COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
HAZARDOUS MATERIALS AND WASTE MANAGEMENT DIVISION

ANALYTICAL RESULTS REPORT

COLORADO SMELTER

PUEBLO, COLORADO

CON000802700

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Approved: Barbara Nabors, PA/SI Unit Leader, CDPHE — Date: 6/30/11

Approved: Sabrina Forrest, Site Assessment Manager, EPA — Date: 10/11/11

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SITE INSPECTION ANALYTICAL RESULTS REPORT
COLORADO SMELTER - CON000802700
PUEBLO, COLORADO

1.0 INTRODUCTION

The Hazardous Materials and Waste Management Division (HMWMD) of the Colorado Department of Public Health and Environment (CDPHE), under a cooperative agreement with the U.S. Environmental Protection Agency (EPA), has prepared this Site Inspection (SI) Analytical Results Report (ARR) for the former Colorado Smelter site in Pueblo, Colorado.

This report has been prepared in accordance with the EPA "Guidance for Performing Site Inspections Under CERCLA," Interim Final, September 1992, the "Region 8 Supplement to Guidance for Performing Site Inspections Under CERCLA," and the CDPHE Quality Assurance Project Plan (QAPP)[1]. A preliminary assessment (PA) report was prepared and approved by EPA on June 26, 2008[2]. Following the PA, a Sampling and Analysis Plan (SAP) was submitted to EPA and approved May 27, 2010[3].

Sampling activities included the collection of waste pile samples, residential yard soil samples, public access road right-of-way and vacant lot samples, and background soil samples, all for metals analysis. Surface water and sediment samples were also collected and analyzed for metals. All samples were collected June 21 – 23, 2010.

Residential soil samples were collected from 47 residential properties and 4 road right-of ways or vacant lots. Waste pile (source) samples were collected from 4 locations. Additionally, 2 background soil samples were collected from an area approximately 2 miles northwest of the site and outside the area likely to be impacted by emissions from the site. All of these samples were collected using a multi-incremental sampling technique. A total of 439 individual aliquots were collected that were subsequently composited into 88 multi-increment samples (an average of 5.0 aliquots per sample). Each residential property was divided into between 1 and 4 multi-incremental sampling units (or decision units) while road and background samples consisted of 1 multi-incremental sample/decision unit.

All of the soil, public access, background and waste pile sample aliquots were analyzed at the Superfund Technical Assessment and Response Team (START) laboratory in Denver, Colorado using an Innov-X Alpha 4000 X-Ray Fluorescence analyzer (XRF). These were subsequently

processed (dried, sieved, and composited) into 88 multi-increment samples which were also analyzed with the XRF. Forty-four of the 439 individual aliquot samples and 11 of the 88 multi-increment samples were selected for EPA's Contract Lab Program (CLP) confirmatory analysis. A summary of soil sample results in attached to this report.

Six surface water samples, including one duplicate, were collected from on-site, Probable Points of Entry (PPE) and Arkansas River. Four co-located sediment samples were also collected. All surface water and sediment samples were sent to an analytical laboratory for analysis of metals through EPA's CLP.

2.0 OBJECTIVES

The purpose of this SI was to gather information for the evaluation of this site with regard to the EPA's Hazard Ranking System (HRS) criteria. The specific objectives of this SI were to:

- Collect samples of fine-grained (<2mm) slag material and soils located onsite to determine if they are a source of contamination.
- Collect soil samples from residential yards in the neighborhoods surrounding the Colorado Smelter site to determine metals concentrations and to identify areas of observed contamination associated with the site.
- Collect background soil samples for the purpose of comparing metals concentrations in background samples with residential soil samples for evaluation under the Hazard Ranking System (HRS).
- Collect surface water samples from onsite seeps, culvert discharges, and the Arkansas River to determine any impacts to surface waters.
- Collect sediment samples from onsite seeps, discharge culverts, and the Arkansas River to determine any impacts to surface waters.

3.0 SITE LOCATION AND SITE DESCRIPTION

The Colorado Smelter site is bound by Santa Fe Avenue to the east, Agram Avenue to the south, Interstate 25 to the west, and the Arkansas River to the north. The site is located in the Southwest Quarter of the Northwest Quarter of Section 6, Township 21 South, Range 64 West. The approximate coordinates are 38˚ 14' 55" north latitude, 104˚ 36' 30" west longitude[4]. The site location is depicted on Figure 1.

The Colorado Smelter site is located within a business, industrial and residential neighborhood near the Arkansas River and the central business district of Pueblo, Colorado. It is reported that the smelter was constructed on the mesa of a large ravine. Waste slag was deposited in the ravine, which contained a significant stream of water[5].

3.1 POTENTIAL CONTAMINANTS

Emissions from smelting operations often contain inorganic constituents such as lead and arsenic. Soils contaminated with cadmium, arsenic, lead and zinc may be found in residential areas surrounding smelter plant sites. Ingestion of soil and inhalation of windblown soil are potential human exposure pathways of concern and may occur due to the extent of off-site contamination in surface soils near the site[6].

During a site visit conducted by CDPHE on November 27, 2007, it was observed that waste remaining at the site of the former Colorado Smelter includes remnants of destroyed buildings and large slag piles. The site covers an area of approximately 25 acres. With an escarpment height of approximately 30 feet, there is an estimated 50,000 cubic yards of slag located on site[7].

3.2 GEOLOGY AND HYDROGEOLOGY

Artificial fill and Quaternary Piney Creek and Post Piney Creek alluvium comprise the surficial deposits. The artificial fill consists of gravel, silt, clay, concrete waste, and smelter waste and slag. The Piney Creek alluvium is 10 to 46 feet thick and consists of yellowish-gray to medium-brown silt, clay, sand and gravel. It has a hydraulic conductivity of approximately 27 feet per day[8].

The alluvium lies over sedimentary bedrock composed of chalk and shale beds of the Cretaceous Pierre Shale and the Smokey Hill Shale Member of the Niobara Formation. These strata have a total thickness of approximately 3500 feet and are relatively impermeable, acting as aquatards preventing the downward migration of groundwater.

The uppermost major aquifer is the Dakota Sandstone. It is approximately 3500 feet to the top of the aquifer in the Pueblo area[9].

3.3 HYDROLOGY

The Colorado Smelter site is located immediately south of the Arkansas River, approximately one mile west of the confluence of Fountain Creek. A portion of the site is situated within the 500

year floodplain, although the majority of area is designated Flood Zone C by the Federal Emergency Management Agency, and are therefore outside of the 500-year flood plain[10].

Downtown Pueblo was constructed along the banks of the Arkansas River. On June 3, 1921, a sudden rainstorm flooded both the Arkansas River and Fountain Creek. The flood destroyed approximately one third of the downtown area. Between 1921 and 1926, cement banks and dikes were constructed to reroute the Arkansas River to its present location and protect the city from future flooding.

Stream flow in the Arkansas River varies dramatically from below 20 cubic feet per second (cfs) in December and January to over 4000 cfs in June. Average annual flow of the Arkansas River in Pueblo is 573 cfs, while average annual flow in Fountain Creek is 97 cfs[11].

3.4 CLIMATE

Pueblo temperatures fluctuate seasonally, with an average of 160 days of below freezing lows and 64 days of above 90˚F highs. Annual precipitation averages 11.2 inches, of which over half falls as rain between the months of May and August. Relative humidity is fairly low, typically 45 to 60 percent[12]. The 2-year 24-hour rainfall event is 2.0 inches[13].

Average wind speed is 7.7 miles per hour and predominately flows from the west-northwest, although occasional upslope conditions cause a reversal in wind direction[14].

4.0 SITE HISTORY AND PREVIOUS SITE INVESTIGATIONS

4.1 SITE HISTORY

The Colorado Smelting Company smelter (also known as Colorado Smelter, Boston Smelter, Boston & Colorado Smelter, and Eilers Smelter) began operating in 1883. It was constructed in a ravine between Santa Fe Avenue and the Denver & Rio Grande railroad tracks[15].

The owners of the Madonna Mine, located in Monarch, built the Colorado Smelter in order to smelt their extracted silver-lead ore in a cost effective manner. The smelter operated eight blast furnaces, two calcining furnaces, one fusing furnace and twenty kilns[16].

The Colorado Smelter was merged into the American Smelting and Refining Company (ASARCO) in 1899. The facility was closed in 1908. Some of the slag was used as track ballast

for the D&RG track constructed between Florence and Canon City. In 1923, bricks from the blast furnace smoke stack were used to construct the St. Mary School[17].

4.2 PREVIOUS SITE INVESTIGATIONS

Several previous investigations have been performed at the Blende Smelter site and at nearby locations. This work was performed by CDPHE, by the EPA contractor Ecology and Environment Inc. (E&E), and by other entities. The results of these investigations were documented in the following reports:

TABLE 1		
July 1991	CDPHE	Preliminary Assessment, Santa Fe Bridge Culvert[18]
February 1994	CDPHE	Sample Report, Screening Site Inspection, Santa Fe Avenue Bridge Culvert[19]
June 1995	CDPHE	Analytical Results Report, Expanded Site Inspection, Santa Fe Avenue Bridge Culvert[20]
July 1995	E&E	Analytical Results Report, Boston Smelter[21]
October 1995	E&E	Site Screening Report, Boston Smelter[22]
1995	Pueblo County Health Department	"GuardCare '95" Blood Lead Screening
2006	Diawara, et al.	Arsenic, Cadmium, Lead and Mercury in surface soils, Pueblo, Colorado: implications for population health risk[23]

In 1991, CDPHE conducted a preliminary assessment (PA) of the Santa Fe Bridge Culvert site (COD982572513). In performing the PA, it was discovered that several smelters had operated in the Pueblo vicinity between 1878 and 1921. Large slag piles remained, including some located in areas where residential development had occurred. Concerned that these slag piles were a potential source of contaminants, CDPHE expanded the area of investigation from a focus solely on the culvert to include an evaluation of these additional source areas. One of the sites identified was the location of the Colorado Smelter.

During September 1994, CDPHE collected residential soil samples located throughout the Pueblo area to evaluate the overall impact on soils from the historic smelter operations. The results of this sampling effort were documented in the 1995 Analytical Results Report for the Expanded Site Inspection of the Santa Fe Avenue Bridge Culvert[24]. Thirteen source samples were collected, including two from the Colorado Smelter waste piles (SS-7 and SS-8). Residential exposure to contaminated soils was evaluated by collecting four background samples (SO-1, SO-2, SO-3 and SO-4) and 35 samples located within 200 feet of a residence. Arsenic exceeded the Superfund Chemical Data Matrix (SCDM) benchmark for cancer risk (0.43

milligrams per kilogram (mg/kg))[25] in every residential soil sample collected. However, the arsenic concentrations in residential soils reached analytical significance in only eleven samples, where the concentrations exceeded three times background. Eight of the samples in which arsenic was elevated above analytical significance were located within one mile of the Colorado Smelter.

In 1995, an EPA contractor performed in situ x-ray fluorescence (XRF) lead and arsenic analysis on eight waste pile samples at the location of the former Colorado Smelter. No background analysis was performed. None of the samples analyzed for arsenic indicated concentrations above the detection limit (XRF-39, XRF-40, XRF-43 and XRF-49). However, the detection limit for the XRF for arsenic was reported at 67 mg/kg, significantly above the SCDM benchmarks for cancer (0.43 mg/kg) and non-cancer (23 mg/kg) risk, and the Residential Soil Cleanup Table Value Standard established by CDPHE in 1997 (0.21 mg/kg). Therefore, the full extent of arsenic contamination could not be established. Analytical results for lead were variable, ranging from less than 100 mg/kg to 9700 mg/kg. Two of the samples exceeded 400 mg/kg for lead, the screening level recommended in EPA's OSWER Directive 9355.4-12 and CDPHE's Residential Soil Cleanup Table Value Standard[26].

On August 16, 1995, an EPA contractor conducted a systematic grid sampling of the slag pile and adjacent soils. A total of 88 samples were collected and analyzed for arsenic, cadmium and lead using an X-ray fluorescence spectrometer (XRF). Seventeen samples were sent to a laboratory for confirmatory analysis. Very poor correlation was observed between the XRF analysis and laboratory analysis for both arsenic and cadmium, therefore the XRF generated data for arsenic and cadmium is of little value. However, the XRF lead analysis correlated well with the laboratory lead analysis[27]. The observed concentration of lead in the slag pile ranged from an estimated 56 mg/kg to a high of 9300 mg/kg. A total of 59 of the 88 samples collected exceeded 400 mg/kg lead.

Sampling of surface soils in the Pueblo region was also conducted by affiliates of the Colorado State University in Pueblo. Sixty-eight soil samples were collected at 33 locations and analyzed for arsenic, cadmium, lead and mercury. The results of the sampling effort were presented in the August 2006 publication of *Environmental Geochemistry and Health*. Samples were collected every two kilometers along four parallel transects running northwest to southeast across the city limits. Two sets of paired samples were collected within a one mile distance of the Colorado Smelter site[28].

All 68 samples exceeded the carcinogenic risk SCDM benchmark for arsenic, although only ten samples contained concentrations of arsenic greater than three times the average background level of 7.2 mg/kg. None of the soil samples exceeded 400 mg/kg for lead. The overall average concentration for lead and arsenic was 88 and 12.5 mg/kg, respectively. The average concentration of lead and arsenic for the samples collected within one mile of the Colorado Smelter site was 155 and 7.2 mg/kg, respectively. The study concluded that a higher-density geochemical survey is needed to identify smaller and possibly higher amplitude "hotspots" within the city[29].

Due to the unsystematic nature of previous studies, the extent of soil contamination near the site of the former Colorado Smelter was unknown.

5.0 DATA QUALITY OBJECTIVES FOR SAMPLING

5.1 DATA QUALITY OBJECTIVES

The EPA Data Quality Objectives (DQO) Process is a seven-step systematic planning approach to develop acceptance or performance criteria for EPA-funded projects. Based upon the potential risks associated with the potential hazardous substances, the project team identified high metals concentrations in residential soils near the Colorado Smelter in Pueblo, Colorado, to be the main source of exposure. Therefore soil samples were collected from residential yards and public right-of-ways located within one mile of the Colorado Smelter. Background soil was collected from a location approximately two miles northeast of the site and outside areas likely impacted by prevailing winds. Contamination of local surface water bodies from residual smelter waste was also identified as a possible source of exposure. Surface water and sediment samples were therefore also collected.

The questions to be resolved by this investigation were: whether or not metals (primarily lead and arsenic) are present in residential yards at concentrations above health-based benchmarks, and whether or not onsite and nearby surface waters and sediments are adversely impacted by the former smelter. The primary study question for this investigation was: Do residential yard soils or surface water bodies contain contamination derived from the former smelter site? The information sought to arrive at a decision included:

1. Analytical data from soil samples in residential yards and roadways near the former Colorado Smelter to determine if contaminants from the smelter are present;

2. Analytical data for background soil from location(s) near the site to serve as a basis for comparison with soils collected within local neighborhoods; and

3. Analytical data from surface waters and sediments to determine if contaminants from the Colorado Smelter are present; and

4. Analytical data from the site of the former Colorado Smelter so attribution from the site can be established.

Sample results from this study were used to develop decision rules, define tolerance limits on decision errors, and optimize the sampling design. Sample results were compared to background sample data to determine if an observed release or observed contamination could be documented (generally defined as three times background for the purpose of demonstrating attribution to the site) as defined in the EPA HRS guidelines. Sample results that do not meet this threshold will not be considered for scoring the site under HRS. Additionally sample results were compared to Superfund Chemical Data Matrix (SCDM) benchmarks[30] and CDPHE's soil cleanup table value standards[31]. Judgmental sampling was used to bias samples toward more potentially contaminated areas. Statistical sampling was not used and a tolerance limit on decision errors was not calculated. For soil and source sampling, multi-increment samples were collected to more accurately reflect the average concentration of the sampling zone or decision unit.

5.2 SUMMARY OF SAMPLING ACTIVITIES

CDPHE obtained ownership information from the Pueblo County Assessor's office and a mailing that included a letter, a Fact Sheet, and an Access Agreement was sent to approximately 100 property owners. Phone contact was also made if phone numbers were available. Permission to sample residential soil was obtained for 47 properties. The majority of samples were collected from areas located to the southeast of the former smelter, as this is downwind of prevailing winds.

Sampling activities were conducted from June 21 – 23, 2010. The sampling team consisted of Martin O'Grady and Mary Boardman of CDPHE.

Residential yards with homes were divided into between 1 and 4 zones or decision units such as front yard, back yard, and side yards. The general format used for labeling zones is shown in

Figure 2. In each zone 5 individual aliquots were collected. Five individual samples were collected for each right-of-way, background and source sample. The sample labeling scheme included 5 components; the letters “CO” for Colorado Smelter, a 2 letter designation for media type (“SO” for soil, “WP” for waste pile, “SW” for surface water, or “ SE” for sediment), the sample number, the zone number, and the aliquot number (e.g. CO-SO-05-2.3).

In general, samples were collected from the top 2-inches of the ground surface. A total of 439 individual samples were collected into 1-quart plastic bags. The samples were brought back to Denver and delivered to URS Operating Services (UOS), EPA’s Superfund Technical Assessment and Response Team (START) contractor. UOS analyzed the samples directly through the plastic bag using X-ray fluorescence (XRF). Later, UOS combined the samples into 88 multi-increment samples (77 residential soil, 4 right-of-way, 2 background and 4 source) dried, sieved with a 250 micrometer mesh, and placed in small plastic cups and re-analyzed with the XRF. The 250 micrometer mesh was used to obtain samples representing respirable particles.

Surface water samples were collected from 5 locations within nearby surface water bodies. This included 2 samples from the Arkansas River (CO-SW-01 and CO-SW-02), 2 from the Probable Points of Entry (CO-SW-03 and CO-SW-04) and 1 from an on-site seep (CO-SW-06). Four co-located sediment samples were also collected. No sediment was available for sampling at the Santa Fe Avenue Bridge Culvert surface water sample location (CO-SW-03). All surface water and sediment samples were shipped to an analytical laboratory for analysis of metals through EPA’s CLP.

6.0 SOURCE CHARACTERIZATION

It was noted during a November 27, 2007 site visit conducted by CDPHE that waste materials including slag remained at the site of the former Colorado Smelter. The site covers an area of approximately 25 acres. There is an estimated 50,000 cubic yards of slag located on site.

6.1 SOURCE SAMPLE LOCATIONS AND ANALYTICAL RESULTS

Source samples were collected from 4 locations along the waste pile. Samples were collected from the top 2-inches of the ground surface. All of these samples were collected using a multi-incremental sampling technique. Five individual aliquots were collected from each location. The aliquots were subsequently composited into multi-increment samples. Each source sample consisted of 1 multi-incremental sample/decision unit.

The waste pile sample aliquots were analyzed at the UOS laboratory in Denver, Colorado using a Niton XRF XLt 700 Series X-Ray Fluorescence analyzer (XRF). The samples were initially analyzed through the plastic bags. The samples were subsequently processed (dried, sieved, and composited) into 5 multi-increment samples which were also analyzed with the XRF.

The results of the XRF metals analysis are presented in Table 2. Soil screening level benchmarks are provided for comparison. As indicated in the data summary table, all source samples contained concentrations of lead above 400 mg/kg, the screening level recommended in EPA's OSWER Directive 9355.4-12[32] and CDPHE's Residential Soil Cleanup Table Value Standard[33].

TABLE 2
Multi-increment Source Sample XRF Data (mg/kg)

	CO-WP-01-1	CO-WP-02-1	CO-WP-03-1	CO-WP-04-1	Benchmark
Arsenic	542 U	147 U	807 U	128 U	23[a]/0.43[b]/0.21[c]
Chromium	90 J	94 J	49 U	49 U	230[a]
Cobalt	601	400	567	330	
Copper	1720	318	1710	343	2,570[c]
Iron	68500	55500	86600	53800	
Lead	5420	1470	8070	1280	400[c,d]
Manganese	2650	1990	4740	3670	11,000[a]
Mercury	1.2 U	1.2 U	1.2 U	1.2 U	23[a]/18[c]
Nickel	12 U	12 U	12 U	12 U	1,600[a]
Selenium	1.4 U	1.4 U	1.4 U	1.4 U	390[a]
Zinc	4650	3980	11700	4470	23,000[a]

[a]Superfund Chemical Data Matrix (SCDM) Reference Dose Screening Concentration for residential soils[34].
[b]SCDM Cancer Risk Screening Concentration for residential soils[35].
[c]CDPHE's Residential Soil Cleanup Table Value Standard[36].
[d]EPA's OSWER Directive 9355.4-12[37].

It should be noted that due to interference between lead and arsenic with the XRF instrument, high lead concentrations can sometimes result in arsenic being reported as non-detect (U value) when, in fact, it is present (see Section 11.3.1). As a rule of thumb, if the lead concentration is 10-times higher than the arsenic concentration, then the arsenic detection limit may exceed the arsenic concentration. No information regarding arsenic concentrations could be extracted from the validated data due to the high detection limits.

The raw XRF data was reviewed for arsenic concentrations calculated by the XRF instrument using algorithmic corrections and secondary spectral peaks. While these results do not pass

quality control and data validation protocols, it can provide qualitative information on the presence of arsenic. The raw arsenic concentrations for the multi-increment source samples were: 130 mg/kg for CO-WP-01-1; < 32 mg/kg for CO-WP-02-1; 391 mg/kg for CO-WP-03-1; and < 29 mg/kg for CO-WP-04-1.

Twelve source samples, including 9 individual aliquots and 3 composites, were selected for EPA's Contract Lab Program (CLP) confirmatory analysis. The results of the confirmation analysis are discussed in the Data Quality Assessment section of this report.

7.0 AIR PATHWAY

During smelter operations, heavy metal contaminants were likely exhausted through the smoke stacks and dispersed through the air pathway to surficial soils. The blast furnace smokestack was 132 feet high. The stack from the fusing and calcining furnaces was 95 feet high. The desulphuring kilns were vented from a stack 65 feet high[38].

An estimated 3,500 acres of wetlands are located within four miles of the site[39]. Runyon/Fountain Lake is a designated State Wildlife Area, and is located between one quarter and one-mile east-northeast of the site[40]. The Arkansas River valley, referred to as the Central Arkansas Playas, is located east of the site, approximately 2 miles away, and has been classified as a potential conservation area due to its high biodiversity. The Central Arkansas Playas area is identified on Figure 1. According to the Colorado Natural Heritage Program, several threatened or endangered species have been identified in Pueblo County[41].

The nearest residence is approximately 200 feet from the slagheap. Residences are located east of the site across South Santa Fe Avenue and south of the site across Agram Avenue. A park is located immediately south of the ravine.

Small businesses are located on-site. This includes Ace Enterprises, Top Notch Trailers, Domenic & Sons Paint & Body Shop, Chem Way Lawn Care, Meadow Gold Dairies, Northern Colorado Paper, and Ryder Truck Rental.

The resident population within the target distance limits was estimated from the Environmental Justice Geographic Assessment Tool maintained by EPA[42], and is shown in Table 3.

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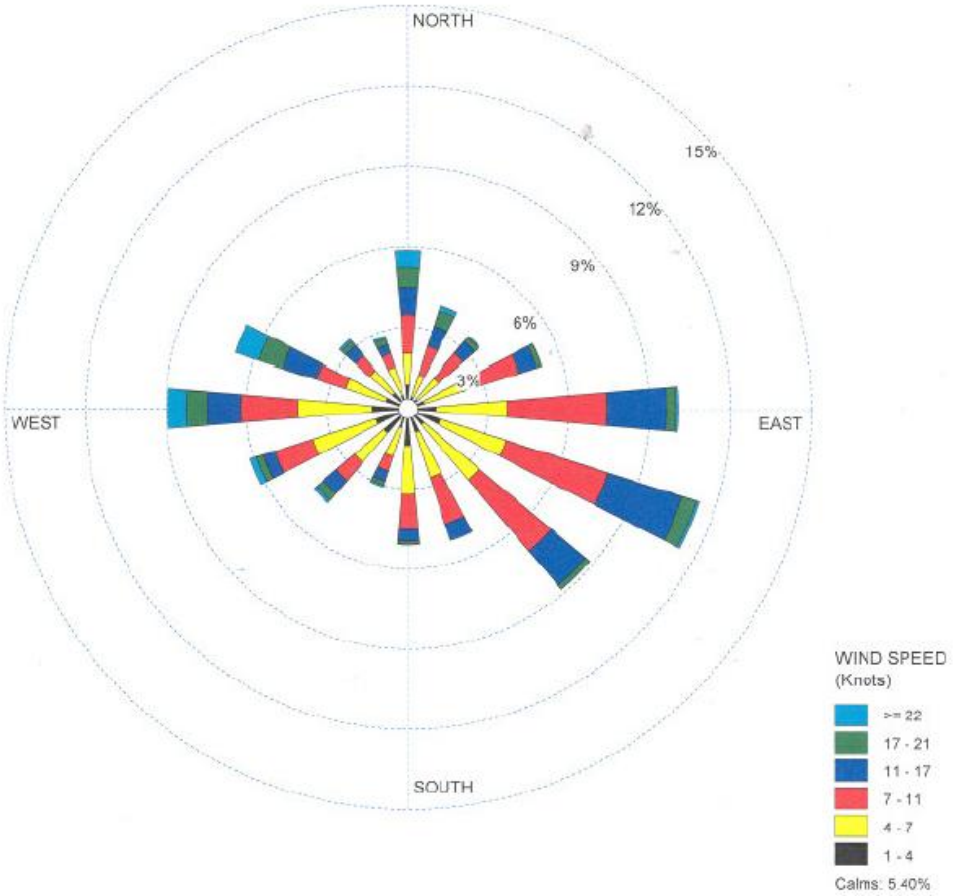
TABLE 3	
Distance	Estimated Number of Persons
0 – ¼ mile	628
¼ - ½ mile	1,375
½ - 1 mile	5,235
1 – 2 miles	20,925
2 – 3 miles	33,304
3 – 4 miles	31,707
Total	93,174

A wind rose plot generated from the meteorological monitoring site located at the Pueblo Municipal Airport provides information on wind speed and direction near the Colorado Smelter site. Wind speeds in Pueblo average seven to eight miles per hour, and range from calm (5.4 % of the time) to gusts exceeding 20 miles per hour (3.5% of the time). Predominant winds are from the west-northwest, although occasional upslope conditions result in gusty eastern winds[43]. A wind rose plot of wind data collected from the Pueblo Airport is shown as Figure 3.

FIGURE 3



During sampling activities, fine-grained source and soil particulates were observed. Fine-grained source and soil particulates contaminated with heavy metals may pose an ongoing risk to human health via inhalation. However, no releases to the air pathway by direct observation were noted during sample collection activities or previous site visits. Evaluation of the air pathway is being deferred until after the collection and evaluation of residential soils. If the results of analysis of residential soils indicate unacceptable concentrations of heavy metals, the air pathway may be investigated.

8.0 GROUND WATER PATHWAY

Sources are uncontained with regard to the groundwater pathway. However, it is unlikely shallow groundwater is used as a drinking water source since the area is serviced with a municipal water supply. Four municipal groundwater wells are located between 2 and 3 miles east-southeast of the site. The wells appear to be in a different hydro-geologic zone and are likely not impacted by the Colorado Smelter site. Contamination of the Dakota aquifer is unlikely given the low permeability of the overlying Pierre Shale as well as the depth to the Dakota aquifer. It is probable there are no targets for the groundwater pathway.

The seep observed on the slagheap during previous site visits may indicate a hydraulic connection between groundwater and surface water. Both the seep and the Santa Fe Avenue Bridge Culvert may serve as conveyances of shallow groundwater to the surface water of the Arkansas River. Therefore, they are evaluated under the surface water pathway.

9.0 SURFACE WATER PATHWAY

The Arkansas River is channeled by dikes through the stretch that is adjacent to the site of the former Colorado Smelter. Flow is from northwest to southeast. The Arkansas River downstream of the site PPE is classified as a warm water fishery. An estimated 124 pounds of fish per acre are present in the Pueblo area. The predominant species are long nosed sucker and white sucker[44]. Greenback cutthroat trout, a threatened species, have been recorded in the county of Pueblo. The Arkansas River is also classified for use as a water supply, for agriculture, and for recreation[45].

Wetlands intermittently line both banks of the Arkansas River and its tributary downstream of the PPE. These wetlands are generally palustrine with scrub and shrub coverage. There are roughly 12 miles of wetland frontage within the 15-mile target distance limit[46].

The St. Charles Mesa Water District operates two surface water intakes (from the Arkansas River and from the Bessemer Ditch). The Arkansas River surface water intake is located approximately 100 feet downstream of the probable point of entry from the Colorado Smelter, and serves an estimated 5,500 people. The Bessemer Ditch intake is located over four miles southeast of the site in Lombard Village and cannot be impacted by the site.

Three probable points of entry (PPE), located within a 500 foot stretch of the Arkansas River, were observed during the November 27, 2007 site visit. A large storm water culvert is located at the northwestern corner of the site. The culvert discharges into a ditch that transports water from multiple locations to the Arkansas River. No water was flowing into the culvert at the time of sampling. At the northeastern corner of the site, a small grate collects surface water into a storm water pipe. The pipe travels in a northeasterly direction towards the Arkansas River, although the discharge point was not observed.

The Santa Fe Avenue Bridge culvert is located between the other two PPE locations. This culvert conveys orange-colored water directly into the Arkansas River. The inlet to the culvert could not be found, and it is possible it does not daylight but instead drains alluvial groundwater from beneath the slagheap.

9.1 SEDIMENT SAMPLE LOCATIONS AND ANALYTICAL RESULTS

Sediment samples were collected from four locations. Two samples were collected from the Arkansas River. One sample was collected upstream of the site (CO-SE-01) and one was collected downstream (CO-SE-02). Sample CO-SE-04 was collected at the base of the site where the water flows into a storm culvert for conveyance to the Arkansas River. Additionally, one sediment sample (CO-SE-06) was collected from the on-site seep, collocated with the surface water sample. Sample locations are depicted on Figure 4. Analytical results are summarized in Table 4.

Due to the absence of developed sediment benchmarks, soil screening level benchmarks are provided for comparison. The benchmark for lead is 400 mg/kg, the residential soil screening level recommended in EPA's OSWER Directive 9355.4-12[47], and CDPHE's Residential Soil Cleanup Table Value Standard[48]. The remaining benchmarks provided are the Superfund Chemical Data Matrix (SCDM) Reference Dose Screening Concentrations[49] for residential soils. Concentrations of arsenic and lead are above the reference benchmarks for the onsite sediment sample.

Comparison of concentrations in release samples with concentrations in background samples reveals that there are no elevated metals in the sediments of the Arkansas River downstream of the Probably Point of Entry (PPE) from the site. There is no apparent impact on Arkansas River sediments due to the Colorado Smelter.

Sediment sample CO-SE-06, collected from the on-site seep, contains concentrations of several metals that are much higher than in the other sediment samples. Although not directly applicable, the soil screening benchmarks for arsenic and lead were exceeded.

TABLE 4
Sediment Data (mg/kg)

	Arkansas River		On-site Ravine		Benchmark
	CO-SE-01 Upstream	CO-SE-02 Downstream	CO-SE-04	CO-SE-06	
Aluminum	3950	2560	3140	5530	
Antimony	7.4 UJ	7.4 UJ	9.6 UJ	20.2 J	31
Arsenic	6.4	3.4 UJ	19.1	45.8	23
Barium	111	70.7	253	1690	5475
Beryllium	0.42 J+	0.30 J+	0.36 J+	0.75 J+	156
Cadmium	1.7 U	0.69 U	13.4	6.8	39
Chromium	8.0	5.6	5.7	6.6	230
Cobalt	6.2 UJ	6.2 UJ	8.0 UJ	8.5 UJ	
Copper	16.8 J+	9.0 J+	92.9	427	
Iron	15200	9510	10000	39700	
Lead	26.7	17.7	293	2410	400
Manganese	210 J	233 J	607 J	6830 J	11000
Nickel	15.0 J+	7.2 J+	10.0 J+	12.2 J+	1600
Selenium	4.4 U	4.3 U	9.1	11.0	390
Silver	1.2 UJ	1.2 UJ	1.6 UJ	4.1 J-	391
Thallium	3.1 U	3.1 U	4.0 U	4.3 U	
Vanadium	30.8	18.7	22.0	29.5	548
Zinc	105	71.5	3700	10700	23000

The benchmark for lead is 400 mg/kg, the screening level recommended in EPA's OSWER Directive 9355.4-12[50], and CDPHE's Residential Soil Cleanup Table Value Standard[51]. The remaining benchmarks provided are the Superfund Chemical Data Matrix (SCDM) Reference Dose Screening Concentrations for residential soils[52]. Shaded cells indicate concentration is greater than benchmark.

9.2 SURFACE WATER SAMPLE LOCATIONS AND ANALYTICAL RESULTS

Surface water samples were collected from two locations along the Arkansas River, from the Santa Fe Avenue Bridge Culvert, and from two onsite locations, as depicted on Figure 4.

The two surface water samples collected from the Arkansas River were collocated with the sediment samples. Sample CO-SW-01 was the background sample and CO-SW-02 was

collected downstream of the PPEs. Analytical results for the Arkansas River samples are summarized Table 5.

Comparison of concentrations in release sample CO-SW-02 with concentrations in background sample CO-SW-01 reveals that no elevated concentrations are present in the Arkansas River downstream of the PPE from the site. Elevated concentrations are defined as three times background.

TABLE 5
Surface Water Data – Arkansas River (ug/L)

	CO-SW-01 Upstream Arkansas River		CO-SW-02 Downstream Arkansas River		Benchmark[a]
	Total	Dissolved	Total	Dissolved	Dissolved
Aluminum	137	20.0 U	91.0	20.0 U	
Antimony	2.0 U	2.0 U	2.0 U	2.0 U	
Arsenic	0.85 J	0.73 J	0.65 J	0.62 J	100[b]
Barium	46.1 J	42.0 J	46.0 J	43.6 J	
Beryllium	1.0 U	1.0 U	1.0 U	1.0 U	
Cadmium	1.0 U	1.0 U	1.0 U	1.0 U	1.2
Chromium	0.50 J	0.33 J	0.54 J	0.36 J	231
Cobalt	1.0 U	1.0 U	1.0 U	1.0 U	
Copper	3.2	2.2	2.0 U	2.0 U	29.3
Iron	209	200 U	143 J	200 U	1000[b]
Lead	1.6	1.0 U	1.1	1.0 U	10.9
Manganese	38.2	1.0 U	33.5	1.7	2618
Nickel	1.7	1.3	1.4	1.4	168
Selenium	2.9 J	2.8 J	3.6 J	3.4 J	597
Silver	1.0 U	1.0 U	1.0 U	1.0 U	0.81[c]
Thallium	1.0 U	1.0 U	1.0 U	1.0 U	
Vanadium	0.94 J	0.41 J	0.39 J	0.34 J	
Zinc	64.8	34.3	38.9	33.2	405.3

[a]Benchmarks are chronic Table Value Standards from CDPHE Water Quality Control Division Regulation 32[53]. A capped hardness value of 400 mg/L was used in the calculation of hardness-based values.
[b]Table Value Standard is for Total Recoverable analysis.
[c]Table Value Standard is for Brown Trout.

Surface water samples were collected from the Santa Fe Avenue Bridge Culvert discharge to the Arkansas River (CO-SW-03), the on-site ravine where it flows into a storm culvert prior to discharge to the Arkansas River (CO-SW-04), and in the middle of the on-site ravine where water appears to be in contact with slag materials (CO-SW-06). Analytical results are summarized in Table 6.

Surface water samples were compared to surface water benchmarks defined as the Table Value Standards from the CDPHE Water Quality Control Division Regulation 32, Classifications and Numeric Standards for Arkansas River Basin[54]. The on-site seep (CO-SW-06) sample showed concentrations of cadmium, copper, lead and zinc above benchmarks. The Santa Fe Avenue bridge culvert (CO-SW-03), an observed PPE to the Arkansas River, discharges water with an elevated concentration of iron. The other identified site discharge (CO-SW-04) contained water flowing from the site with concentrations of cadmium, copper, iron, lead and zinc above benchmarks.

TABLE 6
Surface Water Data - PPEs (ug/L)

	CO-SW-03 Santa Fe Ave Bridge Culvert		CO-SW-04 Discharge to Storm Culvert		CO-SW-06 On-site Seep		Benchmark[a]
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Dissolved
Aluminum	20.0 U	20.0 U	677	20.0 U	262	20.0 U	
Antimony	2.0 U	2.0 U	4.1	3.9	3.7	3.1	
Arsenic	0.67 J	0.97 J	15.9	11.3	16.6	10.2	100[b]
Barium	13.9 J	13.2 J	63.3 J	31.9 J	39.0 J	34.7 J	
Beryllium	1.0 U	1.0 U	1.0 UJ	1.0 U	1.0 U	1.0 U	
Cadmium	1.0 U	1.0 U	4.4	0.58 J	1.8	1.2	1.2
Chromium	0.37 J	0.33 J	2.3	0.43 J	0.68 J	0.49 J	231
Cobalt	1.0 U	1.0 U	2.4	1.0 U	1.0 U	1.0 U	
Copper	2.0 U	2.0 U	35.5	7.4	33.2	10.0	29.3
Iron	12000	200 U	7380 J	200 U	556	49.9 J	1000[b]
Lead	0.49 J	0.39 J	184	1.0 U	64.6	1.9	10.9
Manganese	489	446	938	15.5	93.9	14.5	2618
Nickel	4.5	4.8	14.7	6.4	7.1	6.4	168
Selenium	8.7	12.5	88.0	901	103	94.8	597
Silver	1.0 U	1.0 U	1.0 UJ	1.0 U	1.0 U	1.0 U	0.81[c]
Thallium	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	1.0 UJ	
Vanadium	5.0 U	5.0 U	4.4 J	0.49 J	1.5 J	0.42 J	
Zinc	82.2	80.5	1480	304	802	608	405.3

[a]Benchmarks are chronic Table Value Standards from CDPHE Water Quality Control Division Regulation 32[55]. A capped hardness value of 400 mg/L was used in the calculation of hardness-based values.
[b]Table Value Standard is for Total Recoverable analysis.
[c]Table Value Standard is for Brown Trout.
Shaded cells indicate concentration is greater than benchmark

10.0 SOIL EXPOSURE PATHWAY

It is likely the emissions from the smoke stacks resulted in widespread contamination of surficial soils with heavy metals. Soils contaminated with cadmium, arsenic, lead and zinc may be found in residential areas surrounding former smelter plant sites. Approximately 93,000 residents live

within one mile of the Colorado Smelter site. The nearest residence is located approximately 200 feet from the slagheap.

Since the prevailing wind direction in Pueblo is from the west-northwest, the chosen locations for soil samples were heavily biased to the east-southeast. Residences located to the south were chosen for sampling due to the ages of the homes suggesting they were constructed while smelter operations were still ongoing. These soils are presumably less likely to have been disturbed. Samples were also collected from residences located to the west and north of the site.

10.1 BACKGROUND SAMPLES

Two 5-point multi-increment samples were collected from an area approximately 2 miles northwest of the site and outside the area likely to be impacted by emissions from the site.

TABLE 7
Background Soil Data (mg/kg)

	CO-BG-01-1	CO-BG-02-1	3x Highest Background
Arsenic	16	14	48
Chromium	65 J	63 U	195
Cobalt	121 J	160 J	480
Copper	20 J	20 J	60
Iron	17780	17311	53340
Lead	47	22	141
Manganese	268	217	804
Mercury	6.4 U	7	21
Nickel	40	33 U	120
Selenium	4.0 J	2.8 J	12
Zinc	133	84	399

10.2 RESIDENTIAL SOIL SAMPLE LOCATIONS AND ANALYTICAL RESULTS

Sample locations are depicted on Figure 5. Individual aliquot sample locations and XRF multi-increment results are depicted on Figure 6. Analytical results inclusive of XRF and CLP data are presented as an attachment at the end of the report. A total of 47 residential lots were sampled for this investigation. An additional 3 vacant lots were sampled, as was 1 road frontage.

Residential lots were divided into between one and five zones. In each zone, 3 to 5 discrete, multi-increment samples were collected. The discrete samples, or aliquots, were collected into plastic bags and analyzed with the XRF. These samples were not homogenized or processed,

however they were generally dry and fairly uniform. The aliquots were later combined (composited), dried and sieved, placed in sample cups and analyzed with the XRF in a bench-top mode at URS's laboratory in Denver, Colorado. Seventy-eight residential and 4 vacant lot or road frontage soil multi-increment samples were analyzed. Results are presented in Table 8.

Seventy-three of the multi-increment samples contained concentrations of one or more metal greater than three times background. Metals exceeding background concentrations in some of the samples include arsenic, cobalt, copper, iron, lead, manganese, and zinc.

TABLE 8
Multi-increment Soil Sample XRF Data (mg/kg)

	Arsenic	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc
CO-SO-01-2	66 U	49 U	342	162	35400	662	994	1.2 U	12 U	1.4 U	1330
CO-SO-01-3	79 U	81 J	360	133	39100	785	958	8	12 U	1.4 U	1160
CO-SO-02-1	40 U	49 U	540	123	30600	403	800	1.2 U	12 U	1.4 U	738
CO-SO-02-4	37 U	49 U	328	86	33000	371	726	1.2 U	12 U	5.0	653
CO-SO-03-1	15	49 U	239 J	37 J	25000	71	440	1.2 U	12 U	3.9 J	255
CO-SO-03-2	16	49 U	188 J	38	24100	36	424	1.2 U	12 U	3.9 J	235
CO-SO-04-1	28	60 J	313 J	82	30200	275	524	1.2 U	12 U	3.7 J	498
CO-SO-04-4	31 U	49 U	208 J	89	30900	308	467	1.2 U	12 U	3.5 J	638
CO-SO-05-1	25 U	49 U	234 J	205	27200	253	566	1.2 U	12 U	1.4 U	494
CO-SO-05-3	24 U	49 U	377	154	32200	243	571	1.2 U	12 U	3.1 J	644
CO-SO-06-2	28 U	62 J	319 J	87	31900	277	673	1.2 U	12 U	3.1 J	642
CO-SO-06-3	11	49 U	233 J	28 J	26600	69	408	6	12 U	1.4 U	169
CO-SO-07-2	25 U	49 U	210 J	46	26300	245	566	1.2 U	12 U	1.4 U	606
CO-SO-07-4	19 U	49 U	210 J	43	24300	194	567	1.2 U	12 U	1.4 U	454
CO-SO-08-1	26 U	70 J	320 J	59	29600	263	579	4.0 U	25 U	0.9 U	430
CO-SO-09-1	23 J	62 U	264 J	46	24600	151	484	4.0 U	25 U	0.9 U	282
CO-SO-09-4	29 U	62 J	331 J	58	33900	287	595	4.0 U	25 U	0.9 U	461
CO-SO-10-1	37 U	117 J	312 J	104	36800	371	917	4.0 U	25 U	0.9 U	970
CO-SO-11-4	23 U	77 J	297 J	66	31900	232	574	7.0 J	25 U	2.5 J	585
CO-SO-12-1	17 U	62 U	229 J	33	26300	166	465	4.0 U	25 U	0.9 U	326
CO-SO-13-1	42 U	69 J	291 J	153	43400	421	875	4.0 U	25 U	0.9 U	1124
CO-SO-13-4	23 U	62 U	295 J	74	36300	226	677	7.0 J	25 U	0.9 U	573
CO-SO-14-1	11 J	89 J	264 J	35	26500	93	610	4.0 U	25 U	0.9 U	345
CO-SO-14-4	18 U	62 U	201 J	37	26500	177	648	6.2 J	25 U	0.9 U	386
CO-SO-15-1	32 U	108 J	290 J	62	33700	321	660	9.0 J	25 U	0.9 U	622
CO-SO-15-4	33 U	62 U	287 J	71	33600	326	685	4.0 U	25 U	3.0 J	672
CO-SO-16-4	25 J	62 U	266 J	38	29300	165	569	8.0 J	25 U	3.5	423
CO-SO-17-1	18 J	62 U	248 J	48	29500	150	550	4.0 U	25 U	0.9 U	374
CO-SO-17-4	12 U	90 J	271 J	40	27100	123	518	4.0 U	25 U	0.9 U	316
CO-SO-18-4	34 U	82 J	322 J	90	37600	339	818	4.0 U	25 U	0.9 U	893
CO-SO-19-2	37 U	84 J	317 J	67	40500	365	889	4.0 U	25 U	0.9 U	970
CO-SO-20-1	26 U	62 U	347 J	54	33700	263	560	4.0 U	25 U	0.9 U	420
CO-SO-20-3	36 U	62 U	309 J	79	35600	632	764	4.0 U	25 U	0.9 U	783

TABLE 8
Multi-increment Soil Sample XRF Data (mg/kg)

	Arsenic	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc
CO-SO-21-4	23 J	75 J	333 J	48	30600	221	536	4.0 U	25 U	0.9 U	460
CO-SO-22-1	32	62 U	248 J	49	30200	180	556	7.0 J	25 U	0.9 U	438
CO-SO-22-3	24 J	62 U	344 J	45	31200	235	573	4.0 U	25 U	0.9 U	535
CO-SO-23-4	40 U	69 J	266 J	75	31500	401	709	7.0 J	25 U	0.9 U	701
CO-SO-24-1	45	62 U	356 J	101	42500	373	1050	10 J	25 U	0.9 U	970
CO-SO-25-3	34 U	65 J	373 J	116	46300	338	1010	4.0 U	25 U	0.9 U	901
CO-SO-26-2	44 U	62 U	384 J	153	46100	441	1110	4.0 U	25 U	0.9 U	1250
CO-SO-27-2	25 U	70 J	368 J	94	36900	253	839	10 J	25 U	3.6	691
CO-SO-28-1	41 U	62 U	297 J	88	35700	412	833	4.0 U	25 U	0.9 U	764
CO-SO-28-4	45 U	62 U	349 J	91	34800	448	779	4.0 U	25 U	2.8 J	860
CO-SO-29-1	15 J	71 J	221 J	33	29400	137	590	9.0 J	25 U	2.3 J	279
CO-SO-29-4	24 U	69 J	323 J	63	37000	236	662	8.0 J	25 U	3.7	632
CO-SO-30-2	51 U	62 U	524	55	49300	510	956	4.0 U	25 U	0.9 U	1150
CO-SO-30-4	41 U	62 J	245 J	56	23900	406	618	4.0 U	25 U	0.9 U	672
CO-SO-31-1	35 U	66 J	326 J	82	37700	351	782	4.0 U	25 U	2.6 J	874
CO-SO-31-4	47 U	62 U	312 J	100	35800	473	711	4.0 U	25 U	0.9 U	871
CO-SO-32-3	28 U	62 U	303 J	56	37200	280	665	9.0 J	25 U	0.9 U	611
CO-SO-32-4	38	62 U	308 J	51	35500	379	639	4.0 U	25 U	0.9 U	649
CO-SO-33-1	33 U	62 U	315 J	75	35500	328	729	7.0 J	25 U	0.9 U	822
CO-SO-34-2	35	62 U	246 J	45	31300	147	581	4.0 U	25 U	0.9 U	322
CO-SO-34-4	32	70 J	251 J	44	27400	114	492	7.0 J	25 U	2.8 J	299
CO-SO-35-1	39 U	79 J	301 J	104	34500	394	834	4.0 U	25 U	0.9 U	671
CO-SO-36-3	52 U	78 J	332 J	91	44000	519	928	4.0 U	25 U	0.9 U	772
CO-SO-37-1	37 U	62 U	259 J	64	32800	369	749	4.0 U	25 U	0.9 U	659
CO-SO-38-1	41 U	93 J	344 J	96	39800	407	927	4.0 U	25 U	0.9 U	827
CO-SO-38-4	62 U	62 U	404 J	136	49900	616	1100	8.0 J	25 U	0.9 U	1320
CO-SO-39-1	36 U	83 J	252 J	57	37600	363	770	7.0 J	25 U	0.9 U	791
CO-SO-39-4	43 U	62 U	314 J	104	38100	428	792	4.0 U	25 U	0.9 U	768
CO-SO-40-1	188	84 J	545	131	68000	515	1400	4.0 U	25 U	0.9 U	1360
CO-SO-40-4	149	100 J	455 J	135	62600	581	1610	4.0 U	25 U	0.9 U	1630
CO-SO-41-1	105	133 J	435 J	122	66900	542	1590	4.0 U	25 U	0.9 U	1420
CO-SO-41-4	64 U	75 J	572	169	65100	640	1640	4.0 U	25 U	0.9 U	1680
CO-SO-42-1	135	62 U	567	147	74500	538	1520	4.0 U	25 U	0.9 U	1640
CO-SO-42-4	36 U	62 U	302 J	111	42000	359	915	8.0 J	25 U	0.9 U	840
CO-SO-43-1	129	73 J	253 J	145	47700	616	1350	4.0 U	25 U	0.9 U	1290
CO-SO-43-4	195	68 J	478	182	60400	742	1400	4.0 U	25 U	0.9 U	1660
CO-SO-44-2	31 U	68 J	376 J	69	35500	306	740	4.0 U	25 U	0.9 U	727
CO-SO-44-4	24 U	62 U	345 J	109	30900	243	581	4.0 U	25 U	0.9 U	496
CO-SO-45-1	36 U	62 U	454 J	87	46400	355	921	4.0 U	25 U	0.9 U	846
CO-SO-45-4	17 J	62 U	293 J	40	29300	136	566	8.0 J	25 U	0.9 U	412
CO-SO-46-1	33 U	62 U	160 J	77	25000	327	577	4.0 U	25 U	0.9 U	512
CO-SO-46-4	30 U	62 U	333 J	79	30800	301	552	4.0 U	25 U	0.9 U	678
CO-SO-47-2	38 U	62 U	218 J	102	32500	379	736	4.0 U	25 U	0.9 U	818
CO-SO-48-4	23 U	62 U	268 J	74	25900	227	514	4.0 U	25 U	0.9 U	436
CO-SO-49-1	22 U	62 U	216 J	39	27700	216	624	4.0 U	25 U	0.9 U	456
CO-SO-50-1	10 J	62 U	247 J	24 J	24300	94	488	4.0 U	25 U	3.0 J	210

TABLE 8
Multi-increment Soil Sample XRF Data (mg/kg)

	Arsenic	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc
CO-SO-51-1	33 U	62 U	227 J	65	27100	329	601	4.0 U	25 U	3.4	503
CO-SO-51-2	26 U	62 U	141 U	56	25100	263	440	4.0 U	25 U	0.9 U	464
Benchmark	0.43	230	-	-	-	400	11000	23	1600	390	23000
3x Background	48	195	480	60	53400	141	804	21	120	12	399

Cells shaded with blue are greater than three times background
Cells shaded with red are greater than three times background and greater than the screening benchmark

As anticipated, the concentrations of lead decrease with distance from the site. Seventy-two of the multi-increment samples collected from 49 residential properties (or vacant lots) exceed three times background concentrations for lead. A total of 23 multi-increment residential soil samples, collected from 15 unique properties, contained concentrations of lead in excess of 400 ppm, the residential soil screening criteria recommended in EPA's OSWER Directive 9355.4-12[56] and in CDPHE's Soil Remediation Objectives policy[57].

Six multi-increment residential soil samples, collected from 4 unique properties, exceeded both three times background and the SCDM benchmark for arsenic. It should be noted that due to interference between lead and arsenic with the XRF instrument, high lead concentrations can sometimes result in arsenic being reported as non-detect (U value) when, in fact, it is present (see Section 11.3.1). As a rule of thumb, if the lead concentration is 10-times higher than the arsenic concentration, then the arsenic detection limit may exceed the arsenic concentration. Arsenic contamination may be more widespread than can be realized from the data.

The raw XRF data was reviewed for arsenic concentrations calculated by the XRF instrument using algorithmic corrections and secondary spectral peaks. While these results do not pass quality control and data validation protocols, it can provide qualitative information on the presence of arsenic. One additional multi-increment soil sample contained a concentration of arsenic that exceeded three times background. Sample CO-SO-38-4 had a calculated arsenic value of 53 mg/kg.

10.3 PUBLIC ACCESS SAMPLES

As discussed in Section 10.2, 4 5-point multi-increment samples were collected along the edge of roadways or in vacant lots as depicted on Figure 6. These were samples CO-SO-08, CO-SO-12, CO-SO-49 and CO-SO-50. The results from the analysis of these samples are included with the residential soil results in Table 8 above.

11.0 DATA QUALITY ASSESSMENT

A Data Quality Assessment is used to assess the type, quantity, and quality of data in order to verify that the planning objectives, Quality Assurance Project Plan components, and sample collection procedures were satisfied and that the data are suitable for its intended purpose. The data quality assessment conducted for this project to determine data quality and usability included:

- A Quality Assurance/Quality Control (QA/QC) review of field generated data and observations;
- A review of the individual data validation reports for all CLP sample delivery groups, and the procedures used by the validator (Tech Law) to qualify data for reasons related to dilution, reanalysis, control sample results, and duplicate analysis of samples;
- An assessment of the quality of both CLP and XRF data measured and generated in terms of accuracy, sensitivity, precision, and representativeness; including an evaluation of QC samples such as field replicates, laboratory blanks and standards, and laboratory control samples including matrix spikes to assess the quality of the field activities and laboratory procedures ; and
- A summary of the usability of the data, based upon the assessment of data conducted during the previous steps.

There were four types of data included in the data quality assessment for the Fountain Foundry project, including:

- CLP laboratory Target Analyte List (TAL) metals data for surface water samples, including total and dissolved analyses;
- CLP laboratory TAL metals data for sediment samples;
- XRF data for soil samples; and
- CLP laboratory TAL metals data for XRF collaborative comparison.

11.1 FIELD QUALITY CONTROL PROCEDURES

All Technical Standard Operating Procedures (TSOPs) for field activities as specified in the approved SAP[58] were followed thus maintaining representativeness and comparability in the data set. The DQOs for this project have been met and the data collected are of sufficient quality to answer the site investigation questions.

Six surface water samples, including a duplicate, were collected into 1-liter polyethylene bottles, preserved with nitric acid to a pH of less than 2.0, placed in a cooler with ice, and sent to ChemTech Consulting Group for CLP analysis of total and dissolved TAL metals.

Four sediment samples were collected into 8-ounce glass jars and shipped with the surface water samples to ChemTech for TAL metals analysis. The samples were preserved with ice to a temperature of approximately 4ºC.

A total of 439 source, background, and residential soil samples were collected into zip-top polypropylene bags. The samples were delivered to the Superfund Technical Assessment and Response Team (START) laboratory for analysis of metals by X-ray fluorescence (XRF). The samples were analyzed directly in the bags using a Niton SRF XLt 700 Series portable XRF analyzer. Additionally, the samples were composited, dried, sieved, placed in method specific polyethylene sample cups per EPA Method SW-846 6200 guidelines, and analyzed with the XRF. A total of 88 multi-increment samples were analyzed, each one composited from the five aliquots collected in each “zone” or decision unit as described in Section 5.2.

For confirmatory analysis, roughly 10% of the XRF soil samples (including individual aliquot and multi-increment) were shipped by UOS via Fedex to Sentinel Inc., for Target Analyte List (TAL) metals analysis by CLP Method ICP-AES ILM05.4. The samples for confirmatory analysis were selected to provide a range of concentrations based on XRF data.

11.2 DATA VALIDATION AND INTERPRETATION

A total of 439 individual soil samples were collected into 1-quart seal top polypropylene bags. These were analyzed directly through the poly bag with the XRF at the START laboratory in Denver. Later, the samples were combined into 88 multi-increment samples (collected from 47 residential properties, 4 road right-of-ways, 4 waste piles and 2 background locations) dried, sieved and placed in small plastic cups and analyzed with the XRF.

A QA/QC check was run on the XRF run logs and resulting data. There were two distinct types of samples within the XRF data set: aliquot grab samples which were analyzed directly in zip-top polypropylene sample bags and zone composite samples, which were multi-increment samples created by combining equal amounts of all aliquot samples in a zone, drying, sieving, and then placing the sample in a small plastic cup for analysis on the XRF.

Results were qualified as estimated based upon two criteria. The first criterion is noted by a “J” qualifier and indicates that the associated numerical value is an estimated quantity because quality control criteria were not met. The presence of the analyte is considered reliable. The second criterion is noted by a “U” and indicates that the associated numerical value was not detected above the reported detection limit.

XRF lead results were reviewed to determine samples to be selected for laboratory analysis. Fifty-seven samples were submitted to Sentinel, Inc. for Target Analyte List (TAL) metals analysis through the EPA Contract Lab Program (CLP). Eleven of these samples were zone composites. The remaining 44 were aliquots. Two of the aliquot samples were submitted along with duplicates. The need to construct a representative curve with a broad range of lead values with a cluster of data around the CDPHE residential screening level of 400 parts per million (ppm) was a strong factor in determining which samples were sent for confirmatory analysis.

The sediment and surface water samples were submitted to ChemTech Consulting Group for analysis of total and dissolved metals by ICP-MS (ILM05.4) through CLP.

The analytical data received from the laboratory was reviewed and validated as planned. All data was determined to be usable as qualified.

11.3 DATA QUALITY INDICATORS

Quality attributes are qualitative and quantitative characteristics of the collected data. Data Quality Indicators (DQIs) are specific indicators of quality attributes. The DQI’s most relevant to environmental studies are precision, bias, representativeness, comparability, completeness, and sensitivity. The following DQIs were considered during the review of field collection techniques, field QA/QC results, as well as laboratory QA/QC.

11.3.1 Precision

Precision is the measure of agreement among repeated measurements of the same property under identical, or substantially similar, conditions and is expressed as the relative percent difference (RPD) between the sample pairs. Duplicates are used to evaluate precision.

11.3.1.1 XRF Data

XRF analytical precision was controlled by the use of duplicate samples, which are denoted by a “D” following the sample ID (e.g., “CO-SO01-3.5D”). Nineteen samples were analyzed in

duplicate via the XRF. This included 12 aliquot samples and 7 multi-increment zone composites. Duplicate results are presented in Table 9.

Duplicate aliquot grab samples were created by analyzing a seal top poly bag sample twice; once on each side of the bag. Duplicate zone composite samples were created by preparing two separate composites from the same aliquot samples. The two different types of duplicates are designed to control two different areas of uncertainty: the duplicates of individual aliquots in seal top poly bags assess variability within discrete samples and the duplicates created by compositing all the aliquots in a zone are designed to verify the appropriateness of the sample unit area. If the zone relative percent differences (RPDs) for the zone composite samples were high that would indicate a need to re-assess the size of the sample unit.

TABLE 9
XRF Soil Duplicates (mg/kg)

Aliquot Samples			
Sample Identification	Lead Result	Duplicate Lead Result	%RPD
CO-SO-02-1.2	249	256	2.77
CO-SO-04-1.4	300	340	12.5
CO-SO-08-1.2	402	402	2.26
CO-SO-13-1.1	497	497	1.40
CO-SO-15-1.1	259	259	9.91
CO-SO-17-4.1	85	88	3.47
CO-SO-20-1.2	112	138	20.8
CO-SO-21-4.5	221	221	0.00
CO-SO-30-2.2	478	468	2.11
CO-SO-39-4.5	240	247	2.87
CO-SO-41-1.4	592	595	0.51
CO-WP-04-1.5	695	665	5.93
Average RPD 5.38%			
Multi-Increment Samples			
Sample Identification	Lead Result	Duplicate Lead Result	%RPD
CO-SO-02-1	403	408	1.23
CO-SO-08-1	275	275	4.46
CO-SO-22-1	180	182	1.10
CO-SO-35-1	394	395	0.25
CO-SO-46-4	301	296	1.68
CO-SO-51-2	274	274	4.10
CO-WP-01-1	5417	5384	0.61
Average RFP 1.92%			
Combined Average RPD 4.10%			

The RPDs for lead results ranged from 0.00 – 20.8%, with an average RPD of 4.10%. None of the duplicates exceeded the acceptable goal of 35% RPD for metals in soil. See Table 9 below for a summary of the replicate results.

11.3.1.2 CLP Data

A duplicate surface water sample was collected in the field and submitted blind to ChemTech Consulting Group for analysis of total and dissolved metals. The duplicate sample was assigned a unique sample identifier. Analytical results are presented in Table 10.

The duplicate sample for total metals analysis was inadvertently filtered. Therefore, no field duplicate data for total metals is available. ChemTech performed duplicate sample analysis by analyzing a second sample aliquot at least once per every 20 samples analyzed, as a part of routine QA/QC procedures. These laboratory duplicate results were within acceptable criteria.

TABLE 10
Surface Water Duplicates (ug/L)

	Total			Dissolved		
	CO-SW-04	Duplicate (CO-SW-05)	% RPD	CO-SW-05	Duplicate (CO-SW-05)	% RPD
Aluminum	677	na	na	20.0 U	20.0 U	na
Antimony	4.1	na	na	3.9	3.7	5.3
Arsenic	15.9	na	na	11.3	11.0	2.7
Barium	63.3 J	na	na	31.9 J	33.6 J	5.2
Beryllium	1.0 U	na	na	1.0 U	1.0 U	na
Cadmium	4.4	na	na	0.58 J	0.63 J	8.3
Chromium	2.3	na	na	0.43 J	0.43 J	0
Cobalt	2.4	na	na	1.0 U	1.0 U	na
Copper	35.5	na	na	7.4	7.7	4.0
Iron	7380 J	na	na	200 U	200 U	na
Lead	184	na	na	1.0 U	1.0 U	na
Manganese	938	na	na	15.5	11.6	29
Nickel	14.7	na	na	6.4	6.6	3.1
Selenium	88.0	na	na	90.1	87.2	3.3
Silver	1.0 U	na	na	1.0 U	1.0 U	na
Thallium	1.0 U	na	na	1.0 U	1.0 U	na
Vanadium	4.4 J	na	na	0.49 J	0.71 J	37
Zinc	1480	na	na	304	348	14
Average			na			10.2

The average RPD for the surface water duplicate was 10.2% for dissolved metals, below the acceptable criteria of 20%. The analyte specific RPD met the criteria of less than 20% for each dissolved metal except for manganese. However, the concentration of manganese was lower

than any of the applicable benchmarks. The overall precision requirements for water samples analyzed at the CLP laboratory were met for all dissolved metals.

No field duplicates of sediments were collected. ChemTech performed a laboratory duplicate sample analysis as part of routine QA/QC procedures. The RPD was within acceptable criteria for all metals.

Two duplicate samples, one residential soil and one source sample, were submitted to Sentinel (through the EPA CLP program) and analyzed for TAL metals without mercury. Results for the duplicate samples are included in Table 11.

The average RPD for the duplicate soil sample was 5.3%. The calculated RPD for each analyte was below 35%, the acceptable limit for soil. More variability was observed with the source (waste pile) sample. The average RPD was 20.1%, and analyte specific RPDs ranged from less than 1 to greater than 74%. The RPD was greater than 35% for copper, iron, lead, manganese and zinc. The variability is likely due to the heterogeneity of the waste pile. Although the samples were dried, sieved with a 250 micrometer mesh, and placed in small plastic cups, the slag particulates may have variable mineral composition.

TABLE 11
CLP Soil Duplicates (mg/kg)

	CO-SO-08-1.5 MH2W97	CO-SO-08-1.52 MH2W98	% RPD	CO-WP-02-1.3 MH2WD1	CO-WP-02-1.32 MH2WD2	% RPD
Aluminum	6240	6160	1.29	15000	15200	1.32
Antimony	6.0 U	6.0 U		22.1 J	22.2 J	0.45
Arsenic	5.5 J	5.7 J	3.57	53.5	47.8	11.25
Barium	136 J	132 J	2.99	816 J	814 J	0.25
Beryllium	0.33 J	0.34 J	2.99	0.90 J	1.0 J	10.53
Cadmium	2.7	2.9	7.14	5.2 J	5.1 J	1.94
Chromium	20.3	17.6	14.25	15.7 J	14.6 J	7.26
Cobalt	4.6 J	4.3 J	6.74	13.8 J	13.5 J	2.20
Copper	38.3	38.1	0.52	1270 J	675 J	61.18
Iron	22100 J	21300 J	3.69	198000	120000	49.06
Lead	158 J	156 J	1.27	8500	4470	62.14
Manganese	349 J	325 J	7.12	11200	6480	53.39
Nickel	11.0	10.2	7.55	27.2 J	26.8 J	1.48
Selenium	3.5 U	3.5 U		5.6 J	5.9 J	5.22
Silver	0.46 J	0.50 J	8.33	5.6 J	5.7 J	1.77
Thallium	2.5 U	2.5 U		0.79 J	0.94 J	17.34
Vanadium	40.4	37.4	7.71	41.6 J	41.1 J	1.21
Zinc	276 J	263 J	4.82	46100	21100	74.40
Average			5.33			20.13

Analytical precision was demonstrated to be acceptable for residential soil samples. Although the duplicate variability was above acceptable limits for the waste pile sample, the results of both analyses demonstrate concentrations of copper, iron, lead, manganese and zinc well above three times background.

11.3.2 Accuracy/Bias

Accuracy is the degree of agreement between an observed value (sample result) and an accepted reference value; *bias* describes the systematic or persistent distortion associated with a measurement process. The terms *accuracy* and *bias* are used interchangeably in this document.

Analyte accuracy/bias can be evaluated using different types of QC samples, including: Standard Reference Materials (SRM), laboratory initial calibration/continuing calibration verification (CCV), laboratory control spike/laboratory control spikes duplicates (LCS/LCSD), matrix spike/matrix spike duplicates (MS/MSD), standard blanks and method blanks.

11.3.2.1 XRF Data

XRF analytical accuracy was controlled using a Standard Reference Material (SRM) and blanks. SRM 2709 is a low level metals soil standard from the National Institute of Standards and Technology that was analyzed and used to develop a daily Method Detection Limit (MDL) and Reporting Limit (RL) for all metals. As discussed previously, the MDL and RL for arsenic was generally dependant on the concentration of lead in the sample. SRM 2709 was analyzed 42 times over the course of sample analysis. None of the SRM 2709 results were outside of control limits.

Two different types of blanks were also analyzed with both the aliquot and multi-increment samples, a standard blank and a method blank. The standard blank is made of a material known to be free of metals contaminants, and was analyzed at least twice per day. The method blank was prepared with certified clean sand, and was subjected to the same preparatory procedure for analysis as the samples. In 16 standard blank and 4 method blank analyses, there were no detections for lead or arsenic.

With XRF analytical detectors, results may be biased high due to lead interference in some samples. One of the weaknesses of XRF analysis is that the peaks in the spectra that are used to analyze lead and arsenic are close together and this can adversely affect the precision of the result values. Typically lead, being the larger peak, interferes with the value for arsenic

(artificially elevating it). In some XRF analyzers this flaw is compensated for making the reporting limit for arsenic 1/10 of the lead result by default. The Niton XRF arsenic detection limit is either three times the standard deviation of the XRF standard or one-tenth of the lead result, whichever is greater when lead is present.

While the data is still acceptable for decision making for lead, additional scrutiny, including fixed laboratory analysis, may be warranted for samples where the lead value is high and arsenic is non-detect.

11.3.2.2 CLP Data

A review of the CLP forms I though X for each Sample Delivery Group (SDG) was conducted to assess bias. Both positive and negative interference and blank contamination was noted by the laboratory and validator. The laboratory analyzed samples for TAL metals by CLP Method ILM05.4. Sample matrices include water, sediment and soil, including source and background samples.

Six water samples, including one duplicate, were sent to ChemTech Consulting Group for CLP analysis for total and dissolved metals by ICP-MS (ILM05.4). All data was usable as qualified. Qualifiers used with the surface water samples included “U” (the analyte was not detected above the reported level), “J” (the numeric value is an approximate concentration) and “UJ” (the reported quantitiation limit is estimated because quality control criteria were not met).

Four sediment samples were submitted for CLP analysis for metals by Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES) (ILM05.4). No data were qualified as rejected (R). Data qualifiers included “J” because the result was estimated; “J-” because the result was biased low; and “J+” because the result was biased high. Beryllium, cobalt and nickel were all qualified “J+” and silver was qualified “J-“ or “UJ” due to ICP interference. Antimony and manganese were estimated and were qualified “J” or “UJ” for all samples due to a matrix spike recovery of less than 75%, but post digestion recovery of greater than 75%.

Fifty-seven samples were submitted to Sentinel, Inc. for Target Analyte List (TAL) metals analysis through the EPA Contract Lab Program (CLP). Twelve of these samples were zone composites. The remaining 44 were aliquots. Two of the aliquot samples were submitted along with duplicates. The samples were analyzed to provide confirmatory information to ensure the accuracy of the XRF results. The CLP results were validated, and appropriate data qualifiers

applied to the sample results. No data were qualified as rejected. Several samples were qualified for various analytes. The data are acceptable for use as intended. Qualifiers included:

- "U" – the analyte was not detected above the reported level;
- "J" – the analyte was definitively detected, but the concentration is estimated;
- "J+" – the analyte concentration is estimated, but may be biased high;
- "J-" – the analyte concentration is estimated, but may be biased low; or
- "UJ" – the analyte was not detected above the reported level, but the reported quantitation level is estimated;

11.3.3 Representativeness

Representativeness is the measure of the degree to which data accurately and precisely represent a characteristic of a population parameter, variations at a sampling point, a process called condition, or an environmental condition. Representativeness was achieved by adherence to TSOPs for sampling procedures, adherence to field and laboratory QA/QC procedures, appropriateness of sample location, and achieving the acceptance criteria specified in the SAP. A review of the SAP, field log books, and laboratory data packages reveals no deviations or failures in the data that is being used for decision making at the site.

The use of multi-incremental sampling ensures that the data is representative of actual site conditions, and that the decision unit was constructed appropriately. Multi-increment samples are made by combining equal amounts from individual samples, drying and sieving them and then analyzing with the XRF. Multi-increment sampling provides a more representative estimate of the mean concentration for the area. The individual aliquots were also analyzed, and the results reviewed. Excessive variability within a decision unit could indicate the decision unit is too large.

11.3.4 Completeness

The Colorado Smelter SAP[59] called for the collection of:

- 2 background soil samples,
- up to 10 source samples,
- soil samples from up to 50 residences or right-of-ways,
- 2 surface water and sediment samples from the Arkansas River,
- 3 surface water and sediment samples from Probable Points of Entry (PPE), and
- up to 3 opportunity surface water and sediment samples from on-site seeps, springs or wetlands.

The 2 background samples were collected as anticipated (100% completeness). Five source samples were collected (50% completeness). Samples were also collected from 47 residences and 4 road right-of-ways (102% completeness).

Surface water and sediment samples were collected from the 2 Arkansas River locations (100% completeness). Surface water samples were collected from the 2 readily identified PPEs in which there was water, and 1 sediment sample was collected from the only PPE in which sediment was present (50% completeness). An opportunity source surface water and sediment sample was collected from the on-site ravine.

11.3.5 Comparability

Comparability is used to describe how well samples are interchangeable within a data set, as well as between two independent data sets. The soil samples collected were relatively dry and the percent moisture content of the samples from both data sets was similar. All samples were collected in three contiguous days. Finally, all samples were collected by the same personnel using the same SAP, TSOPs, sampling equipment and at approximately the same time of day. Thus the data within each data set are comparable.

To establish the comparability between XRF and CLP laboratory analysis, a subset of samples that were analyzed via XRF were also analyzed by the CLP laboratory.

Soil samples that were analyzed via the CLP laboratory program were chosen to meet requirements for developing a site score under the HRS. These results provide additional data to demonstrate the validity of XRF samples analyzed directly in the seal top poly bags and processed as multi-increment samples.

Eleven multi-increment soil samples and 44 individual aliquots were shipped to Sentinel Inc. for laboratory analysis. When the results were received, a discrepancy between the XRF and laboratory results for lead in five of the source samples. While the XRF results ranged from 3,765 – 11,928 mg/kg, the laboratory reported the lead values as not detected at 1.0 mg/kg. The laboratory reanalyzed the 5 samples, and reported the lead concentration as greater than 10,000 mg/kg in each. After the third analysis, a numeric value was reported for lead. Lead results for these 5 samples are presented in Table 12.

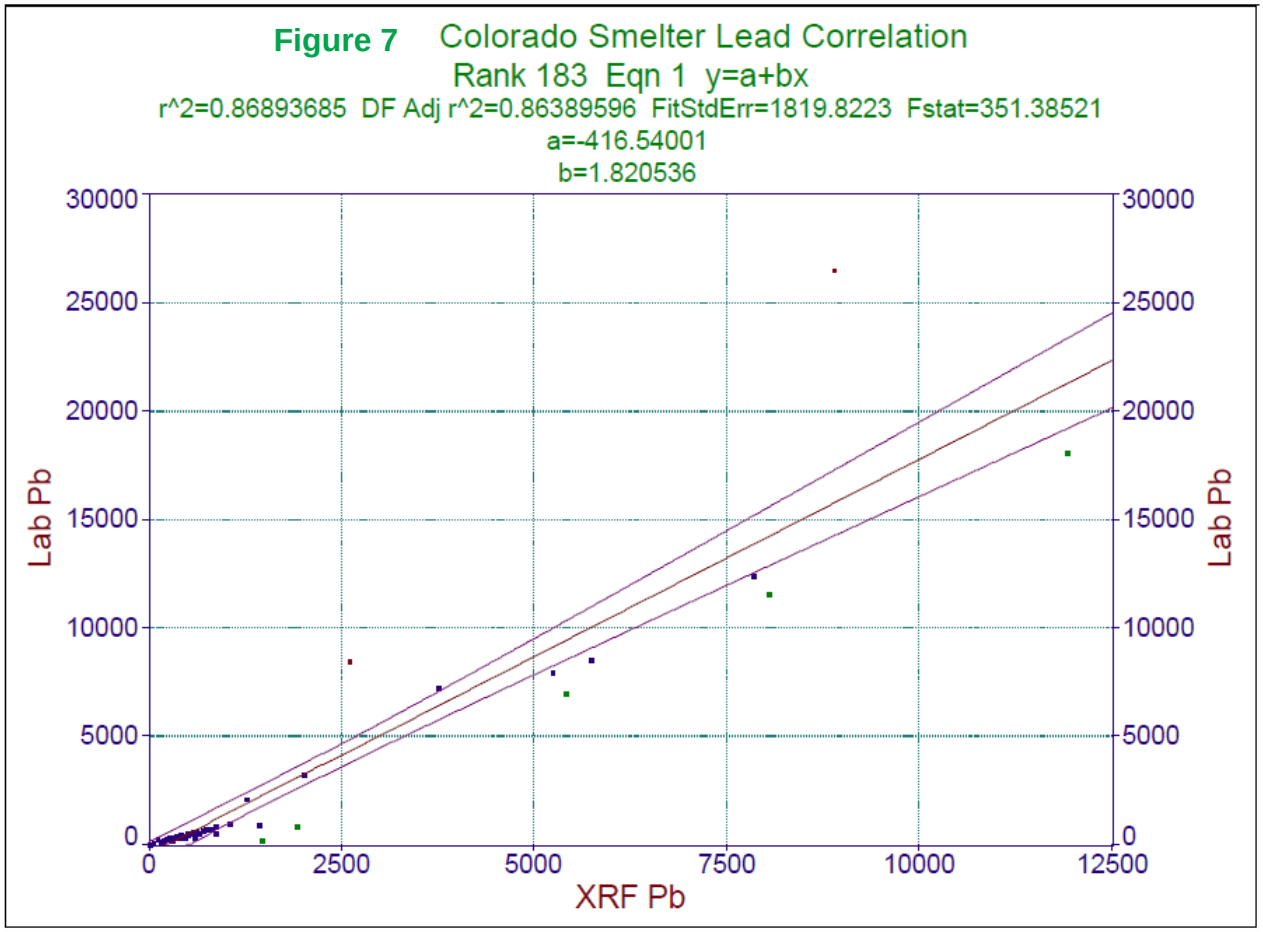
TABLE 12 Source Sample Lead Analysis (mg/kg)					
			CLP Analysis		
XRF Sample ID	CLP Sample ID	XRF Analysis	September 2010	November 2010	January 2011
CO-WP-04-1.3	MH2WD3	3765	1.0 U	> 10000	7260
CO-WP-01-1.2	MH2WD5	5742	1.0 U	> 10000	8570
CO-WP-03-1.1	MH2WD6	7852	1.0 U	> 10000	12400
CO-WP-01-1.3	MH2WD7	8891	1.0 U	> 10000	26500
CO-WP-03-1.3	MH2WD8	11928	1.0 U	> 10000	18100

Table 13 contains the lead concentrations recorded for each sample analyzed by both XRF and laboratory means. The RPD was calculated for each sample and ranged from 0.13% to 147%, with an average of 26%. High RPD's were generally associated with very low or very high concentrations. XRF instruments are characteristically more accurate when analyzing mid-range levels of metals (i.e. 100-1,000 ppm). Acceptable RPD's for soil analysis are 35% or less. While 17 of the 55 samples had RPD's outside this limit, the overall average RPD was an acceptable 26%.

TABLE 13 Confirmation Analysis (Concentrations in parts per million (ppm))				
XRF Sample Identification	Lab CLP Sample Identification	XRF Lead Result	Lab Lead Result	% RPD
CO-SO-03-2	MH2W82	63	72.2 J	13.61
CO-SO-22-1	MH2W83	180	188 J	4.35
CO-SO-51-2	MH2W84	263	261 J	0.76
CO-SO-24-1	MH2W85	373	397 J	6.23
CO-SO-40-1	MH2W86	515	536 J	4.00
CO-SO-40-4	MH2W87	581	621 J	6.66
CO-SO-43-1	MH2W88	616	576 J	6.71
CO-SO-43-4	MH2W89	742	743 J	0.13
CO-WP-04-1	MH2W90	1278	2140 J	50.44
CO-WP-01-1	MH2W91	5417	7010 J	25.64
CO-WP-03-1	MH2W92	8066	11600 J	35.94
CO-BG-02-1.5	MH2W93	9.2	15.8 J	52.80
CO-SO-12-1.2	MH2W94	32	42.1 J	27.26
CO-SO-14-1.4	MH2W95	67	63.4 J	5.52
CO-SO-07-4.1	MH2W96	124	270 J	74.11
CO-SO-08-1.5	MH2W97	168	158 J	6.13
CO-SO-22-3.1	MH2W99	208	201 J	3.42
CO-SO-24-1.1	MH2WA0	233	253 J	8.23
CO-SO-40-1.1	MH2WA1	259	312 J	18.56
CO-SO-40-1.2	MH2WA2	280	319	13.02

TABLE 13 Confirmation Analysis (Concentrations in parts per million (ppm))				
XRF Sample Identification	Lab CLP Sample Identification	XRF Lead Result	Lab Lead Result	% RPD
CO-SO-24-1.2	MH2WA3	289	275	4.96
CO-SO-43-1.2	MH2WA4	309	268	14.21
CO-SO-51-2.1	MH2WA5	316	225	33.64
CO-SO-42-1.5	MH2WA6	348	351	0.86
CO-SO-40-4.1	MH2WA7	366	329	10.65
CO-SO-41-1.5	MH2WA8	379	401	5.64
CO-SO-40-1.4	MH2WA9	388	411	5.76
CO-SO-38-1.4	MH2WB0	394	387	1.79
CO-SO-41-1.2	MH2WB1	405	373	8.23
CO-SO-41-1.1	MH2WB2	406	364	10.91
CO-WP-02-1.2	MH2WB3	414	478	14.35
CO-SO-43-1.5	MH2WB4	432	406	6.21
CO-SO-32-4.4	MH2WB5	466	423	9.67
CO-SO-31-4.5	MH2WB6	479	364	27.28
CO-SO-42-1.3	MH2WB7	500	499	0.20
CO-SO-43-1.1	MH2WB8	513	463	10.25
CO-SO-40-4.3	MH2WB9	551	540	2.02
CO-SO-41-1.4	MH2WC0	592	353	50.58
CO-SO-43-4.4	MH2WC1	644	554	15.03
CO-SO-43-4.3	MH2WC2	711	683	4.02
CO-SO-43-4.1	MH2WC3	814	755	7.52
CO-SO-42-1.1	MH2WC4	860	565	41.40
CO-SO-43-1.4	MH2WC5	864	836	3.29
CO-SO-40-4.2	MH2WC6	1053	962	9.03
CO-SO-28-4.3	MH2WC7	1430	945	40.84
CO-SO-18-4.5	MH2WC8	1471	223	147.34
CO-SO-01-3.4	MH2WC9	1924	828	79.65
CO-WP-02-1.1	MH2WD0	2028	3240	46.01
CO-WP-02-1.3	MH2WD1	2607	8500	106.11
CO-WP-04-1.3	MH2WD3	3765	7260	63.40
CO-WP-03-1.5	MH2WD4	5243	7950	41.04
CO-WP-01-1.2	MH2WD5	5742	8570	39.52
CO-WP-03-1.1	MH2WD6	7852	12400	44.91
CO-WP-01-1.3	MH2WD7	8891	26500	99.51
CO-WP-03-1.3	MH2WD8	11928	18100	41.11
Average				25.65

Figure 7 is the regression correlation graph for lead results in the two data sets – XRF and laboratory analysis. The coefficient of correlation (r^2) value for lead was 0.869, demonstrating an excellent correlation between the XRF and laboratory in the data set.



11.3.6 Sensitivity

Sensitivity is the ability of the method or instrument to detect the target analytes at the level of interest and is generally discussed as detection limits. Related to sensitivity is the capability of a method or instrument to discriminate between small differences in analyte concentration. Before sampling begins, it is important to compare detection limits and project requirements in order to select a method with the necessary detection limits to meet the project goals. Data validation includes a review of final reporting limits to determine if matrix issues such as dilutions and interferences have affected the end use of the data.

A laboratory Method Detection Limit (MDL) is a statistically derived detection limit that represents a 99 percent confidence level that the reported signal is different from a blank sample. The MDL is lower than the concentration at which the laboratory can quantitatively report.

The laboratory reporting limit (RL) is the lowest concentration of analyte in a sample which can be quantitatively determined with suitable precision and accuracy. The RL must be less than the

action limits for the project quality objectives to be definitively met. Ideally, the RL should be less than one-third the applicable benchmark used for decision making.

The sensitivity requirements for arsenic in soil and sediments were not met for this project. The XRF arsenic reporting limit was calculated between 10 and 32 mg/kg. As discussed previously, in the presence of high lead concentrations, the detection limit for arsenic becomes even higher. The CLP analysis method detection limit of 1 mg/kg for arsenic was also not sensitive enough to meet the Superfund Chemical Data Matrix (SCDM) benchmark for cancer risk (0.43 mg/kg); however it was sensitive enough to compare to the Reference Dose Screening Concentration (23 mg/kg)[60].

The sensitivity requirements for the remaining metals were met in all media. The detection limits were below the relevant benchmarks. Some data results were qualified, and the concentration reported is therefore considered an estimate. However, some variation in concentration does not affect the overall conclusions provided by the data. Dilutions were performed for target analytes with concentrations above the top point of the calibration curve. All dilutions were appropriate.

11.4 DATA USABILITY SUMMARY

The data quality indicators of precision, accuracy, representativeness, completeness, comparability and sensitivity were evaluated. All data is usable as qualified.

Analytical precision was demonstrated through the use of duplicate samples. Ten percent of the multi-increment soil samples analyzed by XRF were sent for laboratory confirmatory analysis. The results generated by both XRF and ICP-AES demonstrated excellent correlation. Additionally, the duplicate sample results were within acceptable criteria for both the XRF and CLP analysis of soil samples. A duplicate surface water sample was submitted to the CLP lab blind, and results of the analysis were within control limits.

The accuracy of the data was verified through use of several quality control samples, including standards, blanks, and spikes. Although some uncertainty or bias may exist in the results, the amount of bias was controlled to an acceptable level. The uncertainty does not affect the ability to use the data as intended.

Representativeness was achieved by adherence to TSOPs for sampling procedures, adherence to field and laboratory QA/QC procedures, appropriateness of sample location, and achieving the

acceptance criteria specified in the SAP. A review of the SAP, field log books, and laboratory data packages reveals no deviations or failures in the data that is being used for decision making at the site.

The Colorado Smelter SAP[61] called for the collection of 2 background soil samples, up to 10 source samples, up to 8 surface water and sediment samples, and soil samples from up to 50 residences. Samples were collected from 47 residences and 4 road right-of-ways, as well as 2 background locations, resulting in completeness of greater than 100% for the soil samples. Five source samples were also collected (50% completeness). Surface water samples were collected from 5 of 8 possible locations (63% completeness), and sediments from 4 of 8 possible locations (50% completeness). While there were less source samples and surface water and sediment samples collected than anticipated, an adequate number of samples were collected to meet the objectives of this SI.

Comparability was insured by having all samples collected by the same personnel using the same SAP, TSOPs, sampling equipment and at approximately the same time of day. Additionally, ten percent of the soil samples analyzed by XRF were sent for laboratory confirmatory analysis. The results generated by both XRF and ICP-AES demonstrated excellent correlation for lead.

The sensitivity requirements for arsenic in soil and sediments were not met for this project. The XRF arsenic detection limit was calculated at 10 to 32 mg/kg. The CLP analysis method detection limit of 1 mg/kg for arsenic was also not sensitive enough to meet the Superfund Chemical Data Matrix (SCDM) benchmark for cancer risk (0.43 mg/kg), although it was sensitive enough to compare to the non-cancer benchmark (23 mg/kg) [62]. The sensitivity requirements for the remaining metals were met in all media. The detection limits were below the relevant benchmarks. Some data results were qualified, and the concentration reported is therefore considered an estimate. However, some variation in concentration does not affect the overall conclusions provided by the data.

12.0 SUMMARY AND CONCLUSIONS

The Colorado Smelter operated between 1883 and 1908. The area around the smelter is now largely residential. Emissions from smelting operations often contain inorganic constituents such as lead and arsenic, and contamination of soils surrounding former smelter plant sites is possible. Ingestion of soil and inhalation of wind-blown soil are potential human exposure

pathways of concern. The Colorado Smelter was constructed in a ravine, and surface water flowing through the site contacts waste slag piles.

For this investigation CDPHE collected samples for the evaluation of the surface water and soil exposure pathways.

A seep is located on the Colorado Smelter site. Water from the seep flows along the base of the ravine until it enters a storm water discharge, one of the sites PPEs. Sediment sample CO-SE-06, collected downstream of the seep at the bottom of the ravine, contains concentrations of several metals that are much higher than in the other sediment samples. Although not directly applicable, the soil screening benchmarks for arsenic and lead were exceeded. The surface water sample collected from the same location (CO-SW-06) showed concentrations of cadmium, copper, lead and zinc above benchmarks.

There is an observed release of water containing elevated concentrations of iron from the Santa Fe Avenue Bridge Culvert (CO-SW-03). A second Probable Point of Entry (PPE) consisting of a storm water discharge conveys water with elevated concentrations of cadmium, copper, iron, lead and zinc (CO-SW-04).

Comparison of concentrations in release samples (CO-SW-02 and CO-SE-02) with concentrations in background samples (CO-SW-01 and CO-SE-01) reveals that there are no elevated metals in the surface water or sediments of the Arkansas River downstream of the Probably Point of Entry (PPE) from the site. There is no apparent impact on the Arkansas River due to the Colorado Smelter.

CDPHE collected residential soil samples from 47 residential properties. Vacant lot and roadway samples were collected from 4 locations. Background soils were collected from 2 locations. Source samples were collected from 4 locations. A total of 439 individual samples were collected into 1-quart plastic bags. These were analyzed directly through the plastic bag with the XRF at the START laboratory in Denver, Colorado. The samples were later combined into 88 multi-increment samples, dried, sieved and placed in small plastic cups and re-analyzed with the XRF. Select samples were analyzed through EPA's contract laboratory program.

A review of the XRF multi-increment sample results indicate that 73 of the residential soil samples contained concentrations of one or more metals greater than three times background.

Metals exceeding background concentrations in some of the samples include arsenic, cobalt, copper, iron, lead, manganese, and zinc.

As anticipated, the concentrations of lead decrease with distance from the site. Seventy-two of the multi-increment soil samples collected from 47 residential properties exceed three times background concentrations for lead. Twenty-three residential soil multi-increment samples, collected from 15 unique properties, contained concentrations of lead that were also in excess of 400 ppm, the residential soil screening criteria recommended in EPA's OSWER Directive 9355.4-12[63] and in CDPHE's Soil Remediation Objectives policy[64].

Six multi-increment residential soil samples, collected from 4 unique properties, exceeded both three times background and the SCDM benchmark for arsenic. It should be noted that due to interference between lead and arsenic with the XRF instrument, high lead concentrations can sometimes result in arsenic being reported as non-detect (U value) when, in fact, it is present (see Section 11.3.1). As a rule of thumb, if the lead concentration is 10-times higher than the arsenic concentration, then the arsenic detection limit may exceed the arsenic concentration. A fifth residential property had a raw arsenic value calculated by the XRF instrument of 53 mg/kg. Although this result did not pass quality control protocols, it is an indication arsenic may be elevated on that property as well. Arsenic contamination may be more widespread than can be realized from the data.

An evaluation was conducted to determine if the study questions posed for this SI were met.

Objective	Result
Collect samples of fine-grained (<2mm) slag material and soils located onsite to determine if they are a source of contamination.	Adequate samples were collected to determine the on-site slag material and soils contain concentrations of heavy metals elevated with respect to background and may be a source of contamination.
Collect soil samples from residential yards in the neighborhoods surrounding the Colorado Smelter site to determine metals concentrations and to identify areas of observed contamination associated with the	Sufficient samples were collected to indicate there are areas of observed contamination in nearby residential neighborhoods. However, the extent of the contamination has not been adequately defined. Resolution issues

site.	associated with the XRF analysis of arsenic may have led to its presence being under reported.
Collect background soil samples for the purpose of comparing metals concentrations in background samples with residential soil samples for evaluation under the Hazard Ranking System (HRS).	Two 5-point multi-increment samples were collected from an area approximately 2 miles northwest of the site and outside the area likely to be impacted by emissions from the site.
Collect surface water samples from onsite seeps, culvert discharges, and the Arkansas River to determine any impacts to surface waters.	Adequate samples were collected to determine there is no impact to surface waters in the Arkansas River from the Colorado Smelter site.
Collect sediment samples from onsite seeps, discharge culverts, and the Arkansas River to determine any impacts to surface waters.	Adequate samples were collected to determine there is no impact to surface waters in the Arkansas River from the Colorado Smelter site.

Based on the results from this site investigation, the Colorado Smelter site will be referred to EPA for further evaluation.

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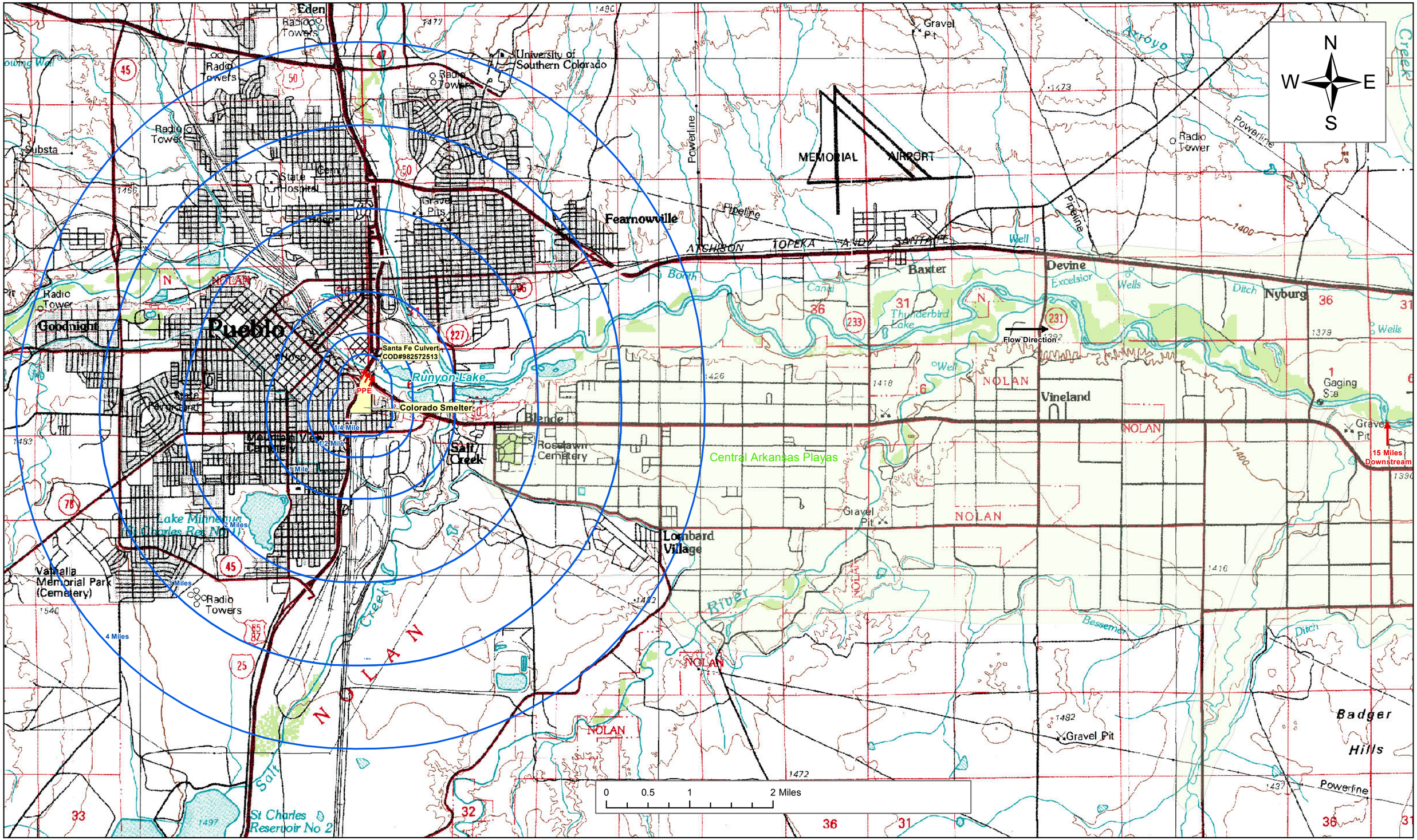
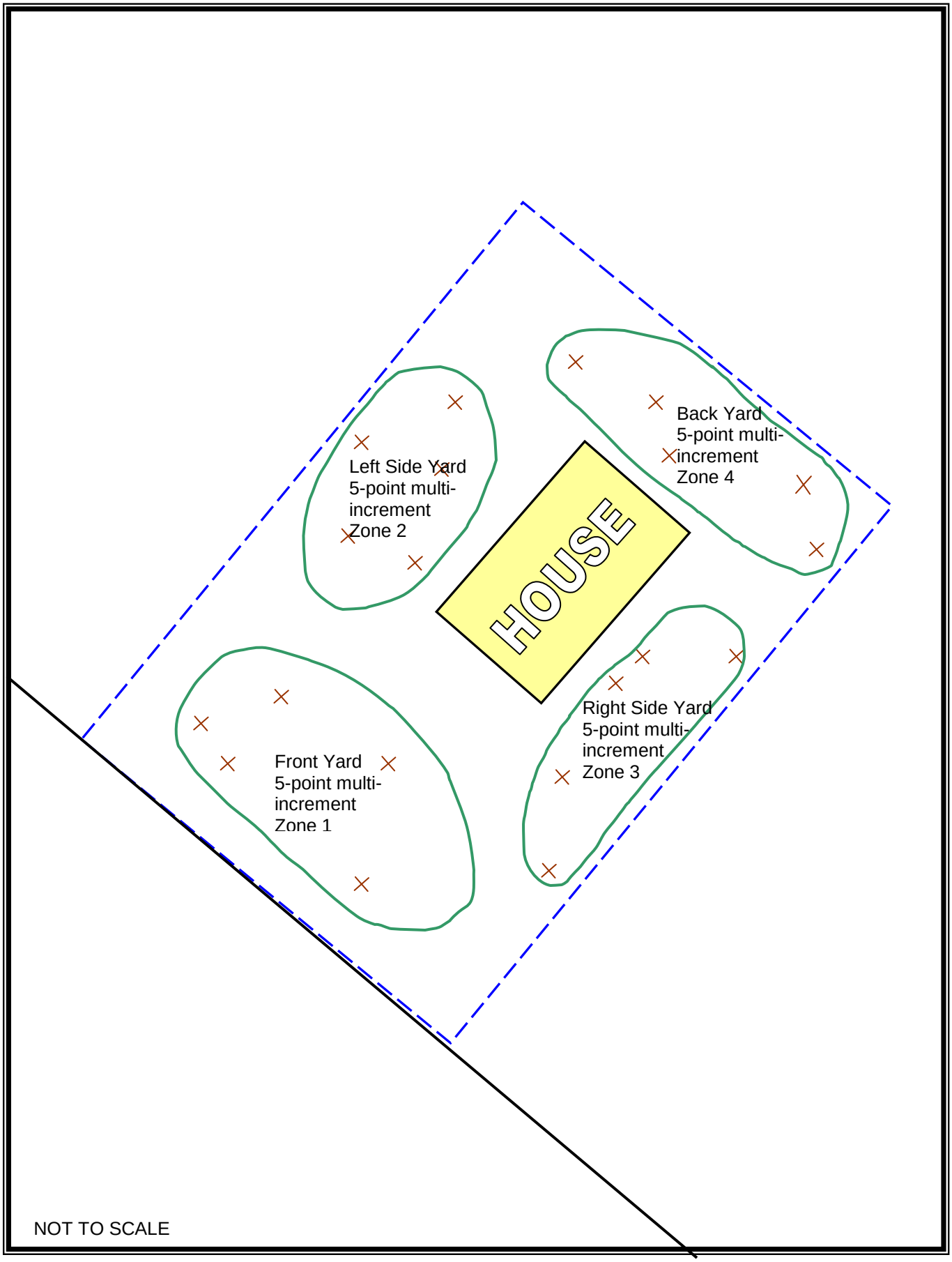


Base map from USGS 1to24 topographic quadrangle (1977)

Colorado Smelter
Site Inspection Analytical Results Report
June 22, 2011

Site Location and Area of Influence

Figure 1



Colorado Smelter
Site Inspection Analytical Results Report
June 22, 2011

Residential Soil
Sampling Schematic

Figure 2

Base Image from Pueblo County

Colorado Smelter
Site Inspection
Analytical Results Report
June 22, 2011

Surface Water
and Sediment
Sample Locations

Figure 4

Base Image from Pueblo County

Colorado Smelter
Site Inspection
Analytical Results Report
June 22, 2011

Soil Sample Locations

Figure 5

Base Map from Pueblo County

LEGEND

Soil Composite Results

Lead (mg/kg)

- 0 - 199
- 200 - 399
- 400 - 600
- 601 - 800
- 801 - 8066

Soil Aliquot Results

Lead (mg/kg)

- 0 - 199
- 200 - 399
- 400 - 800
- 801 - 2000
- 2001 - 12000

Colorado Smelter
Site Inspection Analytical Results Report
June 22, 2011

Soil Sample Results

Figure 6

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
BACKGROUND 1 (BG-01)	1	1	66		16	J								
	1	2	63		12	J								
	1	3	57		18									
	1	4	52		17									
	1	5	22		27									
	ZONE 1 COMPOSITE		**47**		**16**									
BACKGROUND 2 (BG-02)	1	1	34		18									
	1	2	27		11	J								
	1	3	8.9		15	J								
	1	4	17		11	J								
	1	5	9.2		16	J					15.8	J	9.5	
	ZONE 1 COMPOSITE		**22**		**14**									
SOIL 1 (SO-01) RESIDENCE	2	1	461		46	U								
	2	2	479		48	U								
	2	3	806		81	U								
	2	4	489		49	U								
	2	5	507		51	U								
	ZONE 2 COMPOSITE		**662**		**66**	**U**								
	3	1	640		64	U								
	3	2	646		65	U								
	3	3	727		73	U								
	3	4	1924		192	U					828		12.7	
	3	5	608		61	U								
	ZONE 3 COMPOSITE		**785**		**79**	**U**								
SOIL 2 (SO-02) RESIDENCE	1	1	264		26	U								
	1	2	249		25	U	256		26	U				
	1	3	311		31	U								
	1	4	509		51	U								
	1	5	406		41	U								
	ZONE 1 COMPOSITE		**403**		**40**	**U**	**408**		**41**	**U**				
	4	1	324		32	U								
	4	2	202		20	U								
	4	3	159		16	U								
	4	4	199		20	U								
	4	5	442		44	U								
	ZONE 4 COMPOSITE		**371**		**37**	**U**								
SOIL 3 (SO-03) RESIDENCE	1	1	55		11	J								
	1	2	53		13	J								
	1	3	52		20									
	1	4	67		12	J								
	1	5	54		16	J								
	ZONE 1 COMPOSITE		**71**		**15**									
	2	1	33		8.6	J								
	2	2	24		11	J								
	2	3	51		7.0	J								
	2	4	48		10	J								
	2	5	86		14	J								
	ZONE 2 COMPOSITE		**63**		**16**						**72.2**	**J**	**9.4**	
SOIL 4 (SO-04) RESIDENCE	1	1	264		26	U								
	1	2	101		29									
	1	3	272		27	U								
	1	4	300		30	U	340		34	U				
	1	5	289		29	U								
	ZONE 1 COMPOSITE		**275**		**28**									
	4	1	245		25	U								
	4	2	316		32	U								
	4	3	298		30	U								
	4	4	212		21	U								
	4	5	101		20									
	ZONE 4 COMPOSITE		**308**		**31**	**U**								

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
SOIL 5 (SO-05) RESIDENCE	1	1	94		19									
	1	2	259		26	U								
	1	3	205		21	U								
	1	4	249		25	U								
	1	5	285		29	U								
	ZONE 1 COMPOSITE		**253**		**25**	**U**								
	3	1	217		22	U								
	3	2	191		19	U								
	3	3	227		23	U								
	3	4	178		18									
	3	5	415		42	U								
	ZONE 3 COMPOSITE		**243**		**24**	**U**								
SOIL 6 (SO-06) RESIDENCE	2	1	164		16	U								
	2	2	244		24	U								
	2	3	302		30	U								
	2	4	231		23	U								
	2	5	224		22	U								
	ZONE 2 COMPOSITE		**277**		**28**	**U**								
	3	1	18		12	J								
	3	2	19		13	J								
	3	3	25		14	J								
	3	4	32		13	J								
	3	5	181		18	U								
	ZONE 3 COMPOSITE		**69**		**11**									
SOIL 7 (SO-07) RESIDENCE	2	1	177		18	U								
	2	2	163		16	U								
	2	3	96		9.6	U								
	2	4	138		14	U								
	2	5	185		19	U								
	ZONE 2 COMPOSITE		**245**		**25**	**U**								
	4	1	124		12	U					270	J	4.3	J
	4	2	179		18	U								
	4	3	96		11	J								
	4	4	33		7.8	J								
	4	5	93		15	J								
	ZONE 4 COMPOSITE		**194**		**19**	**U**								
SOIL 8 (SO-08) ROAD FRONTAGE	1	1	331		33	U								
	1	2	393		39	U	402		40	U				
	1	3	192		19	U								
	1	4	156		16	U								
	1	5	168		17	U					158	J	5.5	J
	ZONE 1 COMPOSITE		**263**		**26**	**U**	**275**		**28**	**U**				
SOIL 9 (SO-09) RESIDENCE	1	1	117		17									
	1	2	80		20									
	1	3	144		16	J								
	1	4	143		17									
	1	5	114		14	J								
	ZONE 1 COMPOSITE		**151**		**23**	**J**								
	4	1	301		30	U								
	4	2	351		35	U								
	4	3	315		32	U								
	4	4	172		17	U								
	4	5	294		29	U								
	ZONE 4 COMPOSITE		**287**		**29**	**U**								
SOIL 10 (SO-10) RESIDENCE	1	1	230		23	J								
	1	2	258		26	U								
	1	3	255		26	U								
	1	4	444		44	U								
	1	5	363		36	U								
	ZONE 1 COMPOSITE		**371**		**37**	**U**								
SOIL 11 (SO-11) RESIDENCE	4	1	219		22	U								
	4	2	259		26	U								
	4	3	278		28	U								
	4	4	128		16	J								
	4	5	184		18	U								
	ZONE 4 COMPOSITE		**232**		**23**	**U**								

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
SOIL 12 (SO-12) VACANT LOT	1	1	12		12	J								
	1	2	32		13	J					42.1	J	8.9	
	1	3	244		24	U								
	1	4	198		20	U								
	1	5	156		16	U								
	ZONE 1 COMPOSITE		**166**		**17**	**U**								
SOIL 13 (SO-13) RESIDENCE	1	1	504		50	U	497		50	U				
	1	2	318		32	U								
	1	3	288		29	U								
	1	4	185		19	U								
	1	5	169		17	U								
	ZONE 1 COMPOSITE		**421**		**42**	**U**								
	4	1	183		23	J								
	4	2	204		20	U								
	4	3	206		21	U								
	4	4	206		21	U								
	4	5	208		22	J								
	ZONE 4 COMPOSITE		**226**		**23**	**U**								
SOIL 14 (SO-14) RESIDENCE	1	1	68		14	J								
	1	2	75		15	J								
	1	3	104		20	J								
	1	4	67		11	J					63.4	J	4.8	J
	1	5	53		12	J								
	ZONE 1 COMPOSITE		**93**		**11**	**J**								
	4	1	217		22	U								
	4	2	131		18	J								
	4	3	146		15	U								
	4	4	235		24	U								
	4	5	134		15	J								
	ZONE 4 COMPOSITE		**177**		**18**	**U**								
SOIL 15 (SO-15) RESIDENCE	1	1	286		29	U	259		26	U				
	1	2	235		24	U								
	1	3	198		20	J								
	1	4	312		31	U								
	1	5	291		29	U								
	ZONE 1 COMPOSITE		**321**		**32**	**U**								
	4	1	252		25	U								
	4	2	255		26	U								
	4	3	312		31	U								
	4	4	231		23	U								
	4	5	252		25	U								
	ZONE 4 COMPOSITE		**326**		**33**	**U**								
SOIL 16 (SO-16) RESIDENCE	4	1	310		31	U								
	4	2	148		22	J								
	4	3	84		20	J								
	4	4	53		17	J								
	4	5	185		19	J								
	ZONE 4 COMPOSITE		**165**		**25**	**J**								
SOIL 17 (S0-17) RESIDENCE	1	1	222		22	U								
	1	2	178		22	J								
	1	3	76		12	J								
	1	4	66		7.1	U								
	1	5	71		17	J								
	ZONE 1 COMPOSITE		**150**		**18**	**J**								
	4	1	85		14	J	88		10	J				
	4	2	38		11	J								
	4	3	102		12	J								
	4	4	90		17	J								
	4	5	180		18	J								
	ZONE 4 COMPOSITE		**123**		**12**	**U**								
SOIL 18 (SO-18) RESIDENCE	4	1	214		21	U								
	4	2	255		26	U								
	4	3	184		18	U								
	4	4	409		41	U								
	4	5	1471		147	U					223		6.6	
	ZONE 4 COMPOSITE		**339**		**34**	**U**								

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
SOIL 19 (SO-19) RESIDENCE	2	1	358		47									
	2	2	389		39	U								
	2	3	268		27	U								
	2	4	281		32									
	2	5	269		27	U								
	ZONE 2 COMPOSITE		**365**		**37**	**U**								
SOIL 20 (SO-20) RESIDENCE	1	1	112		15	J								
	1	2	112		12	J	138		14	U				
	1	3	368		37	U								
	1	4	231		23	U								
	1	5	297		30	U								
	ZONE 1 COMPOSITE		**263**		**26**	**U**								
	3	1	297		30	U								
	3	2	336		34	U								
	3	3	309		31	U								
	3	4	320		32	U								
	3	5	257		26	U								
	ZONE 3 COMPOSITE		**362**		**36**	**U**								
SOIL 21 (SO-21) RESIDENCE	4	1	214		21	U								
	4	2	192		20	J								
	4	3	187		19	U								
	4	4	194		19	U								
	4	5	221		22	U	221		22	U				
	ZONE 4 COMPOSITE		**221**		**23**	**J**								
SOIL 22 (SO-22) RESIDENCE	1	1	147		33									
	1	2	161		26									
	1	3	148		28									
	1	4	168		27									
	1	5	153		34									
	ZONE 1 COMPOSITE		**180**		**32**		**182**		**36**		**188**	**J**	**25.7**	
	3	1	208		21	U					201	J	13.3	
	3	2	174		17	U								
	3	3	177		18	U								
	3	4	221		22	U								
	3	5	206		35									
	ZONE 3 COMPOSITE		**235**		**24**	**J**								
SOIL 23 (SO-23) RESIDENCE	4	1	408		41	U								
	4	2	278		28	U								
	4	3	307		31	U								
	4	4	417		42	U								
	4	5	571		57	U								
	ZONE 4 COMPOSITE		**401**		**40**	**U**								
SOIL 24 (SO-24) RESIDENCE	1	1	233		39						253	J	31.3	
	1	2	289		51						275		39.3	
	1	3	273		28									
	1	4	453		45	U								
	1	5	482		48	U								
	ZONE 1 COMPOSITE		**373**		**45**						**397**	**J**	**29.2**	
SOIL 25 (SO-25) RESIDENCE	3	1	243		24	U								
	3	2	309		31	U								
	3	3	295		30	U								
	3	4	229		30									
	3	5	319		32	U								
	ZONE 3 COMPOSITE		**338**		**34**	**U**								
SOIL 26 (SO-26) RESIDENCE	2	1	365		37	U								
	2	2	376		38	U								
	2	3	394		40									
	2	4	384		38	U								
	2	5	355		36	U								
	ZONE 2 COMPOSITE		**441**		**44**	**U**								
SOIL 27 (SO-27) RESIDENCE	2	1	167		27									
	2	2	168		22									
	2	3	264		26	U								
	2	4	212		21	U								
	2	5	153		17	J								
	ZONE 2 COMPOSITE		**253**		**25**	**U**								

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
SOIL 28 (SO-28) RESIDENCE	1	1	453		45	U								
	1	2	377		38	U								
	1	3	409		41	U								
	1	4	282		28	U								
	1	5	259		28									
	ZONE 1 COMPOSITE		**412**		**41**	**U**								
	4	1	379		38	U								
	4	2	263		26	U								
	4	3	1430		143	U					945		9.6	
	4	4	339		34	U								
	4	5	386		39	U								
	ZONE 4 COMPOSITE		**448**		**45**	**U**								
SOIL 29 (SO-29) RESIDENCE	1	1	34		8.0	J								
	1	2	29		12	J								
	1	3	282		28	U								
	1	4	198		20	U								
	1	5	164		16	U								
	ZONE 1 COMPOSITE		**137**		**15**	**J**								
	4	1	258		26	U								
	4	2	291		29	U								
	4	3	157		16	U								
	4	4	163		16	U								
	4	5	206		21	U								
	ZONE 4 COMPOSITE		**236**		**24**	**U**								
SOIL 30 (SO-30) RESIDENCE	2	1	257		26	U								
	2	2	478		48	U	468		47	U				
	2	3	396		40	U								
	2	4	257		26	U								
	2	5	609		61	U								
	ZONE 2 COMPOSITE		**510**		**51**	**U**								
	4	1	397		40	U								
	4	2	291		29	U								
	4	3	655		66	U								
	4	4	367		37	U								
	4	5	78		29									
	ZONE 4 COMPOSITE		**406**		**41**	**U**								
SOIL 31 (SO-31) RESIDENCE	1	1	276		28	U								
	1	2	263		26	U								
	1	3	394		39	U								
	1	4	336		34	U								
	1	5	312		31	U								
	ZONE 1 COMPOSITE		**351**		**35**	**U**								
	4	1	400		40	U								
	4	2	507		51	U								
	4	3	451		45	U								
	4	4	328		33	U								
	4	5	479		48	U					364		11	
	ZONE 4 COMPOSITE		**473**		**47**	**U**								
SOIL 32 (SO-32) RESIDENCE	3	1	191		19	U								
	3	2	286		29	U								
	3	3	236		24	U								
	3	4	285		29	U								
	3	5	246		25	U								
	ZONE 3 COMPOSITE		**280**		**28**	**U**								
	4	1	322		32	U								
	4	2	238		24	U								
	4	3	624		62	U								
	4	4	466		47	U					423		5.5	
	4	5	278		28	U								
	ZONE 4 COMPOSITE		**379**		**38**									
SOIL 33 (SO-33) RESIDENCE	1	1	231		27									
	1	2	330		33	U								
	1	3	263		26	U								
	1	4	235		24	U								
	1	5	254		25	U								
	ZONE 1 COMPOSITE		**328**		**33**	**U**								

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
SOIL 34 (SO-34) RESIDENCE	2	1	146		26									
	2	2	179		36									
	2	3	81		9.0	J								
	2	4	158		41									
	2	5	118		41									
	ZONE 2 COMPOSITE		**147**		**35**									
	4	1	74		20									
	4	3	142		29									
	4	4	141		33									
	4	5	25		22									
	ZONE 4 COMPOSITE		**114**		**32**									
SOIL 35 (SO-35) RESIDENCE	1	1	417		42	U								
	1	2	369		37	U								
	1	3	45		9.0	J								
	1	4	438		44	U								
	1	5	258		26	U								
	ZONE 1 COMPOSITE		**394**		**39**	**U**	**395**		**40**	**U**				
SOIL 36 (SO-36) RESIDENCE	3	1	361		36	U								
	3	2	394		39	U								
	3	3	425		43	U								
	3	4	551		55	U								
	3	5	535		54	U								
	ZONE 3 COMPOSITE		**519**		**52**	**U**								
SOIL 37 (SO-37) RESIDENCE	1	1	337		34	U								
	1	2	420		42	U								
	1	3	188		19	U								
	1	4	295		30	U								
	1	5	187		19	U								
	ZONE 1 COMPOSITE		**369**		**37**	**U**								
SOIL 38 (SO-38) RESIDENCE	1	1	306		31	U								
	1	2	284		28	U								
	1	3	170		21									
	1	4	394		39	U					387		19.5	
	1	5	405		41	U								
	ZONE 1 COMPOSITE		**407**		**41**	**U**								
	4	1	480		48	U								
	4	2	458		46	U								
	4	3	496		50	U								
	4	4	479		48	U								
	4	5	794		79	U								
	ZONE 4 COMPOSITE		**616**		**62**	**U**								
SOIL 39 (SO-39) RESIDENCE	1	1	90		26									
	1	2	154		19									
	1	3	429		43	U								
	1	4	667		67	U								
	1	5	217		22	U								
	ZONE 1 COMPOSITE		**363**		**36**	**U**								
	4	1	362		36	U								
	4	2	132		13	U								
	4	3	720		72	U								
	4	4	423		42	U								
	4	5	240		24	U	247		25	U				
	ZONE 4 COMPOSITE		**428**		**43**	**U**								
SOIL 40 (SO-40) RESIDENCE	1	1	259		319						312	J	211	
	1	2	280		145						319		133	
	1	3	570		97									
	1	4	388		104						411		94.1	
	1	5	475		92									
	ZONE 1 COMPOSITE		**515**		**188**						**536**	**J**	**139**	
	4	1	366		61						329		53	
	4	2	1053		419						962		343	
	4	3	551		134						540		112	
	4	4	331		33	U								
	4	5	333		67									
	ZONE 4 COMPOSITE		**581**		**149**						**621**	**J**	**126**	

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
SOIL 41 (SO-41) RESIDENCE	1	1	406		102						364		72.6	
	1	2	405		54						373		47.1	
	1	3	482		50									
	1	4	592		430		595		425		353		58.7	
	1	5	379		45						401		37	
	ZONE 1 COMPOSITE		**542**		**105**									
	4	1	532		53	U								
	4	2	525		53	U								
	4	3	618		62	U								
	4	4	591		59	U								
	4	5	531		53	U								
	ZONE 1 COMPOSITE		**640**		**64**	**U**								
SOIL 42 (SO-42) RESIDENCE	1	1	590		429						565		191	
	1	2	481		48	U								
	1	3	500		115						499		78.6	
	1	4	421		63									
	1	5	348		39						351		32.8	
	ZONE 1 COMPOSITE		**538**		**135**									
	4	1	153		15	U								
	4	2	267		27	U								
	4	3	257		28									
	4	4	550		55	U								
	4	5	471		47	U								
	ZONE 4 COMPOSITE		**359**		**36**	**U**								
SOIL 43 (SO-43) RESIDENCE	1	1	513		51	U					463		26.9	
	1	2	309		31	U					268		17.6	
	1	3	588		144									
	1	4	864		225						836		190	
	1	5	432		152						406		119	
	ZONE 1 COMPOSITE		**616**		**129**						**576**	**J**	**88.4**	
	4	1	814		341						755		217	
	4	2	616		94									
	4	3	711		165						683		144	
	4	4	644		116						554		85.5	
	4	5	470		94									
	ZONE 4 COMPOSITE		**742**		**195**						**743**	**J**	**154**	
SOIL 44 (SO-44) RESIDENCE	2	1	321		32	U								
	2	2	319		32	U								
	2	3	440		44	U								
	2	4	43		17									
	2	5	74		14									
	ZONE 2 COMPOSITE		**306**		**31**	**U**								
	4	1	46		15									
	4	2	19		19									
	4	3	241		24	U								
	4	4	168		27									
	4	5	277		28	U								
	ZONE 4 COMPOSITE		**243**		**24**	**U**								
SOIL 45 (SO-45) RESIDENCE	1	1	381		38	U								
	1	2	230		23	U								
	1	3	375		38	U								
	1	4	135		14	U								
	1	5	220		22	U								
	ZONE 1 COMPOSITE		**355**		**36**	**U**								
	4	1	132		13	U								
	4	2	96		10	U								
	4	3	100		10	U								
	4	4	87		8.7	U								
	4	5	92		9.2	U								
	ZONE 4 COMPOSITE		**136**		**17**	**J**								

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
SOIL 46 (SO-46) RESIDENCE	1	1	260		26	U								
	1	2	172		17	U								
	1	3	179		18	U								
	1	4	245		25	U								
	1	5	233		23	U								
	ZONE 1 COMPOSITE		**327**		**33**	**U**								
	4	1	208		21	U								
	4	2	260		26	U								
	4	3	189		19	U								
	4	4	319		32	U								
	4	5	215		22	U								
	ZONE 4 COMPOSITE		**301**		**30**	**U**	**296**		**30**	**U**				
SOIL 47 (SO-47) RESIDENCE	2	1	420		42	U								
	2	2	246		25	U								
	2	3	158		16	U								
	2	4	159		16	U								
	2	5	339		34	U								
	ZONE 2 COMPOSITE		**379**		**38**	**U**								
SOIL 48 (SO-48) RESIDENCE	4	1	193		19	U								
	4	2	227		23	U								
	4	3	236		24	U								
	4	4	195		20	U								
	4	5	32		3.2	U								
	ZONE 4 COMPOSITE		**227**		**23**	**U**								
SOIL 49 (SO-49) VACANT LOT	1	1	176		18	U								
	1	2	144		14	U								
	1	3	225		23	U								
	1	4	115		15									
	1	5	79		13									
	ZONE 1 COMPOSITE		**216**		**22**	**U**								
SOIL 50 (SO-50) VACANT LOT	1	1	130		13	U								
	1	2	103		10	U								
	1	3	21		16									
	1	4	58		8.0	J								
	1	5	66		11									
	ZONE 1 COMPOSITE		**94**		**10**	**J**								
SOIL 51 (SO-51) RESIDENCE	1	1	160		16	U								
	1	2	260		26	U								
	1	3	279		28	U								
	1	4	319		32	U								
	1	5	348		35	U								
	ZONE 1 COMPOSITE		**329**		**33**	**U**					225		5.8	
	2	1	316		32	U								
	2	2	267		27	U								
	2	3	253		25	U								
	2	4	383		38	U								
	2	5	296		30	U								
	ZONE 2 COMPOSITE		**263**		**26**	**U**	**274**		**27**	**U**	**261**	**J**	**6.3**	**J**
WASTE PILE 1 (WP-01)	1	1	2706		271	U								
	1	2	5742		574	U					8570		528	
	1	3	8891		889	U					26500		1740	
	1	4	5897		590	U								
	1	5	9942		994	U								
	ZONE 1 COMPOSITE		**5417**		**542**	**U**	5384		538	U	**7010**	**J**	**302**	
WASTE PILE 2 (WP-02)	1	1	2028		203	U					3240		28.1	
	1	2	414		41	U					478		33.1	
	1	3	2607		261	U					8500		53.5	
	1	4	2243		224	U								
	1	5	508		51	U								
	ZONE 1 COMPOSITE		**1468**		**147**	**U**								
WASTE PILE 3 (WP-03)	1	1	7852		785	U					12400		452	
	1	2	11578		1158	U								
	1	3	11928		1193	U					18100		1200	
	1	4	8630		863	U								
	1	5	5243		524	U					7950		359	
	ZONE 1 COMPOSITE		**8066**		**807**	**U**					**11600**	**J**	**640**	

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

SOIL SAMPLE RESULTS

CONCENTRATIONS IN MG/KG

Sample			XRF DATA				XRF DUPLICATES				LABORATORY			
	Zone	Aliquot	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q	Lead	Q	Arsenic	Q
WASTE PILE 4 (WP-04)	1	1	332		33	U								
	1	2	876		88	U								
	1	3	3765		377	U					726.0		133.0	
	1	4	1854		185	U								
	1	5	695		70	U	655		66	U				
	ZONE 1 COMPOSITE		**1278**		**128**	**U**					**2140**	**J**	**29.4**	

Orange cells indicate a lead value greater than 400 ppm. Yellow cells indicate an arsenic detection greater than 3 times background.

Title: CO-SW-02

Date: 06/21/10

Time: 1140

Direction: East (Downstream)

Description: Surface water and sediment sampling location is downstream of water intake (marked with arrow) located along Arkansas River.

Title: CO-SW-01

Date: 06/21/10

Time: 1230

Direction: East (Downstream)

Description: Surface water and sediment location is upstream of all PPE sources, along Arkansas River.

Title: CO-SW-03

Date: 06/21/10

Time: 1150

Direction: South

Description: Sample collected from Santa Fe Avenue Bridge Culvert discharge; probable PPE.

Title: CO-WP-01

Date: 06/21/10

Time: 1430

Direction: West

Description: Southeast corner of waste pile.

Title: CO-WP-02

Date: 06/21/10

Time: 1500

Direction: South

Description: Northeast corner of waste pile.

Title: CO-WP-04

Date: 06/21/10

Time: 0900

Direction: South

Description: West side of waste pile.

Title: CO-SO-01

Date: 06/21/10

Time: 1615

Direction: North

Description: 503 E. Arroyo Ave.

Title: CO-SO-02

Date: 06/21/10

Time: 1635

Direction: East

Description: 1044 S. Santa Fe Ave.

Title: CO-SO-03

Date: 06/21/10

Time: 1645

Direction: East

Description: 1018 S. Santa Fe Ave.

Title: CO-SO-04

Date: 06/21/10

Time: 1700

Direction: East

Description: 1008 S. Santa Fe Ave.

Title: CO-SO-05

Date: 06/21/10

Time: 1725

Direction: Northwest

Description: 615 E. Arroyo Ave.

Title: CO-SO-07

Date: 06/22/10

Time: 0900

Direction: South

Description: 210 W. Arroyo Ave.

Title: CO-SO-08

Date: 06/22/10

Time: 0910

Direction: Southwest

Description: Frontage at northwest corner of Arroyo Ave. and Elm St.

Title: CO-SO-09

Date: 06/22/10

Time: 0920

Direction: West

Description: 1023 Elm St.

Title: CO-SO-11

Date: 06/22/10

Time: 1000

Direction: South

Description: 706 Topeka Ave.

Title: CO-SO-12

Date: 06/22/10

Time: 1010

Direction: West

Description: Vacant lot at west end of Topeka Ave.

Title: CO-SO-14

Date: 06/22/10

Time: 1040

Direction: West

Description: 1215 Russ Ave.

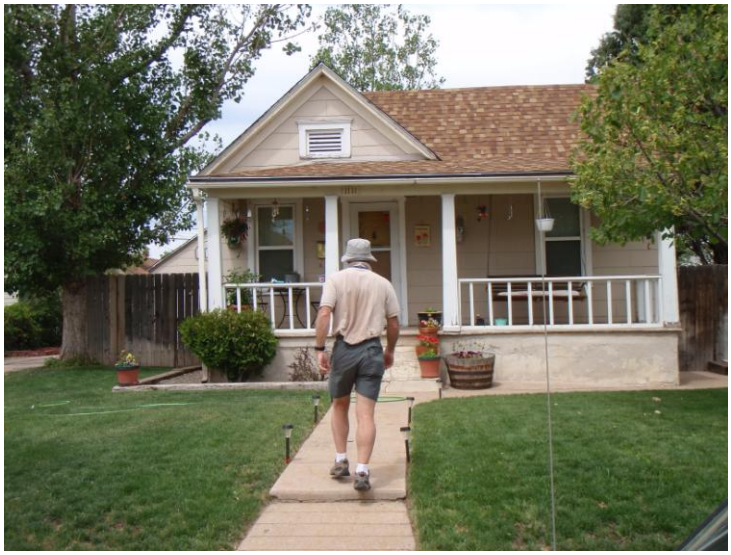
Title: CO-SO-15

Date: 06/22/10

Time: 1100

Direction: East

Description: 1104 Russ Ave.



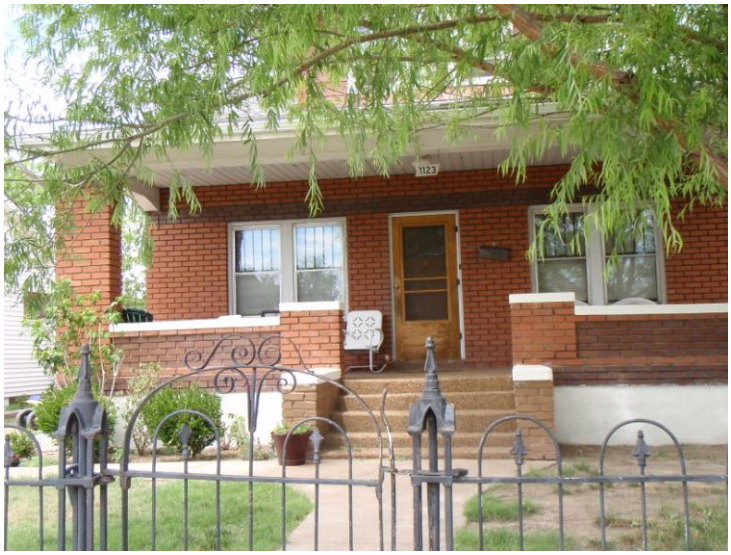
Title: CO-SO-16

Date: 06/22/10

Time: 1120

Direction: West

Description: 1111 Egan Ave.



Title: CO-SO-17

Date: 06/22/10

Time: 1130

Direction: West

Description: 1123 Egan Ave.

Title: CO-SO-18

Date: 06/22/10

Time: 1145

Direction: West

Description: 1227 Mahren Ave.

Title: CO-SO-19

Date: 06/22/10

Time: 1200

Direction: Northwest

Description: 1213 Mahren Ave.

Title: CO-SO-21

Date: 06/22/10

Time: 1225

Direction: East

Description: 1114 Mahren Ave.

Title: CO-SO-22

Date: 06/22/10

Time: 1240

Direction: Northwest

Description: 1107 Mahren Ave.

Title: CO-SO-24

Date: 06/22/10

Time: 1415

Direction: Southeast

Description: 1222 Bohmen Ave.

Title: CO-SO-25

Date: 06/22/10

Time: 1430

Direction: Southwest

Description: 1245 Mahren Ave.

Title: CO-SO-26

Date: 06/22/10

Time: 1440

Direction: East

Description: 1240 Mahren Ave.

Title: CO-SO-27

Date: 06/22/10

Time: 1445

Direction: Southeast

Description: 1244 Mahren Ave.

Title: CO-SO-28

Date: 06/22/10

Time: 1455

Direction: East

Description: 1124 S. Santa Fe Ave.

Title: CO-SO-29

Date: 06/22/10

Time: 1525

Direction: East

Description: 1106 S. Santa Fe Ave.

Title: CO-SO-30

Date: 06/22/10

Time: 1540

Direction: Northwest

Description: 1101 Bohmen Ave.

Title: CO-SO-31

Date: 06/22/10

Time: 1550

Direction: West

Description: 1103 Bohmen Ave.

Title: CO-SO-32

Date: 06/22/10

Time: 1605

Direction: West

Description: 1111 Bohmen Ave.

Title: CO-SO-33

Date: 06/22/10

Time: 1615

Direction: Northwest

Description: 1107 Bohmen Ave.

Title: CO-SO-34

Date: 06/22/10

Time: 1630

Direction: West

Description: 1111 S. Santa Fe Ave.

Title: CO-SO-35

Date: 06/22/10

Time: 1710

Direction: South

Description: 212 E. Mesa Ave.

Title: CO-SO-36

Date: 06/22/10

Time: 1730

Direction: South

Description: 218 E. Mesa Ave.

Title: CO-SO-38

Date: 06/23/10

Time: 0950

Direction: South

Description: 402 E. Mesa Ave.

Title: CO-SO-39

Date: 06/23/10

Time: 1000

Direction: East

Description: 1216 Eilers Ave.

Title: CO-SO-40

Date: 06/23/10

Time: 1020

Direction: East

Description: 1234 Eilers Ave.

Title: CO-SO-41

Date: 06/23/10

Time: 1030

Direction: West

Description: 1233 Berwind Ave.

Title: CO-SO-42

Date: 06/23/10

Time: 1045

Direction: East

Description: 1228 Berwind Ave.

Title: CO-SO-43

Date: 06/23/10

Time: 1055

Direction: East

Description: 1216 Berwind Ave.

Title: CO-SO-46

Date: 06/23/10

Time: 1200

Direction: Southeast

Description: 101 Summit Ave.

Title: CO-SO-47

Date: 06/23/10

Time: 1210

Direction: East

Description: 928 Box Elder St.

Title: CO-SO-48

Date: 06/23/10

Time: 1220

Direction: Northwest

Description: 629 Elm St.

Title: CO-SO-50

Date: 06/23/10

Time: 1300

Direction: North

Description: Vacant lot at the northeast dead end of Box Elder St.

Title: CO-SO-51

Date: 06/23/10

Time: 1320

Direction: Northwest

Description: 525 Moffat Ave.