Data Summary Report for Process Areas Groundwater Conditions

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SECTION 1.0
INTRODUCTION

The Atlantic Richfield Company ("ARC") conducted site characterization activities in the Process Areas of the Yerington Mine Site in accordance with the Process Areas Work Plan submitted May 5, 2004 to the U.S. Environmental Protection Agency ("EPA"), the U.S. Bureau of Land Management ("BLM") and the Nevada Division of Environmental Protection ("NDEP"). This Data Summary Report ("DSR") for Process Areas Groundwater Conditions has been prepared in compliance with the Unilateral Administrative Order for Initial Response Activities (UAO 0-2005-2011) issued by EPA to ARC under Section 106 of the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"). Field investigations of soil and groundwater conditions in the Process Areas were performed by Brown and Caldwell from September 2004 through April 2005. A similar DSR will be prepared for Process Areas Soil Conditions when the soils analytical data has been compiled, mapped and subjected to ARC's quality control process.

The purpose of the site characterization program is to investigate the occurrence, three-dimensional extent and magnitude of constituents of concern ("COCs") in Process Areas soils and underlying groundwater that may have resulted from past operations at the Yerington Mine Site. This DSR presents sampling methods, hydrogeologic data and analytical results of groundwater samples collected from November 2004 through January 2005 as part of the agency-approved Process Areas Work Plan (Brown and Caldwell, 2004).

1.1 Site Location and Background

The Yerington Mine Site is located approximately one mile west of the town of Yerington in Lyon County, Nevada (Figure 1-1). The Yerington Mine Site consists of the remains of an open pit copper mine, waste rock piles, leached ore tailings piles, evaporation ponds, and ore processing facilities including tanks, buildings, underground utilities and remnant foundations

(Figures 1-2 and 1-3). The Process Areas, which cover an area approximately 5,000 feet long and 2,000 feet wide or about 230 acres, includes only the central processing facilities.

The Anaconda Mining Company began mining operations in the early 1950s. From 1953 to 1965, operations at the site consisted of mining and processing copper oxide ores. The copper oxide ores were processed using a Vat Leach extraction process. The Vat Leach process involved crushing of graded, pit-mined oxide copper ore to a uniform, minus 0.5-inch size. The crushed ore was loaded into one of a row of eight large concrete leach vats within which a weak sulfuric acid solution produced a pregnant leach solution. The leach solution was conveyed to nearby precipitation cells where copper was precipitated onto scrap iron and de-tinned cans. The barren solution then passed to iron launders where excess iron was removed, then re-acidified before returning to the Leach Vats. Tailings were deposited as solids in the Oxide Tailings Area and copper concentrates were sent off site for smelting.

In 1965, the mill and concentrator were modified to allow processing of both oxide and sulfide ores. The sulfide ore process circuit involved fine crushing and copper sulfide recovery by chemical flotation, in which lime was added to the process solution to maintain a basic pH. Sulfide tailings were conveyed as slurry to the Sulfide Tailings Area. A copper concentrate was produced from the sulfide ore, and was also shipped off site for smelting. Historic records also indicate that dump leaching of the W-3 Waste Rock dump began in 1965, where sulfuric acid was applied to the W-3 Waste Rock dump to increase copper production (Anaconda, 1965). Processing of copper ores at the Yerington Mine Site also produced technically enhanced naturally occurring radioactive minerals ("TENORM") in tailings and process solutions.

In 1989, Arimetco International initiated leaching operations at the mine site. Arimetco constructed new processing components including solvent extraction and electro-winning plants located across the road from the Process Areas. Arimetco used facilities in the Process Areas, including the administration, warehouse and maintenance buildings. As shown in Figure 1-3, the process areas includes a heap leach pond operated Arimetco. Facilities such as the electro-

winning circuit and heap leach pads operated by Arimetco were not evaluated during this phase of site characterization.

1.2 Previous Investigations

The following reports provide background information associated with groundwater conditions in the portion of Mason Valley that includes the Yerington Mine Site, with some relevance to groundwater conditions underlying the Process Areas.

- Seitz, Harold, Van Denburgh, A.S. and La Camera, Richard J., 1982, *Ground Water Quality Downgradient from Copper Ore Milling Wastes at Weed Heights, Lyon County, Nevada*, U. S. Geological Survey Open File Report 80-1217.
- Huxel, C.J., 1969, Water Resources and Development in Mason Valley, Lyon and Mineral Counties, Nevada, 1948-65. State of Nevada Department of Conservation and Natural Resources, Division of Water Resources, Water Resources Bulletin No. 38.
- Dalton, Dennis, 1999, *Arimetco Yerington Mine and Process Facility Site Assessment of Groundwater Quality*, consultant report prepared for Arimetco, Inc. for submittal to NDEP.
- Piedmont Engineering, 2001, *Yerington Shallow Aquifer Data Evaluation Report*, consultant prepared for Atlantic Richfield Company, March 20, 2001.
- Applied Hydrology Associates, 1983, *Evaluation of Water Quality and Solids Leaching Data,* consultant report prepared for Anaconda Minerals Company, May 25, 1983.
- Applied Hydrology Associates, *Annual Monitoring and Operations Summary*, consultant reports prepared for Atlantic Richfield Company, ongoing.

1.3 Physical Setting

The Process Areas of the Yerington Mine Site are located on the distal edge of an alluvial fan, between the Singatse Mountain Range and fluvial deposits associated with the Walker River (Figure 1-4). The source area for the fan is a major drainage feature referred to as The Canyon on the USGS Yerington 7.5-minute quadrangle (1986). The head of The Canyon is shown near Singatse Peak at approximately 6,000 feet above mean sea level (amsl) and runs approximately two miles south and east to the head of the alluvial fan at approximately 4,800 feet amsl and the base is between 4380 feet and 4420 feet amsl. The Process Areas are located approximately one

mile down slope from the head of the fan at an elevation of approximately 4,450 feet amsl. Natural topography in the area has been altered by mining and milling operations.

The Yerington Mine Site and Process Areas are located on the west side of Mason Valley, a structural basin surrounded by uplifted mountain ranges. Mason Valley is bordered by the Singatse Range to the west, the Desert Mountains to the north, and the Wassuk Range to the east. The Yerington Mine Site is located on the flank of the Singatse Range on an east facing alluvial fan. The mountain blocks are primarily composed of granitic, metamorphic and volcanic rocks with minor amounts of semi-consolidated to unconsolidated alluvial fan deposits. The Singatse Range has been subject to metals mineralization, as evidenced by the large copper porphyry ore deposit at the Yerington Mine. Proffett and Dilles (1984) published a geologic map of the Yerington District that describes these features.

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 mine site. These unconsolidated deposits, collectively called the valley-fill deposits by Huxel (1969), comprise four geologic units: younger alluvium (including the lacustrine deposits of Lake Lahontan), younger fan deposits, older alluvium and older fan deposits. Lake Lahontan lacustrine deposits appear to have been removed and reworked by the Walker River as it meandered across the valley (Huxel, 1969). Huxel estimated that Pleistocene Lake Lahontan in Mason Valley persisted for a relatively short time and was less than 60 feet deep.

Seitz et. al. (1982) described the geologic setting of the area around the mine site based on existing information and the sub-surface information obtained through the drilling of test wells (i.e., monitor wells) north of the site by the U.S. Geological Survey in 1978. Alluvial fan deposits along the west margin of the valley and stream- and lake-deposited materials on the valley floor underlie the tailings and evaporation ponds. Based on the lithology of core samples collected during this investigation, the alluvial fan underlying the Process Areas is comprised of generally fine-grained mud-flow deposits and coarser grained channel deposits.

The principal source of recharge to the alluvial aquifer beneath the Yerington Mine Site is the Walker River, located immediately east of the site (Huxel, 1969). In addition to the Walker River, minor recharge from the Singatse Range to the groundwater flow system beneath the mine site may also occur. Recharge from direct precipitation is negligible because of the low annual average precipitation rate of 5.46 inches per year at the mine site (Huxel, 1969). Additional recharge to groundwater in the area of the mine site comes from agricultural practices, including the use of surface water and the conveyance of surface water in the West Walker Ditch to agricultural areas located immediately east and north of the mine site.

The hydrogeology of the Process Areas, described in more detail in Section 2.4 of this DSR, is strongly influenced by the depositional setting of the alluvial fan and the transition from fan sediments to lake sediments related to former Lake Lahontan. More permeable or transmissive zones beneath the Process Areas are composed of sandy materials in channel deposits that appear to occur as discontinuous lenses, consistent with their depositional setting on the distal margin of the alluvial fan. Groundwater recharge to this portion of the alluvial fan appears to be limited, and would primarily be sourced from the Singatse Range as little or no recharge is expected from the Walker River or by direct precipitation to the Process Areas.

SECTION 2.0
GROUNDWATER CHARACTERIZATION ACTIVITIES

The groundwater characterization activities conducted by ARC in the Process Areas at the Yerington Mine Site included: 1) the drilling of 28 boreholes using a roto-sonic core drilling rig; 2) lithologic logging of the cores; 3) the construction of monitor wells in three of the drilled boreholes; 4) the collection of grab groundwater samples from the uppermost portion of the alluvial aquifer in each borehole not constructed as a well and the collection of a groundwater sample from each of the three monitor wells; 5) the submittal of the groundwater samples for chemical analyses; and 6) the abandonment of all boreholes not constructed as monitor wells. All field work was performed in accordance with the agency-approved Process Areas Work Plan, dated May 5, 2004, and subsequent written correspondence between ARC, the EPA and the BLM. Field work was also performed in accordance with the Site Health and Safety Plan (Brown and Caldwell, 2002), which has been revised as of May 2005 to reflect known occurrences of radioactive materials at the site. Results from all field activities are described in this section of the DSR, and copies of field notebooks are provided in Appendix A. Laboratory analytical results from borehole grab samples, and samples collected from the constructed monitor wells, are presented in Section 3.0.

Borehole and groundwater sample locations, and monitor well locations, were identified on the basis of: 1) current knowledge of groundwater flow conditions including potential background and down-gradient locations; 2) potential sources of COCs to soils and underlying groundwater; and 3) an even distribution of locations throughout the Process Areas. Figure 2-1 shows the locations of all planned and completed boreholes and monitor wells. As a result of not encountering groundwater to a depth of 210 feet below ground surface (bgs) and poor drilling conditions, as described below in Section 2.1, monitor well PA-MW1 was re-located from the southwest to the southeast side of the Process Areas.

2.1 Borehole Drilling and Logging

The hydrogeology of the vadose zone and shallow alluvial aquifer in the Process Areas was characterized using the roto-sonic core drilling method, which utilizes a vibrating drill head turning slowly to advance the core barrel. A Water Development Corporation (WDC) roto-sonic drilling rig was used to conduct the groundwater investigations. The rig used a five-inch diameter core barrel to collect core samples and advance the borehole. A six-inch diameter outer casing was utilized to stabilize loose material from falling into the borehole. The core barrel was vibrated and rotated into the formation and the cored material remained in place as the core barrel advanced, which prevented lithologic intervals from mixing vertically. No drilling fluid or air was used in the drilling, which minimizes potential contamination or stripping of volatile organics from samples.

The core was recovered at the surface and temporarily stored in plastic sleeves. The lithology of the core was described using ASTM Method D 2488, Description and Identification of Soils (Visual-Manual Procedure). Described intervals were selected based on field estimation of the grain-size distribution and the characteristics of the fine-grained portion of the sample. Detailed lithologic logs for all boreholes are presented in Appendix B.

Groundwater grab samples were collected from 23 of the 28 boreholes drilled. One of the boreholes did not encounter groundwater, and three of the boreholes were completed as monitor wells and sampled in accordance with the Quality Assurrance Project Plan ("QAPP") for the Yerington Mine Site (Brown and Caldwell, 2003a). Boreholes not completed as monitor wells were abandoned according to State and Federal regulations by refilling the holes with bentonite chips to within 10 feet of the surface and then topping with a 10 foot cement cap.

Borehole depths ranged between 97 and 210 feet bgs, and were drilled between 0.5 and 36 feet below the top of saturated alluvium. Table 2-1 summarizes borehole drilling information including ground surface elevation, total borehole depth and depth to groundwater (note that all surface elevation data is rounded to the nearest foot, including monitor well data that was surveyed to within 0.01 feet).

Table 2-1. Borehole Drilling Data

Borehole ID	Surface Elevation of Borehole (feet, amsl)	Total Depth of Borehole (feet)	Depth to Water (feet, bgs)
PA-MW1	4437	126	93
PA-MW2	4482	159	139
PA-MW3	4457	129.5	113
PA-GW1	4542	210	NA
PA-GW4	4468	128	125
PA-GW5	4477	143	133
PA-GW6	4466	139	124
PA-GW7	4466	127	123
PA-GW8	4467	134	127
PA-GW9	4465	139	124
PA-GW10	4465	135	120
PA-GW11	4458	135	115
PA-GW12	4439	99	99
PA-GW13	4496	167	152
PA-GW14	4488	152	122
PA-GW15	4476	138	136
PA-GW16	4476	144	135
PA-GW17	4456	154	118
PA-GW18	4455	130	116
PA-GW19	4432	117	112
PA-GW20	4436	99	98
PA-GW21	4420	97	81
PA-GW22	4437	109	96
PA-GW23	4444	114	104
PA-GW24	4466	129	126
PA-GW25	4436	119	96
PA-GW26	4446	115	105
PA-GW27	4440	109	106

The borehole drilled at the location intended for the construction of monitor well PA-MW1 (identified as PA-GW1 in Table 2-1) was selected as a potential background site that may not have been impacted from either the Process Areas or from the Arimetco solvent extraction and electro-winning facilities. This was the only borehole in the Process Areas area that: 1) did not encounter groundwater; and 2) encountered an unusually thick, dense and dry clay-rich formation (potential aquitard) that resulted in difficult drilling conditions. A field determination was made to abandon the borehole because drilling was extremely slow, the drill was over-

heating and no groundwater was encountered at depths well below the elevation where groundwater was tagged throughout the Process Areas. The final PA-MW1 location, shown in Figure 2-1, was also selected as a potential background site for groundwater conditions beneath the Process Areas.

2.2 Monitor Well Installation

Monitor wells PA-MW1, PA-MW2, and PA-MW3 were installed using the same sonic core rig used for drilling the boreholes. After the borehole designated as a monitor well location was drilled to the total depth, the outer casing was driven to the designed depth of the monitor well to stabilize the borehole during well installation. Two-inch nominal diameter PVC casing and screen were installed to the designed depths within the outer casing. Annular materials were installed by pouring the material between the well and the outer casing. Material depths were continuously measured to determine if the material bridged during installation. If materials bridged, the sonic head was applied to the outer casing to break the bridge. As the annulus was filled, the outer casing was pulled in an effort to keep the bottom of the outer casing no more than a few feet above the top of the fill interval.

The monitor wells were designed to include twenty feet of screen and installed so that the water level was approximately three to five feet below the top of the screen. The well screen and casing were constructed with Schedule 40 PVC, and the screen includes 0.020-inch wide mill slots. Filter pack materials included No. 3 Monterey Sand with a finer No. 60 Monterey Sand installed in the upper one-foot of the screen interval. Bentonite chips were installed from the top of the filter pack to ten feet bgs. Neat cement was installed from the ground surface to the top of the bentonite fill. A concrete pad and six-inch steel monument were installed to protect the well. Table 2-2 summarizes the monitor well construction data.

Table 2-2. Monitor Well Construction Data

	PA-MW1	PA-MW2	PA-MW3
Casing and Screen Type	2-inch SCH40 PVC	2-inch SCH40 PVC	2-inch SCH40 PVC
Screen Slot Size	0.020-inch	0.020-inch	0.020-inch
Screened Interval (feet, bgs)	90.5 – 110.5	134.5 – 154.5	109 – 129.5
Bottom of Sump (feet, bgs)	111	155	129.5
Neat Cement (feet, bgs)	0 - 10	0 - 10	0 – 10
Bentonite Chips (feet, bgs)	10 - 86	10 - 130	10 – 105
No. 60 Monterey Sand	86 - 87	130 - 131	105 - 106
No. 3 Monterey Sand	87 - 126	131 - 159	106 – 129.5

2.3 Surveying and Groundwater Elevation Measurements

All borehole locations were surveyed for X and Y coordinates using a Trimball GeoXT handheld GPS unit with an accuracy of one meter or less. The GPS unit has an integrated receiver that uses WAAS (Wide Area Augmentation System) correction messages to improve GPS accuracy. X and Y coordinates from the GPS unit are accurate to within approximately three feet. Ground surface elevations at each location were also recorded with the GPS unit, accurate to within 10 feet. However, for improved accuracy to +/- 1-foot, the ground surface elevations for all borehole locations were estimated from the 2-foot contour elevation map of the Yerington Mine Site and surrounding area, created in 2001 by Aero-Data Corp.

For the three completed monitor wells, the X and Y coordinates and elevations were surveyed on May 12, 2005 by Tri-State Surveying, and tied in to National Geodetic Survey (NGS) benchmark survey monuments. Groundwater elevation measurements in the monitor wells are accurate to within 0.01 feet.

Groundwater elevations at each borehole location were measured in open boreholes or temporary well screens using a manual water level probe prior to groundwater sample collection. Borehole groundwater elevations were calculated on the basis of the survey information described above and the depth-to-water measurements from the ground surface. In the case of the three monitor wells, depths to groundwater were measured on the basis of the Tri-State survey of the top of the PVC casing in each monitor well.

Calculated borehole groundwater elevations should be considered approximate because the potential for boreholes instabilities, and undeveloped temporary screens and wells used to collect water samples. Stability issues in open boreholes may have caused water levels to appear high if sloughed material raised the column of water in the borehole. Water levels measured in undeveloped temporary screens and wells may not reflect true static water levels.

Table 2-3 presents estimated groundwater elevations from the boreholes drilled in the Process Areas. As described above, the estimated groundwater elevations are accurate to within one foot, and are based on the 2-foot contour map of the site.

Table 2-3. Borehole Groundwater Elevation Data

Location	Date	Groundwater Elevation (feet, amsl)	Water Level (feet, bgs)
PA-GW4	11/4/2004	4343	125
PA-GW5	11/21/2004	4344	133
PA-GW6	1/5/2005	4342	124
PA-GW7	10/29/2004	4343	123
PA-GW8	11/2/2004	4340	127
PA-GW9	1/22/2005	4341	124
PA-GW10	11/8/2004	4345	120
PA-GW11	11/10/2004	4343	115
PA-GW12	12/18/2004	4341	99
PA-GW13	1/8/2005	4344	152
PA-GW14	2/3/2005	4366	122
PA-GW15	11/19/2004	4341	136
PA-GW16	11/18/2004	4341	135
PA-GW17	11/12/2004	4338	118
PA-GW18	1/23/2005	4339	116
PA-GW19	12/5/2004	4320	112
PA-GW20	12/1/2004	4338	98
PA-GW21	11/24/2004	4339	81
PA-GW22	11/22/2004	4341	96
PA-GW23	12/4/2004	4340	104
PA-GW24	11/16/2004	4340	126
PA-GW25	12/7/2004	4340	96
PA-GW26	12/14/2004	4341	105
PA-GW27	1/4/2005	4334	106

Table 2-4 summarizes the initial and subsequent depth-to-groundwater measurements, and groundwater elevation data, for each of the three monitor wells. Note that the measured depth to groundwater in the monitor wells has generally remained within one foot of the initial post-development measurement. As described above, the estimated groundwater elevations were surveyed to an accuracy of 0.01 feet, and reported to the nearest 0.1 feet.

Table 2-4. Monitor Well Groundwater Elevation Data

Location	Measurement Date	Water Elevation (feet, amsl)	Water Level (feet, bgs)
PA-MW1	2/5/2005	4344.3	93.0
PA-MW1	2/7/2005	4345.0	92.2
PA-MW1	3/8/2005	4344.7	92.6
PA-MW2	2/6/2005	4342.0	139.6
PA-MW2	2/9/2005	4342.4	139.2
PA-MW2	3/8/2005	4342.6	139.0
PA-MW3	2/5/2005	4343.6	113.4
PA-MW3	2/9/2005	4343.7	113.4
PA-MW3	3/8/2005	4344.1	113.0

2.4 Process Areas Hydrogeology

Based on the geologic setting, the logging of borehole lithology and the groundwater elevation measurements described above, the hydrogeology of the Process Areas is described as follows. The portion of the alluvial fan underlying the Process Area is comprised of relatively fine-grained mud-flow deposits and relatively coarse-grained water-laid deposits. The mud-flow deposits generally include 50 percent silt and clay, with between 30 and 50 percent sand and between zero and 20 percent gravel. Water-laid deposits are generally moderately sorted and include sands and gravels with variable amounts of silt- and clay-size fractions. The water-laid deposits are interpreted as channel deposits generally comprised of silts and sands, sands with minor amounts of non-plastic fine-grained materials, and clay-rich sands with plastic fine-grained materials.

Six hydrogeologic cross-sections were developed to illustrate the generalized structure of the alluvial fan beneath the Process Areas, based on the borehole lithologic logs presented in Appendix B. A cross-section location map showing borehole locations is presented in Figure 2-2. Cross-sections are included as Figures 2-3 through 2-8. Cross-sections A-A', B-B', and C-C' trend north-northeast and are generally parallel to the slope of the fan. Cross-sections D-D', E-E' and F-F' trend northwest and are created perpendicular to the slope of the fan.

Mud-flow deposits are shown as the fine-grained intervals and water-laid channel deposits are shown as coarse-grained intervals on the cross-sections. The coarser-grained water-laid deposits appear to have been deposited in a braided channel environment, with channels cut into the finer-grained mud-flow deposits (apparent well-developed channels are depicted in cross-sections B-B' and C-C'). The continuity of these channel deposits beneath the Process Areas cannot be determined from the available geologic information.

The thickness and lateral extent of the water-laid channel deposits can be observed in cross-sections D-D', E-E' and F-F'. Most channel deposits are between three and ten feet thick, and are not shown to be laterally extensive because they were likely deposited in a braided steam environment that meandered across the fan. However, localized channel deposits between 10 and 30 feet thick may be more laterally continuous than thinner deposits, as encountered in boreholes PA-GW17 and PA-GW19.

The hydrogeologic cross sections (Figures 2-3 through 2-8) depict the depth to groundwater relative to the fine- and coarse-grained alluvial fan deposits. As shown on the groundwater elevation map presented in Figure 2-9, groundwater beneath the Process Areas was generally encountered at elevations between 4,345 and 4,338 feet amsl. The groundwater elevation measurements from the three monitor wells PA-MW1, PA-MW2 and PA-MW3 are presented to the nearest 0.1 feet, and should be relied upon more heavily than the borehole measurements that, at best, would only be as accurate as the 2-foot contour interval topographic map base. In addition, the borehole groundwater elevation measurements were obtained when drilling and sampling may have created unstable conditions.

The general trend of decreasing groundwater elevations to the north or northwest, measured beneath the Process Areas during the field investigations, is consistent with the groundwater contour map presented in the Draft Final Groundwater Conditions Work Plan (Figure 10B; Brown and Caldwell, 2003b). Note that three locations appear to vary from the typical range of groundwater elevations (between 4,345 and 4,338 feet amsl) observed for the Process Areas: 1) the borehole drilled at the original location for PA-MW1 did not encounter groundwater at the total depth of the borehole, 210 feet bgs; 2) the groundwater elevation from borehole PA-GW19 appears to be lower than the range at 4,320 feet amsl; and 3) the groundwater elevation from borehole PA-GW14 appears to be higher than the range at 4,366 feet amsl. These deviations from the general range of groundwater elevations likely result from the complex depositional structure of the alluvial fan beneath the Process Areas. Based on the observed lithologic character of the two types of deposits, the channel deposits appear to be more transmissive than the mud-flow deposits.

2.5 Borehole and Monitor Well Groundwater Sampling

Grab samples were collected from 23 boreholes after they were drilled to total depth utilizing three methods. For stable boreholes, a bailer was used to sample groundwater from the open borehole. If borehole instability was encountered, a 2-foot long temporary PVC screen was installed using the drill rods as casing, and samples were collected with a bailer, 1.5 inch bladder pump or 1.5-inch Grundfos submersible pump. The temporary screen was often driven below the bottom of the drilled borehole using a hydro-punch tool. Unlike the sample collection procedure from properly constructed monitor wells, the boreholes were not developed prior to the collection of grab samples.

Groundwater samples from the three monitor wells were collected in accordance with the Yerington Mine Site QAPP (Brown and Caldwell, 2003). The methods of groundwater sample collection and sample conditions from the boreholes and from monitor wells are summarized in Table 2-5. Decontamination procedures for borehole sampling included the use of disposable bailers and rinsing of drilling equipment with Alconox soap.

Table 2-5. Groundwater Sample Methods

Borehole ID	Total Depth of Borehole (feet, amsl)	Sample Date	Sample Type	Depth to Water (feet, bgs)	Depth to Bottom of Sample Interval (feet, bgs)	Ground-water Sample Method	Comment
PA-MW1	126	2/7/05	Regular	92	110	B	After development.
PA-MW2	159	2/9/05	Regular	139	154	B	After development.
PA-MW3	129	2/9/05	Regular	113	129	B	After development.
PA-GW4	128	11/4/04	Grab	125	154	TS/B	Temporary screen to 154 feet.
PA-GW5	143	11/21/04	Grab	133	138	OB/B	
PA-GW6	139	1/5/05	Grab	124	130	OB/B	
PA-GW7	127	10/29/04	Grab	123	127	OB/B	
PA-GW8	134	11/2/04	Grab	127	134	OB/B	
PA-GW9	139	1/22/05	Grab	124	150	TW/P	Temporary well to 150 feet.
PA-GW10	135	11/8/04	Grab	120	135	OB/B	
PA-GW11	135	11/10/04	Grab	115	120	TS/B	Temporary screen to 120 feet.
PA-GW12	99	12/18/04	Grab	99	109	TS/B	Temporary screen to 109 feet.
PA-GW13	167	1/8/05	Grab	152	157	TS/B	Temporary screen to 157 feet.
PA-GW14	152	2/4/05	Grab	122	150	TW/B	Temporary well to 150 feet.
PA-GW15	138	11/19/04	Grab	13	138	OB/B	
PA-GW16	144	11/18/04	Grab	135	144	OB/B	
PA-GW17	154	11/12/04	Grab	118	130	TS/B	Temporary screen to 130 feet.
PA-GW18	130	1/23/05	Grab	116	130	TW/P	Temporary well to 130 feet.
PA-GW19	117	12/5/04	Grab	112	117	OB/B	
PA-GW20	99	12/1/04	Grab	98	110	TS/BP	Temporary screen to 110 feet.
PA-GW21	97	11/24/04	Grab	81	97	TS/B	Temporary screen to 97 feet.
PA-GW22	109	11/22/04	Grab	96	109	OB/B	
PA-GW23	114	12/4/04	Grab	104	119	TS/B	Temporary screen to 119 feet.
PA-GW24	129	11/16/04	Grab	126	130	OB/B	
PA-GW25	119	12/7/04	Grab	96	116	TS/B	Temporary screen to 116 feet.
PA-GW26	115	12/14/04	Grab	105	115	TS/B	Temporary screen to 115 feet.
PA-GW27	109	1/4/05	Grab	106	109	OB/B	

Notes:

B - Bailer
OB/B = Open Borehole/Bailer
TS/B = Temp. Screen/Bailer
TW/P = Temp. Well/Pump
TS/BP = Temp. Screen / Bailer & Pump

SECTION 3.0
SUMMARY OF ANALYTICAL RESULTS

Groundwater quality in the alluvial aquifer beneath the Process Areas was evaluated by laboratory analyses of borehole and monitor well samples collected from the 27 locations shown in Figure 2-1. All samples were analyzed for potential COCs including metals, radionuclides, water chemistry, volatile organics, semi-volatile organics, pesticides, herbicides, and PCBs. Concentrations of analytes above laboratory detection limits and/or above EPA maximum contaminant levels ("MCLs") are identified and described in this Section. Background concentrations of tested constituents have not been established for the Yerington Mine Site, including the Process Areas. Therefore, it is not possible at this time to make a comparison of the analytical results from the groundwater samples to background concentrations. However, the relatively low concentrations of all constituents analyzed in the groundwater sample collected from PA-MW1 may reflect ambient groundwater conditions relative to the Process Areas.

The analyses were completed by Sequoia Analytical Laboratories (Morgan Hill, California), Energy Laboratories (Casper, Wyoming), and NEL Laboratories (Las Vegas, Nevada). Summary tables of all analytical data results are provided in Appendix C and original laboratory data reports are provided electronically in Appendix D.

3.1 Metals

Table 3-1 summarizes the analytical results for metals including minimum and maximum detected concentrations, number and frequency of detections, and the number and frequency of samples that exceed MCLs. This section discusses specific metals that exceed primary MCLs and/or appear to occur within specific portions of the Process Areas at elevated concentrations.

Table 3-1. Summary of Metals Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
Aluminum	Yes	mg/L	< 0.013	40.6	920	NA	27	6	NA	22%	NA
Antimony	Yes	µg/L	< 0.087	0.56	2.6	6	27	15	NA	56%	NA
Arsenic	Yes	µg/L	0.57	8.9	70	10	27	27	5	100%	19%
Barium	Yes	µg/L	19	244.2	1900	2000	27	27	NA	100%	NA
Beryllium	Yes	µg/L	< 0.037	2.2	24	4	27	8	4	30%	15%
Boron	Yes	mg/L	0.32	1.8	3.7	NA	27	27	NA	100%	NA
Cadmium	Yes	µg/L	< 0.018	0.98	18	5	27	11	1	41%	4%
Calcium	Yes	mg/L	46	229.6	680	NA	27	27	NA	100%	NA
Chromium, Total	Yes	µg/L	0.56	28.6	390	100	27	27	2	100%	7%
Cobalt	Yes	µg/L	0.59	75.9	1400	NA	27	27	NA	100%	NA
Copper	Yes	µg/L	1	130.6	1300	1300	27	27	NA	100%	NA
Iron	Yes	mg/L	< 0.004	105.5	1400	NA	27	23	NA	85%	NA
Lead	Yes	µg/L	< 0.023	4.7	67	150	27	11	NA	41%	NA
Magnesium	Yes	mg/L	7.4	117.8	800	NA	27	27	NA	100%	NA
Manganese	Yes	µg/L	130	4483.3	54000	NA	27	27	NA	100%	NA
Mercury	Yes	µg/L	< 0.025	0.08	0.96	2	19	7	NA	37%	NA
Molybdenum	Yes	µg/L	11	109.6	1000	NA	27	27	NA	100%	NA
Nickel	Yes	µg/L	1.8	69.2	1100	100	27	27	3	100%	11%
Potassium	Yes	mg/L	5.4	19.1	130	NA	27	27	NA	100%	NA
Selenium	Yes	µg/L	1.1	25.2	290	50	27	27	3	100%	11%
Silver	Yes	µg/L	< 0.018	0.13	2.5	NA	27	6	NA	22%	NA
Sodium	Yes	mg/L	52	278.7	530	NA	27	27	NA	100%	NA
Thallium	Yes	µg/L	< 0.016	0.13	1.5	2	27	16	NA	59%	NA
Vanadium	Yes	µg/L	0.26	29.0	340	NA	27	27	NA	100%	NA
Zinc	Yes	µg/L	< 1.6	180.1	3700	NA	27	19	NA	70%	NA

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

Each of the metals described below either exceed an MCL or occur at a notable concentration within the Process Areas. A figure designation is provided for selected metals with concentrations of importance to understanding groundwater conditions beneath the Process Areas.

Aluminum

Aluminum was detected in 6 out of 27 samples. The average concentration is 40.6 mg/L and the maximum concentration is 920 mg/L. The sample with the highest concentration of aluminum is PA-GW4 (920 mg/L) and the next highest results are GW8 (76 mg/L) and GW7 (76 mg/L). This group of samples is located in the vicinity of the Truck Shop with elevated levels extending from GW4 on the south to GW8 to the north. The EPA has not established a primary MCL for aluminum.

Arsenic (Figure 3-1)

Arsenic was detected in all samples with an average concentration of 8.9 ug/L, and a maximum concentration of 70 ug/L from PA-GW4. As of January 2006, the MCL for arsenic will be 10 ug/L. Five samples exceeded the new MCL: PA-GW4, GW7, GW8, GW5 and MW2. PW-GW4, 5, 7,and 8 are located adjacent to each other on the south side of the Process Area located near the Maintenance and Truck Shop buildings indicating a potential contaminant source located near or south of location PA-GW4.

Barium

Barium was detected in all samples with an average concentration of 244 ug/L, and a maximum concentration of 1,900 ug/L. No samples exceeded the MCL of 2,000 ug/L. The highest concentrations of barium in groundwater were found in samples PA-GW4, GW8 and GW7.

Beryllium (Figure 3-2)

Beryllium was detected in 8 out of 27 samples with an average concentration of 2.2 ug/L and a maximum concentration of 24 ug/L. The MCL for beryllium is 4 ug/L, which was exceeded by four samples (PA-GW4 and 7 near the Maintenance and Truck Shop buildings and PA-GW23 and GW18 on the north side of the Process Area near the Iron Launders.

Cadmium (Figure 3-3)

Cadmium was detected in 11 out of 27 samples with an average concentration of 0.98 ug/L and a maximum concentration of 18 ug/L. The MCL for cadmium is 5 ug/L, which was exceeded from one borehole location (PA-GW23).

Chromium, total (Figure 3-4)

Chromium was detected in all samples with an average concentration of 28.6 ug/L and a maximum of 390 ug/L. Two samples located near the Truck Shop (PA-GW4 at 390 ug/L and GW7 at 110 ug/L) exceeded the 100 ug/L MCL.

Cobalt (Figure 3-5)

Cobalt was detected in all samples with an average concentration of 76 ug/L and a maximum of 1,400 ug/L (PA-GW23). Three samples exhibited elevated cobalt concentrations: PA-GW23 (1,400 ug/L) and PA-GW18 (150 ug/L), located on the north side of the Process Areas, and PA-GW4 (180 ug/L) located on the south side of the Process Areas.

Copper

Copper was detected in all samples with an average of 130 ug/L and a maximum concentration of 1,300 ug/L (PA-GW7, located near the Truck Shop). The MCL for copper is 1,300 ug/L.

Iron (Figure 3-6)

Iron was detected in 23 out of 27 samples with an average concentration of 105 mg/L and a maximum concentration of 1,400 mg/L. The sample locations with the highest values for iron were PA-GW23 (1,400 mg/L) and GW4 (1,100 mg/L).

Lead

Lead was detected in 11 out of 27 samples, but did not exceed the 150 ug/L MCL at any location. The average concentration was 4.7 ug/L, and the maximum was 67 ug/L from PA-GW4.

Magnesium (Figure 3-7)

Magnesium was detected at all sample locations with an average concentration of 118 mg/L and a maximum of 800 mg/L. A group of sample locations on the north end of the Process Areas near the Iron Launders exhibited the following elevated concentrations: PA-GW20 (800 mg/L), GW23 (350 mg/L), and GW18 (320 mg/L). Two other locations exhibited elevated concentrations: PA-GW4 (390 mg/L) located south of the maintenance buildings, and PA-GW24 (390 mg/L) located adjacent to the Sulfide Plant storage and thickener tanks.

Manganese (Figure 3-8)

Manganese was detected in all 27 samples with an average concentration of 4,483 ug/L and a maximum of 54,000 ug/L. The two highest concentrations occurred at PA-GW23 (54,000 ug/L) and GW4 (15,000 ug/L).

Mercury

Mercury was detected in 7 of 19 samples. A laboratory error resulted in no mercury analysis from 8 submitted samples (the error was not detected until the 14-day holding time expired). The average concentration was 0.08 ug/L and the maximum was 0.96 ug/L. No samples exceeded the MCL of 2 ug/L.

Nickel (Figure 3-9)

Nickel was detected in all samples with an average concentration of 69 ug/L and a maximum concentration of 1,100 ug/L (the primary MCL is 100 ug/L). Sample locations PA-GW23 (1100 ug/L), GW4 (180 ug/L) and GW7 (100 ug/L) exhibited the highest concentrations.

Selenium (Figure 3-10)

Selenium was detected in all samples with an average concentration of 25 ug/L and a maximum of 280 ug/L. Samples from PA-GW16 (280 ug/L), GW13 (83 ug/L) and GW21 (56 ug/L) exceeded the MCL of 50 ug/L.

Thallium

Thallium was detected in 16 out of 27 samples but none of the samples exceeded the established MCL of 2 ug/L. The maximum concentration of thallium was 1.5 ug/L in sample PA-GW4.

Vanadium

Vanadium was detected in all samples with an average concentration of 29 ug/L and a maximum concentration of 340 ug/L (there is no MCL for vanadium). PA-GW4 (340 ug/L), GW7 (180 ug/L), and GW8 (130 ug/L) exhibited the highest concentrations.

Zinc (Figure 3-11)

Zinc was detected in 19 out of 27 samples with an average concentration of 180 ug/L and a maximum of 3,700 ug/L. PA-GW23 (3,700 ug/L) and GW4 (420 ug/L) exhibited the highest concentrations. There is no established MCL for zinc.

Summary

Metals with one or more analytical results that exceed a primary MCL include: arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), nickel (Ni) and selenium (Se). The analytical results described above, and summarized in Table 3-1, indicates that past operations have resulted in localized impacts to groundwater. For example: 1) the southern portion of the Process Areas exhibits elevated metals concentrations, typically highest in sample PA-GW4 and decreasing northward to locations PA-GW7 and GW8; and 2) elevated metals concentrations within the north-central portion of the Process Areas (directly north of the Iron Launder Precipitation Tanks and oriented in a generally north-south direction) occur at location PA-GW23, GW18 and GW20.

3.2 Radionuclides

Table 3-2 summarizes the analytical results for radionuclides including minimum and maximum detected concentrations, number and frequency of detections, and the number and frequency of samples exceeding MCLs. In general, no correlation between Uranium, Thorium and Radium-226/228 existed within individual samples.

Table 3-2. Summary of Radionuclide Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
Uranium	Yes	mg/L	0.0003	0.10	0.81	0.03	27	27	15	100%	56%
Thorium-232	Yes	mg/L	< 0.001	0.002	0.025	NA	27	4	NA	15%	NA
Radium-226	Yes	pCi/L	< 0.2	0.44	3.8	5	27	9	NA	33%	NA
Radium-228	Yes	pCi/L	< 1	1.17	6.2	5	27	5	3	19%	11%

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

Uranium (Figure 3-12)

Uranium was detected in all of the 27 samples collected with an average concentration of 0.1 mg/L and a maximum concentration of 0.81 mg/L (PA-GW18). 15 out of 27 samples in the Process Areas exceeded the MCL of 0.030 mg/L. The highest concentration occurred in five samples located on the north end of the Process Areas (north of the Iron Launders and the "Radiation Control Area") in samples PA-GW18 (0.810 mg/L), GW20 (0.282 mg/L), GW19 (0.242 mg/L), GW21 (0.210 mg/L) and GW23 (0.184 mg/L).

Thorium (Figure 3-13)

Thorium was detected in 4 out of 27 samples, and the maximum concentration of 0.025 mg/L was found at location PA-GW4. No MCL has been established for Thorium.

Radium-226/Radium-228 (Figure 3-14)

Of the 27 samples collected, Radium-226 was detected in 9 samples and Radium-228 was detected in 5 samples (the two isotopes of radium were analyzed separately). Three samples (PA-GW4, GW11 and GW10) exceeded the combined Ra-226/228 MCL of 5 pCi/L.

3.3 Water Chemistry

Water chemistry analysis include determination of hardness (as CaCO3), pH, sulfate (as SO4), and total dissolved solids (TDS). Variations in water chemistry may also be used to determine potential contamination of an aquifer and possibly to aid in the determination of the source.

Table 3-3 summarizes the data results for water chemistry analysis, and analytical results for TDS and sulfate are depicted in Figure 3-15.

Table 3-3. Summary of Water Chemistry Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
Hardness (As CaCO3)	Yes	mg/L	160	2,141	26,000	NA	27	27	NA	100%	NA
pH	Yes	pH Units	5.95	7.32	7.99	NA	27	27	NA	100%	NA
Sulfate (As SO4)	Yes	mg/L	6.9	1,132	5,300	NA	27	27	NA	100%	NA
Total Dissolved Solids	Yes	mg/L	440	2,266	8,400	NA	27	27	NA	100%	NA

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

Elevated sulfate and TDS occur on the north end of the Process Area, at locations PA-GW18, GW19, GW20, GW21, GW23, GW24 and GW25 (concentrations at the north end of the Process Areas appear to be 2 to 4 times greater than the average of all Process Area samples.

3.4 Volatile Organic Compounds

A total of 56 volatile organic compounds (VOCs) were analyzed in groundwater samples from all 27 Process Areas locations. Of the 56 compounds, 23 were detected above laboratory detection limits, and only 2 exceeded MCLs. These occurrences were from sample locations PA-GW7, GW10, GW11 and GW26. Table 3-4 summarizes the VOC analytical data.

Table 3-4. Summary of Volatile Organic Compound (VOC) Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
1,1,1,2-Tetrachloroethane	---	µg/L	< 0.087	0.09	< 0.087	NA	27	0	NA	0%	NA
1,1,1-Trichloroethane	---	µg/L	< 0.092	0.09	< 0.092	200	27	0	NA	0%	NA
1,1,2,2-Tetrachloroethane	---	µg/L	< 0.26	0.26	< 2.6	NA	27	0	NA	0%	NA
1,1,2-Trichloroethane	Yes	µg/L	< 0.054	0.12	1.9	5	27	2	NA	7%	NA
1,1-Dichloroethane	---	µg/L	< 0.21	0.20	< 2.1	NA	27	0	NA	0%	NA
1,1-Dichloroethene	Yes	µg/L	< 0.13	0.18	0.46	7	27	5	NA	19%	NA
1,1-Dichloropropene	---	µg/L	< 0.11	0.11	< 1.1	NA	27	0	NA	0%	NA
1,2,3-Trichlorobenzene	Yes	µg/L	< 0.12	0.14	1.2	NA	27	1	NA	4%	NA
1,2,3-Trichloropropane	---	µg/L	< 0.083	0.08	< 0.083	NA	27	0	NA	0%	NA
1,2,4-Trichlorobenzene	---	µg/L	< 0.23	2.38	< 26	70	27	0	NA	0%	NA
1,2,4-Trimethylbenzene	Yes	µg/L	< 0.11	3.48	64	NA	27	6	NA	22%	NA
1,2-Dibromo-3-Chloropropane	---	µg/L	< 0.41	0.40	< 4.1	0.2	27	0	NA	0%	NA
1,2-Dibromoethane (Ethylene Dibromide)	Yes	µg/L	< 0.19	0.20	0.45	NA	27	1	NA	4%	NA
1,2-Dichlorobenzene	---	µg/L	< 0.076	2.30	< 26	NA	27	0	NA	0%	NA
1,2-Dichloroethane	Yes	µg/L	< 0.093	3.66	77	5	27	6	3	22%	11%
1,2-Dichloropropane	Yes	µg/L	< 0.06	0.08	0.9	5	27	1	NA	4%	NA
1,3,5-Trimethylbenzene (Mesitylene)	Yes	µg/L	< 0.088	0.99	19	NA	27	4	NA	15%	NA
1,3-Dichlorobenzene	---	µg/L	< 0.082	2.42	< 27	NA	27	0	NA	0%	NA
1,3-Dichloropropane	---	µg/L	< 0.076	0.07	< 0.76	NA	27	0	NA	0%	NA
1,4-Dichlorobenzene	---	µg/L	< 0.098	2.32	< 26	NA	27	0	NA	0%	NA
2,2-Dichloropropane	---	µg/L	< 1.5	1.47	< 15	NA	27	0	NA	0%	NA
2-Chlorotoluene	---	µg/L	< 0.05	0.05	< 0.5	NA	27	0	NA	0%	NA
4-Chlorotoluene	---	µg/L	< 0.086	0.08	< 0.86	NA	27	0	NA	0%	NA
Benzene	Yes	µg/L	< 0.064	39.2	660	5	27	17	5	63%	19%
Bromobenzene	---	µg/L	< 0.09	0.09	< 0.9	NA	27	0	NA	0%	NA
Bromochloromethane	---	µg/L	< 0.089	0.09	< 0.89	NA	27	0	NA	0%	NA
Bromodichloromethane	---	µg/L	< 0.15	0.15	< 1.5	NA	27	0	NA	0%	NA
Bromoform	---	µg/L	< 0.13	0.13	< 1.3	NA	27	0	NA	0%	NA
Bromomethane	---	µg/L	< 0.2	0.23	< 2.0	NA	27	0	NA	0%	NA

NA – Not applicable, No MCL established

[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

Table 3-4. Summary of Volatile Organic Compound (VOC) Analyses - Continued

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
Carbon Tetrachloride	Yes	µg/L	< 0.069	0.10	0.8	5	27	3	NA	11%	NA
Chlorobenzene	---	µg/L	< 0.065	0.06	< 0.65	100	27	0	NA	0%	NA
Chloroethane	Yes	µg/L	< 0.22	0.22	0.24	NA	27	1	NA	4%	NA
Chloroform	Yes	µg/L	< 0.12	0.26	1.8	NA	27	8	NA	30%	NA
Chloromethane	---	µg/L	< 0.26	0.26	< 2.6	NA	27	0	NA	0%	NA
cis-1,2-Dichloroethylene	---	µg/L	< 0.075	0.07	< 0.75	70	27	0	NA	0%	NA
Dibromochloromethane	---	µg/L	< 0.089	0.09	< 0.89	5	27	0	NA	0%	NA
Dibromomethane	---	µg/L	< 0.099	0.10	< 0. 99	NA	27	0	NA	0%	NA
Dichlorodifluoromethane	---	µg/L	< 0.11	0.11	< 1.1	NA	27	0	NA	0%	NA
Ethylbenzene	Yes	µg/L	< 0.087	1.6	40	700	27	4	NA	15%	NA
Hexachlorobutadiene	---	µg/L	< 0.21	2.58	< 2.8	NA	27	0	NA	0%	NA
Isopropylbenzene (Cumene)	Yes	µg/L	< 0.064	0.34	5.3	NA	27	3	NA	11%	NA
Methylene Chloride	Yes	µg/L	< 0.056	0.22	1.6	NA	27	5	NA	19%	NA
Naphthalene	Yes	µg/L	< 0.08	5.26	56	NA	27	3	NA	11%	NA
n-Butylbenzene	---	µg/L	< 0.15	0.15	< 1.5	NA	27	0	NA	0%	NA
n-Propylbenzene	---	µg/L	< 0.097	0.42	< 8.6	NA	27	1	NA	4%	NA
p-Cymene (p-Isopropyltoluene)	Yes	µg/L	< 0.079	0.17	2.5	NA	27	1	NA	4%	NA
sec-Butylbenzene	---	µg/L	< 0.09	0.09	< 0.9	NA	27	0	NA	0%	NA
Styrene	Yes	µg/L	< 0.11	0.32	4.4	100	27	4	NA	15%	NA
T-Butylbenzene	---	µg/L	< 0.07	0.07	< 0.7	NA	27	0	NA	0%	NA
Tetrachloroethylene(PCE)	Yes	µg/L	< 0.12	0.46	3.7	5	27	11	NA	41%	NA
Toluene	Yes	µg/L	< 0.66	18.4	280	1000	27	22	NA	81%	NA
Trans-1,2-Dichloroethene	---	µg/L	< 0.074	0.07	< 0.74	100	27	0	NA	0%	NA
Trichloroethene (TCE)	Yes	µg/L	< 0.12	0.31	1.5	5	27	7	NA	26%	NA
Trichlorofluoromethane	---	µg/L	< 0.12	0.12	< 1.2	NA	27	0	NA	0%	NA
Vinyl Chloride	---	µg/L	< 0.12	0.12	< 1.2	2	27	0	NA	0%	NA
Xylenes, Total	Yes	µg/L	< 0.36	20.9	380	10000	27	5	NA	19%	NA

NA – Not applicable, No MCL established

[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

1,2,4-Trimethylbenzene (Figure 3-16)

This VOC was detected in 6 out of 27 sample locations with an average concentration of 3.5 ug/L, and a maximum concentration of 64 ug/L. The three highest concentrations of this compound were found in PA-GW10 (64 ug/L), GW11 (18 ug/L) and GW7 (9.8 ug/L). There is no MCL for this compound.

1,2-Dichloroethane (Figure 3-16)

This VOC was detected in 6 out of 27 locations, and exceeded the 5.0 ug/L MCL at two locations: PA-GW10 (77 ug/L) and GW26 (15 ug/L). The average concentration is 3.7 ug/L and the maximum is 77 ug/L.

1,3,5-Trimethylbenzene (Mesitylene; Figure 3-16)

This VOC was detected in 4 out of 27 locations, with an average concentration of 1.0 ug/L and a maximum of 19 ug/L. There is no MCL for this compound.

Benzene (Figure 3-16)

This VOC was detected in 17 out of 27 locations, and exceeded the 5.0 ug/L MCL at four locations. The average concentration was 39.2ug/L, and the maximum value was 660 ug/L. The four samples that exceed the MCL include PA-GW10 (660 ug/L), GW26 (200 ug/L), GW11 (160 ug/L) and GW7 (35 ug/L).

Isopropylbenzene (Cumene); (Figure 3-16)

This VOC was detected in 3 of 27 locations with an average concentration of 0.3 ug/L and a maximum value of 5.3 ug/L. The three samples locations include PA-GW10 (5.3 ug/L), GW11 (1.8 ug/L) and GW7 (0.72 ug/L).

Naphthalene (Figure 3-16)

This VOC was detected in 3 of 27 locations and has an average concentration of 5.26 ug/L and a maximum of 56 ug/L. The three samples locations include PA-GW10 (56 ug/L), GW11 (27 ug/L), and GW7 (26 ug/L).

Summary

The six volatile organic compounds listed above are aromatic compounds commonly found in fuel or solvents, and were identified in the area north and northwest of former above-ground fuel storage tanks. The sites include PA-GW10, GW11, GW7 and GW26 also included underground piping that connected the tanks to a fueling station. Benzene was identified as the compound with the greatest number of detectable quantities and with the highest concentrations.

3.5 Semi-Volatile Organic Compounds

Of the 66 semi-volatile organic compounds (SVOCs) analyzed, only eight compounds were found to exceed laboratory detection limits. None of the sample results exceeded MCLs. Table 3-5 summarizes the SVOC analytical data.

Table 3-5. Summary of Semi-Volatile Organic Compound (SVOC) Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
1,2,4-Trichlorobenzene	---	µg/L	< 0.23	1.3	< 7.5	NA	27	0	NA	0%	NA
1,2-Dichlorobenzene	---	µg/L	< 0.076	1.2	< 7.3	NA	27	0	NA	0%	NA
1,3-Dichlorobenzene	---	µg/L	< 0.082	1.2	< 7.8	NA	27	0	NA	0%	NA
1,4-Dichlorobenzene	---	µg/L	< 0.098	1.2	< 7.4	NA	27	0	NA	0%	NA
2,4,5-Trichlorophenol	---	µg/L	< 1.4	0.9	< 6.8	NA	27	0	NA	0%	NA
2,4,6-Trichlorophenol	---	µg/L	< 1	0.7	< 5.1	NA	27	0	NA	0%	NA
2,4-Dichlorophenol	---	µg/L	< 1	0.7	< 5.2	NA	27	0	NA	0%	NA
2,4-Dimethylphenol	---	µg/L	< 5.2	3.4	< 26	NA	27	0	NA	0%	NA
2,4-Dinitrophenol	---	µg/L	< 4	2.6	< 20	NA	27	0	NA	0%	NA
2,4-Dinitrotoluene	---	µg/L	< 1	0.6	< 5	NA	27	0	NA	0%	NA
2,6-Dinitrotoluene	---	µg/L	< 2	1.3	< 9.9	NA	27	0	NA	0%	NA
2-Chloronaphthalene	---	µg/L	< 3	1.9	< 15	NA	27	0	NA	0%	NA
2-Chlorophenol	---	µg/L	< 1.4	0.9	< 7.3	NA	27	0	NA	0%	NA
2-Methylnaphthalene	Yes	µg/L	< 3.5	5.3	54	NA	27	4	NA	15%	NA
2-Methylphenol (o-Cresol)	Yes	µg/L	< 1.1	0.7	1.3	NA	27	1	NA	4%	NA
2-Nitroaniline	---	µg/L	< 2	1.3	< 9.8	NA	27	0	NA	0%	NA
2-Nitrophenol	---	µg/L	< 2.1	1.3	< 10	NA	27	0	NA	0%	NA
3,3'-Dichlorobenzidine	---	µg/L	< 27	16.7	< 130	NA	27	0	NA	0%	NA
3-Nitroaniline	---	µg/L	< 68	42.2	< 330	NA	27	0	NA	0%	NA
4,6-Dinitro-2-Methylphenol	---	µg/L	< 2.7	1.7	< 13	NA	27	0	NA	0%	NA
4-Bromophenyl Phenyl Ether	---	µg/L	< 1.8	1.1	< 8.4	NA	27	0	NA	0%	NA
4-Chloro-3-Methylphenol	---	µg/L	< 1.8	1.1	< 8.6	NA	27	0	NA	0%	NA
4-Chloroaniline	---	µg/L	< 26	16.1	< 120	NA	27	0	NA	0%	NA
4-Chlorophenyl Phenyl Ether	---	µg/L	< 1.5	0.9	< 7.1	NA	27	0	NA	0%	NA
4-Methylphenol (p-Cresol)	Yes	µg/L	< 1.9	1.5	12	NA	27	1	NA	4%	NA
4-Nitroaniline	---	µg/L	< 2.6	1.6	< 13	NA	27	0	NA	0%	NA
4-Nitrophenol	---	µg/L	< 3.2	2.0	< 15	NA	27	0	NA	0%	NA
Acenaphthene	---	µg/L	< 2.4	1.5	< 12	NA	27	0	NA	0%	NA
Acenaphthylene	---	µg/L	< 2.6	1.6	< 12	NA	27	0	NA	0%	NA
Anthracene	---	µg/L	< 2.4	1.5	< 12	NA	27	0	NA	0%	NA
Benzo(a)Anthracene	---	µg/L	< 1.3	0.8	< 6.1	NA	27	0	NA	0%	NA
Benzo(a)Pyrene	---	µg/L	< 2.2	1.4	< 11	0.2	27	0	NA	0%	NA
Benzo(b)Fluoranthene	---	µg/L	< 2.2	1.4	< 11	NA	27	0	NA	0%	NA
Benzo(g,h,i)Perylene	---	µg/L	< 6.2	3.9	< 30	NA	27	0	NA	0%	NA
Benzo(k)Fluoranthene	---	µg/L	< 2.7	1.7	< 13	NA	27	0	NA	0%	NA
Benzoic Acid	---	µg/L	< 6.1	3.8	< 29	NA	27	0	NA	0%	NA
Benzyl Alcohol	Yes	µg/L	< 1.7	1.3	5.5	NA	27	1	NA	4%	NA
Benzyl Butyl Phthalate	---	µg/L	< 2.4	1.5	< 12	NA	27	0	NA	0%	NA
bis(2-Chloroethoxy) Methane	---	µg/L	< 2.1	1.3	< 10	NA	27	0	NA	0%	NA

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

Table 3-5. Summary of Semi-Volatile Organics (SVOC) Analyses - Continued

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
bis(2-Chloroethyl)Ether(2-Chloroethyl Ether)	---	µg/L	< 1.3	0.8	< 6.2	NA	27	0	NA	0%	NA
bis(2-Chloroisopropyl) Ether	---	µg/L	< 1.7	1.1	< 8.3	NA	27	0	NA	0%	NA
bis(2-Ethylhexyl) Phthalate	Yes	µg/L	< 2.6	10.9	170	NA	27	10	NA	37%	NA
Carbazole	---	µg/L	< 5	3.1	< 24	NA	27	0	NA	0%	NA
Chrysene	---	µg/L	< 1.1	0.7	< 5.3	NA	27	0	NA	0%	NA
Dibenz(a,h)Anthracene	---	µg/L	< 4.1	2.6	< 20	NA	27	0	NA	0%	NA
Dibenzofuran	---	µg/L	< 1.6	1.0	< 7.8	NA	27	0	NA	0%	NA
Diethyl Phthalate	---	µg/L	< 1.9	1.5	< 9.3	NA	27	0	NA	0%	NA
Dimethyl Phthalate	---	µg/L	< 2.3	1.4	< 11	NA	27	0	NA	0%	NA
Di-n-Butyl Phthalate	Yes	µg/L	< 1.9	1.6	7.2	NA	27	4	NA	15%	NA
Di-n-Octylphthalate	---	µg/L	< 2.9	1.8	< 14	NA	27	0	NA	0%	NA
Fluoranthene	---	µg/L	< 2	1.3	< 9.9	NA	27	0	NA	0%	NA
Fluorene	---	µg/L	< 1.9	1.2	< 9.3	NA	27	0	NA	0%	NA
Hexachlorobenzene	---	µg/L	< 2.9	1.8	< 14	1	27	0	NA	0%	NA
Hexachlorobutadiene	---	µg/L	< 0.21	1.4	< 8.1	50	27	0	NA	0%	NA
Hexachlorocyclopentadiene	---	µg/L	< 4.6	2.9	< 22	NA	27	0	NA	0%	NA
Hexachloroethane	---	µg/L	< 5.5	3.4	< 26	NA	27	0	NA	0%	NA
Indeno(1,2,3-c,d)Pyrene	---	µg/L	< 5.4	3.3	< 26	NA	27	0	NA	0%	NA
Isophorone	---	µg/L	< 1.7	1.1	< 8.2	NA	27	0	NA	0%	NA
Naphthalene	Yes	µg/L	< 0.08	5.0	38	NA	27	4	NA	15%	NA
Nitrobenzene	---	µg/L	< 2.1	1.3	< 10	NA	27	0	NA	0%	NA
n-Nitrosodi-n-Propylamine	---	µg/L	< 1.7	1.0	< 8	NA	27	0	NA	0%	NA
n-Nitrosodiphenylamine	---	µg/L	< 7.2	4.5	< 35	NA	27	0	NA	0%	NA
Pentachlorophenol	---	µg/L	< 1.2	0.7	< 5.8	1	27	0	NA	0%	NA
Phenanthrene	---	µg/L	< 2.5	1.5	< 12	NA	27	0	NA	0%	NA
Phenol	Yes	µg/L	< 1.9	2.5	33	NA	27	3	NA	11%	NA
Pyrene	---	µg/L	< 1.4	0.9	< 6.6	NA	27	0	NA	0%	NA

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

3.6 Total Petroleum Hydrocarbons

Total Petroleum Hydrocarbon (TPH) analyses include three sub-groups: gasoline-range organics, diesel-range organics and motor oils. Gasoline range organics were analyzed to include a carbon range of C4-C12, diesel range hydrocarbons in the range of C12-C23, and motor oils in the range of C23-C40. Table 3-6 summarizes the data results for total petroleum hydrocarbon analysis.

Table 3-6. Summary of Total Petroleum Hydrocarbon Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
Gasoline (C4-C12)	Yes	µg/L	< 50	146	1,100	NA	27	12	NA	44%	NA
Diesel (C12-C23)	Yes	µg/L	< 21	2017	11,000	NA	27	26	NA	96%	NA
Motor Oils (C23-C40)	Yes	µg/L	< 92	2605	29,000	NA	27	16	NA	59%	NA

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

TPH – Gasoline Range Organics

Gasoline was detected in 12 out of 27 locations with an average concentration of 146 ug/L and a maximum of 1,100 ug/L. The highest GRO concentration was found in sample PA-GW10 (1,100 ug/L), with lower concentrations in GW11 (680 ug/L) and GW26 (590 ug/L). The highest concentrations of GRO occurred in the same locations as the elevated occurrences of VOCs.

TPH – Diesel Range Organics

Diesel-range organics were detected in 26 out of 27 samples with an average concentration of 2,017 ug/L and a maximum of 11,000 ug/L. The highest concentration was found in sample PA-GW22 (11,000 ug/L) and the second highest was found in GW10 (9,400 ug/L). Generally, the occurrence of DRO in groundwater did not appear to follow any specific pattern.

TPH Motor Oil

TPH Motor oil was detected in 16 of the 27 sample locations with an average concentration of 2,605 ug/L and a maximum of 29,000 ug/L. The highest concentration was found in PA-GWO14, located immediately west of the Vat Leach Tanks, and the second highest concentration was found at GW21 (13,000 ug/L) at the north end of the Process Area. Generally, the occurrence of motor oil compounds in groundwater did not appear to follow any specific pattern.

Summary

Results from gasoline range petroleum hydrocarbons correlates with the results of a small group of volatile organics found in the area north of old fuel tanks. Results of diesel range petroleum hydrocarbons and motor oils is inconclusive and does not appear to indicate any localized contamination although there is at least one result in each group that is five to ten times greater than the average concentration.

3.7 Pesticides

A total of 22 pesticide compounds were analyzed, and 8 compounds were found above laboratory detection limits. None of the pesticide compounds exceeded MCLs. Table 3-7 summarizes the data results for pesticide analyses.

Table 3-7. Summary of Pesticide Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
Aldrin	Yes	µg/L	< 0.009	0.61	0.05	NA	27	1	NA	4%	NA
Alpha BHC (Alpha Hexachlorocyclohexane)	Yes	µg/L	< 0.017	0.49	0.08	NA	27	2	NA	7%	NA
Alpha Endosulfan	---	µg/L	< 0.012	1.9	< 46	NA	27	0	NA	0%	NA
Alpha-Chlordane	---	µg/L	< 0.011	1.5	< 37	NA	27	0	NA	0%	NA
Beta BHC (Beta Hexachlorocyclohexane)	Yes	µg/L	< 0.045	0.64	0.88	NA	27	2	NA	7%	NA
Beta Endosulfan	---	µg/L	< 0.019	2.6	< 64	NA	27	0	NA	0%	NA
Chlordane	---	µg/L	< 0.14	0.17	< 1.0	2	21	0	NA	0%	NA
Delta BHC (Delta Hexachlorocyclohexane)	Yes	µg/L	< 0.022	0.80	0.27	NA	27	5	NA	19%	NA
Dieldrin	---	µg/L	< 0.015	2.0	< 0.015	NA	27	0	NA	0%	NA
Endosulfan Sulfate	---	µg/L	< 0.019	7.5	< 0.019	NA	27	0	NA	0%	NA
Endrin	---	µg/L	< 0.02	1.7	< 0.02	20	27	0	NA	0%	NA
Endrin Aldehyde	---	µg/L	< 0.03	7.2	< 180	NA	27	0	NA	0%	NA
Endrin Ketone	---	µg/L	< 0.12	7.2	< 180	NA	9	0	NA	0%	NA
Gamma BHC (Lindane)	Yes	µg/L	< 0.018	0.56	0.64	2	27	2	NA	7%	NA
Gamma-Chlordane	---	µg/L	< 0.048	1.5	< 37	NA	27	0	NA	0%	NA
Heptachlor	Yes	µg/L	< 0.013	0.62	0.32	0.4	27	1	NA	4%	NA
Heptachlor Epoxide	Yes	µg/L	< 0.012	0.97	0.16	0.2	27	2	NA	7%	NA
Methoxychlor	---	µg/L	< 0.013	6.0	< 150	40	27	0	NA	0%	NA
p,p'-DDD	---	µg/L	< 0.013	6.8	< 170	NA	27	0	NA	0%	NA
p,p'-DDE	---	µg/L	< 0.015	2.8	< 70	NA	27	0	NA	0%	NA
p,p'-DDT	Yes	µg/L	< 0.021	7.6	0.03	NA	27	1	NA	4%	NA

Table 3-7. Summary of Pesticide Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
Toxaphene	---	µg/L	< 0.041	119	< 3000	3	27	0	NA	0%	NA

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

3.8 Herbicides

A total of 10 herbicide compounds were tested, of which one compound was detected above laboratory detection limits. This single value was significantly below the MCL for that compound. Table 3-8 summarizes the data results for herbicide analyses.

Table 3-8. Summary of Herbicide Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
2,4 DB	---	µg/L	< 0.009	1.4	< 3.7	NA	26	0	NA	0%	NA
2,4,5-T (Trichlorophenoxyacetic Acid)	---	µg/L	< 0.009	0.6	< 1.5	NA	26	0	NA	0%	NA
2,4-D (Dichlorophenoxyacetic Acid)	---	µg/L	< 0.009	0.9	< 2.4	70	26	0	NA	0%	NA
Dalapon	Yes	µg/L	< 0.009	0.71	6.1	200	26	1	NA	4%	NA
Dicamba	---	µg/L	< 0.009	0.6	< 1.6	NA	26	0	NA	0%	NA
Dichloroprop	---	µg/L	< 0.009	1.0	< 2.9	NA	26	0	NA	0%	NA
Dinoseb	---	µg/L	< 0.009	1.6	< 4.4	7	26	0	NA	0%	NA
MCPA	---	µg/L	< 0.009	180	< 430	NA	26	0	NA	0%	NA
MCPP	---	µg/L	< 0.009	132	< 350	NA	26	0	NA	0%	NA
Silvex (2,4,5-TP)	---	µg/L	< 0.009	0.9	< 2.5	50	26	0	NA	0%	NA

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

3.9 PCBs

Electrical transformers with PCB were used in the historical operation of the site. A total of 8 PCB compounds were analyzed, and none were found above laboratory detection limits (i.e., none exceeded MCLs). Table 3-9 summarizes the data results for PCB analyses.

Table 3-9. Summary of PCB Analyses

Analyte	Detected	Units	Min	Average [1]	Max	MCL	Number Analyzed	Number Detected	Number >MCL	Frequency of Detection	Frequency Exceed MCL
PCB-1016 (Arochlor 1016)	---	µg/L	< 0.082	0.32	< 1.8	0.5	27	0	NA	0%	NA
PCB-1221 (Arochlor 1221)	---	µg/L	< 0.48	1.0	< 21	0.5	27	0	NA	0%	NA
PCB-1232 (Arochlor 1232)	---	µg/L	< 0.48	1.1	< 21	0.5	27	0	NA	0%	NA
PCB-1242 (Arochlor 1242)	---	µg/L	< 0.48	1.1	< 21	0.5	27	0	NA	0%	NA
PCB-1248 (Arochlor 1248)	---	µg/L	< 0.48	1.0	< 21	0.5	27	0	NA	0%	NA
PCB-1254 (Arochlor 1254)	---	µg/L	< 0.48	1.1	< 21	0.5	27	0	NA	0%	NA
PCB-1260 (Arochlor 1260)	---	µg/L	< 0.016	0.30	< 1.4	0.5	27	0	NA	0%	NA
PCB-1268 (Arochlor 1268)	---	µg/L	< 0.48	0.84	< 21	0.5	9	0	NA	0%	NA

NA – Not applicable, No MCL established
[1] Mathematical average. Non-detected results are averaged as one half the value of the minimum detection limit.

3.10 Quality Control Procedures

The analytical results summarized in Sections 3.1 through 3.9, and presented in Appendices C and D, were subjected to appropriate quality assurance and quality control ("QA/QC") procedures in order to achieve the Data Quality Objectives ("DQOs") established in the Work Plan and the QAPP. Quality assurance objectives are the broad goals for data collection and review. The following quality assurance objectives are described below: precision, accuracy, representativeness, completeness and comparability (PARCC).

- Precision is defined as the degree of reproducibility of the measurements under a given set of conditions. Precision is documented on the basis of replicate/duplicate analyses: usually laboratory duplicate, laboratory control sample duplicates or matrix spike duplicates.
- Accuracy is defined as the bias in a measurement system. Accuracy is documented on the basis of recovery of surrogates, laboratory control samples, and matrix spikes.
- Representativenesss is defined as the degree to which data represent a characteristic of a set of samples. The representativeness of the analytical data is a function of the procedures and carefulness used in procuring and processing the samples. The representativeness can be documented by the relative percent difference between separately procured, but otherwise identical sample aliquots.
- Completeness is defined as the percentage of data of acceptable quality such that the goals of the analytical project can be achieved. The overall project completeness is expressed as the percentage of planned data that is usable for its intended purpose.

- Comparability is defined as the similarity of the accuracy, precision, representativeness, completeness and detection limits of the generated data to data generated by other laboratories for similar samples. The comparability objective is documented by inter-laboratory studies carried out by regulator agencies or carried out for specific projects or contracts; and by comparison of periodically generated statements of accuracy, precision and detection limits with those of other laboratories.

These quality assurance objectives were evaluated during the data review process, which also included a completeness check to ensure that all data has been properly loaded into the database that will be used for report generation. Analytical data that failed to meet the data quality assurance objectives for the project have been qualified as to usability and potential low or high bias during the review process. Data was reviewed in the context of project-specific limits provided in the QAPP and the National Functional Guidelines for Data Review (http://www.epa.gov/superfund/programs/clp/guidance.htm).

QC samples were collected and submitted to the analytical labs in order to evaluate laboratory skills, and assess potential contamination that may have been introduced during sampling or shipping. The QC samples generated during the collection of grab groundwater samples from boreholes and samples collected from constructed monitor wells included trip blanks, field (ambient) blanks, equipment blanks, and duplicate samples.

- Trip Blanks are used to evaluate representativeness by identifying any volatile organic compounds that may have been introduced to the environmental samples during shipment, handling, or storage on site and at the laboratory. Trip blanks are prepared in the laboratory by pouring deionized, distilled water into preserved volatile organic analysis (VOA) vials sample vials in the laboratory. The trip blanks are then shipped to the field, and then shipped back to the laboratory in each cooler containing samples for volatile organic analyses. Trip blanks are never opened in the field. Trip blanks were collected at a frequency of one per cooler that contained samples for volatiles or volatile TPH analysis. Trip blanks were analyzed for volatile organic compounds only (including volatile TPH).
- Equipment Blanks are used to evaluate representativeness by identifying any potential contamination from field procedures or insufficient decontamination. Equipment blanks were prepared in the field (after decontamination of sampling equipment was complete) by collecting the final rinse water. Equipment blanks were analyzed for all the parameters performed on the associated samples.

- Field Duplicates are two samples collected at the same time from the same sample location, and which are submitted to one laboratory as separate samples (i.e., "blind" duplicates). Field duplicate samples can be used to assess the heterogeneity of compounds within the sample matrix and the consistency of the overall sampling effort, including collection, shipping, and analysis; the purpose of submitting them "blind" is to assess the consistency or precision of the laboratory's analytical system. Field duplicate samples were analyzed for the same parameters as the corresponding primary sample.

Laboratory data was assessed through third-party validation and internal verification. Level IV data validation reports prepared by Veridian Environmental are presented in Appendix E. Laboratory results that met all the DQOs have been accepted without qualification. Results associated with QC parameters that did not meet objectives have either been qualified as estimated (J flagged) or rejected as unusable for any purpose (R flagged). Data qualified as estimated is considered usable for its intended purpose, although the reported result may not be accurate or precise. The valid data qualifiers that were added to the data when necessary are defined as follows:

- U - Analyte not detected at the detection limit concentration.
- J - Reported value is an estimated concentration.
- UJ - Analyte not detected at an estimated detection limit concentration.
- R - This data was rejected and was not used for any purposes.
- UR - The analyte was not detected. The detection limit is unreliable and may be representative of a false negative. This data was rejected and is not usable for any purpose.

Internal data verification was performed on the total amount of data produced by the analytical laboratories, and was based on the same QA/QC parameters as data validation except that raw data record reviews and recalculation of results from the raw data were not performed during verification. Validation was performed on approximately 10 percent of the data produced and, based on a detailed internal review, additional data qualifiers as required were added to the results stored in the database before data were finalized. The components of data verification and data validation are presented in Table 3-10 to illustrate the differences between data verification and data validation.

Table 3-10. Data Verification/Validation Requirements

Review Item	Performed for Data Verification[1]	Performed for Data Validation[2]
ORGANIC ANALYSES		
Case Narrative	X	X
Chain-of-Custody Documentation	X	X
Summary of Results	X	X
Holding Times	X	X
Method Blank Analysis Results	X	X
Field Blank Analysis Results	X	X
Surrogate Standard Percent Recoveries (%R)	X	X
Laboratory Control Samples (LCS) - %R	X	X
LCS/LCS Duplicate (LCSD) - Relative Percent Difference (RPD)	X	X
Matrix Spike (MS) - %R	X	X
MS/MS Duplicate (MSD) – RPD	X	X
Laboratory Replicate Analyses (LR) – RPD	X	X
Field Duplicate (FD) – RPD	X	X
Quantitation Below Low Standard or Above High Standard	X	X
Analyte Identification:		
Chromatography Column Precision Between Primary and Confirmation Columns (1C and 2C) - Percent Difference (%D)		X
Analyte Retention Time		X
Internal Standard Areas (IS) - %R		X
Initial Instrument Calibration:		
Standard Analyte Concentrations		X
Analyte Response Factors (RF)		X
Percent Relative Standard Deviation (%RSD)		X
Correlation Coefficient		X
Analyte Retention Time Windows Established		X
Mass Spectrometer Tuning/Mass Calibration		X
Second-Source Calibration Verification		X
Continuing Instrument Calibration:		
Standard Analyte Concentrations		X
Analyte Response Factors (RF) - %D		X
Analyte Retention Times		X
Mass Spectrometer Tuning/Mass Calibration		X
Instrument Analysis Logs (including standards and samples)		X
Preparation Logs		X
Raw Data (samples, blanks, standards, QC samples):		
Chromatograms		X
Mass Spectra of Target Analytes		X
Quantitation Reports – Recalculation		X
Method Detection Limit (MDL) Study Data		X

Table 3-10. Data Verification/Validation Requirements - Continued

Review Item	Performed for Data Verification[1]	Performed for Data Validation[2]
INORGANIC/METALS ANALYSES		
Case Narrative	X	X
Chain-of-Custody Documentation	X	X
Summary of Results	X	X
Holding Times	X	X
Method Blank Analysis Results	X	X
Field Blank Analysis Results	X	X
Laboratory Control Samples (LCS) - %R	X	X
LCS/LCS Duplicate (LCSD) - Relative Percent Difference (RPD)	X	X
Matrix Spike (MS) - %R	X	X
MS/MS Duplicate (MSD) – RPD	X	X
Laboratory Replicate Analyses (LR) – RPD	X	X
Field Duplicate (FD) – RPD	X	X
Quantitation Below Low Standard or Above High Standard	X	X
Analyte Identification:		
Analyte Retention Time (ion chromatography)		X
Daily Initial Instrument Calibration:		
Instrument Calibration Curve Correlation Coefficient		X
Interference Check Standard Results (Method SW6010B only)		X
Calibration Standard Check (SW6010B only)		X
Standard Analyte Concentrations		X
Initial Calibration Verification (ICV) - %R		X
Initial Calibration Blank (ICB) Results		X
Second-Source Calibration Verification		X
Continuing Instrument Calibration:		
Standard Analyte Concentrations		X
Continuing Calibration Verification (CCV) - %R		X
Continuing Calibration Blank (CCB) Results		X
Instrument Analysis Logs (including standards and samples)		X
Sample Preparation/Digestion Logs		X
Standard Preparation Logs		X
Serial Dilution Results - %D		X
Method of Standard Additions (MSA) Results		X
Raw Data (samples, blanks, standards, QC samples):		
Chromatograms		X
Quantitation Reports		X
Calculations		X
Method Detection Limit (MDL) Study Data		X

Notes
[1]Data verification performed for all project samples and associated laboratory QC batches (Level II Data Package)
[2]Data validation performed on a minimum of 10 percent of project samples (Level IV Data Package).

3.11 Data Quality Summary and Analytical Completeness

Individual analytical results were qualified during the data validation and verification procedures. The percentage of results that were qualified as estimated or rejected due to QC deficiencies is an indication of the overall data quality for a given analytical method. Table 3-11

provides a summary of analytical completeness, and the number of results that were qualified by method.

Table 3-11. Analytical Completeness by Method

				Number of results				Completeness	
Method	Parameter	Samples Analyzed (N+FD)	Analytes per sample	Total	Rejected	Estimated due to QC deficiencies	Estimated due to >MDL but <PQL	Percent usable	Percent quantitative*
E150.1	pH	27+3	1	30	0	0	0	100%	100%
E160.1	Total Dissolved Solids	27+3	1	30	0	0	0	100%	100%
E200.8	Thorium-232 and Uranium	27+3	2	60	0	2	0	100%	97%
E300	Sulfate	27+3	1	30	0	2	0	100%	93%
E903.0	Radium-226	27+3	1	30	0	6	0	100%	80%
E904.0	Radium-228	27+3	1	30	0	0	0	100%	100%
SM2340B	Hardness (as $CaCO_3$)	27+3	1	30	0	2	0	100%	93%
SW6010B	Metals by ICP/AES	27+3	7	210	0	10	10	100%	95%
SW6020	Metals by ICP/MS	27+3	17	510	0	47	44	100%	91%
SW7470A	Mercury	19+2	1	21	0	2	4	100%	90%
SW8015B	Gas, Diesel, and Motor Oil	27+3	3	90	0	5	12	100%	94%
SW8081A	Pesticides	27+3	21	634	22	400	8	97%	37%
SW8082	PCBs	27+3	7	220	7	113	0	97%	49%
SW8151A	Herbicides	26+2	10	280	0	64	0	100%	77%
SW8260B	Volatiles	27+3	56	1680	18	145	75	99%	91%
SW8270C	Semivolatiles	27+3	66	1980	0	122	15	100%	94%

* Note: Estimations due solely to results <PQL do not affect the calculated completeness
Calculations do not include any required field or laboratory QC samples, except field duplicates.
N = normal environmental samples FD = field duplicate samples

The analytical results are of acceptable quality and are usable for their intended purpose of characterizing groundwater conditions in the Process Areas. All pesticide and PCB results for sample PA-GW10 were rejected due to low surrogate recoveries. Two results for the pesticide Endrin were rejected due to low LCS recoveries and 18 volatiles results were rejected due to instrument calibration problems. These results are not usable. All methods met the analytical completeness objective of 95 percent usable results, and most methods had higher than 90

percent unqualified results. A number of pesticide, PCB and herbicide results were qualified as estimated, primarily due to spike recoveries below the control limits established in the QAPP.

3.12 Comparability with EPA Split Sample Data

Groundwater split samples collected by EPA's oversight contractor, TetraTech/EMI from borehole locations PA-GW18, PA-GW20, PA-GW23, PA-GW25, and PA-GW9 were analyzed by two separate EPA laboratories for comparison with the analytical data from the laboratories contracted by ARC. Appendix F compares the ARC data with EPA split sample data. Differences in detection limits and the target analyte list from the various laboratories result in a less-than-ideal comparison. Commonly, the detection limits for the EPA laboratories were greater than those for the ARC-contracted laboratories.

In general, results from the EPA and ARC laboratories are similar. In some cases, however, results from one lab are below the MCL while another lab has reported concentrations above the MCL (e.g., thallium at PA-GW23, antimony at PA-GW23, cadmium at PA-GW18, radium-226 at PA-GW20, and radium-225 at PA-GW25).

Differences in reporting units for uranium from the laboratories required results to be converted (ARC's laboratory reported total uranium in ug/L while the EPA laboratory reported results in pCi/L for each of the individual isotopes of uranium). In order to allow for the comparison, the activities of the individual uranium isotopes were summed as total uranium activity, and an activity to mass conversion factor of 0.67 pCi/ug was used to convert the EPA data to ug/L. The converted results are included in Appendix F, and show good comparability between results.

SECTION 4.0

REFERENCES CITED

Aero-Data Corp., 2001. Contour Elevation Map of Yerington Mine Site

American Society of Testing and Materials (ASTM), 1992. Standard D 2487-92. Classification of Soils for Engineering Purposes (Unified Soil Classification System).

Applied Hydrology Associates, 1983, Final Report: Evaluation of Water Quality and Solids Leaching Data Adjacent to the Weed Heights Operation near Yerington, Nevada. Prepared for Anaconda Minerals Company.

Brown and Caldwell, 2002, Draft Quality Assurance Project Plan. Prepared for Atlantic Richfield Company.

Brown and Caldwell, 2002, Site Health and Safety Plan for the Yerington Mine Site, Prepared for Atlantic Richfield Company (revised May 2005).

Brown and Caldwell, 2003a. Draft Final Quality Assurance Project Plan. Yerington Mine Site, Lyon County, Nevada. Prepared for Atlantic Richfield Company. September 19. Work plan.

Brown and Caldwell, 2003b. Draft Final Groundwater Conditions Work Plan. Yerington Mine Site, Lyon County, Nevada. Prepared for Atlantic Richfield Company. February 25.

Brown and Caldwell, 2004, Revised Process Areas Work Plan. Prepared for Atlantic Richfield Company.

Dalton, Dennis, 1999, Arimetco Yerington Mine and Process Facility Site Assessment of Groundwater Quality. Report prepared for Arimetco, Inc.

Huxel, C.J., 1969, Water Resources and Development in Mason Valley, Lyon and Mineral Counties, Nevada, 1948-65. State of Nevada Department of Conservation and Natural Resources, Division of Water Resources, Water Resources Bulletin No. 38.

Proffett, J.M., Jr., and Dilles, J.H., 1984, Geologic Map of the Yerington District, Nevada. Nevada Bureau of Mines and Geology, Map 77.

Piedmont Engineering Inc., 2001, Yerington Shallow Aquifer Data Evaluation Report. Prepared for ARCO Environmental Remediation L.L.C.

Seitz, H.R., A.S. Van Denburgh, and La Camera, R.J., 1982, Ground-Water Quality Downgradient from Copper-Ore Milling Wastes at Weed Heights, Lyon County, Nevada. U.S. Geological Survey, Open-File Report 80-1217.

U.S. Environmental Protection Agency (EPA), 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. Ground Water Forum Issue Paper, by D. Yeskis and B. Zovala. Office of Solid Waste and Emergency Response. EPA 542-S-02-001. May.

U.S. Environmental Protection Agency (EPA), 2003. National Primary and Secondary Drinking Water Standards. EPA 816-F-03-016, June 2003.

U.S. Geological Survey (USGS), 1986. Yerington 7.5 Minute Quadrangle