentiometric surface of the surrounding bedrock flow system, and while groundwater continues to enter the lake, little, if any water re-enters the alluvial or bedrock aquifers. This results in a cone of depression generated by the pit (Figure 3-9, Brown and Caldwell, 2007c [see Attachment 2]). Once the lake elevation reaches equilibrium to that of the regional groundwater, the lake will be in a “flow through” stage and the Pit Lake waters can, increasingly, have an effect on groundwater quality downgradient from the lake (Jewell, 1999). It has been suggested that pre-mining groundwater elevations will be reached sometime during the years 2015 to 2020 (Hershey, 2002) after which time groundwater is expected to begin flowing more to the north-northeast.

EXISTING DATA REVIEW

Figure 3-10, Attachment 2 (Brown and Caldwell, 2007c) shows a hydrogeologic cross-section running generally south to north through the site. This cross-section shows the cone of depression caused by the Pit Lake as it was interpreted at the Eastern extent of the lake using monitoring well WW-59. While there are likely to be steeper gradients to this cone of depression near the Eastern portion of the lake due to the effects of the Walker River, there is little doubt that groundwater locally flows radially inward towards the lake. Accordingly, groundwater that could be impacted by the former Arimetco process area and the HLPs in this area (Phase I/II, Phase IV Slot) is expected to currently discharge at least in part to the lake. In the future, after water levels in the Pit Lake reach equilibrium with the local groundwater, groundwater is expected to resume a more northerly flow direction.

Figure 1-3, Attachment 2 (Brown and Caldwell, 2008b) shows all wells currently installed at the site. These wells are further categorized to specific depth intervals in Figures 2-1, 2-2 and 2-3, Attachment 2 (Brown and Caldwell, 2008b). The portion of OU8 immediately north of the Pit Lake is largely devoid of monitoring wells making it impossible to evaluate groundwater impacts from the former process area and the HLPs. Groundwater impacts from these locations

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to the Pit Lake (currently) and to the area to the north (future) can not be evaluated due to this lack of wells.

The relative lack of existing wells in the vicinity of the former Arimetco process area and Phase I/II and IV Slot HLPs creates a significant data gap in the understanding of the CSM and precludes the USEPA from making informed decisions regarding the necessity and type of remedial actions for these areas. While future investigations are planned in these areas by ARC via Brown and Caldwell (Brown and Caldwell, 2007; Brown and Caldwell 2007b; and Brown and Caldwell 2007c), the short-term focus of those efforts is targeted at the Northern portion of the site. Therefore, in order to refine the CSM in the OU8 areas with particular emphasis on determining if any of the HLPs or ponds at the site are contributing contaminants to groundwater at unacceptable levels, additional groundwater monitoring wells are needed in this area.

PROPOSED WELL LOCATIONS

In order to begin filling the data gaps described above, CH2M HILL proposes eight monitoring wells installed in 5 different boreholes located south of Burch Drive within the Anaconda-Yerington mine site boundary to perform a preliminary investigation of the groundwater conditions associated with the Arimetco OU features. Proposed borehole locations are shown on CH2M HILL Figure 1-1. One monitoring well will be constructed in each of the five boreholes with screened intervals installed at depths that bracket the top of the existing groundwater surface (10 feet above and 10 feet below). Additionally, a second nested well will be constructed in three of the boreholes with screened intervals installed at depths expected to correspond to the equilibrated groundwater elevation after the lake has filled. These three nested wells will allow for effective future monitoring as groundwater elevations increase.

Borehole locations are proposed based on the following criteria:

- Groundwater depth and inferred flow direction,
- Proximity to the Arimetco process area and HLPs,
- Equipment accessibility to selected locations,
- Proximity to existing and/or proposed well locations based on the ongoing site-wide groundwater monitoring network led by ARC, and
- Construction specifications and monitoring objectives of existing and/or proposed ARC well locations.

MW-H12- The proposed well location for MW-H12 (Figure 1-1) associated with the Phase I/II HLP is south of the Phase I/II pad, adjacent to the haul access road, in a low lying area, located between the HLP and the Pit Lake, a the southeastern toe of the HLP. This well is expected to be a bedrock well within the suggested area cone of depression as indicated in Figure 3-9, Attachment 2 (Brown and Caldwell, 2007c). This well is anticipated to have an estimated depth of 205 feet which was determined by extrapolating the current Pit Lake water elevation (approximately 4215 ft amsl) back to the groundwater surface towards the northeast and using depth to groundwater measurements reported in nearby well WW-59B (208 feet at 4312 ft amsl), as indicated in Table 1, reported in the 2008 2nd Quarter Groundwater Monitoring Report (Brown and Caldwell, 2008c).

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The purpose of this well is to assess potential impacts from the Phase I/II HLPs on groundwater flowing towards the Pit Lake and to refine the interpretation of the groundwater gradient in this area. This location also will be used in the future to monitor groundwater conditions upgradient of Phase I/II HLPs once the Pit Lake has equilibrated and groundwater flow directions in this area reverse. A pair of nested wells is proposed for this location. As specified in Table 2, there is one bedrock well proposed in the Pit Lake OU Work Plan (PLMW-1B) located within the northern rim of the pit, and an additional well proposed in the OU-1 Site Wide Groundwater Work Plan (OU1-ONMW-2), proposed to be located on the southwestern toe of the Phase I/II HLP. Based on the ARC proposed locations, there is no indication that the Arimetco proposed well would be a redundancy to the future wells proposed by ARC, as shown in Figures 3-5 (Brown and Caldwell, 2007b) and 5-1 (Brown and Caldwell, 2007c) (Attachment 2).

MW-H4SS- Monitor Well MW-H4SS is associated with the Phase IV Slot HLP. The proposed well location is on the southwest toe of the Phase IV Slot HLP (Figure 1-1) with an estimated depth of 170-feet, based on depth to water of a proximal bedrock well, WW-40B (70.13'), reported in the 2008 2nd Quarter Groundwater Monitoring Report (Brown and Caldwell, 2008c). Although groundwater was encountered at approximately 70 feet (WW-40B) according to the 2008 2nd Quarter Groundwater Monitoring Report, this proposed Arimetco well is appreciably north to northwest of WW-40B, farther from the Pit Lake and more distal from the Walker River influences, where depths of alluvium increase markedly, suggesting that a deeper well is required.

The purpose of this well is to assess potential impacts from the Phase IV Slot HLP on groundwater flowing towards the Pit Lake and to refine the interpretation of the groundwater gradient in this area. This location also will be used in the future to monitor groundwater conditions upgradient of Phase IV Slot HLP once the Pit Lake has equilibrated and groundwater flow directions in this area reverse. A pair of nested wells is proposed for this location. ARC has proposed two bedrock wells as indicated in Table 2, within the Pit Lake OU Work Plan (PLMW-1B and PLMW-7B) that will be proximal to this proposed Arimetco well location. Pit Lake monitor well 1B is proposed within the northern rim of the pit and Pit Lake monitor well 7B is proposed to be located at the southeastern toe of the Phase IV Slot HLP. Based on the ARC proposed locations, there is no indication that the Arimetco proposed well would duplicate future wells proposed by ARC.

MW-H4SN- Monitor Well MW-H4SN is associated with the Phase IV Slot HLP. The proposed well location for MW-H4S is between the former Anaconda W-3 Waste Rock area and the Arimetco Phase IV Slot HLP (Figure 1-1). The proposed depth of this well is 85 feet based on recorded depths to groundwater of the nearby wells. Although there are no monitoring wells currently located south of the W-3 WRA and north of the Phase IV Slot HLP, there are two shallow monitoring wells as shown in Table 1, east of the Phase IV Slot including WW-2S (91.2') and WW-1S (68.4'). There are two additional inactive wells WW-3 and WW-4 located north of the Slot Ponds at the toe of the W-3 WRA that are not currently being monitored. Additionally, there is a well located outside the mine boundary along 95A B/W-15S (56'). The depth of the alluvial saturated zone for this location is not well defined.

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TABLE 1
Existing ARC Monitoring Wells Proximal to Proposed Arimetco Well Locations
Anaconda-Yerington Copper Mine Site

		Elevation/Well Depth			Well Casing and Screen			
Well Number	Hydro-stratigraphic Zone	Measure Point Elevation	Measure Point Stickup	Total Depth of Cased Well	Well Screen Interval		Reported Depth to Water	
		ft amsl	ft ags	ft bgs	ft bgs	ft amsl	ft bmp	ft amsl
WW-1S	Shallow	4409.91	2.29	68.4	43.4 – 63.4	4364.2 – 4344.2	43.02	4366.89
WW-2S	Shallow	4407.07	1.48	91.2	66.2 – 86.2	4339.4 – 4319.4	44.67	4362.4
B/W-21S	Shallow	4405.76	2.76	85.5	64.0 – 84.0	4339.0 – 4319.0	57.40	4348.36
WW-36B	Bedrock	4409.48	3.48	300.0	100.0 – 300.0	4306.0 – 4106.0	NR	NR
WW-40B	Bedrock	4417.67	4.17	NR	NR	NR	70.13	4347.54
WW-59B	Bedrock	4520.92	2.81	630.0	238.0 – 630.0	4280.1 – 3888.1	208.3	4312.62
PA-MW-1S	Shallow	4441.04	3.80	111.0	90.5 – 111.0	4346.7 – 4326.7	96.59	4344.45
PA-MW-3S	Shallow	4460.17	3.10	129.5	109.0 – 129.0	4348.1 – 4328.1	116.62	4343.55

Notes: Values from 2008 2nd Quarter Groundwater Monitoring Report
amsl – above mean sea level
ags – above ground surface
bgs – below ground surface
bmp – below measuring point
S = Shallow
B = Bedrock
NR = Not Reported

The purpose of this well is to assess groundwater conditions currently upgradient of the Phase IV Slot HLP and to refine the interpretation of the groundwater gradient in this area. This location also will be used in the future to monitor groundwater conditions downgradient of Phase IV Slot HLP once the Pit Lake has equilibrated and groundwater flow directions in this area reverse. A pair of nested wells will be constructed in this borehole. There is an ARC proposed bedrock well on the SE corner of the HLP (PLMW-7B) according to the Pit Lake OU WP and a proposed well at the alluvial-bedrock contact (OU1-ONMW-1) according to the OU1-Site-Wide Groundwater WP, as shown in Table 2. In comparing the proposed ARC well locations to the proposed Arimetco well locations, these wells are not expected to provide redundant information.

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TABLE 2
Proposed ARC Monitoring Well Locations
Anaconda-Yerington Copper Mine Site

Proposed Well Number	Hydro-stratigraphic Zone	Proposed Location	Proposed Installation Date	Document
OU1-ONMW-1	Bedrock-Alluvial Contact	Adjacent to the slot area of the Phase IV Slot HLP	> 12 months	Site-Wide Groundwater (OU-1) Work Plan
OU1-ONMW-2	Bedrock-Alluvial Contact	Between the Phase I/II HLP and the Phase IV Slot HLP	> 12 months	Site-Wide Groundwater (OU-1) Work Plan
OU1-ONMW-3	Bedrock-Alluvial Contact	Northeast corner of the former SX/EW facility at the toe of the historical W-3 Waste Rock Area and Leach Operation	> 12 months	Site-Wide Groundwater (OU-1) Work Plan
PLMW-1B	Bedrock	Within the proposed cone of depression on the northern slope of the Pit Lake	> 18 months	Pit Lake (OU-2) RI Work Plan
PLMW-2B	Bedrock	Proximal to the eastern rim of the Pit Lake at the confluence between the Walker River and Pit Lake	> 18 months	Pit Lake (OU-2) RI Work Plan
PLMW-7B	Bedrock	Southeast corner of the Phase IV Slot HLP	> 18 months	Pit Lake (OU-2) RI Work Plan
PLMW-9A	Alluvium	Proximal to the former Bathtub Pond	> 18 months	Pit Lake (OU-2) RI Work Plan

Notes:
B – Bedrock
A – Alluvium
HLP – Heap Leach Pad
OU – Operable Unit
RI – Remedial Investigation

MW-SXS and MW-SXN- There are two proposed monitor well locations in the former Solvent Extraction and Electrowinning (SX/EW) process area, located south of Burch Drive, across from the former Anaconda administrative building (Figure 1-1).

The groundwater flow regime in this area is uncertain. Based on current data, groundwater is suspected to flow in a northward direction as influenced by the Walker River or southward as influenced by the cone of depression created by the Pit Lake. CH2M HILL proposes installation of two monitoring wells near the former Arimetco SX/EW process area, to:

(1) Better determine the hydraulic gradient in this area, and

(2) Determine constituents moving both on and off the former SX/EW process area.

The two proposed SX/EW process area well locations, each to a depth of 120-feet, will be used to monitor groundwater conditions up and downgradient of the former Arimetco process area. MW-SXN is proposed to be placed north of the Arimetco process area along Burch Drive in the parking area directly across from the historical administrative building. MW-SXS is proposed to be placed south of the process area between the toe of the S-23 Waste Rock Area and the old Electrowinning Process Area originally constructed by Copper Tek (Figure 1-1).

Currently there exist only two monitoring wells proximal to the proposed locations, consisting of PA-MW-1S and PA-MW-3S (Table 1), with total depths of 111-feet and 129.5-feet and with depths to water of 96.59-feet and 116.62-feet respectively (Brown and Caldwell, 2008b). As indicated in Table 2, there is a proposed ARC well based on the 2007 OU-1 Site-Wide groundwater WP (OU1-ONMW-3) to be located at the toe of the W-3 WRA proximal to the

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former Anaconda Leaching Operations (Figure 1-1). There is nothing to indicate that the placement of proposed Arimetco well MW-SXN, would duplicate the placement of proposed ARC well OU1-ONMW-3. Two wells in this area will provide further data needed to fully understand the groundwater flow regime, as well as delineate fluids that may be migrating off of the W-3 WRA from fluids that may be migrating away from the historical Arimetco SX/EW process area. Nested wells are not proposed for these locations.

Details regarding these wells are presented in Table 3 and are summarized below. Proposed well locations are shown on Figure 1-1.

RECOMMENDATIONS

It is recommended that eight monitoring wells be installed in five boreholes located adjacent to the HLPs and proximal to the former Arimetco SX/EW process area in order to:

- Determine if process drain-down fluids are coming into contact with the groundwater,
- Assess solute transport pathways relative to the HLP, and
- Evaluate the water quality associated with the Arimetco OU-8.

The eight proposed monitoring wells will result in the installation of 1065 feet of well casing and materials. Each of the five boreholes is estimated to extend five-feet beyond the maximum cased depth of the well, for a total drilling depth of 745 feet.

- Well construction is dependent on depth to water. If depth to water is determined to differ from the estimates in the table above and consequently causes a change in the well construction specifications, an amendment to the RI/FS Work Plan will be prepared and submitted to EPA for review and acceptance.
- Proposed well locations MWH12, MWH4SS, and MWH4SN will be nested wells to allow for future monitoring as the Pit Lake reaches equilibrium with the hydrogeologic conditions surrounding the Site.

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TABLE 3
Proposed Monitoring Well Locations and Construction Specifications
Anaconda-Yerington Copper Mine Site

Proposed Well	Proposed Location	Depth to Groundwater of proximal wells [a]	Interpreted Flow Direction [b]	Proximity to Additional/Proposed Well Locations [c]	Rationale	Proposed Well Construction	Proposed Total Borehole Depth (ft)
MW-H12 (Nested with 2 screen intervals)	South of Phase I/II HLP	WW-1S (42.54'), WW-2S (44.08'), BW21-S (57.0'), WW-59B (208.3')	South	Currently there are no active monitoring wells in this area. There are two proposed well locations OU-ONMW-2, an ARC proposed well to the bedrock-alluvial contact located on the SE corner of Phase I/II HLP and PLMW-1B a bedrock well within the Pit Lake OU boundary between inactive monitor wells PWELL5 and PDW01.	The proposed location is within a low lying area south of the Phase I/II HLP. This area is approximately 30' lower in elevation than the surrounding area and will assess groundwater migrating downgradient (south) of the Phase I/II HLP and potentially into the Pit Lake. This area appears to be within the Pit Lake cone of depression suggesting that groundwater flow is in a south flow direction. Estimated surface elevation at this location is 4495-feet. The current Pit Lake elevation is approximately 4215-feet amsl. The estimated Pit Lake elevation at equilibrium will be 4350 to 4370 ft. amsl. A nested well in this location will monitor both current and future hydrologic conditions as the Pit Lake surface level reaches equilibrium. The shallow nested well interval under current conditions will be dry but is expected to monitor downgradient conditions from the Phase IV HLP in the future.	Shallow Nested Well Screen Interval: 125'-145' Deep Well Screen Interval: 185' to 205'	210
MW-H4SS (Nested with 2 screen intervals)	South of the Phase IV Slot HLP on southwestern toe of HLP	WW-1S (42.54') and WW-2S (44.08') and WW-40B (70.13')	Southwest	There are currently three active wells WW-1S (68.4') and WW-2S (91.2'), and WW-40B (NR), two inactive wells WW-3 and WW-4, and one ARC proposed bedrock well (PLMW-1B) proximal to this proposed location.	This well is proposed to be located on the southwest toe of the Phase IV Slot HLP. This proposed location is suspected to be within the cone of depression generated by the Pit Lake and is intended to assess groundwater migrating downgradient (south) of the Phase IV Slot HLP and potentially into the Pit Lake. Estimated surface elevation at this location is 4460-feet. The current Pit Lake elevation is approximately 4215-feet amsl. The estimated Pit Lake elevation at equilibrium will be 4350 to 4370 ft. amsl. A nested well in this location will monitor both current and future hydrologic conditions as Pit Lake surface level reaches equilibrium. The shallow nested well interval under current conditions will be dry but is expected to monitor downgradient conditions from the Phase IV HLP in the future.	Shallow Nested Well Screen Interval: 85' to 105' Deep Well Screen Interval: 150' to 170'	175
MW-H4SN (Nested with 2 screen intervals)	Between the W-3 WRA and Phase IV Slot HLP	WW-1S (42.54') and WW-2S (44.08')	Unknown (likely northwest, but could be south if well is within the Pit Lake cone of depression)	There are currently two active wells WW-1S (68.4') and WW-2S (91.2'), two inactive wells WW-3 and WW-4, and one ARC proposed well OU1-ONMW-1 proximal to this proposed location	This well will be located in the western portion of the slot between the W-3 WRA and the Phase IV Slot HLP. This proposed location will serve as a triangulation point to confirm groundwater gradient with other installed wells, and will assess groundwater upgradient (and migrating towards and beneath) Phase IV Slot HLP and from the W-3 WRA. Estimated surface elevation at this location is 4420-feet. The estimated Pit Lake elevation is currently 4215-feet amsl. The estimated elevation of Pit Lake at equilibrium is 4350 to 4370 ft. amsl. A nested well in this location will monitor current and future hydrologic conditions and as the surface elevation of the Pit Lake reaches equilibrium. The shallow nested well interval under current conditions will be dry but may serve to monitor conditions beneath the Phase IV Slot HLP in the future.	Shallow Nested Well Screen Interval: 50' to 70' Deep Well Screen Interval: 85' to 105'	110
MW-SXS	North End of former SX/EW Process Area	WW-1S (42.54'), WW-2S (44.08') and PA-MW-1S (96.44') and PA-MW-3S (116.62')	Unknown (potentially within the Pit Lake cone of depression)	There are currently no active monitor wells within the former Arimetco/Copper Tek SX/EW process area. There is one ARC proposed monitor well OU1-ONMW-3 to the bedrock-alluvial contact, to be located in the NE corner of the facility between Burch Drive and the W-3 WRA	Based on the location of the process area facilities and the uncertainty of groundwater flow within the SX/EW process area, there are two monitoring wells (one north and one south) proposed for this area. MWSXN is proposed to be located in the SW corner of the small parking lot south of Burch drive to assess groundwater migrating generally north from (or south and towards) the former SX/EW process area. The location and depth of this well take into account ARC's future installation of well (OU1-ONMW-3) that is proposed to extend to the bedrock-alluvial contact and be located in the former Arimetco process area, at the toe of the W-3 WRA. This well is part of ARC's OU3 RI Work Plan. MWSXS is proposed to be located off of the SW corner of the old EW building between the electrical sub-station and the former acid tank to assess groundwater migrating generally north and towards (or south and from) the former Arimetco/Copper Tek process area. Estimated surface elevation at the SX/EW process area is 4490-feet	Screen Interval: 100' to 120'	125
MW-SXN	South End of former SX/EW Process Area					Screen Interval: 100' to 120'	125
Total Drilling Depth							745

Note:

[a] Recorded groundwater water level monitoring elevations taken from the 2008 2nd Quarter site-wide groundwater sampling event
[b] Flow Directions are based on the 2008 Second-Step Hydrogeologic Framework Assessment Data Summary Report
[c] Proximity to Additional and Proposed well locations determined from the HFA DSR, OU-1 Site-Wide Groundwater Work Plan, Yerington Pit Lake Work Plan
S = Shallow
D = Deep
B = Bedrock
A = Alluvium
NR = Not Reported

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FIGURE 1-1
PROPOSED MONITORING WELL LOCATIONS
HYDROGEOLOGIC ASSESSMENT TECHNICAL MEMORANDUM
ANACONDA COPPER MINE - YERINGTON, NV

CH2MHILL

RDD \\BALDUR\PROJ\ANACONDA_COPPER_354946\MAPFILES\HYDROG_ASSES_TM\FIG1-1_PROP_MON_WELL_HATM.MXD 3/5/2009 00:50:36

Attachment 1
Supporting Figures - CH2M HILL

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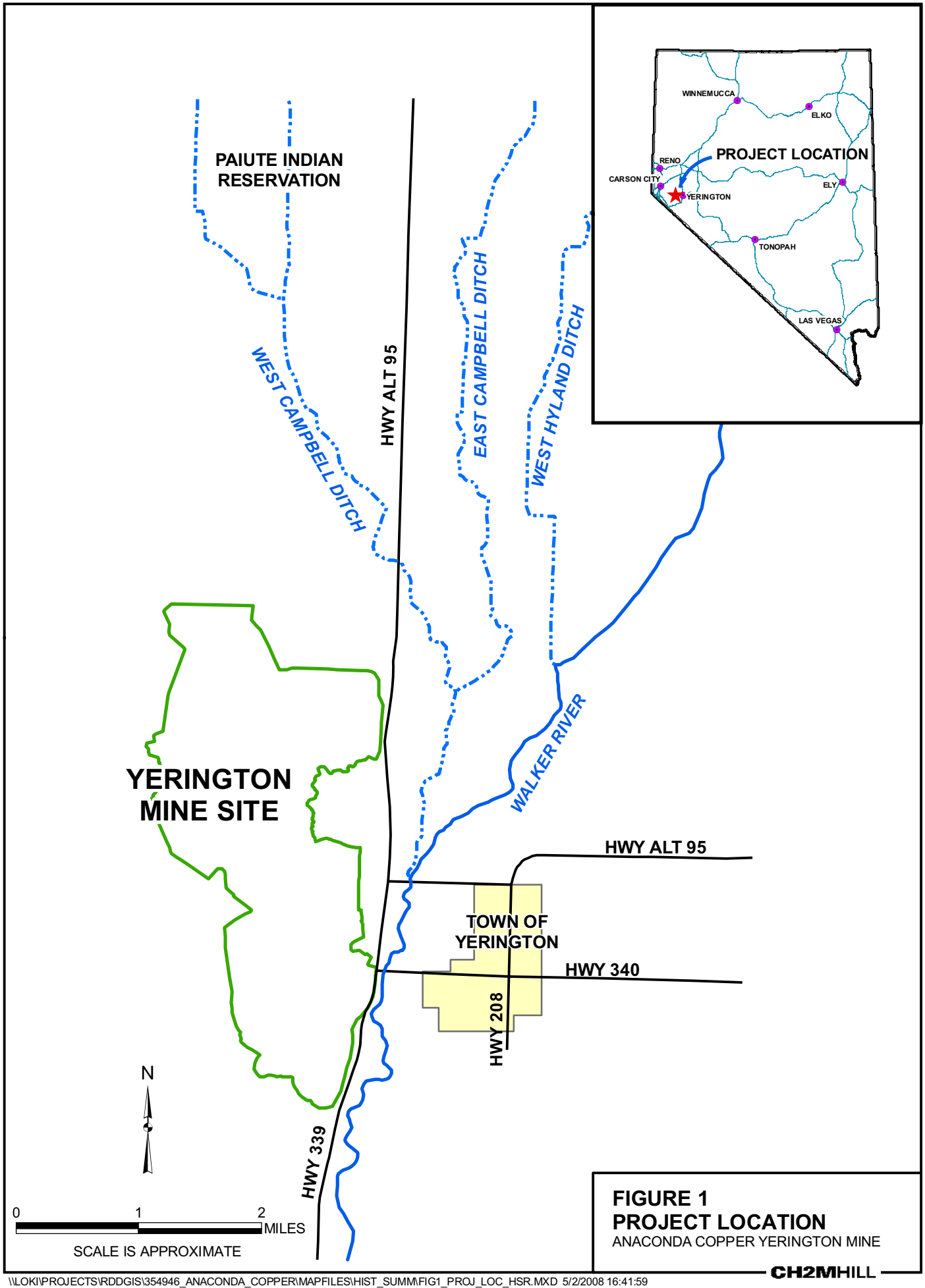

FIGURE 1
PROJECT LOCATION
ANACONDA COPPER YERINGTON MINE

CH2MHILL

\\LOKI\PROJECTS\RDDGIS\354946_ANACONDA_COPPER\MAPFILES\HIST_SUMM\FIG1_PROJ_LOC_HSR.MXD 5/2/2008 16:41:59

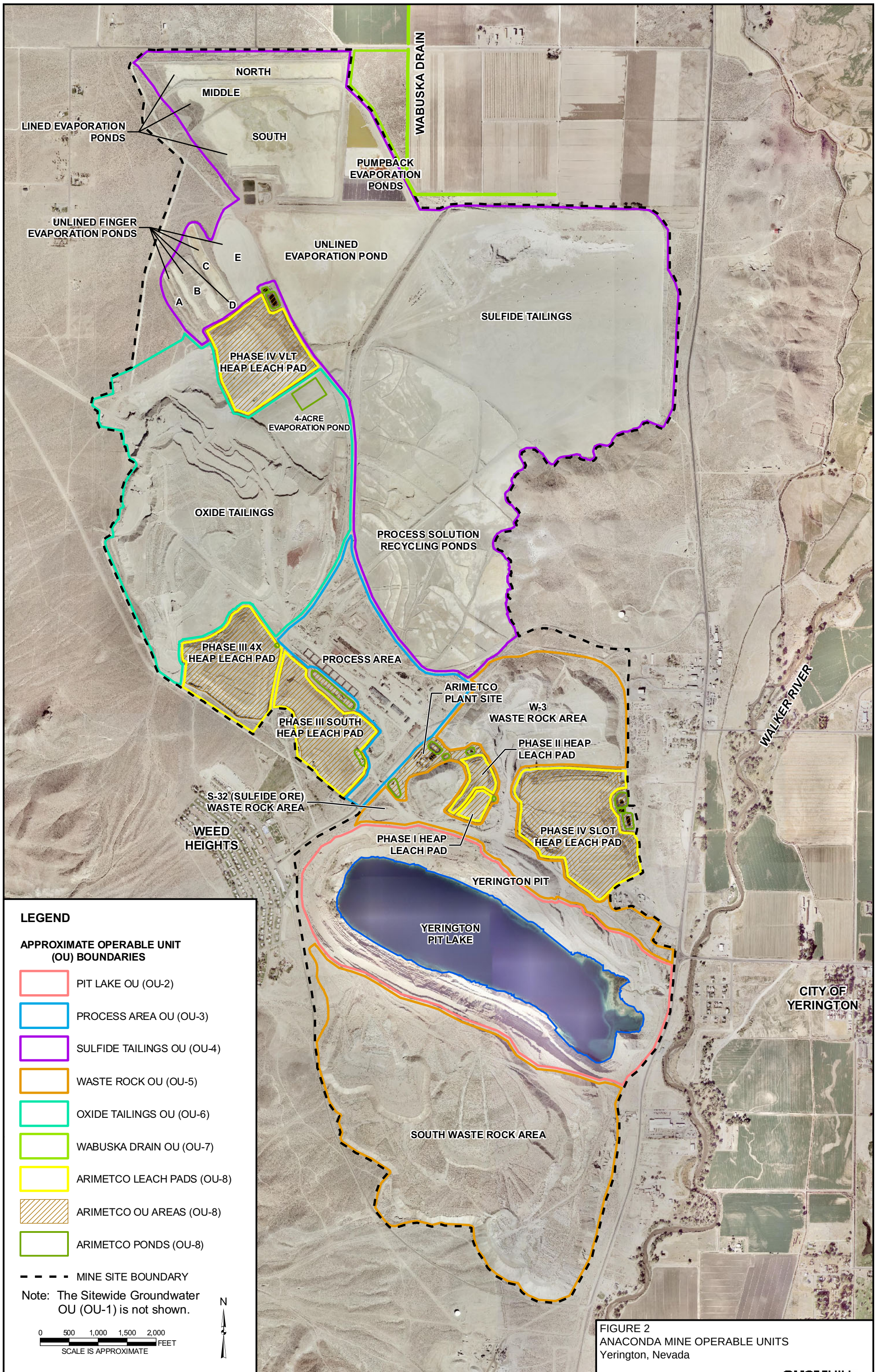

FIGURE 2
ANACONDA MINE OPERABLE UNITS
Yerington, Nevada

CH2MHILL

\\LOKI\PROJECTS\RDDGIS\354946_ANACONDA_COPPER\MAPFILES\OPERABLE_UNITS_NO_FIG.MXD 1/11/2008 13:34:43

Attachment 2
Supporting Figures – Brown and Caldwell

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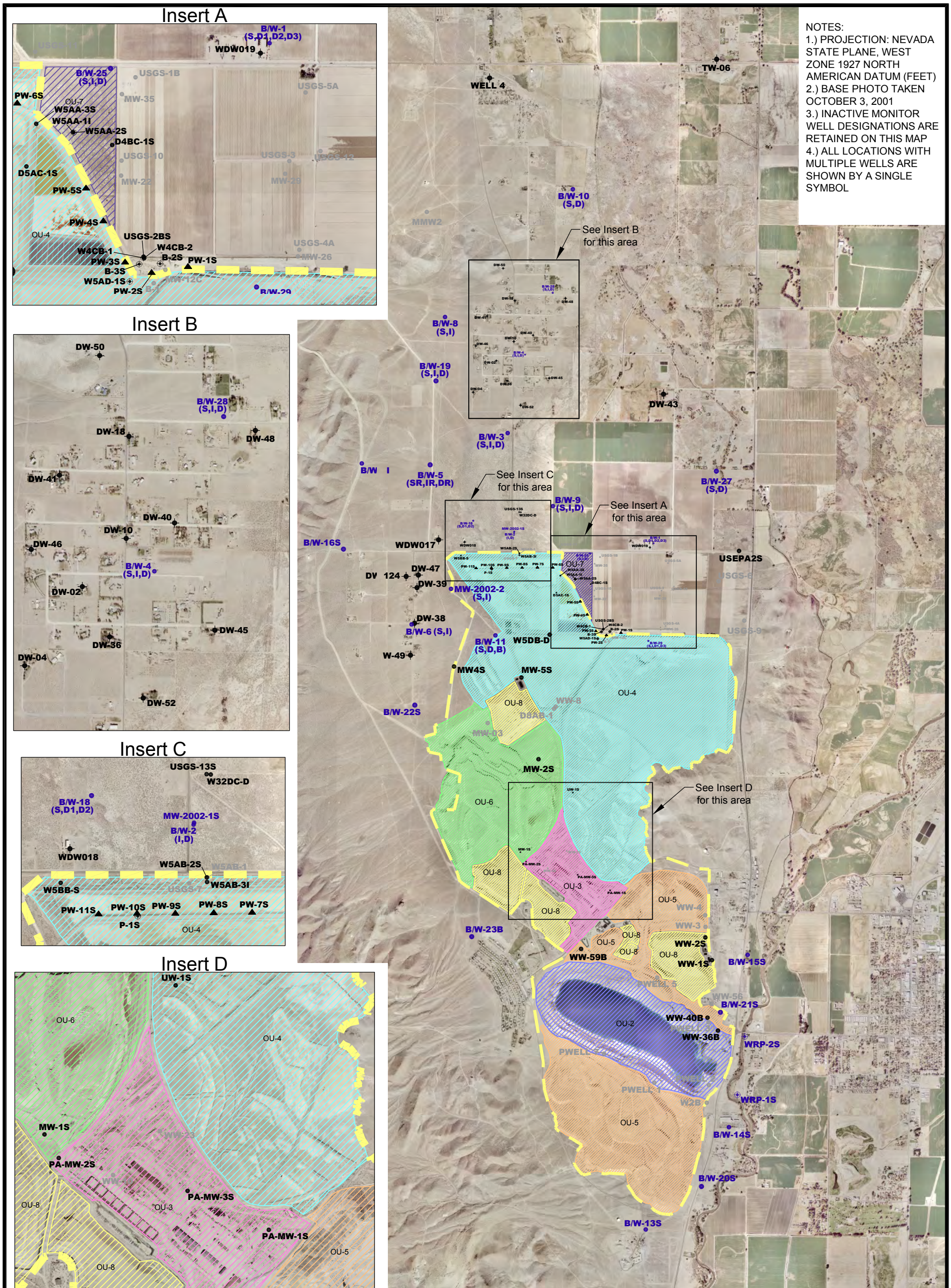


NOTES:
1.) PROJECTION: NEVADA STATE PLANE, WEST ZONE 1927 NORTH AMERICAN DATUM (FEET)
2.) BASE PHOTO TAKEN OCTOBER 3, 2001
3.) INACTIVE MONITOR WELL DESIGNATIONS ARE RETAINED ON THIS MAP
4.) ALL LOCATIONS WITH MULTIPLE WELLS ARE SHOWN BY A SINGLE SYMBOL

EXPLANATION

- SITE BOUNDARY
- INACTIVE MONITORING WELL
- EXISTING DOMESTIC/MONITOR WELL
- EXISTING PIEZOMETER
- EXISTING SECOND-STEP PIEZOMETER
- EXISTING MONITOR WELL
- EXISTING B/W MONITOR WELL
- EXISTING PUMPBACK WELL

BROWN AND CALDWELL

Date: Sept 2008

Atlantic Richfield Company

Project: 134557

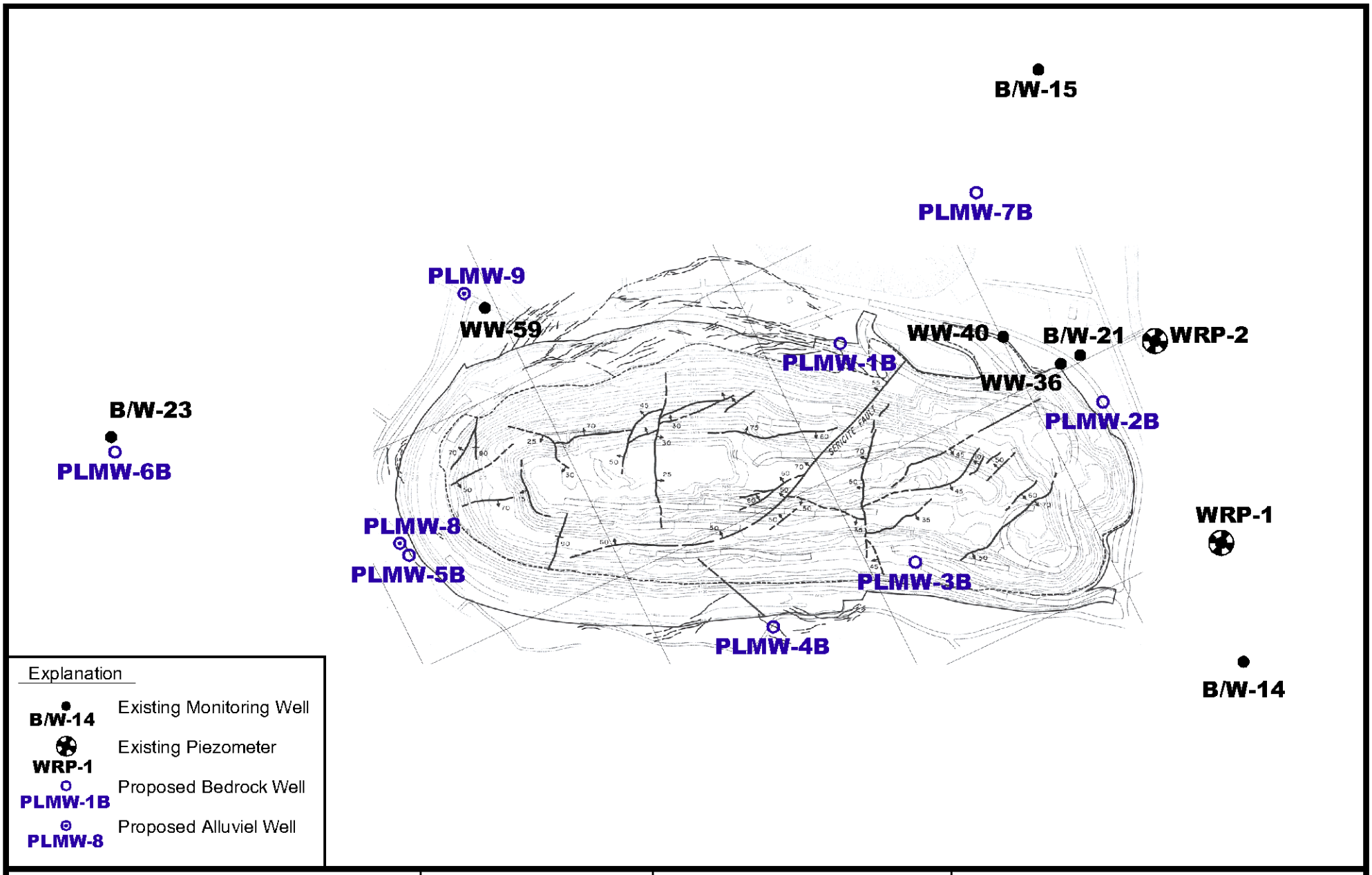
N W E S

1,500 0 1,500 3,000 FEET

Figure 1-3

Monitor Well Locations

P:\Arco-Yerington\Site-Wide Groundwater Monitoring\134557 - Year 2008 Files\CAD\September 2008\Figure 1-3.dwg Sep 10, 2008 - 10:12am rjohnson



integral consulting inc.

BROWN AND CALDWELL

Date: November 2007

Atlantic Richfield Company

Project: 133765

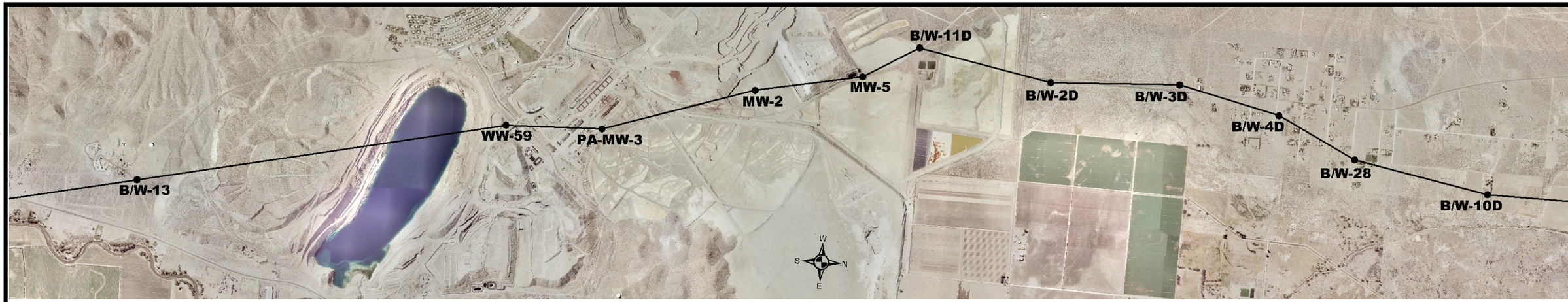
N E S W

600 0 600 1,200 FEET

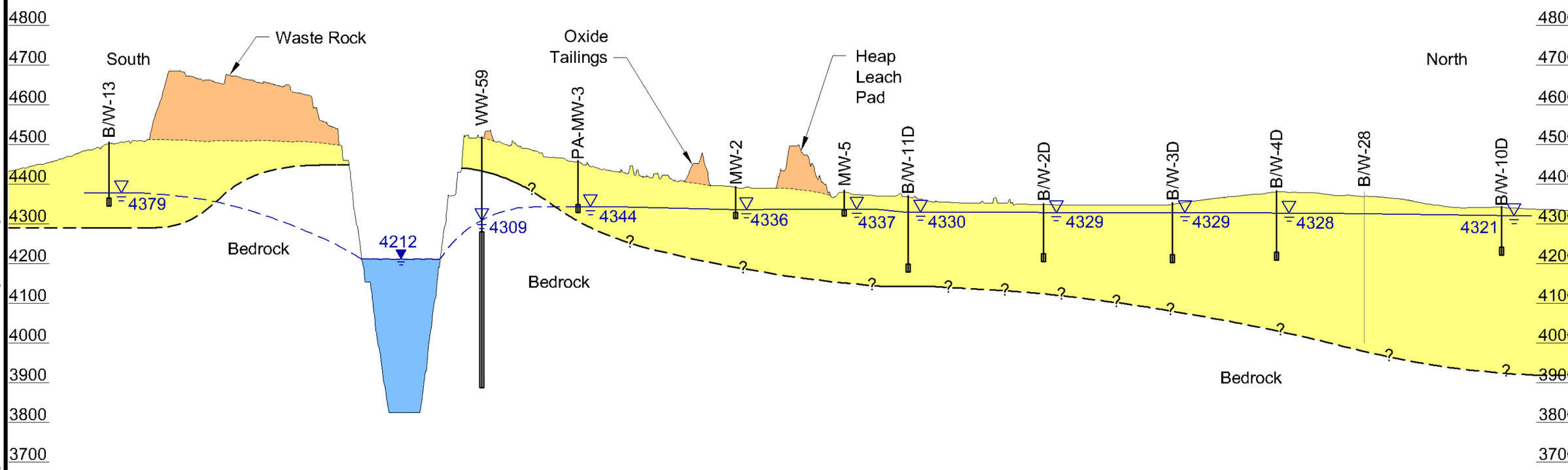
Figure 5-2

Proposed and Existing Monitor Wells and Pit Structural Elements

Nov 19, 2007 - 11:51amrjohnson
P:\ARCO\133765 - Yerington Pit Lake\CAD\November 2007\Figure 5-2.dwg



PLAN
SCALE: 1"=2500'



PROFILE
HORIZONTAL SCALE: 1"=2500' VERTICAL SCALE: 1"=250'
10X VERTICAL EXAGGERATION

integral consulting inc.

BROWN AND CALDWELL

Date: November 2007

Atlantic Richfield Company

Project: 133765

1,250 0 1,250 2,500 FEET

Explanation
- Mine Waste
- Alluvium

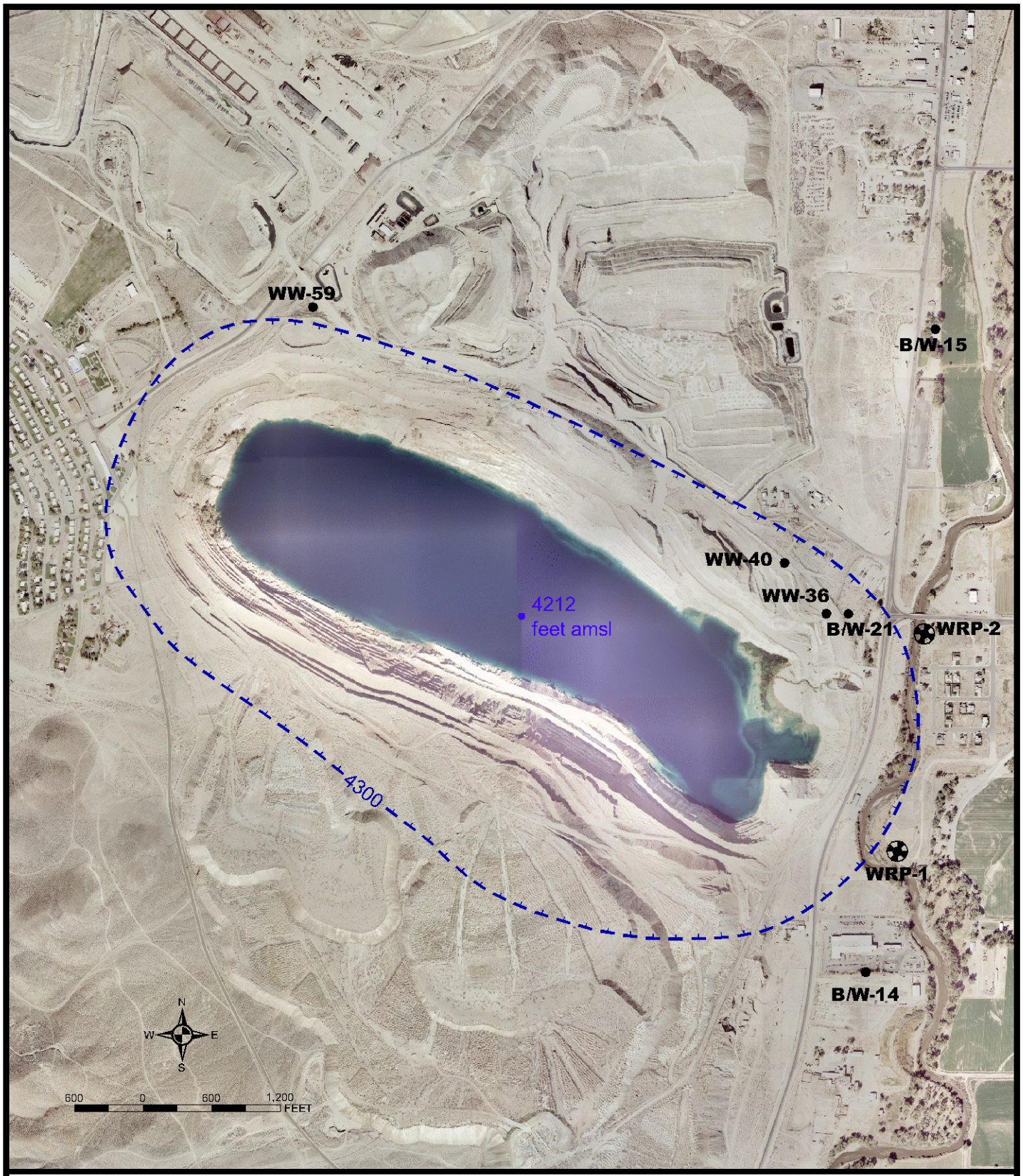
Notes:
1. Groundwater Level Measurements from July 2007.
2. Pit Lake Level Measured on October 26, 2007.
3. Bedrock Encountered while Drilling at B/W-11D3 during November 2007

Figure 3-10

Generalized Hydrogeologic Cross Section (South to North)

rjohnson

P:\ARCO\133765 - Yerington Pit Lake\CAD\November 2007\Figure 3-10.dwg



NOTES:
1.) PROJECTION: NEVADA STATE PLANE, WEST ZONE 1927 NORTH AMERICAN DATUM (FEET)
2.) BASE PHOTO TAKEN OCTOBER 3, 2001
3.) WELL "WW-40" FORMERLY REFERRED TO AS "PWELL 4" AND "PIT EDGE"

EXPLANATION

PIT LAKE ELEVATION AS OF SEPTEMBER 2007

OUTLINE OF CONE-OF-DEPRESSION IN BEDROCK FLOW SYSTEM BASED ON JULY 2007 GROUNDWATER ELEVATION MEASUREMENTS.

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BROWN AND CALDWELL

Date: Nov 2007

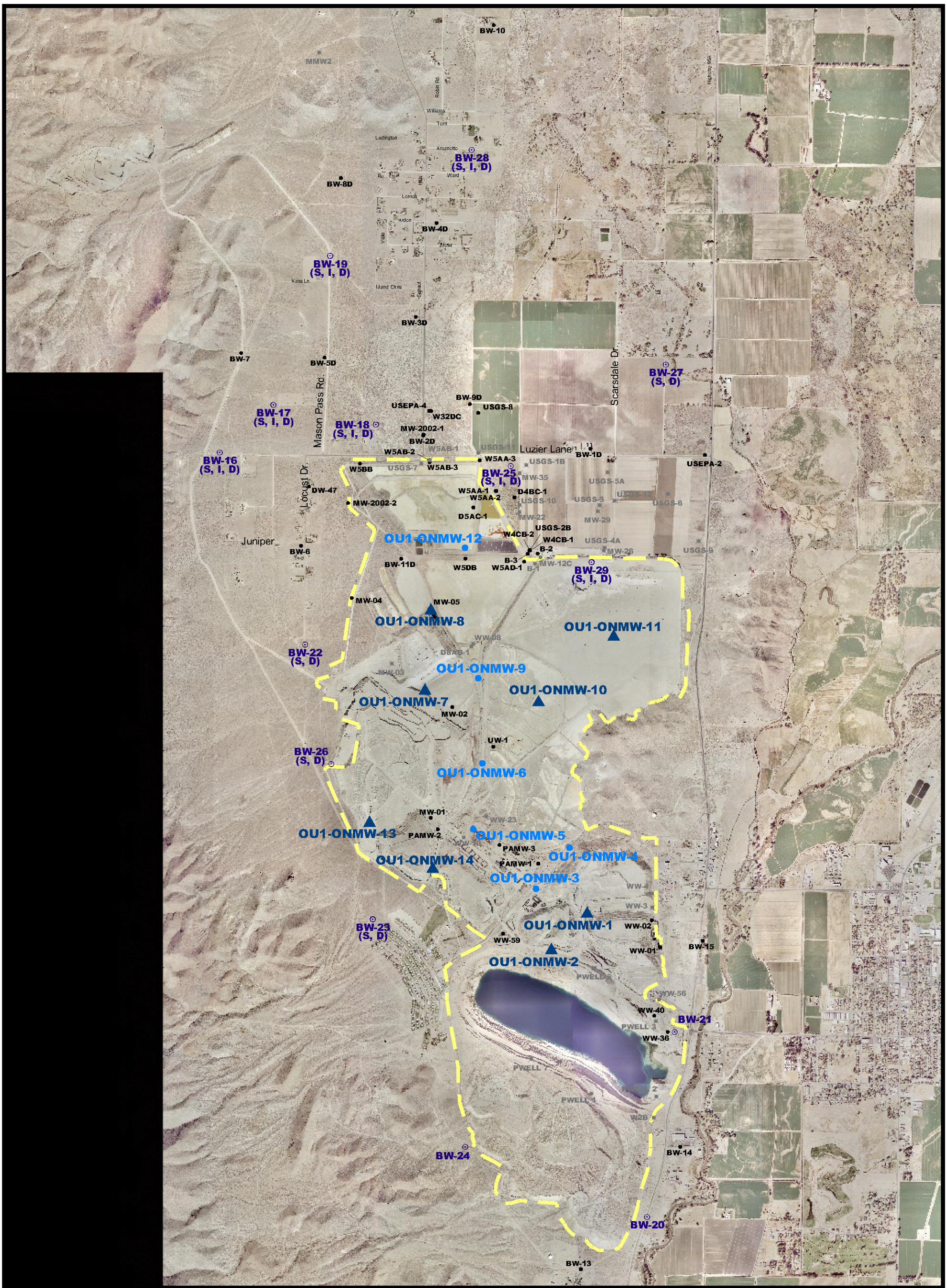
Atlantic Richfield Company

Project: 133765

Figure 3-9

Cone-of-Depression in Bedrock Flow System

P:\ARCO\133765 - Yerington Pit Lake\CAD\November 2007\Figure 3-9.dwg
Nov 29, 2007 - 9:32am
rjohnson



Explanation

NOTES:
1. PROJECTION NEVADA STATE PLANE, WEST ZONE 1927 NORTH AMERICAN DATUM (FEET)
2. BASE PHOTO TAKEN OCTOBER 2001

W2B Inactive Well

BW-16 Proposed Second-Step HFA Monitor Well

MW-05 Existing Monitoring Well

Site Boundary

OU1-ONMW-1 Proposed Monitoring Well (Modified Zonal Sampling)

OU1-ONMW-6 Proposed Monitoring Well (Standard Zonal Sampling)

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BROWN AND CALDWELL

Date: November 2007

Atlantic Richfield Company

Project: 132801

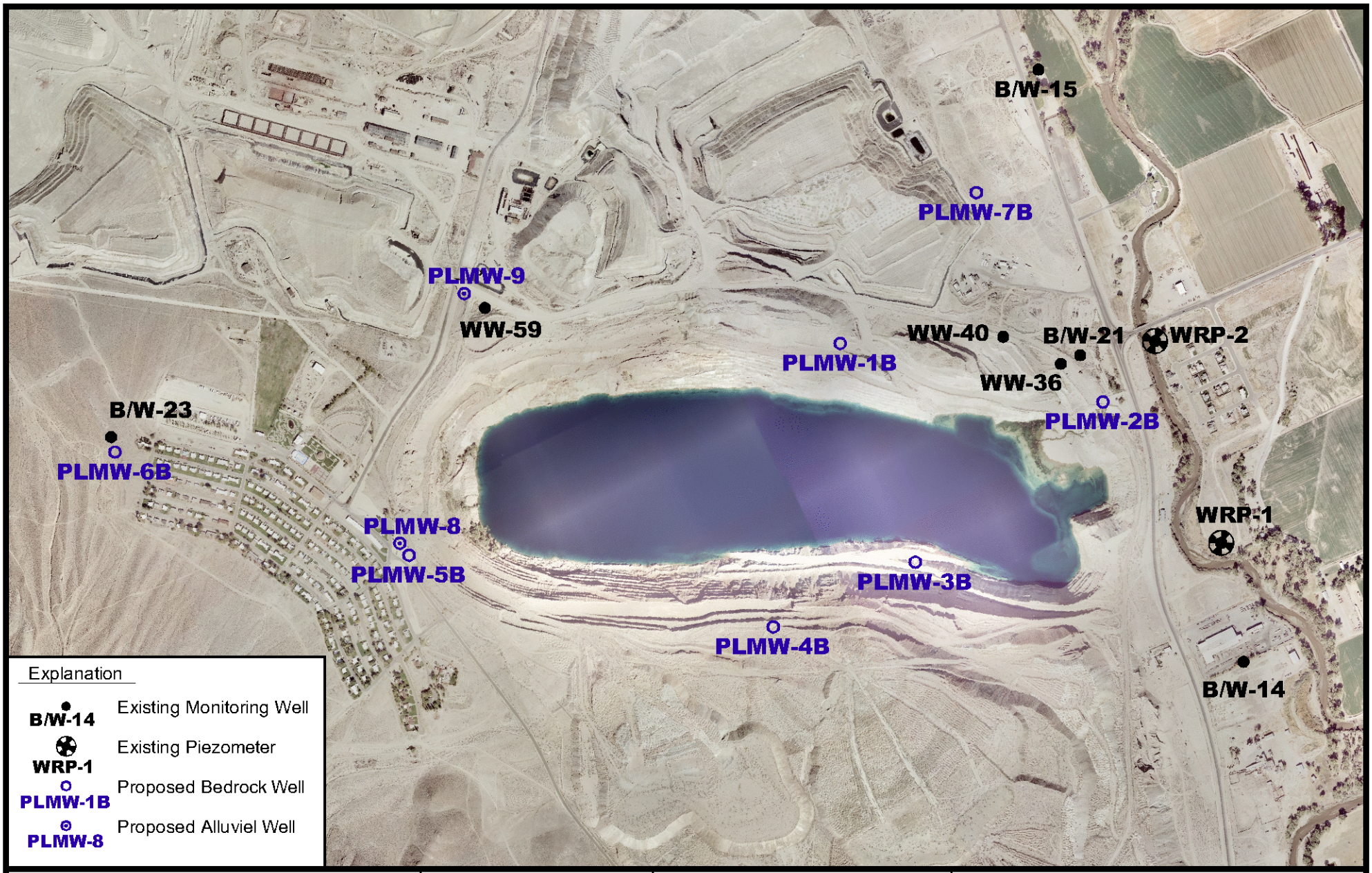
N W E S

1,250 0 1,250 2,500 FEET

Figure 3-5

Proposed OU1 Monitor Well Locations

P:\ARCO\132801 – Site-Wide Groundwater RI Work Plan\CAD\Groundwater RI Work Plan\November 2007\Figure 3-5.dwg Nov 12, 2007 - 6:59pm rjohnson



integral consulting inc.

BROWN AND CALDWELL

Date: November 2007

Atlantic Richfield Company

Project: 133765

N E S W

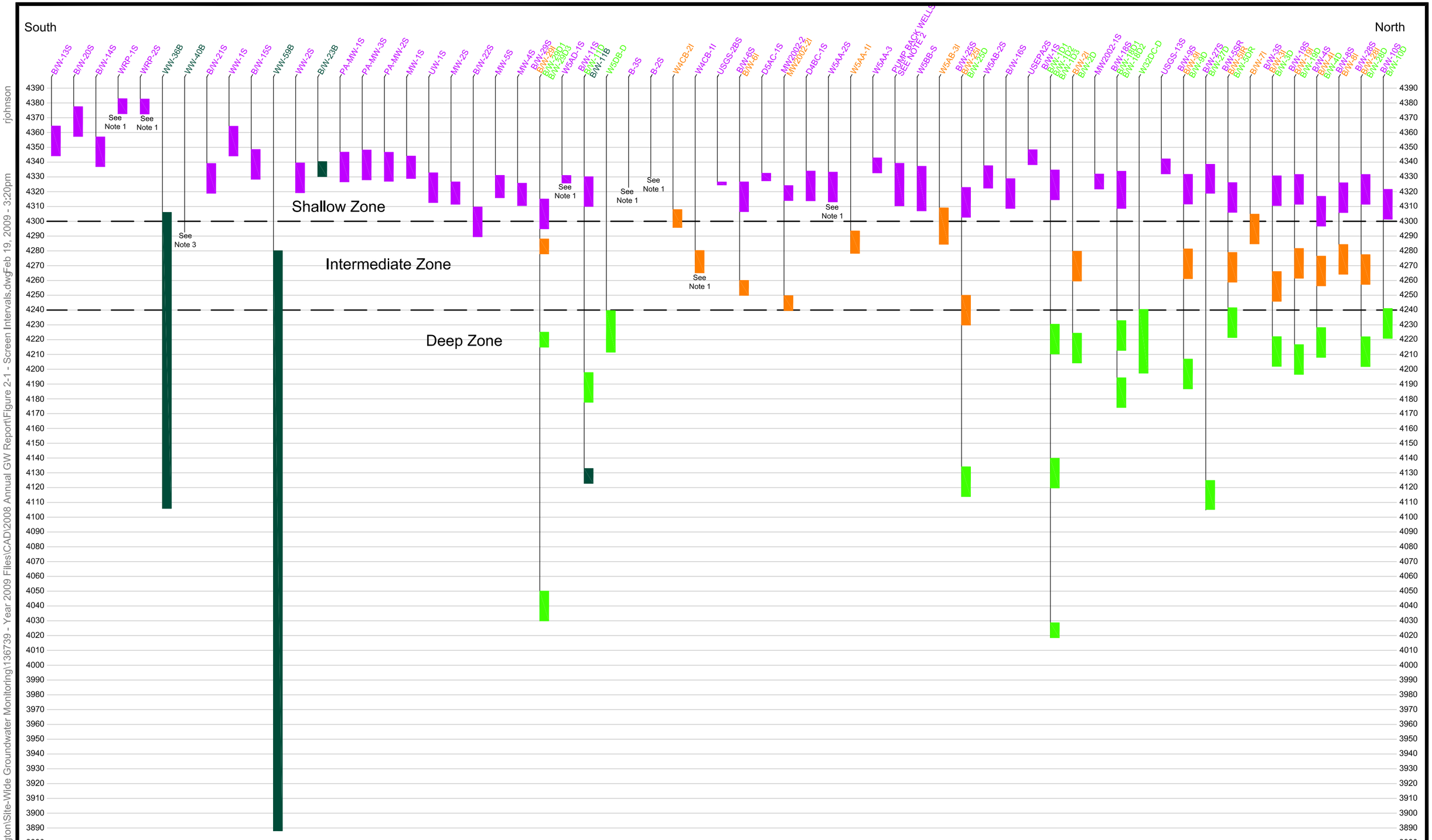
600 0 600 1,200 FEET

Figure 5-1

Proposed and Existing Pit Lake Area Monitor Wells

Nov 19, 2007 - 11:51amrjohnson

P:\ARCO\133765 - Yerington Pit Lake\CAD\November 2007\Figure 5-1.dwg



BROWN AND CALDWELL

NORWEST
Applied Hydrology

Date: March 2009

Atlantic Richfield Company

Project: 136739

Legend:

- MW-4S — Shallow Zone Well
- B/W-7I — Intermediate Zone Well
- B/W-11D — Deep Zone Well
- B/W-23B — Bedrock Zone Well

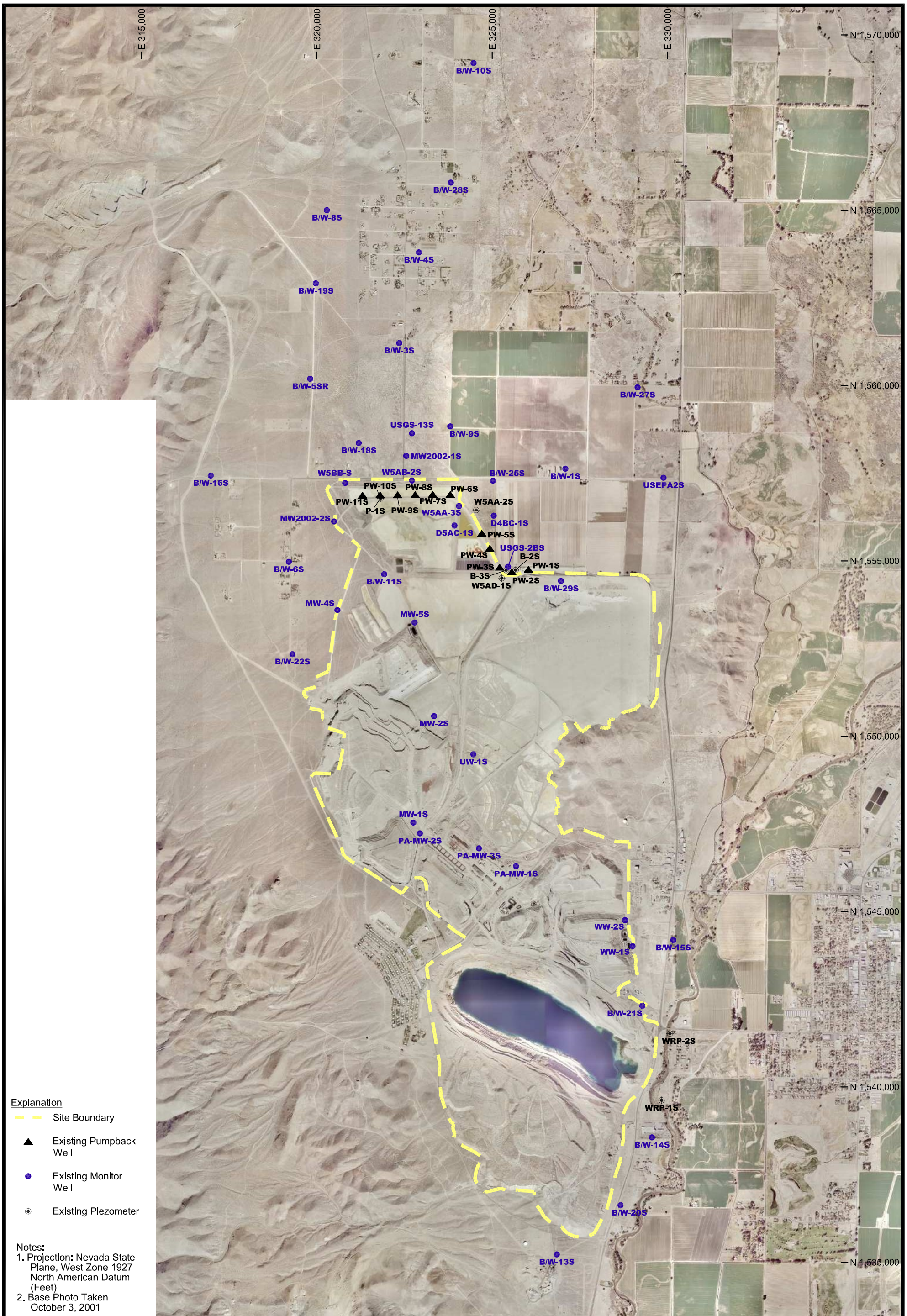
Notes:

1. Only water level measurements are obtained at these wells.
2. Screen intervals for PW-1S to PW-11S and P-1S are all located in the shallow hydrostratigraphic zone.
3. Well screen information is not available for WW-40B, B-2S, and B-3S.
4. Wells are approximately oriented from south to north.
5. Vertical scale is 1" = 60'. No horizontal scale.

Figure 2-1

Monitor Well Screen Intervals And Hydrostratigraphic Zone Designations

P:\Arco-Yerington\Site-Wide Groundwater Monitoring\136739 - Year 2009 Files\CAD\2008 Annual GW Report\Figure 2-1 - Screen Intervals.dwg Feb 19, 2009 - 3:20pm rjohnson



Explanation

- Site Boundary
- Existing Pumpback Well
- Existing Monitor Well
- Existing Piezometer

Notes:
1. Projection: Nevada State Plane, West Zone 1927 North American Datum (Feet)
2. Base Photo Taken October 3, 2001

BROWN AND CALDWELL

NORWEST Applied Hydrology

Date: March 2009

Atlantic Richfield Company

Project: 136739

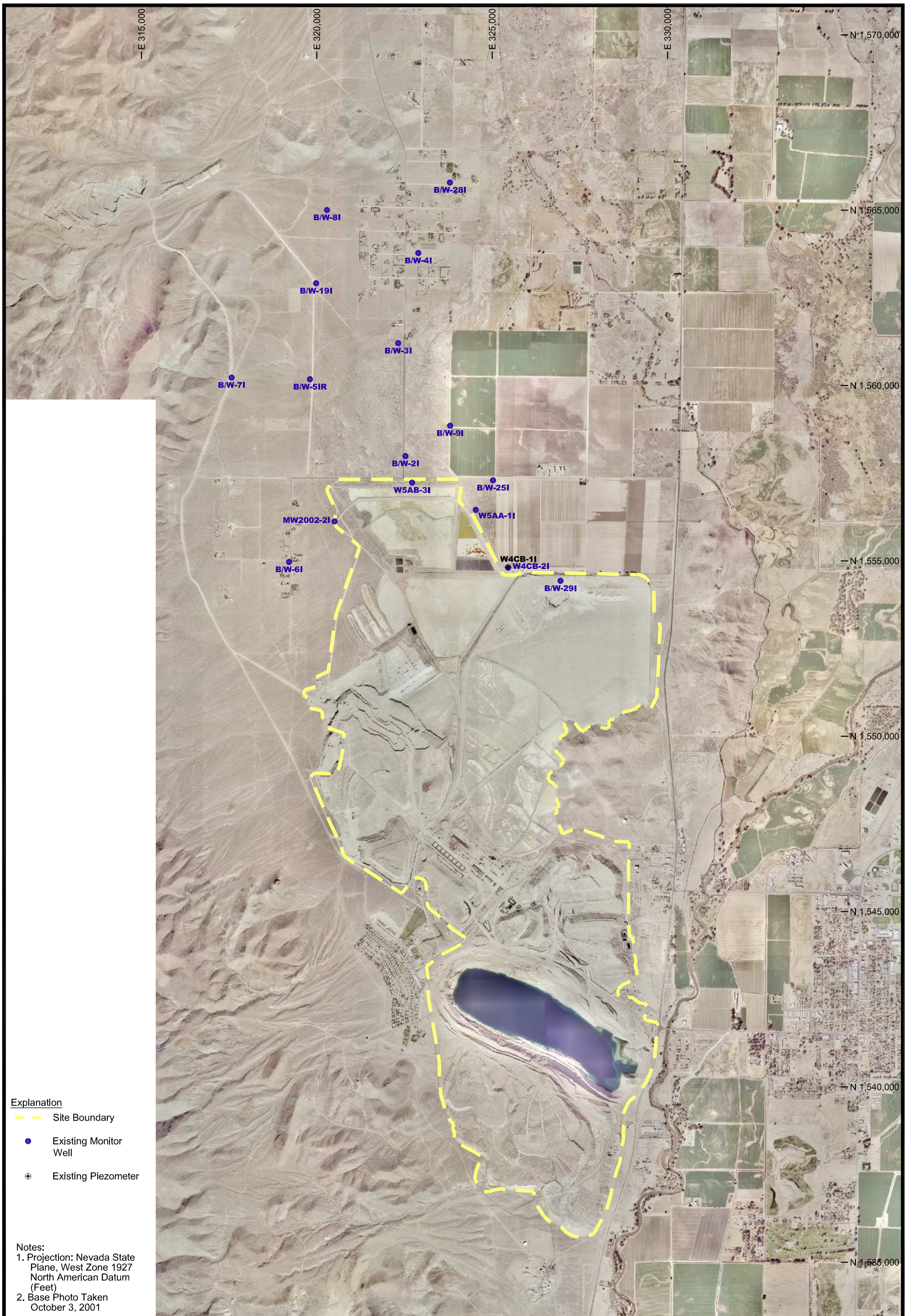
N W E S

1,250 0 1,250 2,500 FEET

Figure 2-2

Shallow Zone Monitor Wells

P:\Arco-Yerington\Site-Wide Groundwater Monitoring\136739 - Year 2009 Files\CAD\2008 Annual GW Report\Figure 2-2 - Shallow Monitor Wells.dwg Feb 18, 2009 3:24pm rjohnson



BROWN AND CALDWELL

NORWEST Applied Hydrology

Date: March 2009

Atlantic Richfield Company

Project: 136739

Figure 2-3

Intermediate Zone Monitor Wells

P:\Arco-Yerington\Site-Wide Groundwater Monitoring\136739 - Year 2009 Files\CAD\2008 Annual GW Report\Figure 2-3 - Intermediate Monitor Well Locations.dwg rjohnson