4-1-1998

EPA Superfund Record of Decision: Murray Smelter Murray City, UT

EPA

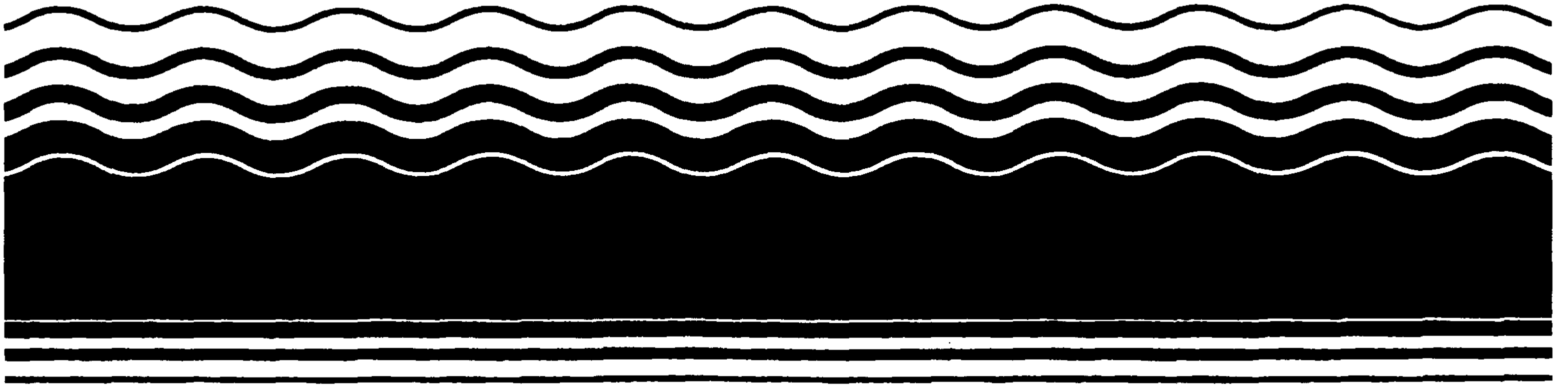
Recommended Citation

EPA, "EPA Superfund Record of Decision: Murray Smelter Murray City, UT" (1998). *All U.S. Government Documents (Utah Regional Depository).* Paper 494.
https://digitalcommons.usu.edu/govdocs/494

PB98-964403
EPA 541-R98-078
October 1998

EPA Superfund
Record of Decision:

Murray Smelter
Murray City, UT
4/1/1998



MURRAY SMELTER
PROPOSED NATIONAL PRIORITIES LIST SITE
MURRAY, UTAH

RECORD OF DECISION

CERCLIS ID UTD980951420

1. Site Name and Location

The Murray Smelter Site ("the Site") is located in the city of Murray, Utah, in Salt Lake County as illustrated on Figure 1. The Site includes the former operational areas of the Murray Smelter and adjacent Germania Smelter which are referred to as the "on-facility" area, as well as surrounding residential and commercial areas where airborne emissions from the smelters impacted the environment or where contamination in shallow ground water may be transported in the future. These surrounding areas are referred to as the "off-facility" area.

The on-facility area is approximately 142 acres. Its boundaries are 5300 South Street to the south, State Street to the east, Little Cottonwood Creek to the north, and the west set of Union Pacific railroad tracks to the west. The off-facility area is approximately 30 acres to the west of the on-facility area, approximately 106 acres south and southeast of the on-facility area, and a small area between 5200 South Street and Little Cottonwood Creek to the east of the on-facility area. The west portion of the off-facility area is bounded by Little Cottonwood Creek to the north, 300 West Street to the west, 5300 South Street to the south, and the on-facility boundary to the east. The south/southwest portion is bounded by 5300 South Street to the north and Wilson Avenue to the south. The off-facility boundaries were determined by EPA based on the results of air dispersion modeling performed in November, 1994. The purpose of the modeling was to identify the area that potentially would have received the greatest amount of deposition resulting from lead and arsenic emissions from the Murray Smelter during its operating period.

For environmental sampling, risk assessment, and risk management purposes, the Site was divided into smaller areas to represent realistic areas of human and ecological exposure. The 142 acre on-facility area was divided into eleven "exposure units" (EU's) and the 136 acre off-facility area was divided into eight "initial study zones" (ISZ's). The riparian area along Little Cottonwood Creek was delineated as the ecological study area. The Site boundaries, EU's, and ISZ's are shown on Figure 2.

2. Operational History

The Germania Smelter was built in 1872 on the north west corner of the on-facility area adjacent to Little Cottonwood Creek. The Germania Smelter processed lead and silver ores. Asarco bought the Germania Smelter in 1899 and operated it until 1902. At the time, Asarco was also constructing the Murray Smelter on property to the south and adjacent to the Germania Smelter. In 1902, operations at Germania stopped and the Murray Smelter began operating and continued processing lead and silver ores until 1949. Smelting operations produced a variety of by products including arsenic (as sulfates/oxides in flue dust or as arsenic trioxide), matte (an iron sulfide matrix with high lead and copper content), arsenical speiss (an iron-arsenic-sulfide matrix), and slag (a vitrified iron silicate).

The on-facility portion of the Site includes both the former Germania Smelter and Murray Smelter facility areas. Minimal specific information is available on the smelter operations at the Germania facility. After operations ceased, the area was regraded with Germania slag and, later, with slag from the Murray Smelter. Subsequently, no significant historical features of the Germania Smelter remain and the description of smelter operations provided below is based solely on descriptions of the Murray Smelter.

At the time of its construction, the Murray Smelter was reportedly the largest primary lead smelter in the world. In addition to lead, several byproducts were also generated including gold, silver, copper, antimony, bismuth, arsenic, and cadmium. The main byproducts by volume were slag, arsenic and cadmium.

Figure 3 is a layout of the Murray Smelter facilities. The Murray Smelter included an extensive rail network, two stacks (330 feet and 455 feet high), eight blast furnaces, roasters, arsenic kitchens, sinter plants, mills and power houses. The facility also included a baghouse for emissions control. Most of the Murray Smelter facilities have been demolished, except for the smelter stacks, some building foundations, and the original office/engine room building.

A flow sheet for Murray Smelter operations for 1920 is shown in Figure 4. Although modifications occurred during the period of operation, the fundamental processes remained the same. The raw material, lead ore, was shipped from various locations and was classified either as sulfide ore or oxide ore. Oxide ore was capable of being smelted directly, whereas sulfide ore required a preliminary roasting step to reduce the sulfur content. The primary manufacturing process was therefore characterized by two major operations: (1) roasting operations to lower the sulfur content of sulfide ores and to produce sintered material suitable for final smelting; and (2) smelting operations to produce lead bullion (shipped away for final refining), matte (sent to the roasters to be treated again by oxidation of its sulfur), and slag. The secondary manufacturing process was the re-processing of flue dust and baghouse dust to produce arsenic trioxide.

2.1 Roasting Operations

Prior to 1920, roasting operations involved three furnace types: (1) four Wedge roasters; (2) four Dwight-Lloyd roasters; and (3) five Godfrey Roasters, operated in conjunction with twenty-seven Huntington and Heberlein ("H&H") pots.

The Wedge roasters received charge consisting of sulfide ore, matte from the blast furnaces, lead concentrates from various points, and silica. These furnaces produced roasted ore which was then loaded into tram cars and conveyed to cooling bins where it was combined with low sulfur ores and charged to the Dwight-Lloyd roasters. Air emissions from the Wedge furnaces passed directly into a dust chamber that ran along the north side of the Wedge roaster building and connected the main roaster flue to the Cottrell Plant. The Dwight-Lloyd roasters, or sintering machines, produced material which was transferred directly into rail cars and sent to the roast bins where the blast furnace charge was made up. Air emissions from the Dwight-Lloyd roasters were also sent to the Cottrell Plant.

The Cottrell Plant was an electrostatic precipitator. Precipitated materials fell or were shoveled directly into rail cars. These materials were either returned to the roasters or sent to the briquetting plant to be briquetted for charging to the blast furnace. Gases from the Cottrell Plant were sent to the 455-foot stack, which began operating in May 1918. During repairs or other activities on the baghouse, the roaster flue and treatment process received blast furnace gases.

The Godfrey Roasters were used to process flue dust from the baghouse and Cottrell Plant. Flue dust was roasted in the Godfrey Roasters and the resulting arsenic trioxide vapor was conveyed to the arsenic kitchens where it was collected as relatively pure arsenic trioxide. Exit gases from the kitchens were sent to the western portion of the baghouse and collected dust was recycled to the Godfrey Roasters. Arsenic trioxide was stored in one of two concrete storage bins before transportation offsite for sale as a product. In 1942, additions were made to the arsenic kitchens to increase their production capacity (additional kitchens were added) and to provide additional storage (new storage bins for arsenic product were installed) and conveyance capacity (a system to convey baghouse dust to the kitchens was installed).

2.2 Smelting Operations

Smelting was achieved by eight blast furnaces. The charge to the blast furnaces included oxide ore, flux material, and roasting products. Air emissions were sent to an enlarged flue, along the west side of the building. From this chamber, the gases passed to a rectangular brick flue, 18 feet wide by 17 feet high, which led to the baghouse. Exit gases from the baghouse were usually sent to the 330 foot stack, although gases from the baghouse or blast furnace were occasionally routed to the 455 foot stack. The baghouse, installed in 1907, was constructed of brick 216 feet long and 90 feet wide, and contained approximately 4,000 woolen bags, each 30 feet in length and 18 inches in diameter. In 1920, the baghouse was divided into four compartments, three of which were operated while the fourth was cleaned out. Dust from the baghouse was either loaded into rail cars for transport to temporary storage areas near the thaw house where it was kept prior to off-site transport or conveyed to the Godfrey Roasters and arsenic kitchens by narrow gauge railway for production of high-grade arsenic trioxide. The material from the baghouse was low-grade arsenic oxide, which contained lower amounts of arsenic than the arsenic kitchen product, with arsenic present in oxide and sulfate forms. Prior to off-site shipment, arsenic kitchen product was stored in a wooden arsenic storage bin to the south east of the thaw house.

2.3 **Materials Used/Generated by the Smelter Operation**

The contaminants of concern to human health at the Site are lead and arsenic[1]. Based on the data generated at the Site and information on historic smelter operations, elevated levels of arsenic and lead at the Site can reasonably be attributed to the following materials:

- **Lead Ore**: No analytical data are available to describe the range of arsenic and lead concentrations in ore materials processed at the smelters. Lead contents for ore from Utah were reported between 4.4 and 32 percent by weight . Ore mineralogy was variable, but may have included: galena, pyrite, arsenopyrite, sphalerite, anglesite, cerussite, and lead oxide (massicot).

- **Blast Furnace Products/By-products**. Four materials were typically generated during blast furnace operation: metallic lead, speiss, matte, and slag. The materials would separate due to their varying densities. Metallic lead was the primary product of the operation, and it is not expected that any quantity is currently present at the Site.

  - **Matte/Speiss**: In smelting of ores at the Murray Smelter, the amount of speiss produced was too small to separate it from the matte. Matte/speiss generated in the blast furnaces was comprised of metal sulfides, with iron being the dominant metal. Analysis of speiss for various smelters in the western U.S. show lead contents between 0.5 and 2 percent and arsenic contents between 31 and 32 percent. Analysis of matte at the same smelters show lead contents between 8.5 and 18 percent and arsenic contents below detection limits. Since speiss contents were probably small at Murray, it is believed that any material present at the Site will contain higher levels of lead than arsenic. Lead matte/speiss concentrate was stored out in the open in the northern plant area.

  - **Slag**: Slag is an amorphous, vitrified furnace product and the primary byproduct of the smelting process. Air-quenched slag was the material generated in the highest volume by the smelter process and significant quantities are still present at the Site. Lead concentrations of 8,200 to 16,000 milligrams per kilogram (mg/kg) and arsenic concentrations of less

---

[1] As will be discussed in subsequent sections of this ROD, contaminants of concern to ecological receptors within the ecological study area include other metals in addition to lead and arsenic. However, the majority of the Site is sufficiently characterized by focusing on lead and arsenic.

than 5 to 1,500 mg/kg have been measured in slag from the Site (both Germania and Murray slag piles). Metals are not typically released from slag under normal environmental conditions. A series of leaching tests was performed on a sample of slag material collected from the Site. The details of the leaching tests and the results are summarized in the final Feasibility Study. The tests indicate that a minimal proportion of the metals present is released from slag when precipitation and ground water are the leaching solutions. However, the release of arsenic appears significantly enhanced at both extreme high and low pH.

- **Flue Dust**: Roasting and furnace operations had a tendency to volatilize arsenic. These gases were collected and transported in flues to treatment units, the Cottrell Plant or the baghouse. Exit gases from these units were sent to the stacks. Flue dust is present in areas where operations were located (flues, the arsenic kitchens, the Cottrell Plant, and the baghouse) and in areas where flue dust was managed (next to the thaw house). Similar materials are also present at the ground surface over a wider area. This is due to dispersion resulting from spillage during material handling, and stack emissions. Arsenic levels in flue dust have been measured at 25,000 mg/kg.

- **Arsenic Trioxide**: Arsenic trioxide was produced primarily during the processing of flue vapors from the Godfrey Roasters in the arsenic kitchens. The material was probably in a relatively pure form, with arsenic primarily present in oxide forms and some sulfate present. Pure arsenic trioxide has been measured at 760,000 mg/kg arsenic. Approximately 2000 cubic yards of arsenic trioxide have been found in the on-facility area of the Site.

  Stack Emissions: Exit gases from the baghouse and Cottrell Plants were routed to the stacks. Stack emissions resulted in the deposition of lead and arsenic onto surface soils in the off-facility area. These emissions occurred during the entire period of smelter operation. Lead levels in off-facility soils impacted by stack emissions have been measured as high as 1800 mg/kg. Arsenic levels in these soils have been measured as high as 610 mg/kg.

2.4 Smelter Demolition

Records indicate that as part of the shut down of the Murray Smelter, existing raw material feed stock was processed and the resulting products and by-products were collected and sold. Due to this sequenced shut down, the amount of residual raw materials, products, and by-products left at the Site is limited. The exception is slag, the primary by-product of the smelting process, which was initially present over a large area. The initial quantity has been significantly reduced by mining in the period since the smelter shut down.

The majority of smelter structures were demolished in the period immediately after operations ceased in 1949. Based on environmental sampling and historical photographs, it appears that demolition of the main smelter structures was conducted in an organized manner. Salvageable materials (e.g., metal from the processing units and rail lines, and other process equipment) were taken off-site, and building structures were subsequently demolished with the brick and concrete debris typically spread in the immediate area. Slag was then brought in from the slag pile area to cover the debris and to provide a suitable surface for subsequent development of commercial/manufacturing operations. Today, smelter materials are typically present within the upper three feet below the current ground surface, primarily in the form of slag brought in for fill, residual materials such as flue dust within footprints of former operations and mixed structural debris from smelter demolition in the immediate vicinity of former structure locations . At a limited number of locations, relatively high levels of arsenic such as that associated with flue dust are present as deep as 10 feet. This is thought to be the result of dissolution and transport by surface water infiltration.

Several smelter structures remained after the initial demolition activities. Some of the structures were used as storage buildings until around 1980 when they were demolished as part of Site development. A few structures, including the engine house and the stacks, are still present today.

3. Site Description

3.1 Land Use

3.1.1 Current Land Use

The on-facility area is currently zoned Manufacturing General Conditional, M-G-C. This zoning designation allows light industrial processes to be conducted with heavier industrial uses allowed after a conditional use permit has been approved by Murray City. The majority of the on-facility area is owned by the Buehner family and leased by a concrete manufacturing company, the unrelated Buehner Corporation. The company makes pre-cast and pre-stressed concrete building and transportation products as well as architectural concrete products. Other uses within the on-facility area include a pipe warehouse and distribution facility, the W.R. White Company; a telecommunications equipment company, Skaggs Telecommunication Services; a Federal Express outlet; the Murray City Police Training Facility; a portland cement transfer and supply facility, Ashgrove Cement; other warehouses; and an abandoned asphalt plant owned by Monroc, Inc. There are two residential trailer parks within the on-facility area. The "Doc and Dell's" trailer park is located on State Street. The "Grandview" trailer park is on the southwest corner of the on-facility area on 5300 South Street. The locations of these trailer parks are noted on Figure 2.

Land use in the off-facility area is mixed residential/commercial. The western portion of the off-facility area is currently zoned M-G-C and Commercial Development Conditional, C-D-C. C-D-C zoning provides areas where a combination of businesses, commercial, entertainment and related activities may be established and maintained. The southern portion of the off-facility area is currently zoned M-G-C and low density single family residential, R-1-8. The Murray Junior High School and the Murray High School are located in the south portion of the off-facility area.

3.1.2 Future Land Use

In 1997, the Murray City council adopted a land use plan for future development of the on-facility portion of the Site and amended its General Plan accordingly. The land use plan for the on-facility area includes construction of a north-south roadway corridor from Vine Street to 5300 South Street through the central portion of the on-facility area. Murray City council has appropriated the funding for the road, which extends north and south of the Site along the alignment shown in Figure 5. This alignment takes into account the City's desire for traffic volume and the owners' desire for sufficient access. Largely due to the construction of this access road, a significant portion of the on-facility area is highly likely to be redeveloped in the near future. Current land owners are discussing options with the City and potential developers to optimize future use of the area. Much or all of the outdoor industrial activity is expected to end, to be replaced with light industrial/ commercial activities. The City will rezone the area to C-D-C use by passing an ordinance establishing an "overlay district" which restricts certain uses and requires city review of development plans within the on-facility area boundaries.

Also, all residential occupation within the on-facility area will soon end. A Site developer has acquired an option to purchase the Doc and Dell's trailer park with the intention of converting the trailer park to commercial uses. Grandview Trailer Park has been purchased by the Utah Transit Authority (UTA) and residential leases are not being renewed. UTA intends to swap the Grandview parcel for a parcel of land owned by the Buehner family near Ashgrove. Within two years, UTA will construct a light rail station platform adjacent to the existing railroad tracks along with associated off-street parking and landscaping. If the land swap with Buehner occurs, then residential occupation of Grandview will be terminated more rapidly as the site is developed. In either case, residential occupation of Grandview will likely end within two years.

The Amendment to the General Plan for Murray City also includes three other potential public use projects:

1) **Murray City Court/Police Administrative Office.** There is interest in locating a court/police complex somewhere south of Little Cottonwood Creek, and south of Vine Street. The City will be establishing its own court system within a few years and will ultimately need facilities to be constructed for this purpose. There is an urgent need to provide adequate police facilities as well as additional space in City Hall. It is anticipated that three to five acres will be needed for this facility.

2) **Little Cottonwood Creek Parkway Improvements.** The Murray Parks & Recreation Department is interested in obtaining property to enhance the south side of Little Cottonwood Creek with landscaping, a walking and bicycle trail, urban plaza, pavilion and restroom facilities contained within approximately 5 acres. This would allow the extension of the City's existing trail system with a target of connecting to the Jordan River trail system.

3) **Smelter Site Interpretive Park.** There is also interest in developing a small interpretive park at the base of the smelter stacks that would be no larger than approximately two acres. The small park could contain a plaza, seating, fountain and landscaped areas. Historical information relating to the smelter Site history would be integrated into the park development.

This type of development provides the opportunity to integrate implementation of remedial actions into development activities, a key objective of EPA's Brownfields Program. Given the interest in developing the on-facility area and the high level of involvement and commitment by the City of Murray and the current land owners, there is sufficient certainty concerning future land use to identify the reasonably anticipated future land use scenario as recommended in the EPA OSWER directive "Land Use in the CERCLA Remedy Selection Process". The reasonably anticipated future land use for the on-facility area is light industrial/commercial use.

In the off-facility area, areas to the west of the on-facility area (ISZ-1 and ISZ-8) are zoned M-G-C and C-D-C but do have some residential occupation. This zoning prevents the construction of new homes, and therefore, residential occupation is expected to end in the future. To the south of the on-facility area (ISZ-6 and ISZ-7) a portion of the land is zoned for residential use and a portion is zoned M-G-C. Similar to the western off-facility area, although there are some existing non-conforming residences, residential occupation is expected to end sometime in the future due to the prohibition of new home construction and the redevelopment of the on-facility area. The reasonably anticipated future land use for the off-facility area is a combination of commercial/light industrial and residential.

3.2 Topography

The Site is mainly flat in the southern portions. Near Little Cottonwood Creek on the north, the terrain slopes steeply. This area used to be filled with slag from the Murray Smelter but over the years since the smelter shut down, the slag has been excavated and used throughout the Salt Lake Valley. A steep wall of concrete debris from recent Site uses and residual slag remains in the northern area where slag used to exist.

3.3 Geologic Units and Soils

The geologic units at the Site consist primarily of lake sediments from Pleistocene Lake Bonneville, however, younger alluvial floodplain deposits are found along Little Cottonwood Creek. The lake sediments consist of clays, silts, and fine sands and underlie the more recent alluvial stream deposits which generally consist of silt, sand, and gravel. Surface soils within the on-facility portion of the Site have been disturbed, affected by the construction and operation of smelting, ore handling, and refining facilities over a period of 77 years. In more recent times, construction and operation of concrete, asphalt, and other commercial or manufacturing facilities have further disturbed the area's soils. In particular, construction of the facilities and the deposition of slag from smelting operations and other fill materials have covered the majority of the original surface soils.

In the off-facility area, surface soils have been significantly affected by extensive general urban development.

3.4 Hydrogeology

The Site lies on an area covered by thick valley-fill (alluvial) deposits that comprise several distinct aquifers within the aquifer system. Specific components of the aquifer system are as follows:

- **Shallow Aquifer**: a shallow, unconfined aquifer comprised of interbedded sandy clays and clayey sands occurring above the Bonneville Blue Clay;
- **Bonneville Blue Clay**: approximately 30-foot-thick continuous layer of clay separating the shallow and intermediate aquifers;
- **Intermediate Aquifer**: a confined aquifer immediately underlying the Bonneville Blue Clay comprising approximately 10 to 20 feet of relatively coarse-grained deposits; and
- **Deep Aquifer**: an artesian aquifer, several hundred feet below the intermediate aquifer, comprising various coarse-grained valley-fill deposits

The shallow aquifer is unconfined with a saturated thickness that ranges from 2.5 to 25 feet within the on-facility area. The average depth to water is approximately 10 feet. The aquifer materials have a geometric mean hydraulic conductivity of 5 feet per day (based on estimates from different locations in the study area ranging from 1 to 112 feet/day). Groundwater in the shallow aquifer flows along the top of the Bonneville Blue Clay, generally north-northeast, toward Little Cottonwood Creek as shown in Figure 6. Water levels measured adjacent to the creek indicate that the shallow aquifer is hydraulically connected to Little Cottonwood Creek and that groundwater discharge to the creek occurs during certain times of the year.

The second component of the aquifer system is the Bonneville Blue Clay. Available hydrogeologic information indicates that the Bonneville Blue Clay is continuous across the facility and the surrounding area. This lithologic unit forms an effective barrier for vertical groundwater movement from the shallow aquifer to the intermediate and deep aquifers. Analyses presented in the Feasibility Study support this conclusion.

Beneath the Bonneville Blue Clay, the intermediate and deep aquifers are separated by more than 200 feet of interbedded fine- and coarse-grained valley-fill and alluvial deposits. Both receive recharge primarily up gradient of the Site. Groundwater in the intermediate aquifer flows north-northwest across the Site as shown in Figure 7, and the aquifer is not hydraulically connected to surface water bodies in the vicinity of the Site. The deep aquifer is the main source of drinking water for most residents in the Salt Lake Valley. Municipal water-supply wells located in the vicinity of the Site are screened more than 500 feet below the ground surface in the deep aquifer.

3.4.1 Potential for Use of Ground Water as a Drinking Water Supply

It is unlikely that the shallow aquifer will ever be used as a potable water supply due to several conditions. Primarily, the water is of poor quality for drinking water. Background total dissolved solids (TDS) concentrations range from 606 to 3,236 mg/L and exceed EPA's secondary drinking water quality standard of 500 mg/L. Additionally, this water supply is only available in limited quantity due to the aquifer thickness coupled with low hydraulic conductivities which do not produce sufficient water for typical water supply needs. The intermediate and deep aquifers provide lower TDS and higher yielding water supplies. However, within EPA's ground water classification system, two factors are considered in designating ground water as a potential drinking water source; water quality and yield. In EPA's regulatory scheme, water is considered to be suitable for drinking if it has a TDS concentration of less than 10,000 mg/L and either can be used without first being treated or can be rendered drinkable after being treated by methods reasonably employed in a public water supply system and can sustain a yield of 150 gallons per day The characteristics of both the shallow aquifer and the intermediate aquifer at the Site meet EPA's criteria for designation as a potential drinking water source, Class IIb and Utah's criteria for designation as a Class II drinking water under Utah's Ground Water Quality Protection Rule. The deep aquifer meets both EPA's and Utah's criteria for designation as a Class I aquifer, a current drinking water source.

3.5 Surface Water

Little Cottonwood Creek is a perennial stream flowing along the north/northeast boundary of the on-facility area and into the Jordan River approximately one mile downstream. The stream has been altered by urban and agricultural development both upstream and downstream of the Site. In the northern portion of the on-facility area, the course of the stream was altered during smelter operation. Facility drawings and aerial photographs indicate that the creek originally flowed through the northern portion of the on-facility area, but during smelter operation the creek was diverted to the north with the former channel incorporated into the slag pile. Today, the upstream reaches of the creek are bordered by residential areas or parks, while the Site and downstream reaches are mainly bordered by commercial/industrial areas.

Historically, Little Cottonwood Creek has been stocked with rainbow trout and German brown trout; however, reproductive success of these fish is thought to be poor due to the steep gradient and a below average availability of good quality pools in the creek. In the vicinity of the Site, Little Cottonwood Creek is designated by the State of Utah for secondary contact recreation use such as boating and wading (classification 2B), for cold water game fish use (classification 3A) and agricultural use (classification 4). A survey of Little Cottonwood Creek conducted in 1997 found no diversions of surface water for agricultural use downgradient of the Site. Although no formal petition has been brought forward to the Utah Water Quality Board to change the agricultural use designation, existing evidence documented in the survey report suggests that such use is not likely in the future.

In addition to the use designations assigned by the State of Utah, fisheries habitat in Utah is inventoried and classified on a statewide basis by the Utah Division of Wildlife Resources. The section of stream near the Murray Smelter has been designated as a Class 5 stream based on esthetics, availability, and productivity as determined in a physical habitat survey conducted in 1974. According to the classification system, Class 5 streams are now practically valueless to the fishery resource, however many waters in this class could provide valuable fisheries if sufficient quantity of water could be provided.

On the northern area of the Site, shallow ground water within the floodplain of Little Cottonwood Creek surfaces at three distinct locations to form wetlands. An area of 0.75 acres of wetlands were identified in a delineation study done in June, 1997 by Hydrometrics titled "Report of Wetland Determination, Little Cottonwood Creek Riparian Area, Former Murray Smelter Site, Murray, Utah".

3.6 Climate

The Salt Lake area has a semi-arid climate. Average precipitation is approximately 16 inches per year and the average air temperature is approximately 64 degrees Fahrenheit. The Site elevation is approximately 4280 - 4315 feet above sea level.

3.7 Floodplain

The most recent flood insurance study which includes Little Cottonwood Creek was done by HUD in 1994. Several differences have been observed between existing floodplain topography and the floodplain cross section data utilized for development of the most recent floodplain map. Existing conditions, compared with conditions from which previous floodplain delineations were based, show more floodplain area in the southbank (within the on-facility area) and less flood plain area in the northbank (north of the Site boundary). The larger existing southbank floodplain area probably resulted from excavation of slag from this area, or it may have been excluded from previous studies because it may not be part of the effective flow conveyance. Most of the site is outside of the 100 year floodplain as shown on Figure 8 from the HUD study.

3.8 Nearby Populations and Demographics

Based on data from the 1990 census, approximately 20,000 people live within a mile radius of the Site. The majority of this population is non-minority. Of the 20,000, there are approximately 2,100 children 5 years old or younger, 2,700 adults over the age of 60, and 4,200 women of child-bearing age (18-45 years old). Figure 9 summarizes this demographic information.

4 Site History and Enforcement Activities

4.1 Administrative Order on Consent for an Engineering Evaluation/Cost Analysis

In January, 1994, EPA proposed that the Site be listed on the National Priorities List. On August 5, 1994, EPA issued a letter of "Notice of Potential Liability and Demand for Payment " to Asarco. Negotiations between EPA and Asarco commenced shortly thereafter culminating in September, 1995 when EPA, Asarco, and Murray City entered into an Administrative Order on Consent (AOC) for the performance of an Engineering Evaluation/Cost Analysis (EE/CA) for the Site. EPA retained responsibility for performing a baseline human health and ecological risk assessment for the Site. The EE/CA was intended to support a Non-Time-Critical removal action.

4.2 AOC for Time Critical Removal

On September 13, 1995, EPA and Asarco entered into a separate AOC for conducting a time critical removal at the playground area of the Grandview Trailer Park. The scope of this time critical removal was excavation of soils within and adjacent to the playground which contained unacceptable levels of lead and arsenic and backfill of those areas with clean fill. This removal action was completed by Asarco in November, 1995. The removed soils have been temporarily stored in a waste pile on-Site and will be consolidated on-Site as part of the remedial action selected in this ROD.

4.3 Memorandum of Understanding with Murray City

In April, 1996, EPA and Murray City entered into a Memorandum of Understanding which established that Murray City would assist EPA in identifying current and potential future land use at the Site, in developing response action alternatives, and in implementing any institutional controls required by EPA's chosen response action.

4.4 EE/CA

Data needs were identified in the EE/CA Work plan, an attachment to the EE/CA AOC. Environmental sampling to support the EE/CA and risk assessments began in April 1995. Asarco completed a Site Characterization Report in August, 1996. Shortly thereafter, EPA decided to redirect what had been a Non-Time-Critical Removal activity into the remedial action framework. Accordingly, the requirement for an EE/CA was changed to a Feasibility Study. Table 1 shows the completion dates for the major documents which support this Record of Decision (ROD).

DOCUMENT	RESPONSIBILITY	COMPLETION DATE
Site Characterization Report	Asarco	August, 1996
Baseline Human Health Risk Assessment	EPA	May, 1997
Feasibility Study Report	Asarco	August, 1997
Baseline Ecological Risk Assessment	EPA	September, 1997
Proposed Plan	EPA	September, 1997

Table 1: Completion Dates for Major Documents Supporting the ROD

4.5 Information Requests

EPA sent CERCLA 104(e) requests to Asarco and on-facility property owners by letter dated April 25, 1996 seeking information on operations at the Site and material handling and storage details. Responses to the information requests were provided by all recipients.

5. Scope of Response Action

The remedial action which is the subject of this ROD is the second of the three response actions EPA considers to be necessary at the Site. The first response action was a time critical removal of soils located in and adjacent to the playground area at the Grandview Trailer Park. These soils were contaminated with lead and arsenic at levels considered by EPA to be unacceptably high. The area was backfilled with clean fill. The decision to undertake the time critical removal action is documented in an Action Memorandum signed by EPA Region 8 on November 7, 1995. Asarco completed the Grandview Trailer Park time critical removal action in November, 1995.

The remedial action described in this ROD addresses contaminated ground water, the subsurface soil which is the source of the ground water contamination, contaminated surface soils, and the surface water of Little Cottonwood Creek as follows:

1. **Contaminated ground water**. Source control will be implemented by excavation and off-site disposal of the principal threat wastes at the Site, approximately 2000 cubic yards of residual undiluted arsenic trioxide. This material is considered a principal threat due to its high mobility and its demonstrated ability to act as a source of ground water contamination. In addition, direct contact with this material may result in acute human health risks. Further source control will be implemented by excavation of approximately 68,000 cubic yards of low level threat waste, diluted arsenic trioxide or flue dust mixed with soil, fill, or debris from former smelter structures. This material will be consolidated within a repository system constructed within the Site boundaries. The repository will be designed as the base for a new access road through the Site which was planned by Murray City. The access road is expected to be the catalyst for Site development. Monitored natural attenuation will address the residual ground water contamination within and down gradient of these source areas. Institutional controls in the form of a Murray City ordinance establishing an "overlay district" **and** restrictive easements that run with the land both will prohibit the construction of new wells or use of existing wells (except EPA approved monitoring wells) within the on-facility area and the western and eastern portions of the off-facility area.

2. **Contaminated surface soils**. On-facility surface soil containing levels of lead and arsenic which exceed remediation levels will be covered. The barriers will provide protection by breaking the exposure pathways associated with long term direct contact with these soils. Site development itself is expected to result in additional protection of human health since land uses associated with unacceptable human health risks will end. Also, the development will result in the construction of additional barriers (new buildings, roads, sidewalks parking lots, and landscaping) over remaining surface soil and slag. Although no unacceptable risks associated with exposure to slag were identified by EPA, the development of the Site will ensure no exposure to slag in the future. Institutional controls in the form of a Murray City ordinance will establish an "overlay district" which includes zoning to prevent residential and contact intensive industrial uses within the former smelter operational areas and will require maintenance of the barriers and controls on excavated subsurface material within this same area. Restrictive easements that run with the land will be established in addition to the overlay district to prevent residential or contact intensive industrial uses.

Off-facility surface soils containing levels of lead exceeding remediation levels will be removed and replaced with clean fill. The removed soil will be used on-facility as subgrade material in construction of the repository system.

3. **Surface water**. Little Cottonwood Creek, which forms the northern boundary of the Site and to which shallow ground water discharges, will be monitored to ensure continued protection during the ground water natural attenuation process. Additional monitoring of the ecological study area of the Site will be used to reduce the uncertainties identified in EPA's predictions of ecological risk.

The remedial action protects ground water and Little Cottonwood Creek and incorporates the construction of a new north-south access road through the site which will encourage future development of the Site and help achieve Murray City's goal of more appropriate land use through site development. Institutional controls will prevent exposure of people to ground water with arsenic concentrations that represent an unacceptable risk and will also ensure that future uses of the land will be protective and that the remediation will be maintained.

EPA expects that an additional response action will be required at the Site. A structural analysis of the existing stacks at the Site was completed in January, 1998. The study concludes that both stacks as they exist today are not able to withstand seismic events which are specified in the current Uniform Building Code. Based on information collected as part of Site characterization efforts on the nature and extent of contamination on interior bricks of the stacks, EPA expects that an additional time critical removal action will be required to address the potential for release of hazardous substances and resulting health risks associated with the potential structural failure of the stacks.

6. Highlights of Community Participation

EPA's community involvement activities at the Site began in March, 1995 with the establishment of the information repository at the Murray City Library. In August, 1995, when the EE/CA work plan was in final preparation, EPA and UDEQ released a fact sheet describing the scope and objectives of the site investigation. With the assistance of Murray City officials, two public meetings were conducted on August 9, 1995 and August 10, 1995 to inform the affected citizens of Murray about the upcoming investigation activities on or near their property.

In September, 1996, EPA released another fact sheet describing the preliminary results of the baseline human health and ecological risk assessments. Since the results were specific to separate populations, EPA conducted six separate public meetings and two availability sessions to explain the results of environmental sampling and risk assessments.

In October, 1996, EPA initiated the formation of the Murray Smelter Working Group consisting of representatives of UDEQ, Asarco, owners of property and businesses on the Site, Murray City, and EPA. The purpose of the Working Group was to inform EPA about pending Site development plans and to provide a forum for discussing alternative cleanup strategies for the on-facility area of the Site. In a series of open meetings conducted during October, 1996 through February, 1997, implications of remedial alternatives were discussed by the working group. EPA provided information on the nature and extent of contamination and the clean up requirements.

The following commitments were made as a result of the Working Group sessions:

1. Current property owners, Murray City, and Asarco are committed to accomplishing the necessary tasks to ensure that a new road will be constructed on the Site between Vine Street and 5300 South Street. These tasks include dedication of the land for the road right of way and agreement on the establishment of a "Special Improvement District" to fund utility construction.

2. Current property owners and Murray City are willing to work together to establish appropriate public and private institutional controls as required by EPA's selected remedy.

3. Asarco is willing to use its best efforts to design a remedial action that is consistent with the Murray City General Land Use Plan.

The agreements among the members of the Murray Smelter Working Group are memorialized in an Agreement in Principle signed in May, 1997.

In September, 1997, EPA released the Proposed Plan for the Site and made available all supporting documents in the information repository established at the Murray City Library and the EPA Superfund Records Center at the EPA Region 8 offices in Denver, Colorado. The notice of availability of these documents was published in the Salt Lake City Tribune and the Deseret News on September 23, 1997. A public comment period was held from September 22, 1997 until October 22, 1997. In addition, a public meeting was held on October 1, 1997. Responses to the comments received during the public comment period are included in the Responsiveness Summary which is part of this ROD. A summary of the highlights of community participation is presented in Table 2.

This decision document presents the selected remedial action for the Murray Smelter Site in Murray, Utah, chosen in accordance with CERCLA and the National Contingency Plan. The decision for this Site is based on the administrative record.

ACTIVITY	*SUBJECT*	*DATE*
Fact Sheet	summary of site investigation activities	August, 1995
Public Meeting	explanation of sampling activities	August 9-10, 1995
Fact Sheet	draft risk assessment release	September, 1996
Public Meetings/Availability Sessions	draft risk assessment and sampling results	September, 1996
Murray Smelter Working Group Sessions	future site use plans and remediation alternatives	October, 1996 - February, 1997
Fact Sheet	Proposed Plan of Action	September, 1997
Public Meeting	comments on the Proposed Plan	October, 1997
Public Comment Period	Proposed Plan of Action	September 22 - October 22, 1997

Table 2: Highlights of Community Participation Activities

7 Summary of Site Characteristics

7.1 Scope of Site Investigation Activities

Using data available from Preliminary Assessment/Site Investigation activities, EPA performed screening level calculations to identify the chemicals of concern which would be the focus of site characterization, risk assessment, and remedial activities at the Site. This analysis is documented in the "Preliminary Scoping Report" prepared by EPA in December, 1994. The analysis concludes that lead and arsenic are the chemicals likely to be of substantial concern to humans. Based on these results, the EE/CA Work Plan specified lead and arsenic chemical analysis of soil and ground water samples collected to support site characterization and the baseline human health risk assessment. Recognizing that chemicals of concern to ecological receptors, especially aquatic organisms, often are different from those of concern to humans, EPA selected the ecological chemicals of concern by evaluating historical data collected from surface water, sediment, and soil in the Little Cottonwood Creek riparian zone. This evaluation was done by the EPA Region 8 Ecological Technical Assistance Group (ETAG) at a meeting on January 31, 1995. In addition to arsenic and lead, the ETAG identified aluminum, cadmium, copper, mercury, nickel, selenium, silver, thallium, and zinc as ecological chemicals of concern to be investigated in the ecological study area.

7.2 Soil and Dust Investigation

The site investigation for surface soil, subsurface soil, and dust is detailed in the Final EE/CA Work Plan completed in September, 1995. Prior to sampling, the on-facility area was divided into eleven EUs based on current property boundaries and land use. Similarly, the off-facility area was divided into eight ISZs based on consideration of the predicted pattern of historic air deposition from the site along with current street and land use features. A total of 10-20 surface soil samples (defined as 0"-2" deep) were collected from each on-facility EU. More samples were collected from the larger exposure units. In addition, test pits were excavated in several exposure units, using existing and historical features to select the location of the pits. Special emphasis was placed on areas where potential sources of contamination such as historical locations of the smelter flues, the bag house, waste transfer facilities, the roasting areas, the arsenic kitchen, and the smelting areas were located. At each test pit, subsurface samples were collected in one foot intervals to a depth of 5 feet.

In the off-facility area, surface soil samples were collected from 10 to 16 distinct residential yards (depending on the size of the ISZ) within each ISZ. Each sample was a composite of surface soil from 4 to 6 sub-locations within the yard. In addition, 16 soil borings were collected (two different locations in each ISZ) and subsurface soil samples were collected from the 0"-2", 2"-6", 6"-12" and 12"-18" intervals. These subsurface samples were collected to characterize the vertical extent of contamination in each off-facility ISZ. Indoor dust samples were collected from 22 different homes or buildings in the off-facility areas. Samples were collected using a hand held vacuum. Typically, each sample was a composite of dust collected from three areas, each about 2 feet by 7 feet. Summaries of sampling results for soil and dust can be found in Tables 3-5.

After the Baseline Human Health Risk Assessment was completed, supplemental soil sampling was conducted in every residential yard within those ISZs which were predicted to have unacceptable risk. A summary of this supplemental sampling effort can be found on Figures 10-12.

CHEMICAL	# OF SAMPLES	AVERAGE	RANGE
Arsenic	22	27 mg/kg	5 mg/kg - 94mg/kg
Lead	21	303 mg/kg	83 mg/kg - 757mg/kg

Table 3: Summary Statistics for Indoor Dust Samples

In order to gain information on the physical and chemical nature of the lead and arsenic present in surface soil, EPA collected 10 samples from locations on the Site. These samples were dried and sieved to yield the fine fraction (< 250 um) and submitted for geochemical characterization. The lead in soil at the Site occurs in a variety of different forms, most commonly as lead phosphates, lead silicates, lead oxides, iron-lead oxides, lead arsenic oxide, and lead sulfide. In contrast, arsenic occurs mainly as ferric-lead-arsenic oxide and lead-arsenic oxide with only small amounts of other arsenic species. The lead and arsenic bearing particles were mainly smaller than 20 um with about 80% of all the lead or arsenic bearing grains existing in a liberated or cemented state, with only about 20% existing within a rock or glass matrix.

7.3 Slag Investigation

EPA collected a single composite sample of slag from nine different locations at the Site. Two of the subsamples were from the Germania smelter slag pile, six were from the face of the slag monolith located adjacent to EU-2, and one was from the slag at the base of the slag pile adjacent to Doc and Dell's trailer park. The composite slag sample was analyzed in duplicate using Contract Laboratory Program methods. The mean values of the duplicate analyses are 695 mg/kg arsenic and 11,500 mg/kg lead.

In addition to chemical analysis, the slag sample was submitted for geochemical characterization. As expected, the principle form of lead-bearing particle in the slag sample is slag (i.e., particles of glassy matrix with lead dissolved in the glassy phase). However, this type of particle contains a relatively low concentration of lead and so does not account for most of the lead mass in the sample. Rather, the majority of the relative lead mass exists in the form of lead oxide with smaller contributions from galena (9%), lead arsenic oxide (6%) and other metal lead oxides (4%). About 87% of all lead bearing particles in the slag sample are liberated, accounting for about 77% of the relative lead mass.

Similarly, the most frequent type of arsenic bearing particle in the slag sample is slag, accounting for 62% of the relative arsenic mass. The majority of these particles are liberated, existing partially or entirely outside the confines of glassy slag particles.

7.4 Ground Water Investigation

The ground water investigation was conducted in two phases which included installation of 13 monitoring wells in the shallow aquifer, 7 monitoring wells in the intermediate aquifer (Phase I), and a hydropunch investigation (Phase II). Several other on-facility wells that had been installed in earlier investigations were also redeveloped and sampled. A presentation of the results of all the ground water sampling performed between October, 1995 and April, 1996 is contained in the final Site Characterization Report. Shallow alluvial and intermediate ground water continues to be monitored quarterly. Summaries of the sampling results for key analytes in shallow ground water can be found in Table 6. A full summary of all ground water sampling results can be found in the October, 1997 Ground Water and Surface Water Monitoring Report. The most severe Site-related impact to shallow ground water was found to be arsenic contamination. Figure 6 illustrates the arsenic levels detected in shallow ground water in

January, 1996. Distinct plumes of contamination can be seen in areas underlying the former locations of smelter operations.

7.5 Surface Water, Sediment, and Riparian Soil Investigation

Samples of surface water, sediment, benthic macroinvertebrates, and riparian soil were collected in the ecological study area and analyzed for ecological chemicals of concern as part of site characterization efforts. Figure 13 shows the locations of these samples. Summaries of the results of this sampling can be found in Tables 7-10.

Subsequent to site characterization efforts, additional quarterly surface water sampling was conducted beginning in July, 1996. Additional locations were established to characterize areas of Little Cottonwood Creek which receive ground water discharge from the shallow aquifer and to characterize the effects of ground water and point source discharges on the water quality of Little Cottonwood Creek. Figure 13a shows these additional locations. This supplemental sampling was limited to arsenic analysis. Summaries of the surface water results can be found in Table 11.

The results of the point source discharge sampling are particularly significant because they indicate that the increase in dissolved arsenic concentrations in Little Cottonwood Creek occurs in the vicinity of the discharge from a storm sewer culvert running north along State Street. Loading calculations presented in the April, 1997 quarterly monitoring report demonstrate that nearly all of the dissolved arsenic loading (88%-100%; accounting for flow measurement accuracy) observed in the creek appears to originate from the culvert point source discharge. Ground water discharge from the shallow aquifer in the on-facility area to the south of the creek was not shown to have a measurable effect on arsenic load in the creek.

8. Summary of Site Risks and Remedial Action Objectives

8.1 Human Health Risks

EPA completed a baseline risk assessment for the Site in May, 1997. Human health risks were calculated separately for four groups of people to characterize risks for the current and reasonably anticipated future land use: on and off-facility residents; on-facility workers who spend most of the day indoors (non contact intensive (NCI) workers); on-facility workers who spend most the day outdoors and are engaged in activities that result in significant exposure to soil and dust (contact intensive (CI) workers); and teenagers who have been observed congregating in areas along Little Cottonwood Creek. The exposure pathways evaluated for each group were ingestion of soil and dust, ingestion of slag (only evaluated for current and future teenagers), and ingestion of ground water. Other exposure pathways to site-related wastes are judged to be sufficiently minor that quantitative evaluation was not warranted. The current land use for the site is a combination of commercial (best represented by NCI workers), industrial (best represented by CI workers), and residential. As discussed in Section 3, the reasonably anticipated future land use for the on-facility area is commercial/light industrial (NCI) and for the off-facility area is a combination of commercial/light industrial (NCI) and residential. The exposure assumptions used in the risk assessment were also used to develop preliminary remediation goals for soil. These assumptions can be found in Appendix B.

The risk assessment was performed using two distinct approaches for the on-facility and off-facility portions of the Site. The majority of the on-facility was divided into seven EUs, sized to approximate the area over which a typical office or industrial worker would come into contact with surface soils during a working lifetime. The residential trailer parks within the on-facility area were divided into four smaller EUs sized to approximate the area over which a child or adult might come in contact with soil during the period of residence. Soil samples were collected within each exposure unit and averaged according to EPA guidance. This average, the "exposure point concentration", was the basis for the risk calculation. EPA will manage risks for the on-facility area by EU.

In contrast, the off-facility was divided into eight ISZs sized to represent neighborhoods, not individual residences. This was because historical data indicated little variability in concentrations of lead and arsenic within neighborhoods. Concentrations in general tended to decrease with distance from the smelter site. The term ISZ was chosen deliberately to reflect that the risk assessment for the off-facility area is an "initial" or screening level assessment. The exposure point concentrations for the off-facility risk assessment were the average concentrations for each ISZ or neighborhood. EPA established the following decision rule for the off-facility : If the screening level risk assessment predicts unacceptable risks in a given ISZ, the assessment will be refined (i.e., additional samples will be collected to characterize each residence, exposure point concentrations will be established based on these samples and will be compared to the remediation goal), if the screening level risk assessment predicts acceptable risks in a given ISZ, that ISZ is considered to require no further action. Based on this decision rule, additional soil samples were collected from each residence within ISZ 1, 6, and 7. The refinement of the screening level assessment was completed after this supplemental soil sampling was performed in ISZs 1, 6 and 7 in January, 1997. A comparison of these sampling results with the residential remediation goals comprises the final risk assessment for the off facility area. EPA will manage risks for the off-facility area by individual yard.

8.1.1 Arsenic Risks

The risks associated with exposure to arsenic in soil are summarized in Table 12 excerpted from the final Human Health Baseline Risk Assessment. Current EPA policy, summarized in OSWER Directive 9355.0-30, states that where the cumulative carcinogenic site risk to an individual based on the reasonable maximum exposure for both current and future land use is less than 10^{-4} , and the non-carcinogenic hazard quotient is less than 1, action is generally not warranted . Using this criteria, the cancer and non-cancer risks associated with the reasonable maximum exposure to arsenic in soil by NCI workers are predicted to be unacceptable in (i.e., warranting remedial action) in EU-3 and EU-4 only. The cancer and non-cancer risks associated with the reasonable maximum exposure to arsenic in soil by CI workers are predicted to be unacceptable in all exposure units. The cancer and non-cancer risks associated with the reasonable maximum exposure to arsenic by residents within the on-facility area are unacceptable in one exposure unit, EU-8. As can be seen in Figure 2, EU-8 is adjacent to areas where people are currently living. However, no trailers are present and no people currently reside within this EU.

In the off-facility area, risks to residents are unacceptable in ISZ-8. Close inspection of ISZ-8 reveals that the unacceptable risk is attributable to one property. The risk assessment broadly assumed that all off-facility properties were used as residences. This particular property is used for a commercial business (it is a lumber yard) and is expected to remain in commercial use in the future. Comparison of soil concentrations to those considered to be acceptable for NCI workers demonstrates that risks are acceptable for commercial use of this property.

The risks associated with the reasonable maximum exposure to arsenic in ground water are summarized in Table 13 excerpted from the final Human Health Baseline Risk Assessment. As can be seen in the table, the non-cancer and cancer risks associated with exposure to arsenic in ground water are unacceptable for both workers and residents.

The risk assessment also evaluated the potential risks associated with exposure of teenagers to slag while visiting the Site. The cancer and non-cancer risks associated with the reasonable maximum exposure to arsenic in slag are below a level of concern. The hazard quotient is 0.2 and the cancer risk is 1 $\times 10^{-5}$.

8.1.2 Lead Risks

The health risks associated with exposure to lead are evaluated in a different manner than those associated with exposure to arsenic. The health effect of most concern associated with lead exposure is the impairment of the nervous system, especially in young children and unborn children. Analyses conducted by the Centers for Disease Control and EPA associate levels of lead in the blood of 10 micrograms per deciliter (ug/dL) and higher with health effects in children. EPA's risk management goal for lead is to achieve a level of protectiveness such that a typical child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding the 10 ug/dL blood lead level. The risk assessment results for lead exposure at the Site are reported as the probability of an individual child or the fetus of an individual pregnant worker having a blood level above the 10 ug/dL goal. EPA's Integrated Exposure/Uptake Biokinetic Model was used to assess risks to residential children. A biokinetic slope factor approach was used to assess risks to adults and teenagers. The risk assessment considered the exposed population within the on-facility EUs 1-7 to be adults.

The health risks associated with exposure to lead in soils at the Site are summarized in Tables 14 and 15 excerpted from the final Human Health Baseline Risk Assessment. Risks to NCI workers are predicted to exceed EPA's health goals in EU-3 only. However, the health risks associated with exposure to lead in soils by CI workers exceed EPA's health goals in all exposure units, with probabilities of 25%-99% of exceeding the target blood lead level. The risks from exposure to lead within the on-facility residential areas of EU 8, 9 and 11 are predicted to exceed EPA's health goals. In the residential areas south and west of the site, risks from exposure to lead exceed EPA's health goals in ISZ-1, ISZ-3, ISZ-6, ISZ-7, and ISZ-8. Close inspection of these results showed that ISZ-3 was occupied by the Murray High School and commercial businesses and further, the elevated lead levels in ISZ-8 were associated with commercial properties. Considering these land uses, the lead risks in ISZ-3 and ISZ-8 were determined by EPA to be acceptable. Supplemental sampling and refinement of the risk assessment was limited to ISZ-1, ISZ-6, and ISZ-7.

The risk assessment also evaluated the potential effect of the exposure of teenagers to slag while visiting the Site. The assessment concluded that there is a less than 0.02% probability of exceeding EPA's health based goal as a result of this exposure.

8.2 Ecological Risks

The ecological risk assessment evaluated potential exposures of fish, birds, mallard ducks, frogs, and pocket gophers to smelter related chemicals of concern within likely habitat areas. Potential risks to ecological receptors were estimated by calculating Hazard Quotients (HQs) and Hazard Indices (HIs). The HQ is the ratio of environmental concentration or dose to a safe level or dose. If the HQ for a chemical is equal to or less than 1, it is assumed that there is no appreciable risk that adverse health effects will occur. If an HQ exceeds 1, there is some possibility that adverse effects may occur, although an HQ above 1 does not indicate an effect will definitely occur. However, the larger the HQ value, the more likely it is that an adverse effect may occur.

Hazard quotients for each contaminant at each location and by each pathway were summed to obtain a Hazard Index (HI) for each receptor. Figures 14 to 17 summarize the HIs for the belted kingfisher, killdeer, valley gopher, and the mallard. The assessment considered exposure via ingestion of water, sediment, soil, and food within the ecological study area of the Site. The HI's are calculated for both the No Observed Adverse Effect Level (NOAEL) and the Lowest Observed Adverse Effect Level (LOAEL). The NOAEL HI is appropriate to consider when determining risks to individual ecological receptors. The LOAEL HI best characterizes risks to populations. Figures for the kingfisher and mallard also illustrate an adjustment with "area use factors" as their home ranges are larger than the actual Site areas. All figures illustrate risk up gradient of the Site, on-Site, down gradient of the Site, and in the depressions (wetlands). Lead concentrations in soils and sediments as well as selenium concentrations in plants are the largest contributors to risk to ecological receptors at the Site.

Hazard quotients for trout and frogs were calculated by comparing exposure point concentrations for surface water with toxicity reference values. The evaluation, documented in the ecological risk assessment, shows essentially no risks to brown trout or frogs in Little Cottonwood Creek.

8.2.1 Discussion of Results

The estimate of relative risk is the risk estimate on-Site divided by the risk estimate up gradient. It is a useful measure of how much higher the risk is due to the Site relative to inherent risks. The estimate of absolute risk is the HQ or the HI for each location. As can be seen in Figures 14-17, in general, the relative risks to terrestrial receptors on-Site are two or more times higher than the risks observed up gradient. Both relative risk estimates and absolute risk estimates are considered by EPA when determining if remedial action is warranted. There are essentially no risks to aquatic life in Little Cottonwood Creek considering both relative and absolute risk estimates. The greatest areas of concern at the Site are the wetlands, where both absolute and relative risk estimates are high.

Interpretation of these risk estimates must take into account the following sources of uncertainty in the calculations:

1. Where measured concentration data were not available, literature based bioaccumulation factors were applied to estimate concentrations. This use of predicted rather than measured data adds to the uncertainty in the assessment. This uncertainty may be significant for the risks predicted for the mallard and the pocket gopher, since predicted excess risk is associated with ingestion of contaminants in vegetation. These plant concentrations driving the risk were predicted using literature based bioaccumulation factors. Without true site measurements, it is difficult to ascertain if this risk is representative.

2. Sample preparation may also lead to some degree of uncertainty. Benthic macro invertebrates which were collected at this Site were not rinsed prior to analysis. This could lead to a carry over of sediments thereby influencing contaminant levels in this media. Sediments were ground and acid-digested. This method of treatment could possibly lead to a release of contaminants from the sediment which might not typically be available to a receptor. Therefore, EPA believes preparation of samples collected from this Site to support the ecological risk assessment may have contributed to artificially high metal concentrations, thereby elevating risk estimates.

3. The risks were calculated on the assumption that the receptor spent 100% of its time within a location. Depending on the home range and actual use of each location, the actual risks could be lower.

Observations of the ecological receptors at the Site in the form of qualitative surveys documented in the ecological risk assessment suggest that the predicted effects are not occurring. EPA believes that further biomonitoring is needed to validate this assumption. Attempts to reduce the risks through active measures such as removing and replacing sediments in the wetlands will likely result in loss of the habitat. In EPA's judgement, the wetlands are of great ecological interest and loss of this habitat may have a more negative impact on the local ecosystem than the highly uncertain predicted risks.

Also relevant to the discussion of ecological risks is the fact that current Site development plans include extensive regrading which will likely result in filling of the wetlands. The Corps of Engineers has jurisdiction over the wetlands if affected by development actions and may or may not allow the filling of these wetlands. If it were to occur, the filling of the wetlands would be an ecological impact in itself but would essentially break the exposure pathways of concern for ecological receptors.

8.3 Remedial Action Objectives

The baseline risk assessment provides the basis for EPA's decision that actual or threatened releases of hazardous substances at the Site may present an imminent and substantial endangerment to public health, welfare, or the environment. Specifically, unacceptable risks were identified for the following exposed populations via **the ingestion of arsenic and lead in dust and soil and the ingestion of arsenic in ground water:**

Current and Future NCI Workers
Current CI Workers
Current and Future Residents

EPA has determined that remedial action is warranted at this Site. Remedial Action Objectives (RAOs) were developed by EPA for the exposure pathways and contaminants of concern associated with unacceptable risks under the current and reasonably anticipated future land use. These RAOs are presented in this section.

8.3.1 Overarching RAO

Development of the on-facility portion of the Site is a key assumption on which this remedy decision is based. Integration of development and Site remediation is a goal of EPA's Brownfields program. EPA's Brownfields Initiative is an organized commitment to help communities revitalize properties where expansion or redevelopment is complicated by real or perceived environmental contamination, to mitigate potential health risks, and to restore economic vitality. Based on consideration of Brownfields goals, the key overarching RAO is:

> Develop a comprehensive remedy that protects human health and the environment, is consistent with the current and reasonably anticipated future land use, and removes obstacles to Site development associated with real or perceived environmental contamination.

EPA developed media-specific RAOs using the basic assumption that the reasonably anticipated future land use will be commercial/light industrial use of the on-facility area and residential use of the off-facility areas where homes are currently located. EPA based this assumption on the information gathered during the Site Characterization and subsequent Murray Smelter Working Group sessions all of which is summarized in Section 3.1. This information supports EPA's conclusion that the current industrial and residential use of the on-facility property will end in the very near future.

8.3.2 Chemical Specific Applicable or Relevant and Appropriate Requirements (ARARs)

In accordance with the National Contingency Plan (NCP), remediation levels are a subset of the RAOs and consist of medium-specific chemical concentrations that are protective of human health and the environment. These remediation levels are based on risk assessment or ARARs. Table 16 presents the chemical specific ARARs for the Site which are incorporated into the RAOs as remediation levels to address specific contaminants and exposure pathways. Appendix B presents the derivation of the risk based remediation levels for soil which are also incorporated into the RAOs. Appendix C presents the technical support for EPA's selection of the remediation level for arsenic in shallow ground water.

8.3.3 On-Facility Soils/Smelter Materials

RAOs: Prevent unacceptable risks to current and future workers or to ecological receptors due to the ingestion of soil/smelter materials containing arsenic or lead.

Reduce the uncertainties in the predicted risks to ecological receptors

Remediation Levels:

The remediation levels for soils/smelter materials are risk-based.

For workers, prevent exposure to soils/smelter materials containing levels of arsenic or lead which would pose a potential excess cancer risk greater than 1E-4; a potential chronic health risk defined by a hazard quotient of one; or result in a greater than 5% chance that the fetus of a pregnant worker would have a blood lead level greater than 10 micrograms per deciliter (µg/dL). Based on the findings of the Baseline Human Health Risk Assessment and a reasonably anticipated future land use that is commercial/light industrial, these levels correspond to:

Surface soils shall not exceed 1,200 milligrams per kilogram (mg/kg) arsenic as the 95% upper confidence limit on the arithmetic mean within any given exposure unit.

Surface soils shall not exceed 5,600 mg/kg lead as the arithmetic mean within any given exposure unit.

8.3.4 On-Facility Groundwater

RAOs: Minimize future transport of arsenic from source materials to the shallow aquifer.

Prevent exposure of human and ecological receptors to ground water with arsenic concentrations that represent an unacceptable risk.

Prevent unacceptable increases in the arsenic concentrations of the intermediate aquifer resulting from arsenic migration from the shallow aquifer.

Remediation levels:

The remediation levels for ground water are based on ground water ARARs.

Meet the MCL (0.05 milligrams per Liter (mg/L)) for dissolved arsenic in shallow groundwater at the east and west Site boundaries.

Meet the MCL (0.05 mg/L) for dissolved arsenic in the intermediate aquifer.

Meet the Alternate Concentration Limit (ACL) of 5.0 mg/L for dissolved arsenic within the unconfined shallow aquifer within the Site boundaries. The compliance points for the ACL in shallow ground water are in the vicinity of ground water discharge locations south of Little Cottonwood Creek.

8.3.5 Little Cottonwood Creek Surface Water

RAOs: Protect Little Cottonwood Creek water quality by preventing unacceptable increases of arsenic concentrations in surface water resulting from ground water discharges or surface water run-off from the Site.

Remediation Levels:

The remediation levels for surface water are based on surface water ARARs.

Meet the Utah Standards of Quality for Waters of the State for trivalent arsenic of 190 micrograms per liter (ug/L) as a 4 day average and 360 ug/L as a 1 hour average in Little Cottonwood Creek.

Meet the Utah Standard of Quality for Waters of the State for dissolved arsenic of 100 ug/L in Little Cottonwood Creek.

8.3.6 Off-Facility Soils

RAOs: Prevent unacceptable risks to current and future residents due to the ingestion of soil containing lead.

Prevent unacceptable risks to current and future NCI workers due to the ingestion of soil containing lead.

Remediation Levels:

The remediation levels for off-facility soils are risk based.

The concentration of lead in surface soils within residential areas of the Site shall not exceed 1200 mg/kg as an arithmetic mean within any given residential yard. EPA developed a range of 630 mg/kg-1260 mg/kg for the remediation level for soils in residential areas. Appendix B provides the details of the development of this range. The April 23, 1997 risk management strategy prepared by EPA provides the rationale for EPA's selection of 1200 mg/kg as the appropriate remediation level for the residential areas of this Site. The specific factors considered in making this determination for each property were the current land use, the reasonably anticipated land use, the likelihood of exposure to soil (measured qualitatively by ground cover), and empirical evidence of exposure to lead.

The concentration of lead in surface soils within commercial areas of the Site shall not exceed 5600 mg/kg as an arithmetic mean within any given commercial property.

8.3.7 On-Facility Ecological Study Areas

RAO: Reduce uncertainties in predicted risks to ecological receptors.

9.0 COMPARATIVE ANALYSIS

This section presents a summary of the comparative analysis of the remedial alternatives developed for the Site to achieve the RAOs. This two-stage analysis reviews the remedial alternatives in relation to the threshold criteria and primary balancing criteria specified in the National Contingency Plan (NCP). Modifying criteria are then discussed in Section 9.2. The findings of the comparative analysis are summarized in Section 9.3, including selection of a comprehensive remedy for the entire Site.

9.1 Identification of Alternatives

A range of comprehensive remedial alternatives was developed to address human health risks and environmental protection for the Site. For the purpose of organizing the various Site materials and their associated environmental effects, smelter materials present in the on-facility area of the Site were put into one of four categories based on information from the Site Characterization Report and the Baseline Risk Assessment :

Category I and II:	Category I and II materials are the sources of arsenic concentrations in ground water above the ACL. Both relatively high arsenic concentrations and large material volumes are necessary for material to be a potential threat to ground water and be classified as Category I or II. Alternatives were developed for Category I and II ground water source material to achieve the RAO of minimizing future transport of arsenic from source materials to the shallow ground water. Alternatives for Category I and II material must achieve the remediation levels established for ground water.
Category I:	Category I materials are distinct in that they are considered by EPA to be principal threat wastes characterized as large volumes of material containing relatively undiluted arsenic trioxide. There is an estimated quantity of 2000 cubic yards of Category I material within the on-facility area. The identification of Category I materials considers : A. Associated with distinctly elevated arsenic concentrations in underlying shallow ground water (greater than or equal to 15 mg/L); B. High arsenic concentrations compared to other categories of materials on Site; C. Visual characteristics (e.g., color, particle size) which indicate arsenic trioxide;

D. Direct contact risks which are considered to be a principal threat if this material were ever brought to the surface at the Site; and

E. Located where former smelter structures which processed or stored arsenic trioxide were historically located. Category I materials are located in the areas of the arsenic kitchens, the western compartment of the baghouse, and the arsenic storage bin(s). The exact limits of Category I material will be defined in remedial design considering the results of sampling material deeper or adjacent to this material.

Category II: Low level threat ground water source material characterized as large volumes of diluted arsenic trioxide or flue dust often mixed with soil, new fill, or debris from former smelter flues. These materials have lower arsenic concentrations than Category I materials and are potentially a significant source of ground water contamination. There is an estimated quantity of 68,000 cubic yards of Category II material within the on-facility area. The identification of Category II materials considers:

A. Located near or within the footprint of former smelter structures such as the concrete flues, the roasting plant, the baghouse, storage areas, transport areas, and the blast furnace area. The exact limits of Category II material will be defined in remedial design considering the results of sampling material deeper or adjacent to this material;

B. Visual characteristics (e.g., color, particle size) which indicate flue dust or diluted arsenic trioxide; and

C. Potential current or future threat to ground water quality. Category II material is associated with arsenic in shallow ground water above the ACL.

Category III: Category III materials are surface soils which are predicted to pose an unacceptable risk to NCI workers within the on-facility area. Alternatives for Category III materials must achieve the remediation levels for on-facility soils/smelter materials. Material in this category will not pose a threat to ground water. The identification of Category III materials considers:

A. Located within on-facility EUs identified as causing unacceptable health risks to NCI workers (EU-3 and EU-4);

B. Lead concentrations greater than 5600 mg/kg as the arithmetic mean within the EU; and

C. Arsenic concentrations greater than 1200 mg/kg as the 95% upper confidence limit on the arithmetic mean within the EU.

Category IV: Slag

Remedial alternatives were developed to address all four categories of smelter materials. The key components of each alternative considered in the comparative analysis are summarized below.

Alternative 1 - No Action

- The Murray Smelter Site would be left in its current condition.

Alternative 2 - Excavation & Onsite Consolidation/Barrier Placement/Monitored Natural Attenuation/Institutional Controls/Removal and Disposal of Off- Facility Soils

- Source control via excavation of Category I and II materials and consolidation in separate repositories in the on-facility area.

- Monitored natural attenuation of shallow ground water within and down gradient of source areas to achieve the ACL. The mechanism of attenuation of arsenic in shallow ground water is adsorption to the iron oxides in the subsurface soil.

- Surface water monitoring in Little Cottonwood Creek and monitoring of the on-Site ecological study area. Monitoring of wetlands will include surface water, sediment and benthic macro invertebrates. Monitoring of terrestrial areas will include plants and soil.

- Institutional controls in the form of a Murray City ordinance establishing an "overlay district" which includes zoning to prevent residential and contact intensive industrial uses within the former smelter operational areas, prohibitions on the development or use of any ground water wells within Site boundaries except for EPA approved monitoring wells, maintenance of the barriers, and controls on excavated subsurface material within the former smelter operational areas. Other institutional controls include restrictive easements that run with the land which contain the same land use and ground water well construction restrictions.

- Covering of Category III materials in place with barriers sufficient to prevent direct contact. Such barriers may be pavement, landscaping, soil caps, or sidewalks.

- Soil removal/replacement with clean soil, or other fill in off-facility residential or commercial properties with lead concentrations in soils that may represent an unacceptable risk . Excavated soil will be used in the on-facility area of the Site as subgrade material during development or road construction.

Alternative 3 - **Excavation/Onsite Consolidation& Offsite Disposal/Monitored Natural Attenuation/Barrier Placement/Institutional Controls/Removal and Disposal of Off-Facility Soils**

- The same actions as Alternative 2, except Category I materials are excavated and disposed offsite.

Alternative 4 - **Excavation/Onsite Consolidation& Offsite Disposal/Barrier Placement/Institutional Controls/Ground Water Extraction/Removal and Disposal of Off-Facility Soils**

- All Alternative 3 components.

- Ground water extraction in areas of highest arsenic concentrations, treatment of extracted ground water, and discharge to the sanitary sewer system.

Alternative 5 - **Excavation/Onsite Consolidation& Offsite Disposal/Barrier Placement/Institutional Controls/In-Situ Ground Water Treatment/Removal and Disposal of Off -Facility Soils**

- All Alternative 3 components.

- Option A - Constructed wetlands to treat shallow ground water prior to discharge to Little Cottonwood Creek.

- Option B - Permeable barrier treatment wall to treat shallow ground water prior to discharge to Little Cottonwood Creek.

Alternative 6 - **Excavation/Onsite Consolidation & Off Site Disposal/Monitored Natural Attenuation/Barrier Placement/Institutional Controls/Off- Facility Community Health Education, Monitoring and Intervention**

- All Alternative 3 components for the on-facility area.

- Community health education and monitoring for residents and workers in off-facility areas of concern. This alternative also includes intervention actions such as surface control, barrier placement or soil removal, if the potential for unacceptable risk is indicated by the monitoring program.

Alternative 7 - Excavation/Onsite Consolidation & Offsite Disposal/Monitored Natural Attenuation/Barrier Placement/Institutional Controls/Soil Tilling in Off-facility Areas

- All Alternative 3 components for the on-facility area
- Deep tilling in off-facility residential or commercial properties with lead concentrations in soils that may represent an unacceptable risk. Institutional controls to protect the integrity of soil barriers and to place requirements on the handling and disposal of any excavated material from beneath the tilled zone if the concentrations in this material are above a level of concern.

9.1.1 Threshold Criteria Analysis

9.1.1.1 Overall Protection of Human Health and the Environment

As demonstrated in the Baseline Risk Assessment, Alternative 1, No Action does not meet the threshold criteria of overall protection of human health and the environment except that no action is appropriate for slag since no unacceptable risks associated with exposure to slag were identified by EPA in the Baseline Risk Assessment. With the exception of Alternative 1, all alternatives considered in the comparative analysis meet the requirements of the RAOs and provide overall protection of human health and the environment. Differences in overall protection are related to the level of certainty with regard to actions for Category I materials and relative effectiveness of actions on ground water and the off-facility soils. There are also differences with respect to the key overarching RAO requiring that remedial actions be consistent with the current and proposed land use.

Source control via excavation and consolidation of Category I and II materials in separate repositories (Alternative 2) would prevent future infiltration of surface water, thus protecting ground water from further impact due to transport of arsenic from this source material. Excavation/onsite consolidation is an effective method of source control at this Site primarily due to the ease in locating the source material. The material is generally within the locations of historical smelter structures. For example, the results of sampling subsurface soils to a depth of 5 feet in the vicinity of the baghouse show that excavation of the upper 2 feet of material from within the footprint of the former baghouse would remove approximately 97 percent of the arsenic present in this source area. (This calculation was done by dividing the mass of arsenic in 2 feet by the total mass of arsenic measured in 5 feet of subsurface soil at the location of the highest arsenic levels.)

Barrier placement over Category III materials is a component of all alternatives except Alternative 1 and would be effective in preventing direct exposure as long as barriers are maintained. The institutional controls which include public and private land use restrictions and a ban on construction of ground water wells (with the exception of EPA approved monitoring wells) within the on-facility area will prevent Site uses which could result in unacceptable risks due to residential or contact intensive use or ground water ingestion. In the off-facility area, soils containing lead exceeding remediation levels would be excavated to at least 18 inches and the excavated soil brought onto the on-facility area for incorporation into remedial actions or development. The off-facility excavated areas would be replaced with soil or other clean fill. Removal of soil with lead concentrations above remediation levels provides protection of human health and the environment by breaking the exposure pathway of direct contact with contaminated source material.

The source control action for Category I materials in Alternatives 3, 4, and 5 is off-site disposal. Although both on-site disposal (Alternative 2) and off-site disposal (Alternatives 3, 4, and 5) actions provide essentially the same level of overall protection, removal of Category I materials from the Site would eliminate completely any long-term concerns regarding the potential for direct exposure (the levels of arsenic in Category I materials may cause acute health effects) and the potential for the materials to act as sources of arsenic to ground water in the future (arsenic in Category I materials is predominantly the soluble oxide and sulfate forms) in the event that the repository was damaged resulting in a release of these materials into the environment. Although not likely to occur, the possibility of its occurrence illustrates the difference between the two alternatives.

Alternative 4 contains the same components as Alternative 3 and adds a ground water extraction system. Site specific hydrologic and chemical factors limit arsenic transport rates to the extraction wells and thus limit the rate at which arsenic may be removed from the aquifer. Long term pumping rates are limited by the flux or supply of ground water introduced to the aquifer. Section 4 of Appendix A of the Feasibility Study contains a conceptual design for a ground water extraction system and approximate time frames are predicted for arsenic extraction rates. The analysis demonstrates that the flux of water through targeted portions of the aquifer will not change as a result of installing a pumping system. Therefore, addition of an extraction system within the source areas will not accelerate the rates of decline in arsenic concentrations in ground water relative to the rates achieved through source control and natural attenuation. The time frame required to meet remediation levels in ground water within the source areas is predicted to be between 100 -125 years with the installation of a ground water extraction system. Monitored natural attenuation is predicted to require approximately 100-150 years to achieve remediation levels throughout the Site . For both source control with monitored natural attenuation and source control with ground water extraction, the same set of site specific factors limits the rate at which arsenic concentrations will decline. In addition, operation of an extraction system may not be compatible with the desired future land use, because of the large area and numerous wells necessary.

Alternative 5 contains the same components of Alternative 3 and adds in-situ treatment of shallow ground water (either by constructed wetlands or by a permeable barrier treatment wall) near Little Cottonwood Creek. Currently ground water discharges to Little Cottonwood Creek. However, the principal areas of elevated arsenic concentrations in ground water are distant from the creek and are not predicted to intercept the creek for over 100 years. Due to source control and attenuation within the aquifer, arsenic concentrations are expected to be significantly lower by the time arsenic from these areas intercepts the creek. The types of treatment systems included in Alternative 5 are not expected to be effective for periods greater than 10 years without extensive routine maintenance. Implementation of either treatment option will have limited short-term effectiveness due to the diffuse source areas which may include ground water from both sides of the creek and surface water runoff and complex ground water flow patterns near the creek and may provide no benefit for long-term effectiveness in reducing arsenic transport to Little Cottonwood Creek. Therefore, implementation of in-situ ground water treatment systems is not expected to provide additional performance over the source control and monitoring actions included in Alternative 3.

Alternatives 6 and 7 include two different options for addressing the off-facility soils containing unacceptable concentrations of lead. Alternative 6 includes community education to inform residents on methods to prevent unacceptable exposures and a voluntary blood-lead monitoring program. If the monitoring program indicates the potential for unacceptable risk, intervention actions would be implemented. These actions would be designed on a case-by-case basis and could include surface control such as vegetation of bare areas, barrier placement or soil removals. This alternative is expected to be protective of human health if participation in the program is sufficiently high. Alternative 7, soil tilling, is also expected to be protective of human health and the environment. In the majority of off-facility areas of concern, lead concentrations are elevated at the surface. The source of this lead is likely due to deposition of emissions from the smelter during its period of operation. In these cases, deep tilling will reduce lead concentrations to below levels of concern. Site characterization data indicate that at some locations lead concentrations are above a level of concern over the entire tilling zone, possibly due to the placement of slag. In these areas, lead concentrations in surface soils would not be reduced below a level of concern by tilling and community health education and monitoring would be implemented to provide long term protection.

9.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

9.1.2.1 Ground Water ARARs

Chemical specific ARARs are identified in Table 16. Section 121 (d)(2)(B)(ii) of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) allows EPA to establish alternate concentration limits (ACLs) to those otherwise applicable under the following conditions stated in 55 Federal Register 8732:

> The ground water must have a known or projected point of entry to surface water with no statistically significant increase in contaminant concentration in the surface water from ground water at the point of entry, or at any point where there is reason to believe accumulation of constituents may occur downstream. In addition, the remedial action must include enforceable measures that will preclude human exposure to the contaminated

ground water at any point between the facility boundary and all known and projected points of entry of such ground water into surface water.

Quarterly monitoring of surface water and ground water at the Site has demonstrated that ground water from the shallow aquifer discharges to Little Cottonwood Creek at locations along the northern Site boundary. The contaminant of concern in ground water is arsenic. Information collected since April, 1997 and documented in quarterly monitoring reports indicates the primary source of arsenic to Little Cottonwood Creek exists at a point discharge at the eastern facility boundary. Loading calculations indicate that 88%-100% of the arsenic loading to Little Cottonwood Creek is due to this point discharge, not to the ground water discharge from the Site. EPA has determined that the conditions at Murray Smelter satisfy the requirements of CERCLA 122 (d)(2)(B)(ii) which allow the establishment of an ACL for groundwater. EPA has established 5.0 mg/L as the ACL for dissolved arsenic in ground water. Appendix C provides a summary of the calculations used by EPA to determine a range of acceptable ACLs. In making its determination, EPA considered the zone of potential shallow ground water discharge from the Site and conservatively assumed all discharge is from the Site or south side of the creek. EPA also based its determination on low flow conditions in Little Cottonwood Creek and Site specific hydraulic conductivity and hydraulic gradient measurements. The ACL of 5.0 mg/L for dissolved arsenic is a ground water concentration which will assure that Little Cottonwood Creek is protected at its beneficial use, agricultural use, given the discharge of shallow ground water to the creek.

In accordance with the NCP, the situation at Murray Smelter fulfills the CERCLA statutory criteria for ACLs, including the analysis in the Feasibility Study which demonstrates that active restoration of the groundwater to MCLs is not practicable. The existing documentation of these conditions precludes the need for an ARAR waiver. The remediation level for dissolved arsenic in shallow ground water within the Site boundaries is the ACL of 5.0 mg/L. Achieving this level will constitute compliance with the groundwater ARARs. The MCL is currently met at the on-facility area boundaries (the north boundary is north of the ground water-surface water mixing zone north of Little Cottonwood Creek).

Source control actions contained in Alternatives 2 through 5 are expected to minimize transport of arsenic from smelter materials and result in improvement of ground water quality such that the ACL will be met within the entire on-facility area in a time frame of 100-150 years. This approach is reasonable given the unlikelihood that the shallow aquifer will ever be in demand as a drinking water source. Improvement in ground water quality would also reduce arsenic discharge to the creek. The additional action of ground water extraction contained in Alternative 4 would not result in a significant decrease in the time required to meet the ACL or a reduction in arsenic loading to the creek. Time frames for achieving the ACL in Alternative 4 are estimated to be 100 - 125 years. There are fundamental technical limitations for the effective performance of an extraction system related to the low aquifer yield and high partitioning of arsenic to aquifer solids. The additional action of an in-situ treatment contained in Alternative 5 would not contribute to reduction of current arsenic concentrations in the shallow aquifer and would have a minimal effect on near- and long-term loading of arsenic to Little Cottonwood Creek. The areas of highest arsenic concentration are currently distant from the creek and are not predicted to intercept the creek for at least 100 years. Attenuation by adsorption is expected to significantly reduce the arsenic concentrations from these areas by the time they reach the creek.

The ACL is currently achieved at monitoring well MW-112, the well location closest to compliance points near Little Cottonwood Creek which will be established as part of the remedy. Within 30-40 years, the effects of the source control actions of Alternative 3 along with the monitoring activities are expected to demonstrate that the rate of natural attenuation of arsenic in shallow ground water is sufficient to predict that the ACL will never be exceeded at the established compliance points. EPA expects the remaining areas of the shallow aquifer to achieve the ACL within a time frame of 100-150 years.

Although not identified as a contaminant of concern, selenium has been detected in the shallow ground water within the Site boundaries at levels exceeding the MCL of 0.05 mg/L. These detections are at 8 well locations within the on-facility area. However, the MCL for selenium has consistently been met at well locations just south of Little Cottonwood Creek and the east and west on-facility boundaries (well locations MW-112, MW-109, MW-102, and MW-104 on Figure 6). The preamble to the NCP states at 55 Federal Register 8753 :

> "...there may be certain circumstances where a plume of ground water contamination is caused by releases from several distinct sources that are in close geographical proximity."

In cases such as these, the NCP preamble suggests that

> "...the most feasible and effective ground water clean up strategy may be to address the problem as a whole, rather than source by source, and to draw the point of compliance to encompass the sources of release."

EPA considered this discussion, the proximity of the sources of arsenic and selenium (both within the former smelter operational area), as well as the reliability of the restrictions on ground water use within the Site boundaries in establishing the points of compliance for the selenium MCL at the well locations just south of Little Cottonwood Creek. The ground water ARAR for selenium is currently met at the points of compliance. Selenium will be included as part of the ground water monitoring component of the remedy.

9.1.2.2 **Surface Water ARARs**

State of Utah Water Quality Standards are identified as applicable in Table 16. The data gathered during the site characterization effort and subsequent sampling events indicate that Utah's aquatic life standard for arsenic (0.19 mg/L arsenic as As [III]) is consistently being met, but that the arsenic standard for agricultural use (dissolved arsenic of 0.1 mg/L) is not being met during low-flow conditions within the on-facility boundaries. The standards for both uses were met at location SW-6, in Little Cottonwood Creek downstream of the Site during the site characterization sampling events.

The source control actions will address the Murray Smelter-related source of the arsenic in the point discharge from the culvert along State Street which discharges to Little Cottonwood Creek. This source has been located near the storm drain along State Street near the Doc and Dell's trailer court. The control of this discharge and the natural attenuation of shallow ground water to the level of the ACL is expected to result in compliance with the surface water ARARs in Little Cottonwood Creek within a period of 3 years. The improvement of ground water quality as a result of source control, natural attenuation and surface water management will protect Little Cottonwood Creek in the future.

Little Cottonwood Creek does not currently meet the beneficial use for agriculture due to high levels of TDS from urban runoff and high phosphorus. Neither TDS nor phosphorus are related to the Site. An investigation of the actual use of Little Cottonwood Creek was conducted in April, 1997. Two diversions of surface water were observed up gradient of the Site, neither of which was for agricultural use purposes. No diversions were observed down gradient of the Site. This information suggests that the current uses of Little Cottonwood Creek are not consistent with the beneficial use. EPA believes that a 3 year period for achieving the agricultural use standard for dissolved arsenic in Little Cottonwood Creek is reasonable in this case.

9.1.2.3 Action- and Location- Specific ARARs

Tables 17 and 18 present the action specific and location specific ARARs for the Site. All alternatives will meet these ARARs. On-facility alternatives which include consolidation of source materials within the Site boundaries do not trigger the land disposal restrictions, therefore these requirements are not applicable. The Site boundaries are considered by EPA to be an "Area of Contamination" as defined in the NCP. Movement of waste within an Area of Contamination does not constitute placement.

9.1.3 Primary Balancing Criteria

9.1.3.1 Short-Term Effectiveness

As discussed above, all alternatives with the exception of Alternative 1, No Action, meet the requirements of the RAOs and provide overall protection of human health and the environment. There are no substantial differences between alternatives 2,3,4,and 5 in terms of short-term effectiveness. Each alternative entails excavation and handling of Category I and II materials. However, dust control measures are easy to implement and the potential for risks to the community or workers will be minimized. Short-term risks from the presence of heavy construction equipment on the Site would be similar with respect to each alternative as well as to the potential risks posed by current industrial uses. Response objectives would be met at the same time for all alternatives once excavated materials are disposed and barriers installed.

Alternative 6 contains community health education and monitoring for the off-facility area. This alternative provides a high level of short term effectiveness. Although there are potential uncertainties associated with the willingness of residents to participate, the high level of involvement by Murray City and the high level of community awareness concerning the Site suggest that the program will be effective in the short term. Alternative 7, tilling in the off-facility areas, may not be as effective as soil removal in breaking the exposure pathway due to the presence of lead below the tilling zone.

9.1.3.2 Long-Term Effectiveness and Permanence

A primary consideration in the evaluation of long-term effectiveness is that a major portion of the on-facility area is expected to be redeveloped in the near future. The expected land use of office/light commercial will reduce the potential for unacceptable risks ("contact intensive" activities would end), and integration of remedial actions with redevelopment, the key overarching RAO, would allow for optimizing the management of smelter materials remaining at the Site such that confidence would be increased that the remedy and subsequent institutional controls/monitoring will be effective over the long term.

Alternatives 2 and 3 differ in terms of actions on Category I materials. Under Alternative 2, Category I materials would be excavated and consolidated in a repository in the on-facility area. Under Alternative 3, Category I materials would be excavated and disposed of off-site. Given the current and reasonably anticipated future land use and the opportunity to install a repository in a suitable location under the control of Murray City, both actions would provide long-term protection of human health and the environment. Removal of Category I materials from the Site would completely eliminate any future concerns regarding the potential for direct exposure or contact of Category I materials with infiltrating ground water and therefore provide a higher level of performance in terms of long-term effectiveness. For Category II materials, consolidation into a repository would provide long term protection of human health and the environment. Category II materials may be low-level sources of arsenic to ground water under ambient infiltration conditions. Minimizing the potential for infiltration of surface water through these materials by consolidation beneath a low-permeability barrier with surface control is expected to be effective in preventing migration of arsenic to ground water. This same action is included in Alternatives 2, 3, 4 and 5. Control on the use of land and ground water, the second component of the institutional controls, will be effective in preventing direct contact with unacceptably high levels of arsenic and lead in soil and ground water and will prevent the migration of arsenic from the shallow aquifer to the intermediate aquifer. These controls will be implemented through city zoning and restrictive easements which run with the land. Thus they will be effective in the long term and are considered permanent restrictions.

Alternatives 3, 4 and 5 contain the same actions on smelter materials and provide the same basic level of long-term effectiveness. Alternatives 4 and 5 include additional actions to contain the extent of arsenic transport. Alternative 4 contains a ground water extraction system in the areas of highest arsenic concentrations in the shallow ground water. The additional action of ground water extraction would eventually provide for reductions in arsenic concentrations in shallow ground water and would be effective for long-term containment of arsenic already present in the shallow aquifer near the former baghouse and thaw house areas. However, modeling indicates that an extensive ground water extraction system would not substantially reduce the time required to achieve the RAOs for the shallow aquifer and Little Cottonwood Creek. Overall, Alternative 4 provides lower performance than Alternative 3 with respect to long-term effectiveness because it would not provide a significant improvement in environmental conditions relative to Alternative 3 and would entail a high level of operation and maintenance.

Alternative 5 includes in-situ treatment of shallow ground water in the vicinity of Little Cottonwood Creek with the purpose of limiting arsenic transport and discharge to the creek. Groundwater monitoring indicates that the two principal areas of ground water contamination do not currently extend to Little Cottonwood Creek and are not predicted to do so for more than 100 years. Source control actions and natural attenuation of arsenic in the aquifer are expected to significantly reduce the arsenic concentration by this time. The long-term performance of systems such as constructed wetlands and permeable barrier treatment walls to treat arsenic is limited. Effective removal is only expected for a period of approximately 10 years due to the mildly-oxidizing groundwater chemistry. Therefore, if these types of systems were installed in the near future, they would not be effective at the time when arsenic from the principal source areas reaches them.

In the off-facility area, lead concentrations in residential soils range up to 1,800 mg/Kg. The remediation level lead in soil in the off-facility area is 1,200 ppm. Alternative 6, which includes community education to provide information on methods to prevent unacceptable exposure, is expected to provide long-term protection of human health through the education/monitoring components with additional assurance due to the option for intervention measures in the future if the potential for unacceptable exposures is indicated.

For Alternative 7, because lead concentrations are above levels of concern throughout the tilling layer at some locations, tilling may not always be effective in reducing concentrations to below the level of concern. In this case, Alternative 7 would rely on similar community education measures described under Alternative 6. Therefore, Alternatives 6 and 7 essentially provide the same level of long-term effectiveness.

The off-facility component of Alternatives 2,3,4, and 5 would provide a high level of long-term protection because surface soils with lead concentrations above a level of concern would be excavated and replaced with clean soil or other fill. If complete removals are achieved, this action would provide the highest level of long-term effectiveness because all soils of concern would be removed.

9.1.3.3 Reduction of Toxicity, Mobility and Volume Through Treatment

With the exception of the no action alternative, the alternatives considered by EPA do not provide significantly different performances in terms of reduction of toxicity, mobility and volume of arsenic or lead through treatment.

Alternatives 2 and 3 do not contain any treatment components except the possible treatment of Category I material before disposal at an off-site facility. For Alternative 2, a reduction in the mobility of arsenic in subsurface soils would be expected due to the minimization of infiltration through Category I and II materials. For Alternatives 3, 4 and 5 a similar reduction would be expected due to removal of Category I materials and minimization of infiltration through Category II materials.

Alternative 4 contains a treatment component; treatment of extracted ground water to remove arsenic prior to discharge to the sanitary sewer. This treatment component would provide little if any reduction in toxicity, mobility or volume of arsenic at the Site in comparison to Alternatives 2 and 3. However, the ground water extraction system would provide some additional reduction in mobility of arsenic in the shallow aquifer relative to Alternatives 2 and 3 due to physical containment of arsenic related to sources in the former thaw house and baghouse areas. The aquifer characteristics which result in low-flow rates and high arsenic attenuation currently limit the mobility of arsenic and an extraction system would have minimal additional benefit.

The in-situ treatment of shallow ground water in the vicinity of Little Cottonwood Creek contained in Alternative 5 would not provide any reduction in toxicity or volume of arsenic at the Site. It would provide a minor reduction in the mobility of arsenic in shallow ground water near Little Cottonwood Creek. As discussed above, the principal areas of ground water contamination are distant from the creek and arsenic from these areas is not predicted to intercept the creek for over 100 years. At this time, the arsenic concentrations are predicted to be significantly lower due to the high attenuation of arsenic in the aquifer. Passive constructed wetlands or a treatment wall would be expected to operate efficiently for only 10 years without continued routine maintenance and would, therefore, not be effective for the time frame of principal interest.

Overall, therefore there are no substantial differences in performance of the alternatives against this criterion. Alternatives 2, 3 and 5 perform at essentially the same level, whereas Alternative 4 performs at a slightly higher level due to physical containment of arsenic in shallow ground water.

For the off-facility area, lead is immobile in Site soils and lead concentrations in the off-facility area are well below levels which would warrant treatment. Treatment is therefore not applicable to off-facility soils.

9.1.3.4 Implementability

The source control activities contained in Alternatives 2, 3, 4 and 5 are implementable either for current land use or for the expected future land use. Excavation of Category I and II materials would be implementable with some minor disruptions to current industrial activities. Physically suitable repository locations for Category I and II materials are also available for current or future land use. Off-site disposal of Category I materials (a component of Alternatives 3, 4 and 5) would also be readily implementable. In addition, barrier placement over Category III materials would be implementable with minor disruption to current industrial/commercial activities, or could be implemented during redevelopment of the area. Institutional controls to protect barriers are implementable given the high degree of involvement of the current land owners and Murray City.

Alternatives 4 and 5 contain the same source control actions as Alternative 3 with the addition of two types of remedial action alternatives on ground water. The extraction system contained in Alternative 4 would be difficult to implement due to the low yield of the aquifer and high partitioning of arsenic to the aquifer solids. A large number of wells would be necessary, each pumping at a low rate over an extended period of time. Operation and maintenance of this type of system, including a treatment plant would be difficult and would not be compatible with future land use. Alternative 4 therefore has a lower performance than Alternatives 2 and 3 in terms of implementability. Either of the options evaluated for in-situ ground water treatment under Alternative 5 (wetlands or treatment wall) would have numerous technical difficulties associated with effective implementation and operation. Considerations include the limited area available (for wetlands), depth and complex flow patterns of ground water in the vicinity of the creek, the presence of the units in the flood plain, and uncertainties associated with the effectiveness of the technologies in removing arsenic. In addition, the technologies would require a high level of long-term maintenance. For the ground water conditions found at the site, effective performance of the types of technologies under consideration is approximately 10 years without on-going maintenance. Replacement of substrate in a wetlands or of ferric sulfate in a treatment wall may be required at approximately 10-year intervals. This action would not be compatible with the future land use and Alternative 5 has a lower performance than Alternative 3 in terms of implementability.

In the off-facility area, community health education and monitoring programs contained in Alternative 6 would be readily implemented because only non-engineering controls are considered. Excavation and soil replacement evaluated under Alternatives 2-5 are also expected to be readily implemented. Residents in the areas of concern have participated in the site characterization study, and there is a high level of awareness concerning the Site in the general community. These types of actions have been performed at several sites around the country. Alternative 7, which requires soil tilling rather than excavation at the same locations, would be more difficult to implement than the other alternatives. This is primarily due to technical difficulties of tilling in small spaces such as residential yards, where structures and plants would make some areas difficult to access.

9.1.3.5 Cost Analysis

Details of the cost analysis are contained in the final Feasibility Study. The costs estimated for the on-facility area are shown in Table 19.

Table 19
Estimated Costs - On-Facility Area (Millions)

Item	Alternative 2	Alternative 3	Alternative 4	Alternative 5a	Alternative 5b
Capital Cost	$8.7	$8.9	$10.8	$10.6	$21.9
Annual O&M	$0.14	$0.14	$0.27	$0.21	$0.23
Present Net Worth	$10.1	$10.3	$14.3	$13.4	$40.2

O&M costs are estimated for 30 years. The extraction component of Alternative 4 and in-situ treatment components of Alternative 5 would require O&M for over 100 years and so would entail substantially higher costs than shown above.

The cost to implement Alternatives 2 and 3 is considered to be low; the costs to implement Alternative 4 and 5a are considered to be moderate; and the cost to implement alternative 5b is considered to be high.

The costs estimated for off-facility alternatives are shown in Table 20.

Table 20
Summary of Estimated Costs for Off-Facility Remedial Alternatives (Millions)

Item	Alternative 6	Alternative 7	Alternative 2-5
Capital Cost	$0.57	$0.64	$1.1
Annual O&M	$0.05	$0.015	$0.013
Present Net Worth	$1.34	$0.93	$1.33

9.2 Modifying Criteria

9.2.1 State Acceptance

The Utah Department of Environmental Quality (UDEQ) was provided the opportunity to review and comment on all documents generated in support of this remedial action decision. UDEQ also participated in all meetings of the Murray Smelter Working Group and the technical task group meetings. In comments on the Proposed Plan, UDEQ indicates agreement that Alternative 3 is the most reasonable choice for the Site. However, UDEQ indicated that this agreement was not based on the length of time or the current levels of contamination. Given the "extremely long" time frames and uncertainty involved in ground water restoration under any alternative, UDEQ has determined that it is technically impracticable within a reasonable time frame to meet ARARs at this Site, and has agreed on that basis and for other reasons given in this ROD (e.g., protection of human health and the environment) that the remedy described in this ROD is appropriate. While EPA characterizes the situation differently, both parties are in agreement about the ultimate approach. UDEQ believes that the long time frame for achieving ground water remediation levels is acceptable only in the context of the technical impracticability of any alternatives.

EPA's responses to UDEQ's comments on the Proposed Plan are provided in the Responsiveness Summary of this ROD.

9.2.2 Community Acceptance

Few comments were received from the community on the Proposed Plan. Based on these comments and EPA's extensive work with the community through the Murray Smelter Working Group sessions, it appears that the community accepts EPA's selected remedy presented in Section 9.4. EPA's responses to verbal and written comments on the proposed plan are provided in the Responsiveness Summary of the ROD.

9.3 SUMMARY

Seven remedial alternatives were evaluated for the Murray Smelter Site. Through an analysis using the nine criteria of the NCP, EPA has selected Alternative 3 as the Site remedy. The remedy consists of the following components:

- Ground water in the shallow aquifer contaminated with arsenic at levels above the ACL of 5.0 mg/L dissolved concentration will be addressed via source control and monitored natural attenuation as follows:

  1. Source control will be implemented by excavation and off site disposal of the principal threat wastes at the Site, an estimated quantity of 2000 cubic yards of Category I material defined in Section 9.1 of this ROD. This material is considered a principal threat due to its high mobility and its demonstrated ability to act as a source of ground water contamination. In addition, direct contact with this material may result in acute human health risks. Off site disposal will be conducted in accordance with EPA's Off Site Rule, 40 CFR 300.440 and the generator requirements identified in Table 17.

  2. Further source control will be implemented by excavation of approximately 68,000 cubic yards of low level threat waste, Category II material defined in Section 9.1 of this ROD. This material will be consolidated within a repository system constructed within the Site boundaries in accordance with the ARARs identified in Table 17. The repository will be designed as the base for a new access road through the Site which was planned by Murray City. The access road is expected to be the catalyst for Site development to commercial/retail uses.

  3. Monitored natural attenuation will address the residual ground water contamination within and down gradient of these source areas. Monitored natural attenuation will continue until shallow ground water achieves the level of the ACL for dissolved arsenic of 5.0 mg/L. The intermediate aquifer will also be monitored to demonstrate continued compliance with the MCL of 0.05 mg/L dissolved arsenic.

  4. The shallow aquifer will be monitored to evaluate the concentrations of selenium at the established compliance points south of Little Cottonwood Creek. The selenium monitoring is not for evaluation of the remedy, it is to ensure continued compliance with the selenium MCL.

  5. Institutional controls in the form of a Murray City ordinance establishing an "overlay district" and restrictive easements that run with the

land which both will prohibit the construction of new wells or use of existing wells within the on-facility area and the western and eastern portions of the off-facility area except for EPA approved monitoring wells.

- Surface soils (0"-2") within the on-facility area contaminated with lead and arsenic exceeding remediation levels of 1200 mg/kg arsenic as the 95% upper confidence limit on the arithmetic mean within an EU or 5600 mg/kg lead as the arithmetic mean within an EU will be addressed as follows:

    1. Soils will be covered in place with barriers sufficient to prevent direct contact. Such barriers may be pavement, landscaping, soil caps, or sidewalks. Site development itself is expected to result in additional protection of human health since land uses associated with unacceptable human health risks will end. Also, development will result in the construction of additional barriers (new buildings, roads, sidewalks parking lots, and landscaping) over remaining surface soil and slag. Although no unacceptable risks associated with exposure to slag were identified by EPA, the development of the Site will ensure no exposure to slag in the future.

    2. Institutional controls in the form of a Murray City ordinance will establish an "overlay district" which includes zoning to prevent residential and contact intensive industrial uses within the former smelter operational areas and will require maintenance of the barriers and controls on excavated subsurface material within this same area. Restrictive easements than run with the land will be established in addition to the overlay district to prevent residential or contact intensive industrial uses.

- Off-facility surface soils (0"-2") containing levels of lead exceeding 1200 mg/kg as the arithmetic mean in individual residential yards or 5600 mg/kg as the arithmetic mean in commercial areas will be removed to a depth of 18 inches and replaced with clean fill. Any landscaping disturbed in this action will be replaced. The removed soil will be used on-facility as subgrade material in construction of the repository system.

- Surface water of Little Cottonwood Creek will be monitored to ensure continued protection during the ground water natural attenuation process at the level of 190 ug/L as a 4 day average for trivalent arsenic and 360 ug/L as a 1 hour average for trivalent arsenic and 100 ug/L for dissolved arsenic.

The established ecological study area will be monitored and the resulting information will be used to reduce the uncertainties identified in the final

Ecological Risk Assessment for the Site. Monitoring of wetlands will include surface water, sediment and benthic macro invertebrates. Monitoring of terrestrial areas will include plants and soil.

The goals of the selected remedy are to protect the intermediate and deep principal aquifer at the level of the MCL for dissolved arsenic, to restore the shallow ground water to the level of the ACL of 5.0 mg/L for dissolved arsenic established to protect Little Cottonwood Creek at its beneficial use, and to remediate surface soils to levels protective of the reasonably anticipated future land use. The remedy incorporates the construction of a new north-south access road through the Site which will encourage future development of the Site and achieve Murray City's goal of more appropriate land use through Site development.

Based on information obtained during the Site investigation and on a careful analysis of all remedial alternatives, EPA believes that the selected remedy will achieve these goals. It may become apparent during the monitored natural attenuation process for ground water that dissolved arsenic levels have ceased to decline and are remaining constant at levels higher than the ACL over some portion of the plume within the shallow aquifer. If it is determined on the basis of system performance data that certain portions of the aquifer cannot be restored to the ACL, EPA will prepare a justification for a waiver of the ground water ARAR based on technical impracticability of achieving further contaminant reduction.

10. Statutory Determinations

Under its legal authorities, EPA's primary responsibility at Superfund sites is to undertake remedial actions that achieve adequate protection of human health and the environment. In addition, section 121 of CERCLA establishes several other statutory requirements and preferences. These specify that when complete, the selected remedial action for this Site must comply with applicable or relevant and appropriate environmental standards established under Federal and State environmental laws unless a statutory waiver is justified. The selected remedy also must be cost-effective and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy meets these statutory requirements.

10.1 Protection of Human Health and the Environment

The Baseline Human Health Risk Assessment identified unacceptable risks over the entire on-facility area associated with potential direct contact with lead- and arsenic-contaminated soil and smelter debris by workers engaged in outdoor industrial activities. The assessment identified substantially less risk (although still unacceptable in limited on-facility areas) associated with exposure to the same materials under a scenario of commercial uses wherein workers would be primarily indoors. The assessment also identified unacceptable risks associated with direct exposure to lead contaminated soil by residents and commercial workers in the off-facility area. Potential ingestion of ground water from the shallow aquifer within the Site boundaries was also predicted to result in unacceptable risk.

There is a large portion of the on-facility area where slag is exposed at the surface. It is not likely that commercial or industrial workers or other adults will spend much time in areas of exposed slag. Therefore, direct contact with slag by workers or residents is likely to be minimal. However, area teenagers have been observed to visit the site in areas where slag is exposed. The Baseline Human Health Risk Assessment characterized risks to teenagers who congregate in areas along Little Cottonwood Creek and are potentially exposed to slag. The assessment concluded that risks associated with exposure to slag are within the range that EPA considers to be acceptable.

The selected remedy employs ground water source control via excavation and off-site disposal of the principal threat at the site, undiluted arsenic trioxide, and will effectively address the identified risk associated with potential migration of this material into shallow ground water and potential future direct contact with this material.

The second component of the selected remedy is ground water source control by excavation and consolidation of ground water source material within an on-Site repository system. The system will be designed with surface water management features. This action will effectively control the infiltration of surface water into arsenic contaminated soil and prevent further migration of arsenic into shallow ground water. The on-Site repository system will be designed to perform as an adequate base for a new access road from Vine Street to 5300 South Street. The repository thus will serve three functions in the protection of human health at the Site:

(1) Reduction of mobility of arsenic to ground water by off-Site disposal of and containment of ground water source material to address risks associated with exposure to contaminated ground water;

(2) Containment of contaminated material which presents unacceptable risks due to direct contact thereby eliminating this exposure pathway; and

(3) Catalyst for development of the Site by providing the base for a roadway which is expected to provide the necessary access to promote commercial uses. The Site development will address the unacceptable risks associated with high contact industrial outdoor activities.

The third component of the selected remedy is a comprehensive public and private institutional controls package which will restrict the use of ground water within the Site boundaries (with the exception of EPA approved monitoring wells) and restrict land uses other than general commercial uses as defined by the Murray City land use code. The institutional controls package will also require that Site features such as roads, parking lots, and landscaping which are functioning as barriers to human exposure be maintained. The institutional controls will provide human health protection into the future. The Site development itself is expected to result in protection of human health through the construction of barriers over remaining low level surface contamination and slag. Although no unacceptable risks associated with exposure to slag were identified, the development of the site will ensure no exposure to slag in the future.

The fourth component of the selected remedy is monitored natural attenuation of ground water down gradient of source areas. Analyses performed during Site Characterization and summarized in the final Site Characterization Report demonstrate that arsenic is being attenuated on the aquifer materials and that iron oxide is the primary mineral phase responsible for the attenuation of arsenic. Through the adsorption mechanism, the unacceptably high levels of arsenic in the shallow aquifer will decrease over time at a rate that depends on the net flux of water moving through the affected portions of the shallow aquifer. The process of adsorption will effectively reduce the dissolved arsenic concentrations in shallow ground water. Performance monitoring will be implemented to evaluate the effectiveness of the attenuation and to ensure protection of human health and the environment. Performance monitoring will include both ground water and surface water monitoring. The effects of the source control actions of Alternative 3 along with the monitoring activities are expected to demonstrate within 30-40 years that the rate of natural attenuation of arsenic in shallow ground water is sufficient to predict that the ACL will never be exceeded at the established compliance points near Little Cottonwood Creek. EPA expects the remaining areas of the shallow aquifer to achieve the ACL within a time frame of 100-150 years.

The last component of the selected remedy is soil removal and replacement with clean fill in off-facility residential or commercial properties with soil lead concentrations that may present an unacceptable health risk. This action will break the exposure pathway of direct contact with soils.

10.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with all applicable or relevant and appropriate chemical requirements presented in Tables 16-18.

10.3 Cost Effectiveness

The selected remedy is cost effective because it has been determined to provide overall effectiveness proportional to its costs, the net present worth value being $11.6 million. The estimated costs of other alternatives are presented in Tables 19 and 20.

The costs of Alternatives 2,3, 6, and 7 are very similar. Comparing Alternatives 2 and 3, the additional effectiveness and protectiveness associated with off-site disposal of principal threat wastes (Alternative 3) was judged to warrant the additional $200,000 cost. The difference between Alternatives 3, 6, and 7 is the option for remediating the off-facility soils. The cost of a community monitoring and health education program is greater than the excavation of contaminated soils and provides an approximately equal level of protectiveness. Alternative 7 includes tilling of soils. This Alternative is less costly than full soil removal but provides slightly less effectiveness in some areas of the Site.

The costs of Alternatives 3, 4, and 5 are quite different reflecting different approaches to ground water remediation. EPA hydrogeologists carefully considered the potential benefits of extracting and treating ground water as described in Alternative 4. The effectiveness of this option is limited by the characteristics of the aquifer which allow very little water to be extracted. The addition of an extraction system will not increase the rate of improvement in ground water quality over natural attenuation processes despite the additional cost. Also considered was the amount of land which would be required for dedication of numerous ground water extraction wells. This land would then be unavailable for Site development. The additional cost of Alternative 4 does not result in effectiveness or benefit for the Site. Alternative 4 also has greater problems with long term implementability, and greater incompatibility with Site development. Alternative 5 includes in-situ ground water treatment in additional to source controls. This alternative requires high operation and maintenance costs without appreciable increase in effectiveness or protectiveness.

Balancing costs with effectiveness, protectiveness, and Site development considerations, Alternative 3 is judged by EPA to be the most cost effective.

10.4 Utilization of Permanent Solutions and Alternative Treatment Technologies (or Resource Recovery Technologies) to the Maximum Extent Practicable

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost effective manner for the Site. Neither extraction and treatment nor in situ treatment of ground water were found to be more effective than natural attenuation at reducing arsenic concentration in ground water. Yet both technologies are more costly. The institutional controls of the selected remedy, while not permanent, will provide the required level of protection during the period of natural attenuation of the ground water. The source control measures will provide a permanent solution by consolidating the material in a engineered repository system preventing contact by water, and people.

Of the alternatives that are protective of human health and the environment and comply with ARARs, EPA believes that the selected remedy provides the best balance in terms of long term effectiveness and permanence; reduction in toxicity, mobility, or volume achieved through treatment; short term effectiveness; implementability; and cost. Overall protection of human health and the environment, long term effectiveness, and cost were the most decisive criteria in selecting Alternative 3 as the remedy.

10.4 Preference for Treatment as a Principal Element

The selected remedy prescribes excavation and off-site disposal for the principal threat waste. On-site treatment as a principal element was found not to be cost effective. However, the principal threat wastes will be treated off-site before disposal. Therefore, the selected remedy satisfies the statutory preference for treatment as a principal element to some degree.

Because the selected remedy will result in hazardous substances remaining on site, a review will be conducted every five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

10.5 Conclusion

EPA's choice of Alternative 3 for remediation of the Site is protective of human health and the environment and is in accordance with CERCLA and the National Contingency Plan.

RECORD OF DECISION
DECLARATION STATEMENT

SITE NAME AND LOCATION

The Murray Smelter proposed National Priorities List Site is located in the city of Murray, Utah in Salt Lake County.

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Murray Smelter Site chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act, as amended by the Superfund Amendments and Reauthorization Act and the National Contingency Plan. This decision is based on the administrative record file for the Site.

The State of Utah does not concur on the selected remedy.

ASSESSMENT OF THE SITE

A period of 77 years of lead smelting operations at this Site (1872-1949) resulted in impacts to the soil, ground water, surface water and sediment. Lead and arsenic have been identified as the contaminants of concern to human health. In addition to lead and arsenic, aluminum, cadmium, copper, mercury, nickel, selenium, silver, thallium, and zinc have been identified as the contaminants of concern to ecological receptors. Risk assessment performed at the Site in 1997 identified elevated risks to ecological receptors as a result of exposure to lead in soils and sediments and selenium in plants. The risk assessment also identified unacceptable risks to humans from ingestion of lead and arsenic in surface soils and the potential ingestion of arsenic in shallow ground water. Although not currently used as a drinking water source, the shallow aquifer at the Murray Smelter site meets EPA's and the State of Utah's criteria for classification as a potential drinking water source, Class IIb. An alternative drinking water source is readily available in the deep principal aquifer and there is no near term future need for the shallow ground water resource. Therefore, EPA believes that a relatively longer time frame for achieving groundwater clean up levels is appropriate at this Site.

Actual or threatened release of hazardous substances from this Site, if not addressed by implementing the response action selected in this Record of Decision, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE REMEDY

The remedial action selected by this ROD is the second of three response actions EPA considers to be necessary at the Murray Smelter Site. EPA expects that an additional time critical removal action will be required to address the potential for release of hazardous substances and resulting health risks associated with the potential structural failure of the two smelter stacks located on the Site.

The remedy selected for the Murray Smelter Site in this ROD consists of the following:

1. **Contaminated ground water**. Source control will be implemented by excavation and off site disposal of the principal threat wastes at the Site, approximately 2000 cubic yards of residual undiluted arsenic trioxide. This material is considered a principal threat due to its high mobility and its demonstrated ability to act as a source of ground water contamination. In addition, direct contact with this material may result in acute human health risks. Further source control will be implemented by excavation of approximately 68,000 cubic yards of low level threat waste, diluted arsenic trioxide or flue dust mixed with soil, fill, or debris from former smelter structures. This material will be consolidated within a repository system constructed within the Site boundaries. The repository will be designed as the base for a new access road through the Site which was planned by Murray City. The access road is expected to be the catalyst for Site development. Monitored natural attenuation will address the residual ground water contamination within and down gradient of these source areas. Institutional controls in the form of a Murray City ordinance establishing an "overlay district" **and** restrictive easements that run with the land both will prohibit the construction of new wells or use of existing wells (except EP approved monitoring wells) within the on-facility area and the western and eastern portions of the off-facility area.

2. **Contaminated surface soils**. On-facility surface soil containing levels of lead and arsenic exceeding remediation levels will be covered. The barriers will provide protection by breaking the exposure pathways associated with long term direct contact with these soils. Site development itself is expected to result in additional protection of human health since land uses associated with unacceptable human health risks will end. Also, the development will result in the construction of additional barriers (new buildings, roads, sidewalks parking lots, and landscaping) over remaining surface soil and slag. Although no unacceptable risks associated with exposure to slag were identified by EPA, the development of the Site will ensure no exposure to slag in the future. Institutional controls in the form of a Murray City ordinance will establish an "overlay district" which includes zoning to prevent residential and contact intensive industrial uses within the former smelter operational areas and will require maintenance of the barriers and controls on excavated subsurface material within this same area. Restrictive easements that run with the land will be established in addition to the overlay district to prevent residential or contact intensive industrial uses.

Off-facility surface soils containing levels of lead exceeding remediation levels will be removed and replaced with clean fill. The removed soil will be used on-facility as subgrade material in construction of the repository system.

3. **Surface water**. Little Cottonwood Creek which forms the northern boundary of the Site and to which shallow ground water discharges will be monitored to ensure continued protection during the ground water natural attenuation process. Additional monitoring of the ecological study area of the Site will be used to reduce the uncertainties identified in EPA's predictions of ecological risk.

The goals of the selected remedy are to restore ground water to the level of the ACL of 5.0 mg/L for dissolved arsenic established to protect Little Cottonwood Creek at its beneficial use and to remediate surface soils to levels protective of the reasonably anticipated future land use. The remedy incorporates the construction of a new north-south access road through the Site which will encourage future development of the Site and achieve Murray City's goal of more appropriate land use through Site development. Based on information obtained during the site investigation and on a careful analysis of all remedial alternatives, EPA believes that the selected remedy will achieve these goals. It may become apparent during the monitored natural attenuation process for ground water that dissolved arsenic levels have ceased to decline and are remaining constant at levels higher than the ACL over some portion of the plume. If it is determined on the basis of system performance data that certain portions of the aquifer cannot be restored to the alternate concentration limit, EPA will prepare a justification for a waiver of the ground water ARAR based on technical impracticability of achieving further contaminant reduction.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action and is cost effective. This remedy utilizes permanent solutions however, the use of alternative treatment technologies was found not to be practicable for this Site. The remedy will achieve significant reduction in the mobility of the Site wastes through containment. The principal threat will be addressed by excavation and off site disposal.

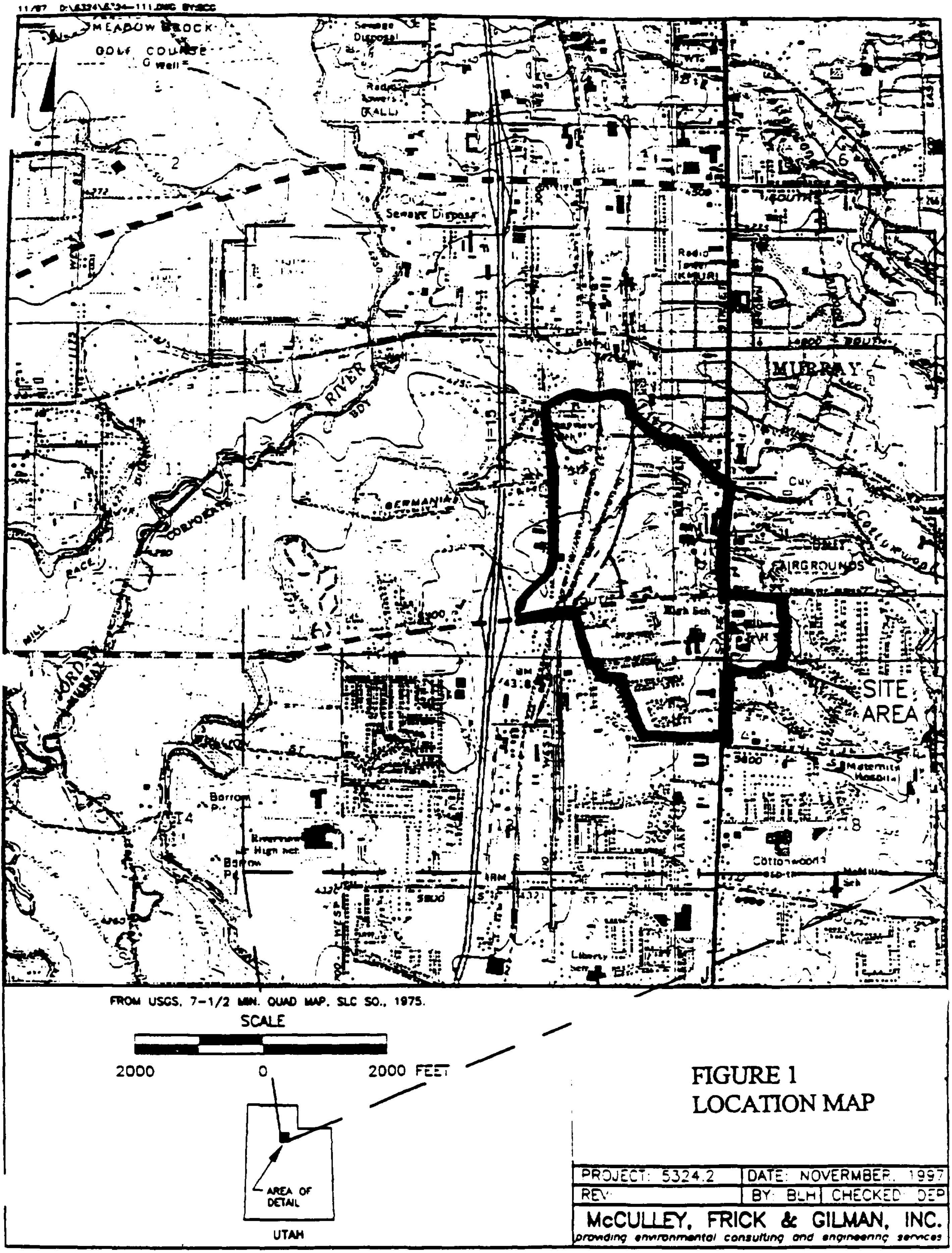
Because this remedy will result in hazardous substances remaining on site above health based levels, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Max H Dodson 4/1/98

Max H. Dodson Date
Assistant Regional Administrator
Office of Ecosystems Protection
And Remediation
U.S. Environmental Protection Agency
Region VIII

FIGURES

11/97 D:\5324\5324-111.DWG BY:BCC



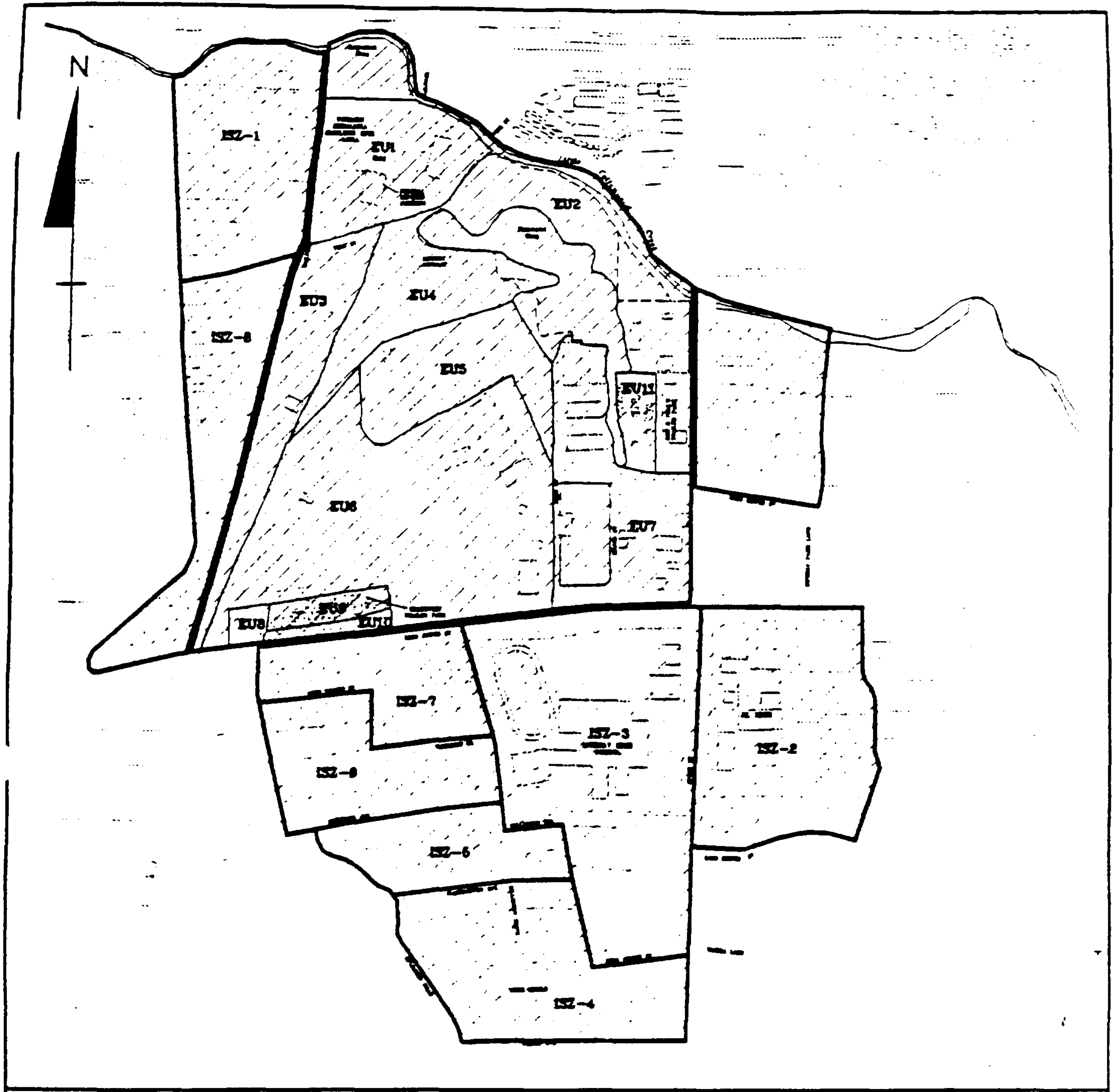
FROM USGS. 7-1/2 MIN. QUAD MAP, SLC SO., 1975.

FIGURE 1
LOCATION MAP

PROJECT: 5324.2	DATE: NOVERMBER, 1997
REV:	BY: BLH CHECKED: DEP

McCULLEY, FRICK & GILMAN, INC.
providing environmental consulting and engineering services

1/98 C:\5324\5324-161.DWG BY:SCC



LEGEND:

▭ ON-FACILITY AREA

▭ OFF-FACILITY AREA

ISZ INITIAL STUDY ZONE

EU Exposure Unit

NOTE:

1. SHADED AREAS ARE INSIDE THE PROPOSED SITE BOUNDARIES FOR GROUNDWATER MONITORING.

SCALE

800 0 800 FEET

FORMER MURRAY SMELTER SITE

FIGURE 2
SITE BOUNDARIES

PROJECT: 5324.2	DATE: JANUARY, 1998
REV.:	BY: KT CHECKED: AK

McCULLEY, FRICK & GILMAN, INC.
providing environmental consulting and engineering services

1/97 S\5324\5324-42.DWG BY SCG

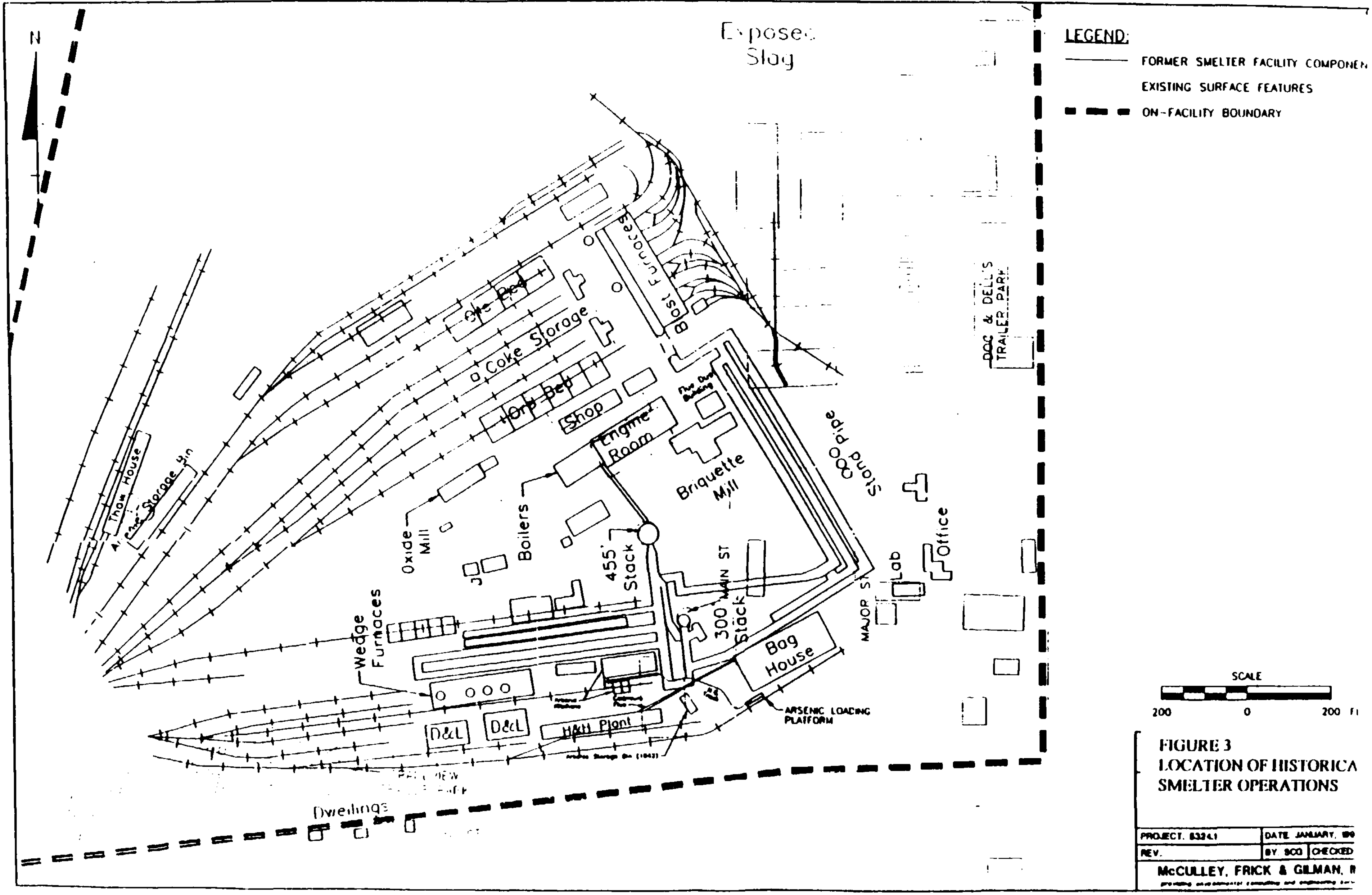
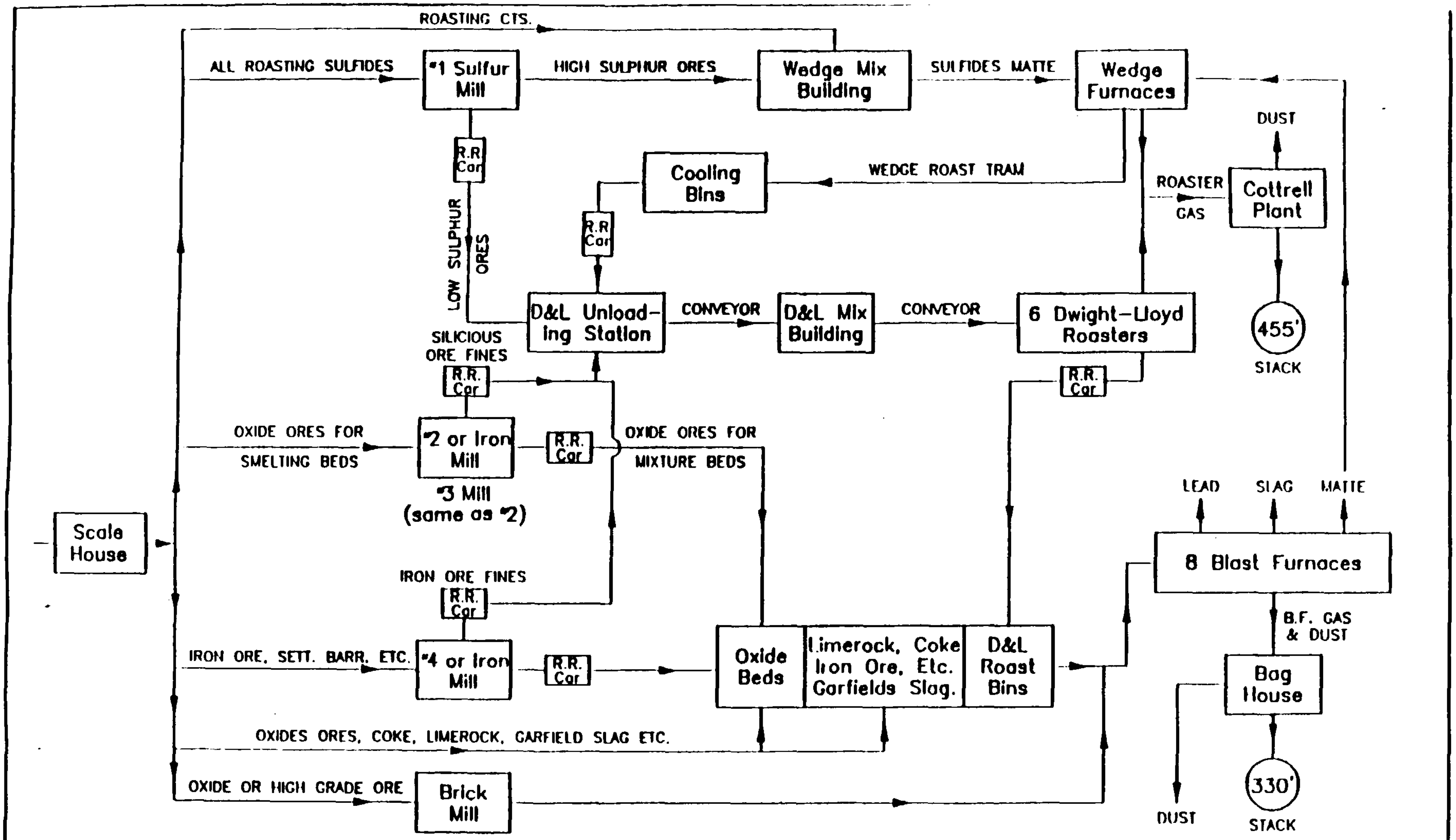


FIGURE 3
LOCATION OF HISTORICA
SMELTER OPERATIONS

PROJECT. 5324.1
DATE JANUARY, 199
REV.
BY SCG
CHECKED

McCULLEY, FRICK & GILMAN, I
providing environmental consulting and engineering serv



SOURCE: SWAIN,1921

FORMER MURRAY SMELTER SITE

FIGURE 4

PROCESS SCHEMATIC FOR MURRAY SMELTER SITE, 1920

PROJECT: 5324.0	DATE: SEPTEMBER, 1998
REV.:	BY: SCG CHECKED: AK

McCULLEY, FRICK & GILMAN, INC.
providing environmental consulting and engineering services

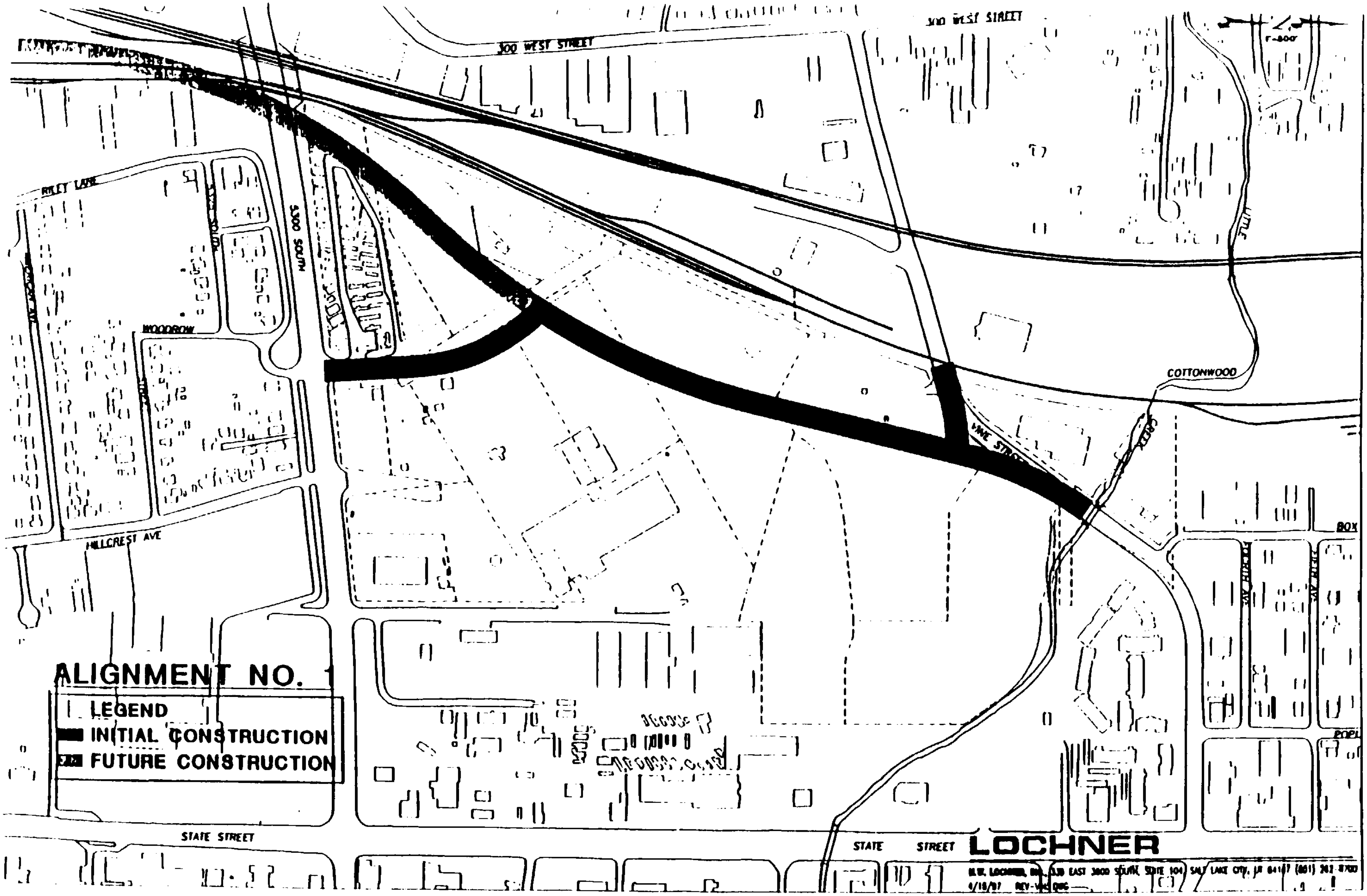
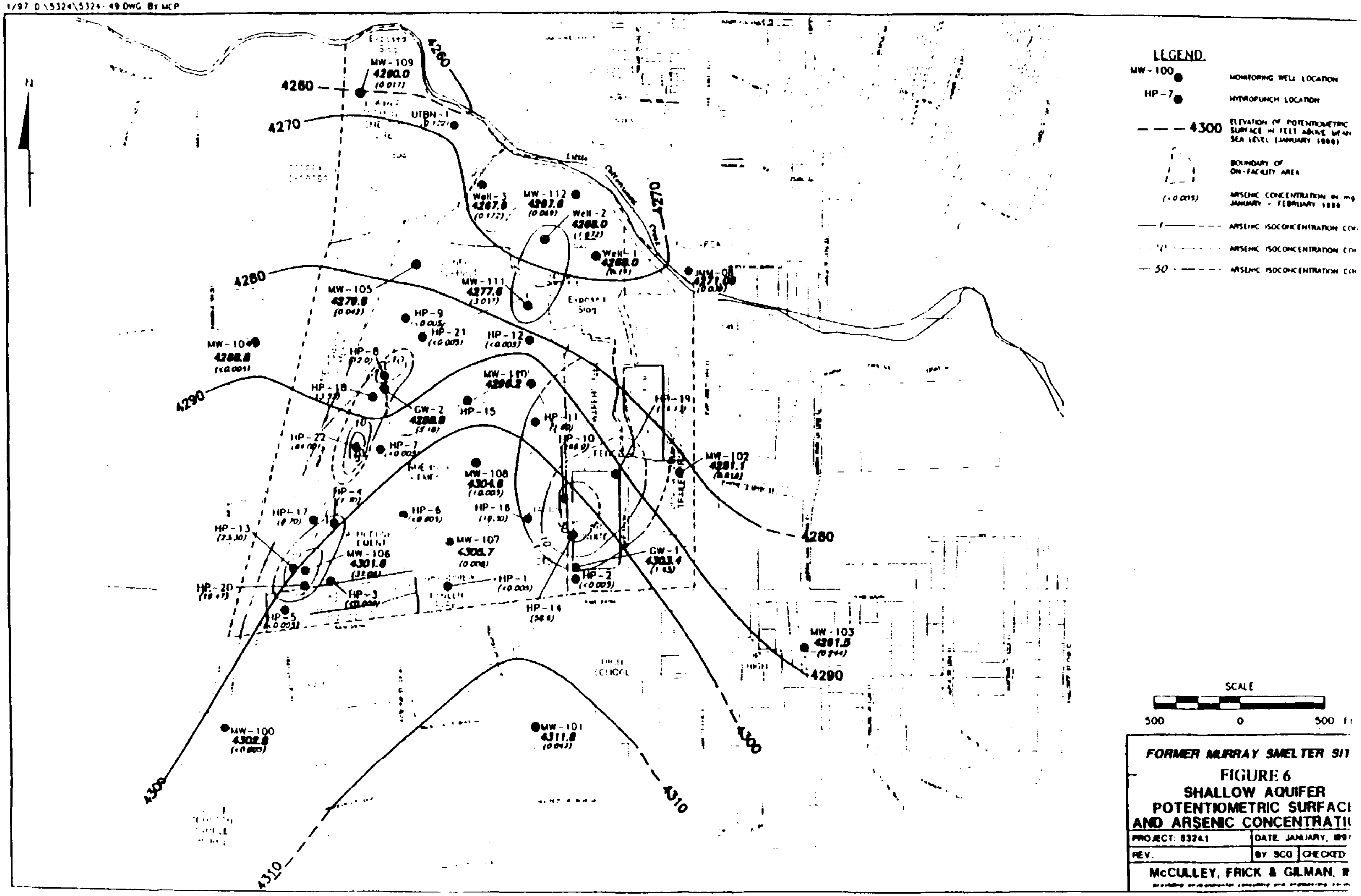

300 WEST STREET
300 WEST STREET
F-800'
LITTLE
COTTONWOOD
CREEK
VINE STREET
BOX
FIFTH AVE
FOURTH AVE
POPL
5300 SOUTH
RILEY LANE
WOODROW
HILLCREST AVE
STATE STREET
STATE STREET
ALIGNMENT NO. 1
LEGEND
INITIAL CONSTRUCTION
FUTURE CONSTRUCTION
LOCHNER
H.W. LOCHNER, INC., 310 EAST 3900 SOUTH, SUITE 104, SALT LAKE CITY, UT 84107 (801) 262-8700
4/18/97 REV-VHS DWG

FIGURE 5

1/97 D:\5324\5324-49.DWG BY MCP



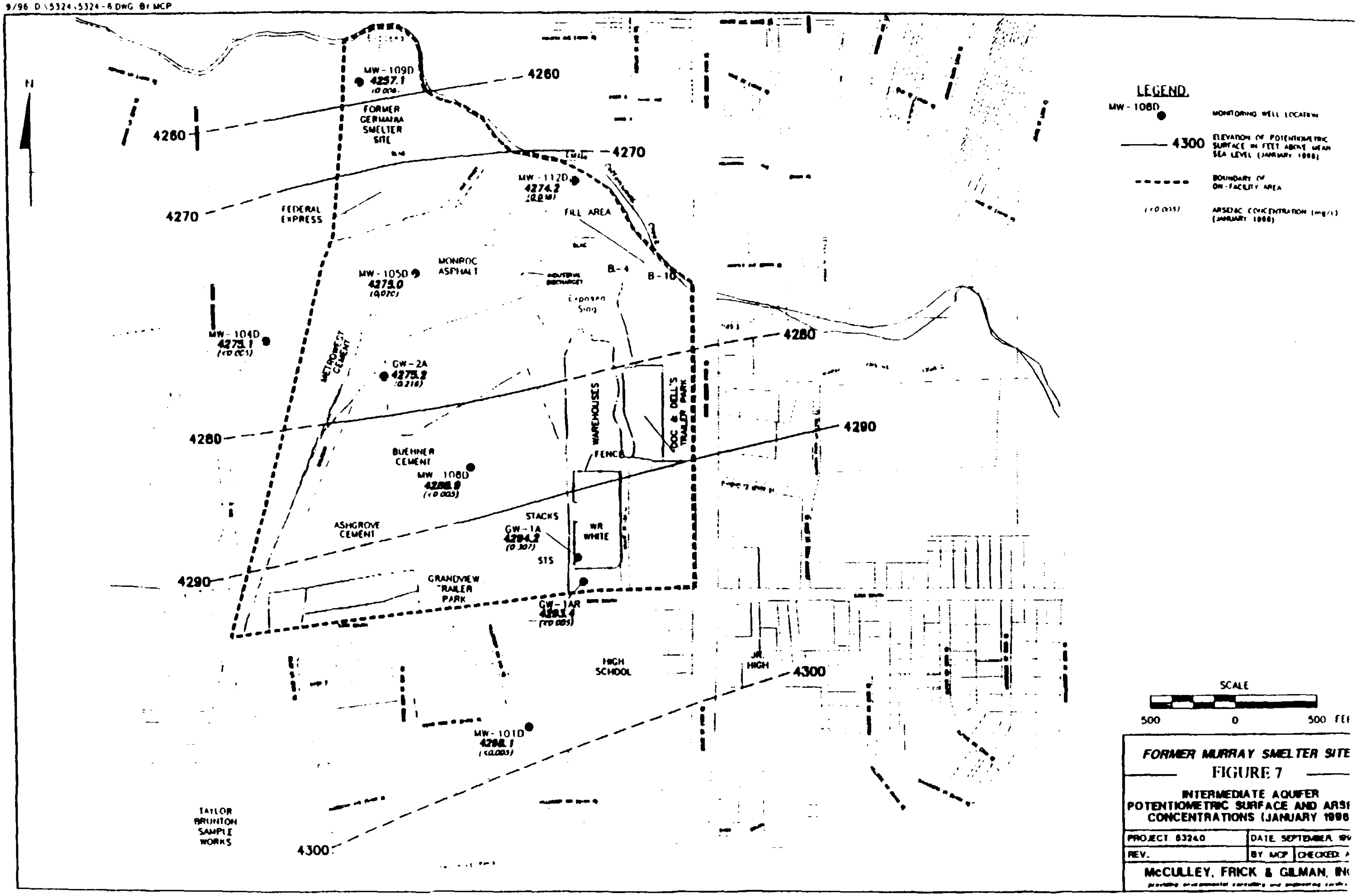
FORMER MURRAY SMELTER SIT

FIGURE 6
SHALLOW AQUIFER
POTENTIOMETRIC SURFACI
AND ARSENIC CONCENTRATI

PROJECT: 53241
DATE: JANUARY, 199
REV.
BY SCG
CHECKED

McCULLEY, FRICK & GILMAN, I
providing environmental consulting and engineering se

9/96 D:\5324\5324-6.DWG BY MCP



FORMER MURRAY SMELTER SITE

FIGURE 7

INTERMEDIATE AQUIFER POTENTIOMETRIC SURFACE AND ARSE
CONCENTRATIONS (JANUARY 1996

PROJECT 53240	DATE SEPTEMBER 19
REV.	BY MCP | CHECKED:

McCULLEY, FRICK & GILMAN, IN
providing environmental consulting and engineering servi

FIGURE .

FLOODPLAIN AREA OF SITE

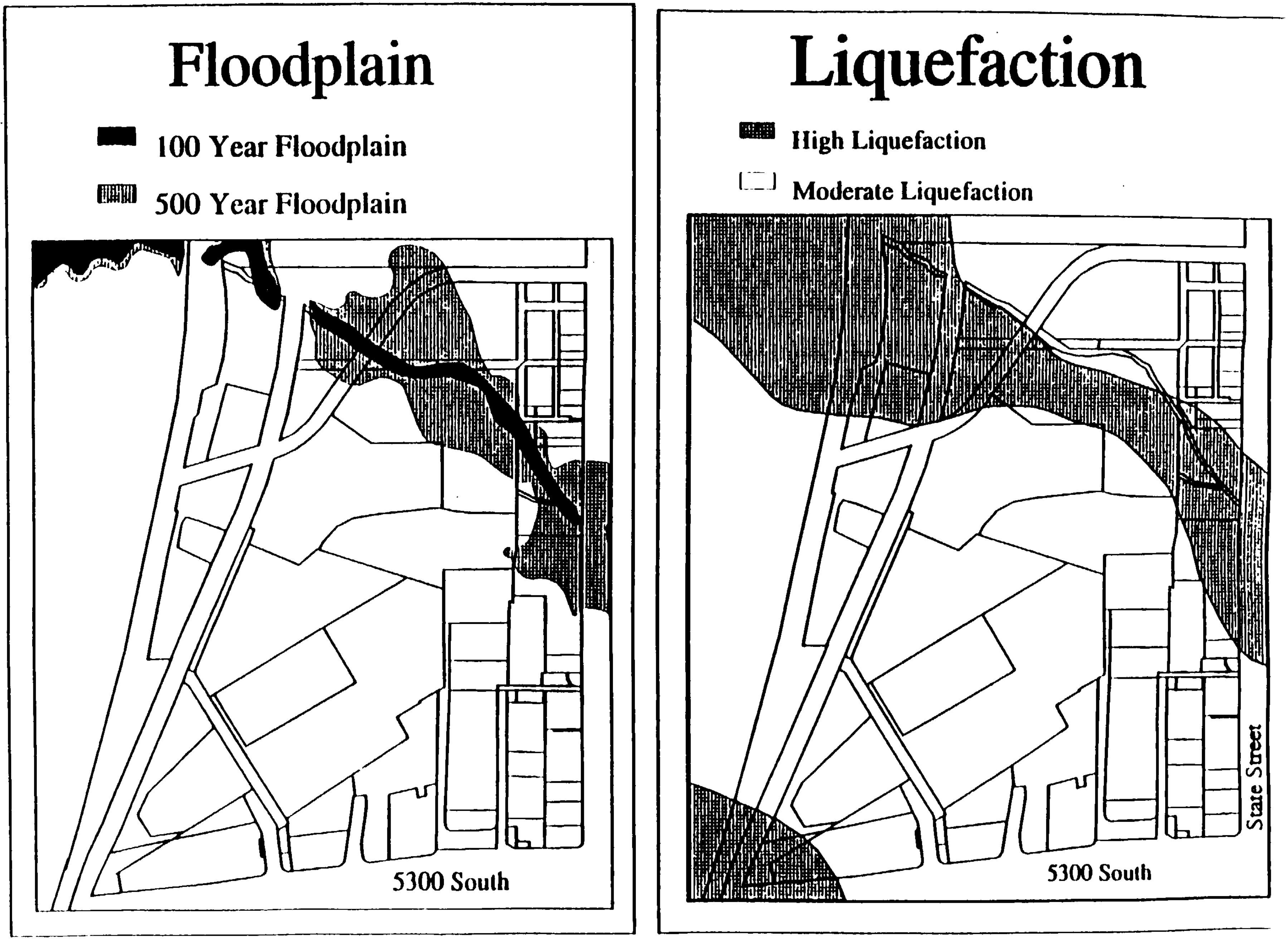
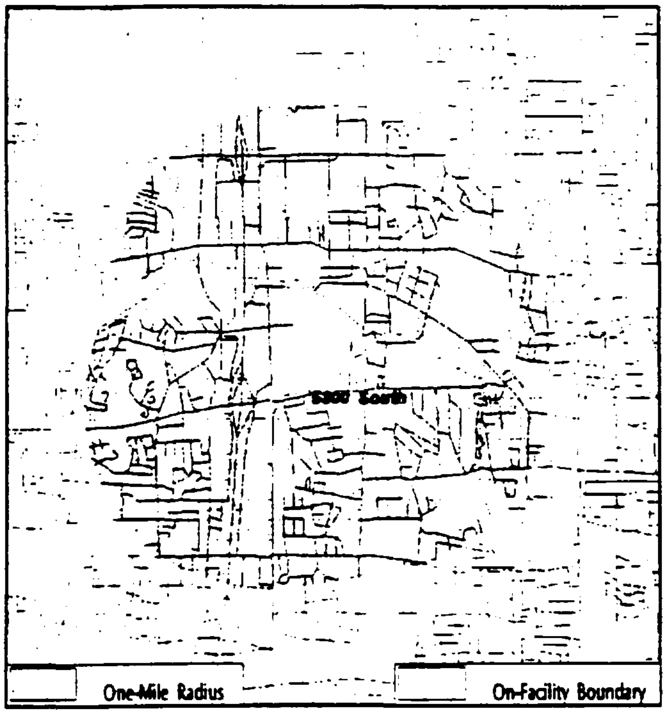
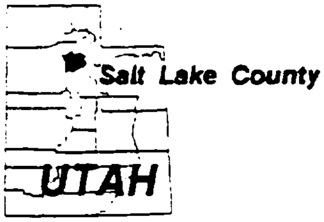


FIGURE 9

Summary Demographic Statistics
Murray, Salt Lake County, Utah

CERCLIS NO. UTD980951420





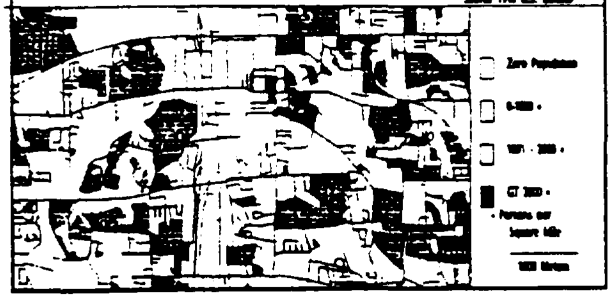
Murray Smelter Area

Summary Statistics Within One Mile of the Site	
Total Number of People	20,000
Total Children 5 Years or Younger	2,863
Total Adults 60 Years or Older	2,792
Total Females Aged 18-45	4,196
Number of Blacks *	762
Number of Whites *	18,300
Number of American Indians *	129
Number of Asians *	296
Number of Hispanics *	866
Other *	319

* Figures assume even distribution

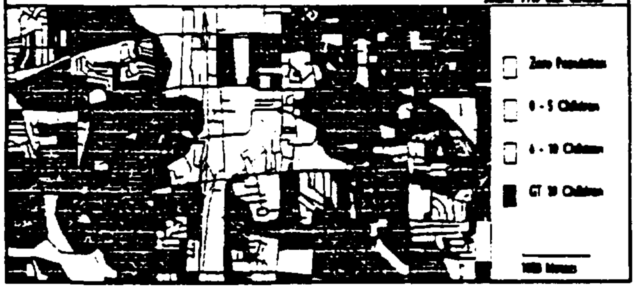
Population Density

Source: 1990 U.S. Census



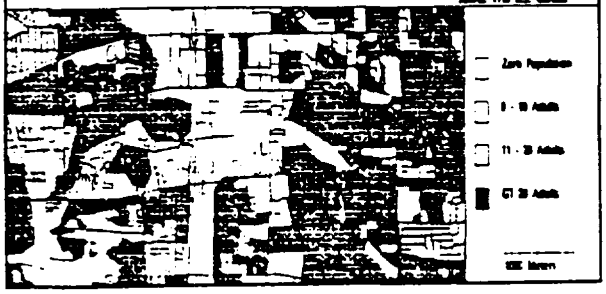
Children 5 Years and Younger

Source: 1990 U.S. Census



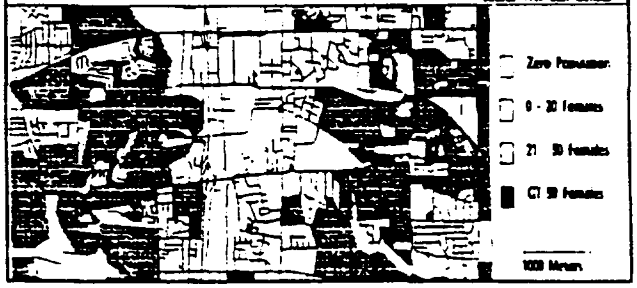
Adults 60 Years and Older

Source: 1990 U.S. Census



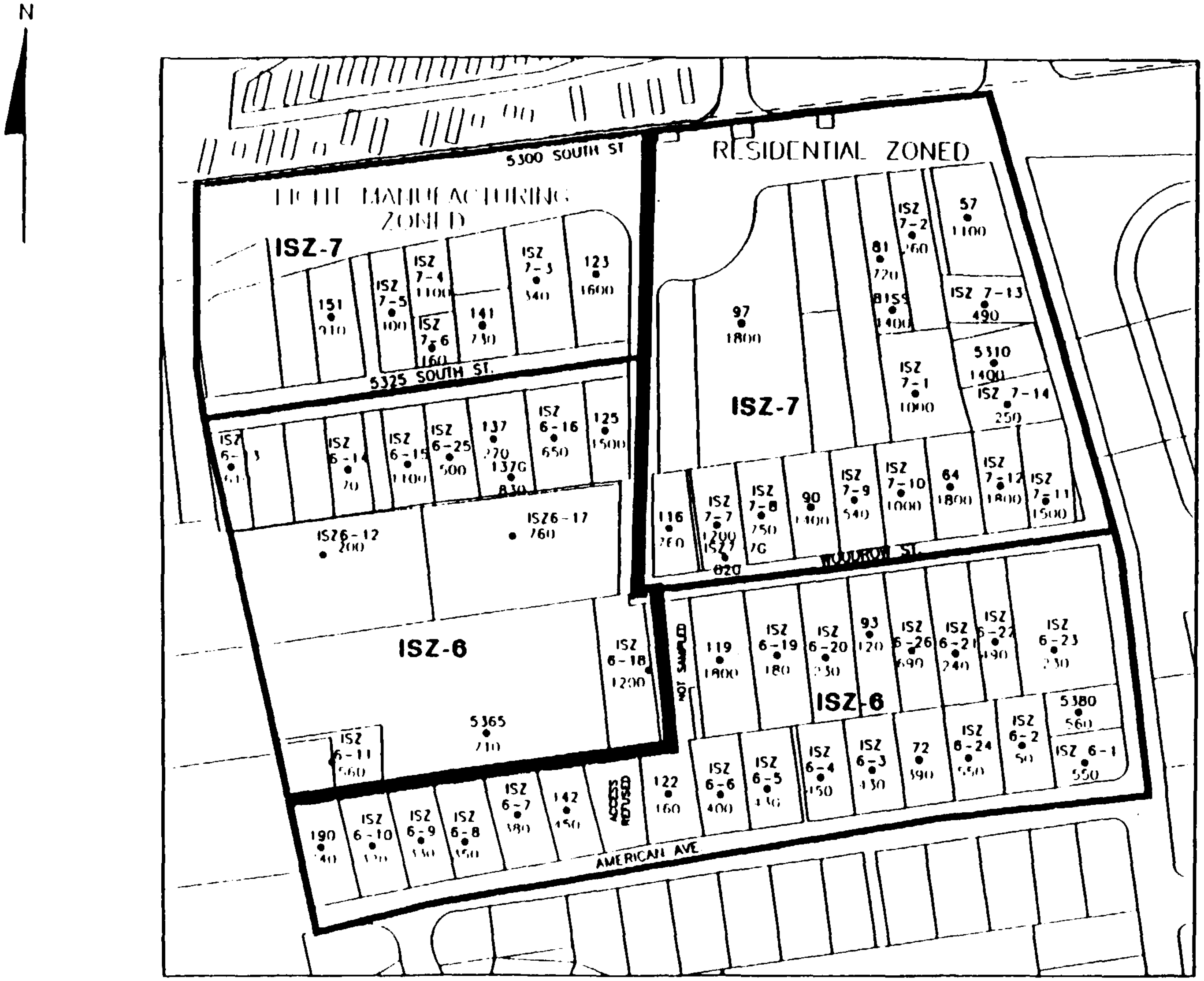
Females Aged 18-45

Source: 1990 U.S. Census



ATSDR GIS Spatial Analysis Activity

1/97 D\5324\9 55.DWG BY SCG



LEGEND:

ISZ 6-1 ● 370	SAMPLE LOCATION WITH LEAD CONCENTRATION (mg/Kg)

SCALE

150 0 150 FEET

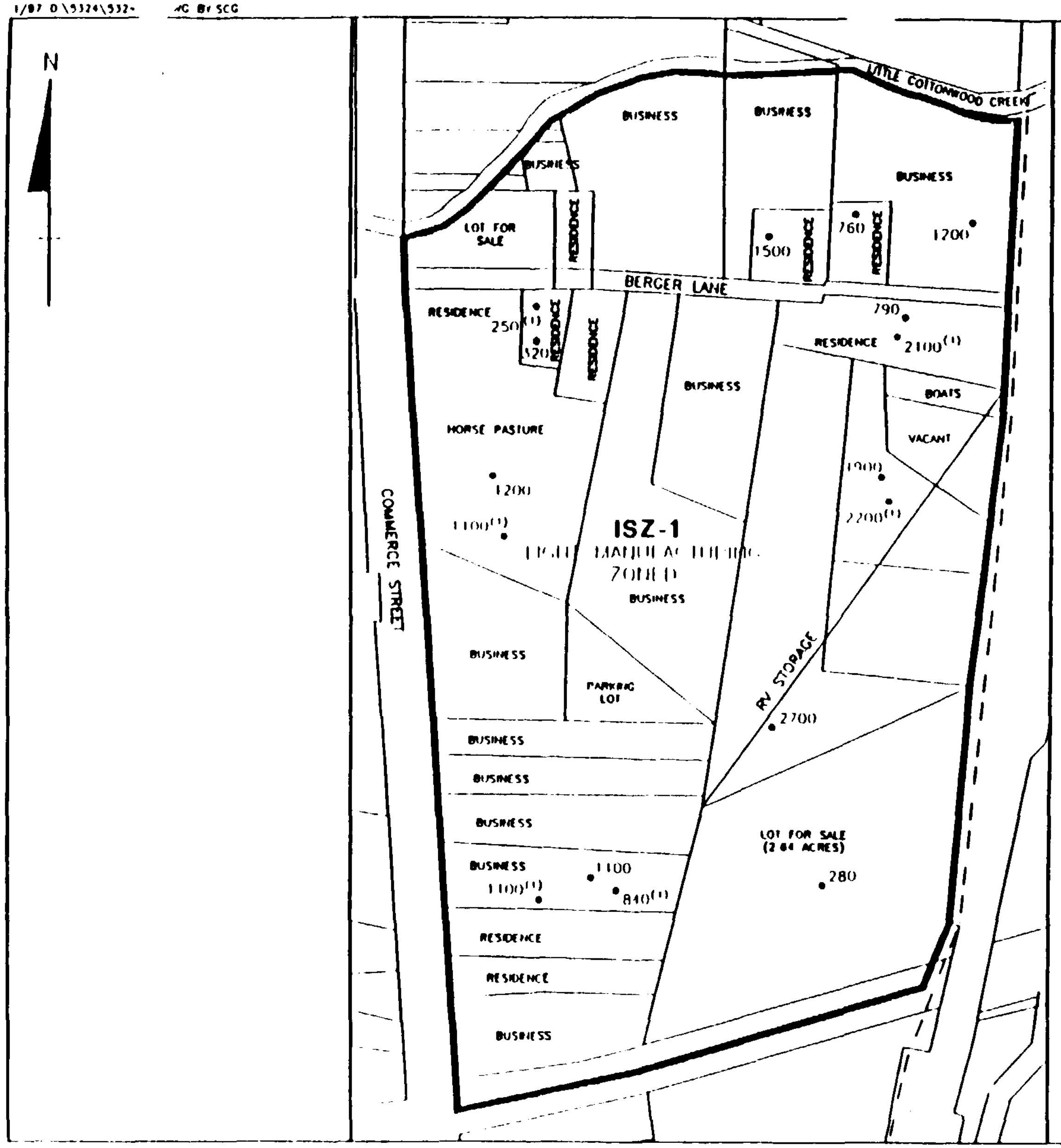
FIGURE 10

LEAD CONCENTRATIONS MEASURED IN SURFACE SOIL IN ISZ-6 AND ISZ-7

PROJECT: 63240	DATE: JANUARY, 1997	
REV.:	BY: AJO	CHECKED: AO

McCULLEY, FRICK & GILMAN, INC

1/87 D\5324\532- G BY SCG



LEGEND:

1000 ●	LEAD CONCENTRATION IN SOIL (mg/Kg)
(1)	GARDEN OR BARE AREA SAMPLE
▬▬	ISZ-1 BOUNDARY
— — —	ON-FACILITY BOUNDARY

NOTE:

1 ISZ-1 IS ZONED FOR COMMERCIAL USE

SCALE

150 0 150 FEET

FIGURE 11

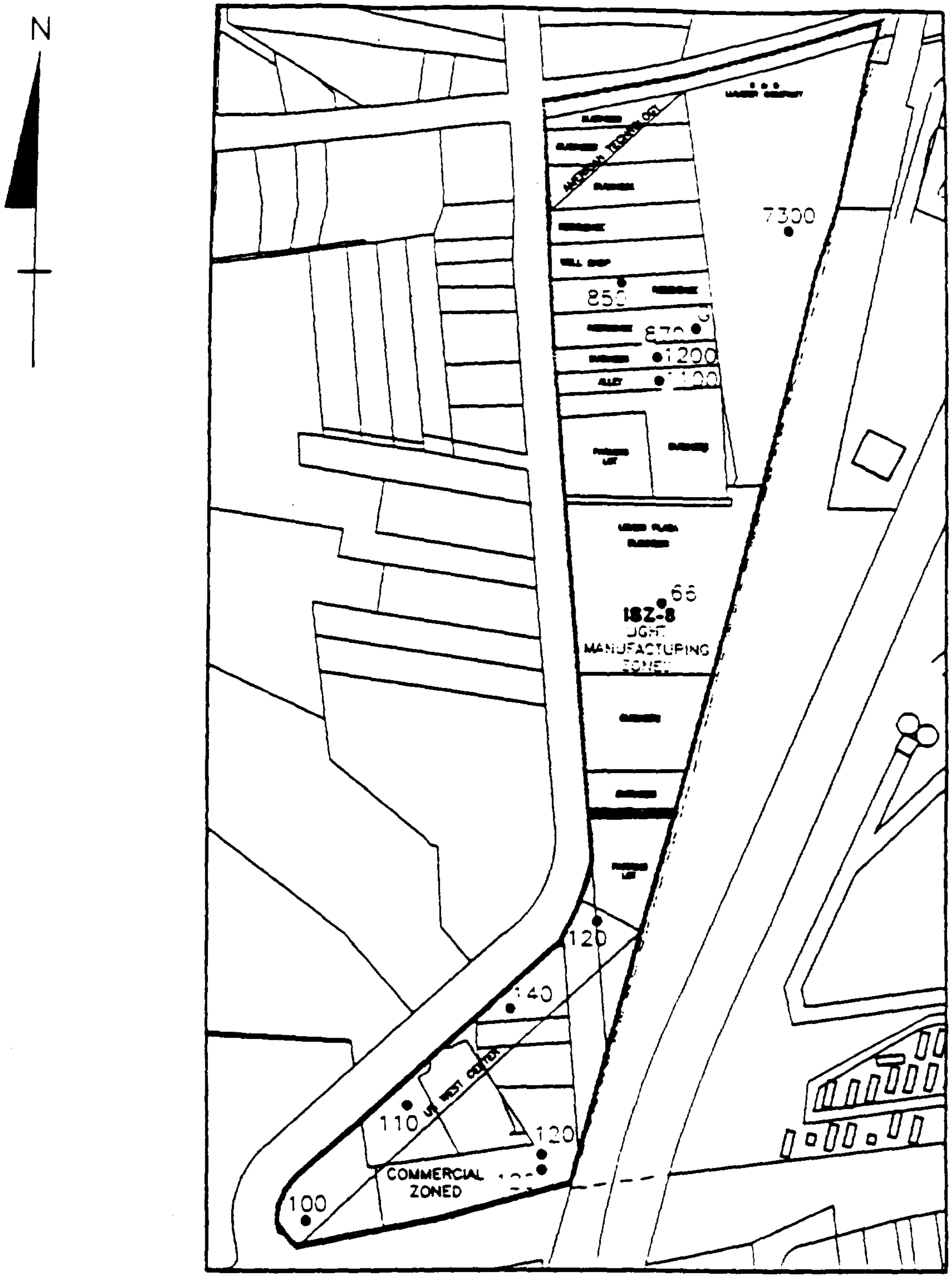
LEAD CONCENTRATIONS MEASURED IN SURFACE SOIL IN ISZ-1

PROJECT: 63240	DATE: JANUARY, 1987	
REV.:	BY AJD	CHECKED: ACK

McCULLEY, FRICK & GILMAN, INC.

providing environmental consulting and engineering services

1/97 D:\5324\5324-64.DWG BY:SCG



LEGEND:

120 ● SAMPLE LOCATION WITH LEAD CONCENTRATION (mg/Kg)

SCALE

300 0 300 FEET

FORMER MURRAY SMELTER SITE

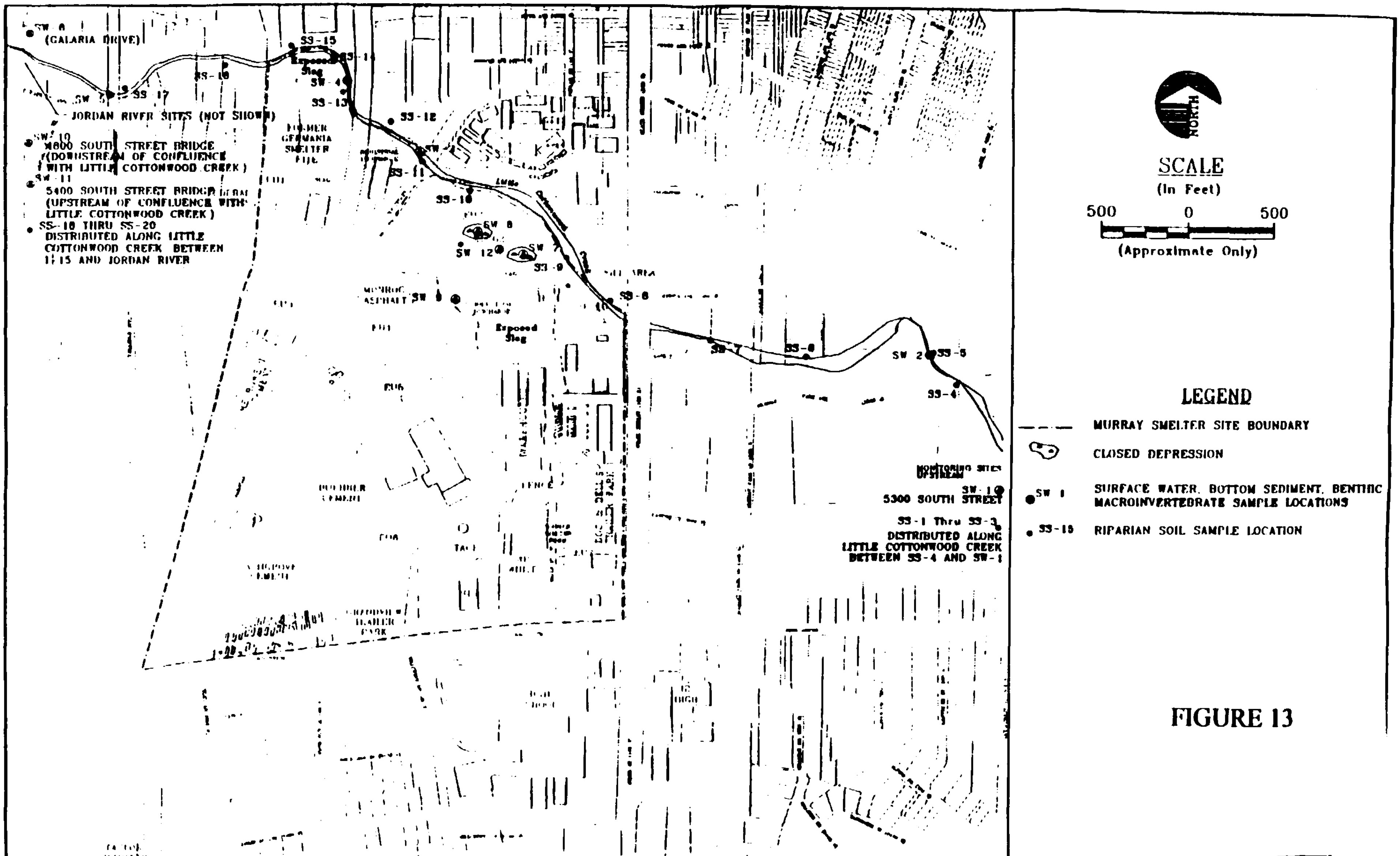
FIGURE 12

LEAD CONCENTRATIONS MEASURED IN SURFACE SOIL IN ISZ-8

PROJECT: 5324.0	DATE: JANUARY, 1997	
REV.:	BY: AJO	CHECKED: ACK

McCULLEY, FRICK & GILMAN, INC.

providing environmental consulting and engineering services



LEGEND

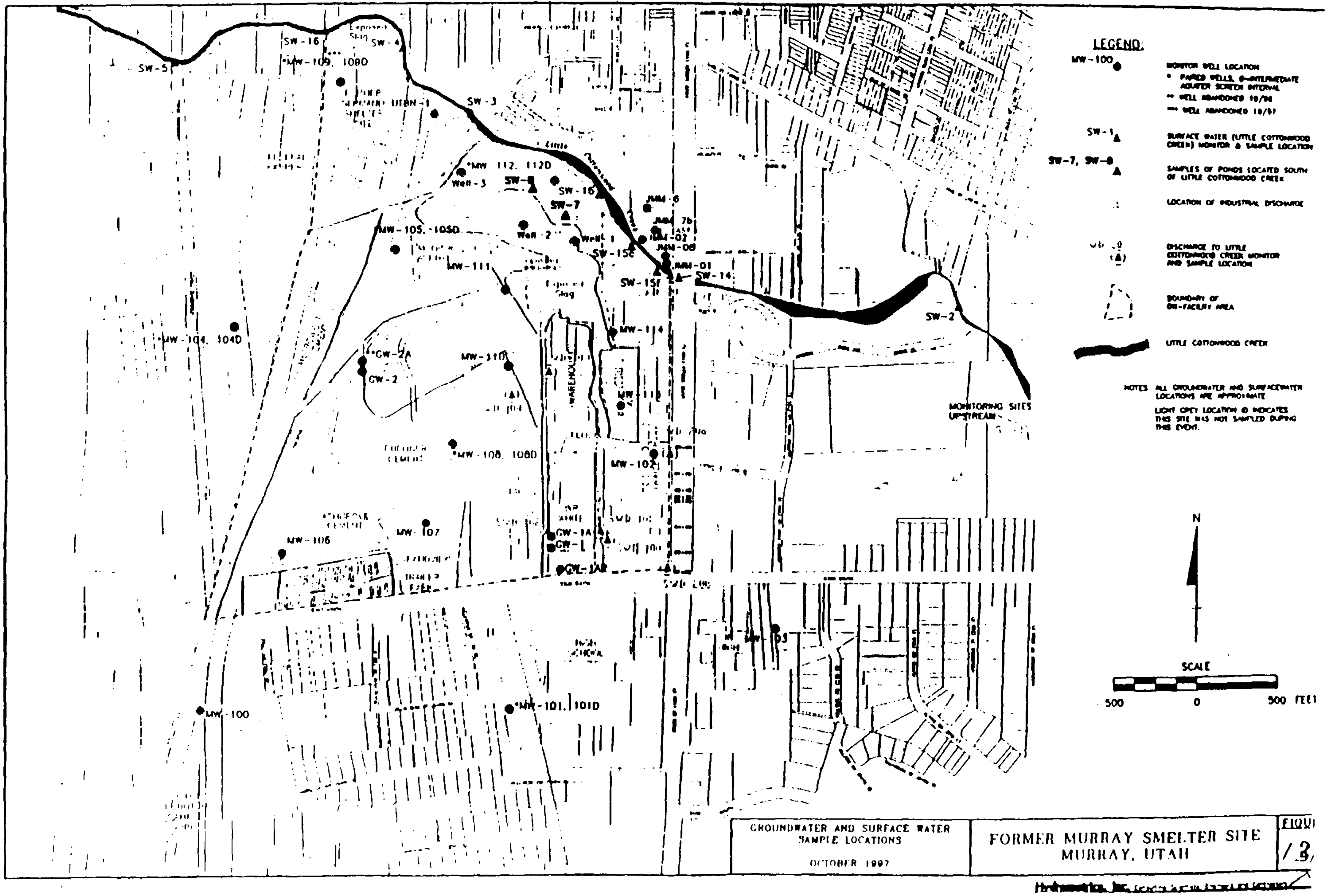
- MURRAY SMELTER SITE BOUNDARY
- CLOSED DEPRESSION
- ● SW 1 SURFACE WATER, BOTTOM SEDIMENT, BENTHIC MACROINVERTEBRATE SAMPLE LOCATIONS
- • SS-15 RIPARIAN SOIL SAMPLE LOCATION

FIGURE 13

ASARCO INCORPORATED
SITE CHARACTERIZATION REPORT
FORMER MURRAY SMELTER SITE
MURRAY, UTAH

SURFACE WATER, RIPARIAN SOIL, BED SEDIMENT, AND BENTHIC MACROINVERTEBRATE SAMPLE LOCATION MAP

Hydrometrics, Inc. [illegible]



GROUNDWATER AND SURFACE WATER
SAMPLE LOCATIONS

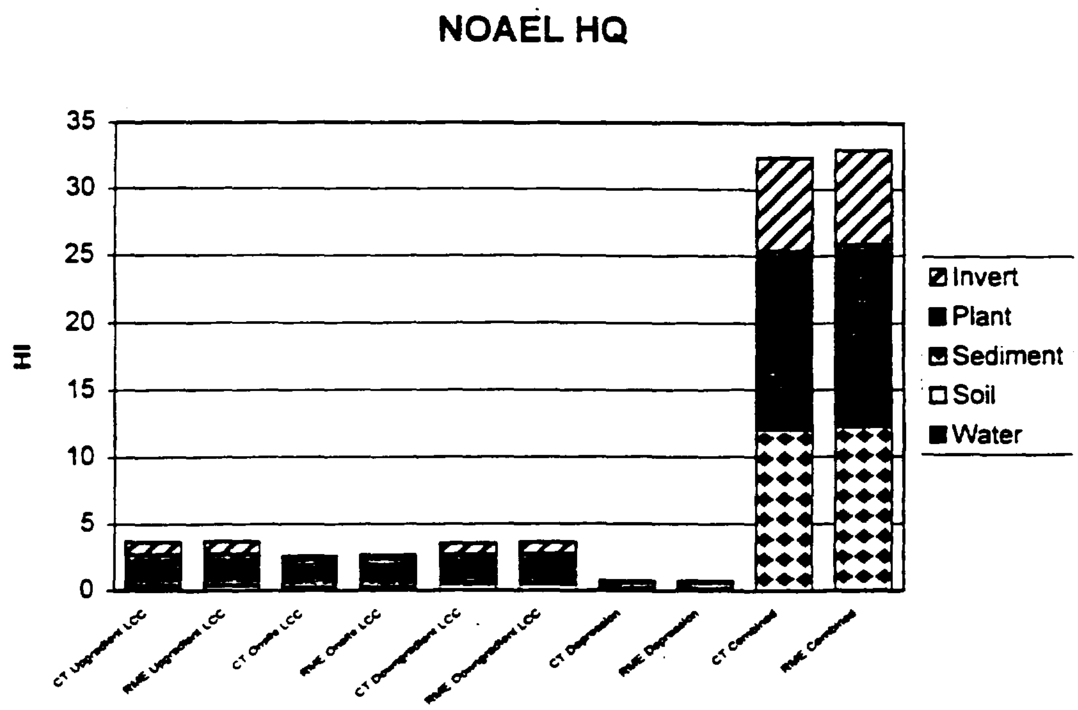
OCTOBER 1997

FORMER MURRAY SMELTER SITE
MURRAY, UTAH

FIGU
/3

Hydrometrics, Inc.

FIGURE 14 RESULTS FOR MALLARD - AUF ADJUSTED


NOAEL HQ

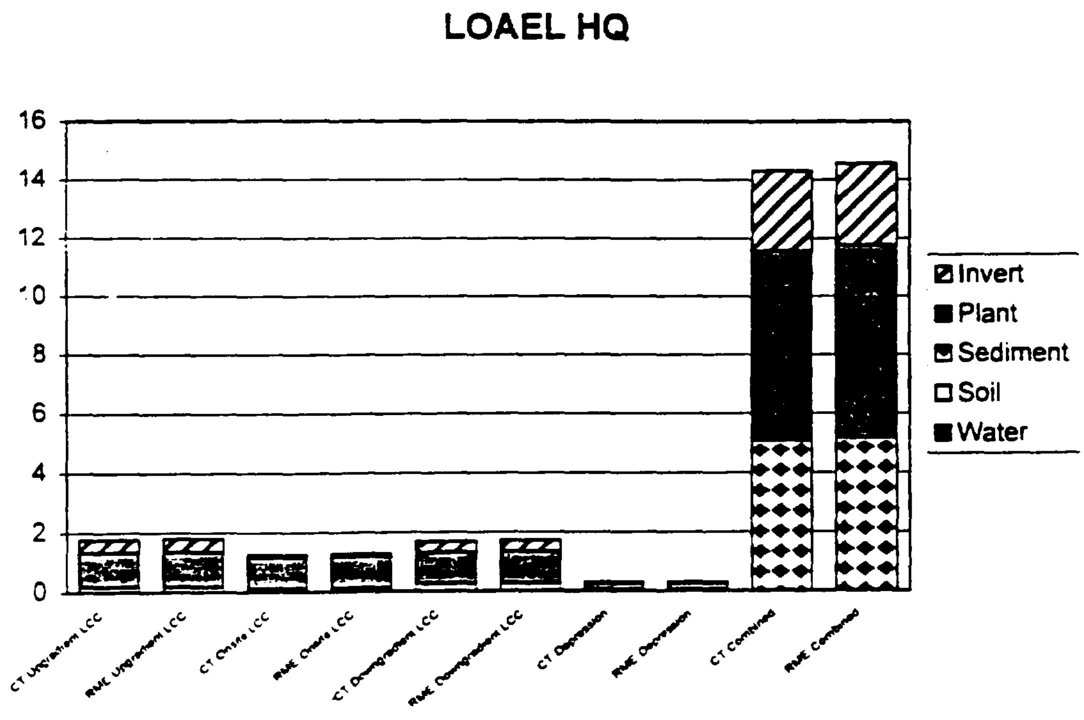
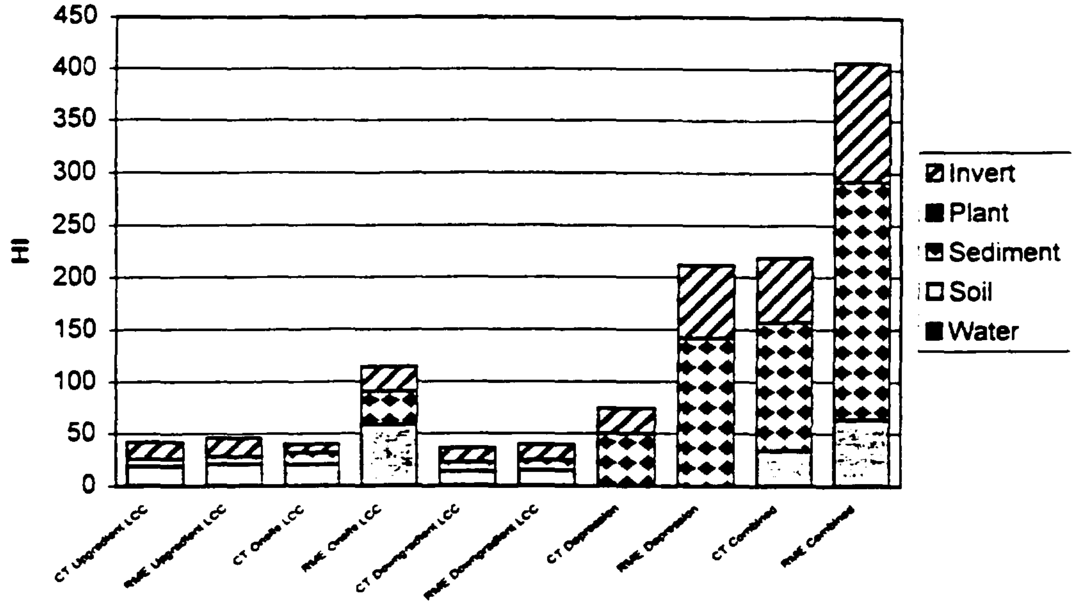

LOAEL HQ

FIGURE 15

RESULTS FOR KINGFISHER - AUF ADJUSTED

NOAEL HQ



LOAEL HQ

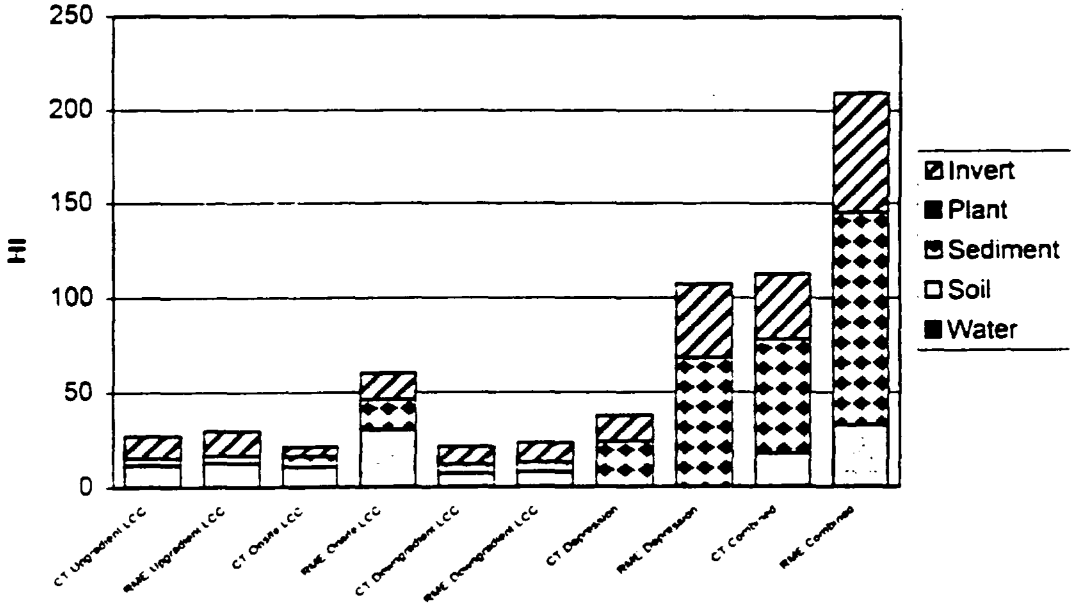
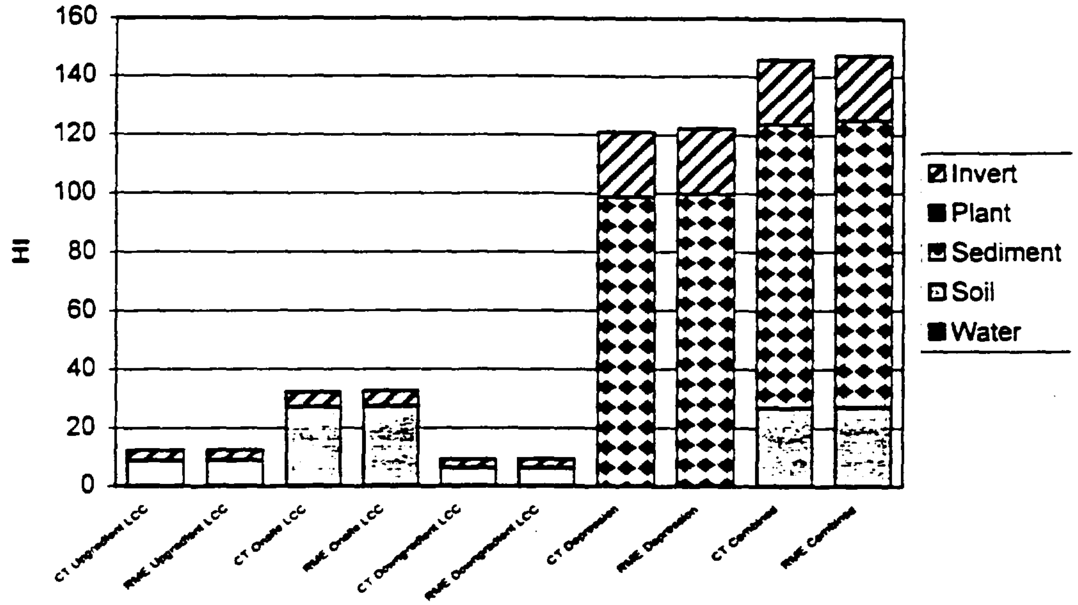


FIGURE 16 RESULTS FOR KILLDEER

NOAEL HQ



LOAEL HQ

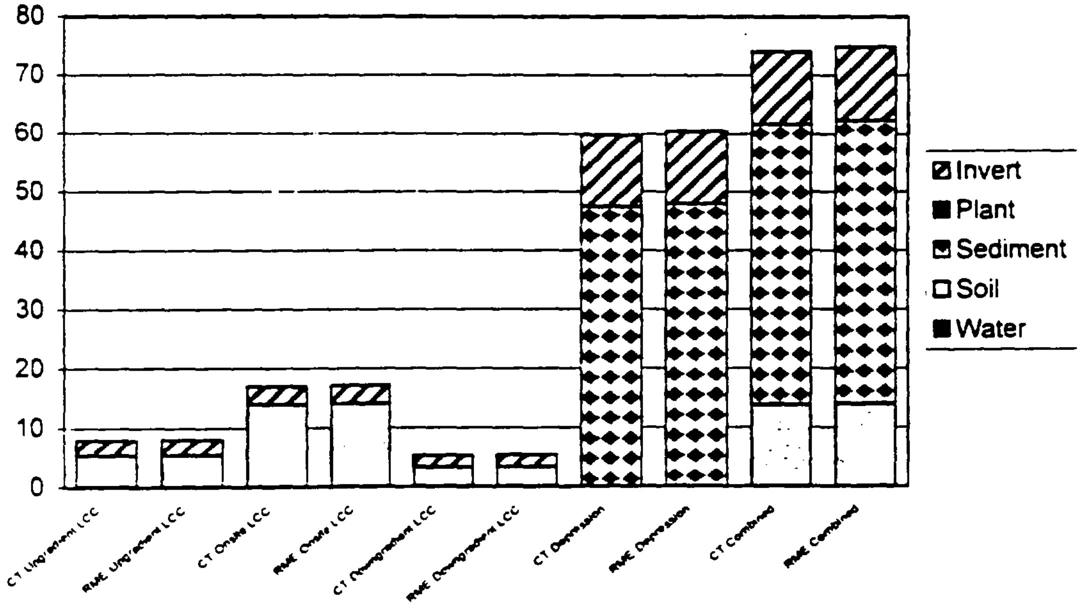
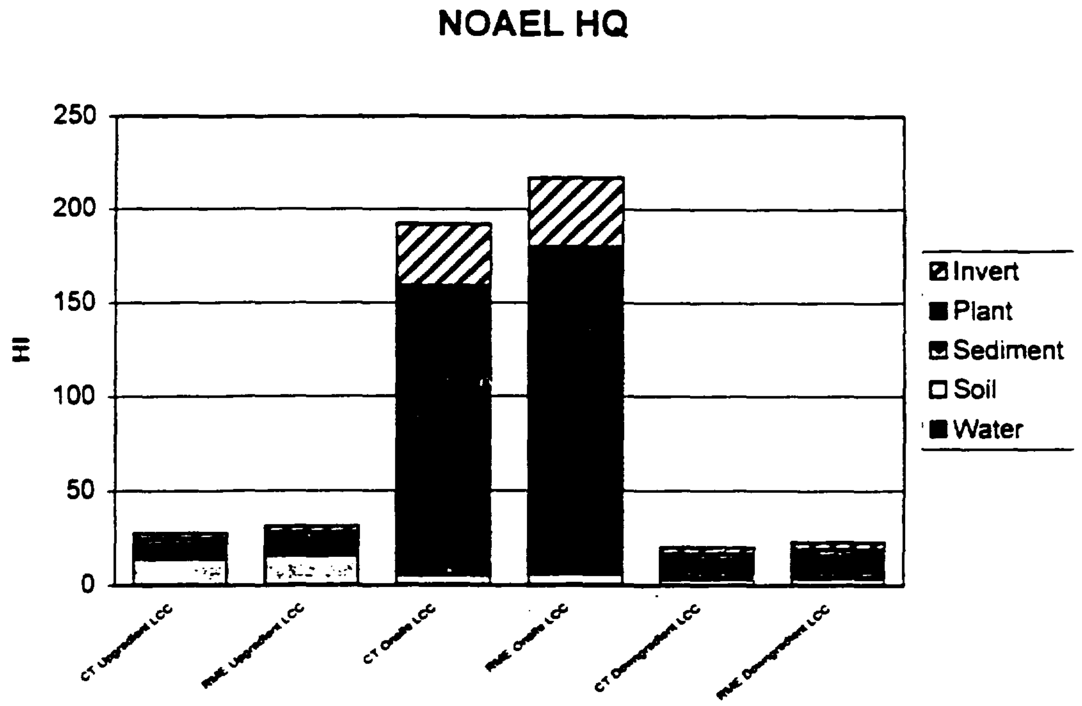
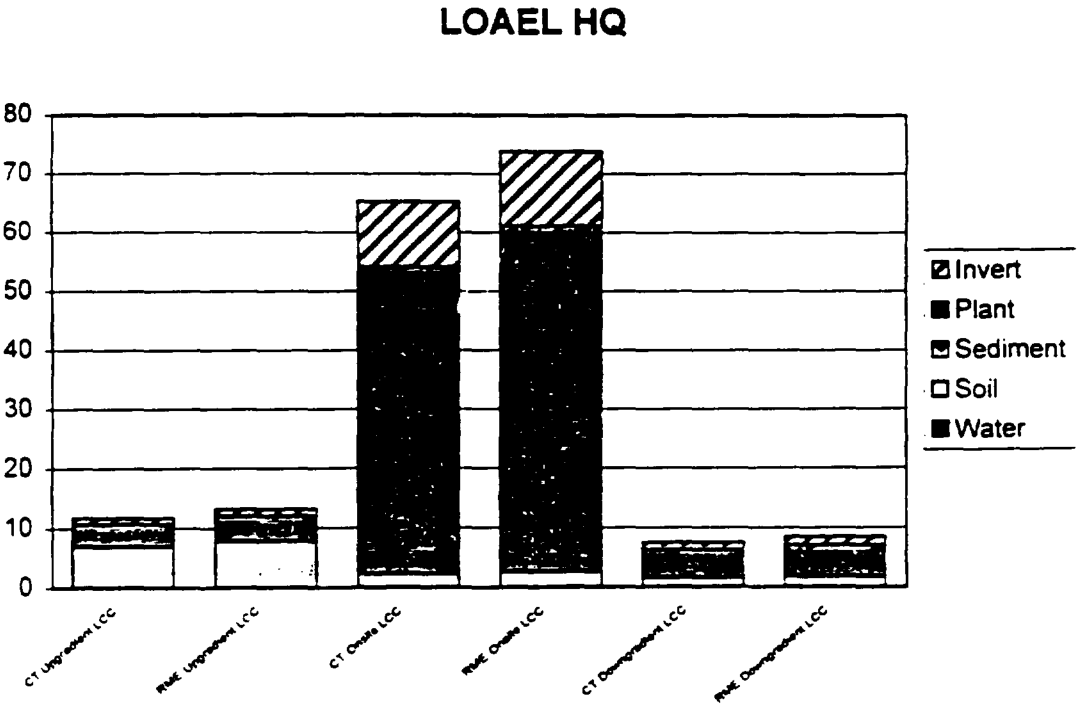


FIGURE 17 RESULTS FOR GOPHER





TABLES

TABLE 4 : LEAD AND ARSENIC IN SURFACE SOIL

Location	Area	Arsenic			Lead		
		Detection Frequency[a]	Average (ppm)	Range (ppm)	Detection Frequency	Average (ppm)	Range (ppm)
On-facility	EU-1	13/19	130	BDL[b]-630	19/19	2905	83-15000
	EU-2	13/17	79	BDL-360	17/17	2879	98-9900
	EU-3	18/18	1172	9-7700	18/18	9548	74-33000
	EU-4	13/20	418	BDL-5400	20/20	1750	37-15000
	EU-5	19/20	100	BDL-520	20/20	2754	110-10000
	EU-6	19/20	432	BDL-5100	20/20	2297	71-7600
	EU-7	19/19	418	18-2200	19/19	2524	92-12000
	EU-8	10/10	1674	64-5000	10/10	6177	570-25000
	EU-9	10/10	118	29-210	10/10	909	340-2000
	EU10	9/10	69	BDL-220	10/10	538	150-1100
	EU-11	8/10	19	BDL-78	10/10	814	100-5700
Off-facility	ISZ-1	19/19	106	13-340	19/19	1299	250-3200
	ISZ-2	7/10	16	BDL-37	10/10	241	80-410
	ISZ-3	10/10	55	7-110	10/10	768	110-1600
	ISZ-4	16/16	43	8-170	16/16	377	110-780
	ISZ-5	16/16	42	7-130	16/16	426	130-640
	ISZ-6	11/12	52	BDL-120	12/12	657	120-1800
	ISZ-7	10/10	126	59-180	10/10	1222	720-1800
	ISZ-8	7/12	76	BDL-450	12/12	1062	66-7300

All data from Hydrometrics 1995a.

[a] Total number of samples with detectable levels over total number of samples analyzed.

[b] BDL = Below detection limit (about 5 ppm).

TABLE 5 : LEAD AND ARSENIC IN SUBSURFACE SOIL

Location	Area	Number of stations	Depth Intervals	Arsenic		Lead	
				Average (ppm)	Range (ppm)	Average (ppm)	Range (ppm)
On-facility	EU-1	2	0-1 ft 1-2 ft 2-3 ft 3-4 ft 4-5 ft	448	BDL-1500	8243	50-16000
	EU-2	1		272	130-340	9480	8200-10000
	EU-4	1		158	BDL-620	1656	66-4800
	EU-5	1		25	BDL-56	222	61-600
	EU-6	19		1224	BDL-48000	2259	57-22000
	EU-7	4		3005	BDL-34000	3793	63-14000
	EU-8	2	0-2 in 2-6 in 6-12 in 12-18 in	2851	64-7200	2751	520-9000
	EU-9	2		1240	13-7500	6858	75-40000
	EU10	2		107	45-140	634	430-1200
Off-facility	ISZ-1	2	0-2 in 2-6 in 6-12 in 12-18 in	69	17-230	334	240-420
	ISZ-2	2		73	27-170	1089	150-3200
	ISZ-3	2		214	53-610	520	87-1600
	ISZ-4	2		68	6-150	486	290-710
	ISZ-5	2		81	44-120	443	230-560
	ISZ-6	2		47	BDL-70	588	120-1000
	ISZ-7	2		185	86-480	2659	550-7300
	ISZ-8	2		132	BDL-450	165	140-190

All data from Hydrometrics 1995a.
BDL = Below detection limit (about 5 ppm).

TABLE 6

SUMMARY OF CHEMICAL ANALYSIS FOR KEY ANALYTES
SHALLOW AQUIFER GROUND WATER
MURRAY SMELTER

WELL	# OF SAMPLES	TDS RANGE	TOTAL ARSENIC			TOTAL LEAD			TOTAL SELENIUM		
			detects	range	mean	detects	range	mean	detects	range	mean
JMM-01	4	787 -1108	4	0.366-0.746	0.502	2	0.064 -0.093	0.079	0		
JMM-02	4	777 - 890	4	0.452-1.008	0.652	2	0.003-0.013	0.008	0		
JMM-06	4	1325 - 1489	0			2	0.002-0.008	0.005	0		
JMM-07B	4	1121 - 1367	4	0.013-0.019	0.015	0			0		
JMM-08	9	549 - 957	9	0.016-0.078	0.039	7	0.002-0.007	0.004	0		
MS-GW-1	9	868 - 1126	9	0.487-30.14	10.98	4	BDL-0.003	0.005	8	0.015-0.192	0.065
MS-GW-2	9	981 - 1270	9	2.87-6.539	4.10	4	BDL-0.005	0.002	8	0.036-0.056	0.046
MW-100	9	852 - 976	1	BDL- 0.002	0.002	6	BDL-0.035	0.01	0		
MW-101	8	484 - 651	8	0.006-0.047	0.014	6	BDL-0.301	0.062	6	BDL-0.016	0.01
MW-102	9	623 - 3409	9	0.013-0.021	0.017	1	BDL-0.001	0.001	3	BDL-0.007	0.004
MW-103	9	1032 - 1110	9	0.098-0.27	0.21	4	BDL-0.003	0.002	0		
MW-104	9	605 - 1439	8	BDL-0.012	0.009	2	BDL-0.01	0.002	6	BDL-0.018	0.012
MW-105	9	726 - 941	9	0.013-0.042	0.022	6	BDL-0.079	0.02	8	0.016-0.053	0.037

TABLE 6

SUMMARY OF CHEMICAL ANALYSIS FOR KEY ANALYTES
SHALLOW AQUIFER GROUND WATER
MURRAY SMELTER

MW-106	9	1491 - 1895	9	23.85-31.06	26.74	6	BDL-0.079	0.02	8	0.07-0.137	0.104
MW-107	9	2126 - 2784	8	BDL - 0.019	0.014	1	BDL-0.001	0.001	8	0.026-0.186	0.12
MW-108	9	995 - 1264	6	BDL - 0.02	0.006	3	BDL-0.026	0.006	8	0.041-0.095	0.076
MW-109	7	1082-1345	7	0.014-0.022	0.018	4	BDL-0.012	0.003	0		
MW-110	9	1329-1530	9	1.689-2.388	2.10	0			8	0.104-0.141	0.139
MW-111	9	658 - 1578	9	2.903-4.535	3.60	7	0.013-0.212	0.107	8	0.075-0.166	0.115
MW-112	9	602 - 1124	9	0.052-0.134	0.104	7	0.027-0.084	0.039	4	BDL-0.059	0.016
MW-113	2	1524-1544	2	0.015-0.021	0.019	0			0		
MW-114	2	490-506	2	0.015-0.021	0.018	0			0		
UTBN-1	10	759-1265	10	0.116-0.27	0.176	8	0.05-0.101	0.069	9	0.011-0.063	0.036
WELL 1	8	535-801	8	0.14-0.316	0.245	5	BDL-0.086	0.024	0		
WELL 2	9	1434-1782	9	1.439-1.974	1.68	3	BDL-0.008	0.006	1	BDL-0.006	0.003
WELL 3	9	843-1309	9	0.134-0.236	0.173	7	0.081-0.214	0.139	8	0.011-0.079	0.028

NOTES:
All values are reported in units of mg/L
Values of one half the detection limit were substituted for below detection limit data in calculation of mean values.

TABLE 7 Exposure Point Concentrations for Surface Water

Part A: Low Flow

Chemical	Upgradient (n=2)		Onsite (n=2)		Downgradient (n=2)		Depression (n=2)
	Total[a]	Dissolved[b]	Total	Dissolved	Total	Dissolved	Total
Aluminum	0.193	[0.05]	0.209	[0.05]	0.534	[0.05]	0.110
Arsenic	[0.0025]	[0.0025]	0.048	0.044	0.054	0.065	0.048
Cadmium	[0.00025]	[0.00025]	[0.00025]	0.0012	0.0009	0.0012	0.0041
Copper	[0.005]	[0.005]	[0.005]	[0.005]	0.012	0.01	0.017
Lead	0.008	0.003	0.004	[0.001]	0.009	[0.001]	0.045
Selenium	[0.0015]	[0.0015]	[0.0015]	[0.0015]	[0.0015]	[0.0015]	0.01
Zinc	0.021	[0.01]	0.035	[0.01]	0.079	0.028	0.149

Part B: High Flow

Chemical	Upgradient (n=2)		Onsite (n=2)		Downgradient (n=2)		Depression (n=2)
	Total[a]	Dissolved[b]	Total	Dissolved	Total	Dissolved	Total
Aluminum	0.644	[0.05]	0.748	[0.05]	1.053	[0.05]	0.185
Arsenic	[0.0025]	[0.0025]	0.010	0.01	0.011	0.01	0.672
Cadmium	0.0007	[0.00025]	0.001	0.001	0.001	[0.00025]	0.003
Copper	0.017	[0.0025]	0.017	0.006	0.03	[0.0025]	0.03
Lead	0.013	[0.001]	0.021	[0.001]	0.032	[0.001]	0.087
Selenium	[0.0025]	[0.0025]	[0.0025]	[0.0025]	[0.0025]	[0.0025]	0.049
Zinc	0.113	0.049	0.117	0.121	0.135	0.072	0.492

All values are expressed in units of mg/L and represent maximum values due to limited samples as described in the text.
[ ] Values in brackets represent 1/2 quantitation (reporting) limit.
[a] Total concentrations were used to evaluate risk to avian receptors.
[b] Dissolved concentrations were used to evaluate risk to fish.
See Appendix C for data and summary statistics.

TABLE 8 Exposure Point Concentrations for Sediment

Chemical	Upgradient (n=10)	Onsite (n=10)	Downgradient (n=10)	Depression (n=10)
Aluminum	5523	6465	5938	11893
Arsenic	29	70	32	492
Cadmium	0.63	3.1	1.4	51
Copper	62	188	409	1628
Lead	302	1699	356	9058
Mercury	0.1	0.33	0.18	0.50
Nickel	37	63	116	40
Selenium	0.55	0.78	0.48	58
Silver	2.3	5.5	3.6	19
Thallium	[0.5]	[0.5]	[0.5]	32
Zinc	526	2389	694	58600

All values reported in units of mg/kg dry weight. EPCs are the minimum of the UCL95 or maximum detected value as described in the text.

[ ] Values in brackets represent 1/2 quantitation (reporting) limit.

See Appendix C for data and summary statistics.

TABLE 9 Exposure Point Concentrations for Riparian Soil

Chemical	Upgradient (n=7)	Onsite (n=8)	Downgradient (n=5)
Aluminum	52611	10780	9800
Arsenic	70	129	55
Cadmium	1.8	6	3
Copper	258	366	193
Lead	771	3100	659
Mercury	0.77	1	0.67
Nickel	67	47	40
Selenium	0.7	11	0.9
Silver	6.6	8.6	6.6
Thallium	[0.5]	1.1	[0.5]
Zinc	685	2332	681

All values reported in units of mg/kg dry weight. EPCs are the minimum of the UCL95 or maximum detected value as described in the text.

[ ] Values in brackets represent 1/2 quantitation (reporting) limit.

See Appendix C for data and summary statistics.

TABLE 10 Exposure Point Concentrations for Benthic Macroinvertebrates

Chemical	Upgradient (n=6)	Onsite (n=4)	Downgradient (n=2)	Depression (n=3)
Aluminum	1100	1169	865	864
Arsenic	12	288	99	133
Cadmium	3	5	3	15
Copper	60	73	64	122
Lead	58	175	50	440
Selenium	17	11	12	58
Silver	0.56	1.3	0.49	2.6
Thallium	[0.5]	[0.5]	[0.5]	9.3
Zinc	373	595	425	3160

All values reported in units of mg/kg dry weight. EPCs are the minimum of the UCL95 or maximum detected value as described in the text.

See Appendix C for data and summary statistics.

TABLE 11

SUMMARY OF ARSENIC CONCENTRATIONS IN SURFACE WATER MEASURED IN QUARTERLY MONITORING EVENTS

MURRAY SMELTER SITE

SAMPLE DATE	UPSTREAM AVERAGE DISSOLVED	UPSTREAM AVERAGE TOTAL	ON-SITE AVERAGE DISSOLVED	ON-SITE AVERAGE TOTAL	DOWNSTREAM AVERAGE DISSOLVED	DOWNSTREAM AVERAGE TOTAL	WETLANDS DISSOLVED	WETLANDS TOTAL
7/22/96	0.007	0.007	0.167	0.146	0.129	0.107	0.26	0.266
12/6/96	<0.005	<0.005	0.173	0.201	0.164	0.202		
1/14/97	<0.005	<0.005	0.288	0.299	0.2	0.255		
4/11/97	<0.005	<0.005	0.176	0.161	0.181	0.184		
7/15/97	0.007	0.008	0.051	0.046	0.042	0.043	0.201	0.232
10/8/97	0.009	0.008	0.123	0.11	0.053	0.061	0.146	0.175

All results are reported in units of milligrams per liter.
Where no result is reported, no sample was collected on that date.

TABLE 12 RISKS FROM ARSENIC IN SURFACE SOIL AND DUST

Population	Location	Area	Arsenic Concentration (ppm)			Noncancer HQ*				Cancer Risk*			
			Mean	Max	EPC	Avg		RME		Avg		RME	
Resident	On-facility	EU-8	1674	5000	5000	1E+00	3E+00	3E+00	9E+00	6E-05	2E-04	6E-04	2E-03
		EU-9	118	210	210	8E-02	1E-01	2E-01	4E-01	5E-06	8E-06	4E-05	8E-05
		EU-10	69	220	220	5E-02	1E-01	1E-01	4E-01	3E-06	8E-06	3E-05	8E-05
		EU-11	19	78	62	2E-02	5E-02	5E-02	1E-01	1E-06	3E-06	1E-05	2E-05
	Off-facility	ISZ-1	106	340	222	7E-02	1E-01	2E-01	4E-01	4E-06	8E-06	4E-05	8E-05
		ISZ-2	16	37	37	2E-02	3E-02	5E-02	8E-02	9E-07	2E-06	9E-06	2E-05
		ISZ-3	55	110	110	4E-02	8E-02	1E-01	2E-01	2E-06	4E-06	2E-05	4E-05
		ISZ-4	45	170	75	3E-02	5E-02	1E-01	2E-01	2E-06	3E-06	2E-05	3E-05
		ISZ-5	42	130	65	3E-02	5E-02	9E-02	1E-01	2E-06	3E-06	2E-05	3E-05
		ISZ-6	52	120	120	4E-02	8E-02	1E-01	2E-01	2E-06	5E-06	2E-05	4E-05
		ISZ-7	126	180	158	9E-02	1E-01	2E-01	3E-01	5E-06	6E-06	5E-05	6E-05
		ISZ-8	76	450	450	5E-02	3E-01	2E-01	8E-01	3E-06	2E-05	3E-05	2E-04
NCI-Worker	On-facility	EU-1	130	630	630	3E-02	1E-01	4E-02	2E-01	1E-06	5E-06	6E-06	3E-05
		EU-2	79	360	360	2E-02	8E-02	2E-02	9E-02	6E-07	3E-06	4E-06	2E-05
		EU-3	1172	7700	7700	3E-01	2E+00	3E-01	2E+00	8E-06	6E-05	5E-05	3E-04
		EU-4	418	5400	5400	9E-02	1E+00	1E-01	1E+00	3E-06	4E-05	2E-05	2E-04
		EU-5	100	520	285	2E-02	7E-02	3E-02	7E-02	8E-07	2E-06	4E-06	1E-05
		EU-6	432	5100	1788	1E-01	4E-01	1E-01	5E-01	3E-06	1E-05	2E-05	7E-05
		EU-7	418	2200	1220	1E-01	3E-01	1E-01	3E-01	3E-06	9E-06	2E-05	5E-05
CI-Worker	On-facility	EU-1	130	630	630	2E-01	9E-01	4E-01	2E+00	6E-06	3E-05	7E-05	3E-04
		EU-2	79	360	360	1E-01	5E-01	3E-01	1E+00	4E-06	2E-05	4E-05	2E-04
		EU-3	1172	7700	7700	2E+00	1E+01	4E+00	3E+01	6E-05	4E-04	6E-04	4E-03
		EU-4	418	5400	5400	6E-01	8E+00	1E+00	2E+01	2E-05	3E-04	2E-04	3E-03
		EU-5	100	520	285	1E-01	4E-01	3E-01	1E+00	5E-06	1E-05	5E-05	2E-04
		EU-6	432	5100	1788	7E-01	3E+00	1E+00	6E+00	2E-05	9E-05	2E-04	1E-03
		EU-7	418	2200	1220	6E-01	2E+00	1E+00	4E+00	2E-05	6E-05	2E-04	7E-04

Shaded cells indicate locations where risks from arsenic exceed typical EPA guidelines (HQ > 1E+00, cancer risk > 1E-04)

* The first value shown is based on the mean concentration, and the second value shown is based on the EPC (usually the maximum)

TABLE 13 POTENTIAL RISKS FROM ARSENIC IN GROUNDWATER

Population	Location	Aquifer	Well	Concentration	Chronic HQ		Cancer Risk	
					Avg	RME	Avg	RME
Resident	On-site	Shallow	MW-100[a]	3	1E-01	2E-01	6E-06	4E-05
			MW-101[a]	6	3E-01	5E-01	1E-05	1E-04
	Off-site		MW-102	18	8E-01	2E+00	5E-05	3E-04
			MW-103	270	1E+01	2E+01	7E-04	5E-03
			MW-104	6	3E-01	5E-01	1E-05	1E-04
			MW-106	27,180	1E+03	2E+03	7E-02	4E-01
		Intermediate	MW-101D	3	1E-01	2E-01	6E-06	4E-05
			MW-104D	19	8E-01	2E+00	5E-05	3E-04
Worker	On-site	Shallow	MW-102	18	4E-01	6E-01	1E-05	1E-04
			MW-105	13	3E-01	4E-01	8E-06	7E-05
			MW-106	27,180	5E+02	9E+02	2E-02	1E-01
			MW-107	3	5E-02	8E-02	2E-06	1E-05
			MW-108	3	5E-02	8E-02	2E-06	1E-05
			MW-109	14	3E-01	5E-01	9E-06	7E-05
			MW-110	2,347	5E+01	8E+01	2E-03	1E-02
			MW-111[b]	2,903	6E+01	9E+01	2E-03	2E-02
			MW-112	52	1E+00	2E+00	3E-05	3E-04
			GW-1	1,287	3E+01	4E+01	8E-04	7E-03
			GW-2	2,870	6E+01	9E+01	2E-03	1E-02
			Well 1	216	4E+00	7E+00	1E-04	1E-03
			Well 2	1,974	4E+01	6E+01	1E-03	1E-02
			Well 3[b]	236	5E+00	8E+00	2E-04	1E-03
			UTBN-1	270	5E+00	9E+00	2E-04	1E-03
		Intermediate	MW-105D	25	5E-01	8E-01	2E-05	1E-04
			MW-108D	3	5E-02	8E-02	2E-06	1E-05
			MW-109D	69	1E+00	2E+00	4E-05	4E-04
			MW-112D	39	8E-01	1E+00	3E-05	2E-04
			GW-1A	790	2E+01	3E+01	5E-04	4E-03
			GW-1AR	6	1E-01	2E-01	4E-06	3E-05
			GW-2A	439	9E+00	1E+01	3E-04	2E-03

Shaded cells indicate wells where risks from arsenic exceed typical EPA guidelines (HQ > 1E+00, cancer risk > 1E-04)

[a] Well located in an up-gradient location

[b] Well is completed in slag

TABLE 14 RISKS TO WORKERS FROM LEAD IN SURFACE SOIL AND DUST

Exposure Area	Mean Lead Concentration (ppm)	Predicted Blood Lead Distribution in NCI-Workers			Predicted Blood Lead Distribution in CI-Workers		
		GM (ug/dL)	95th (ug/dL)	P11.1[a]	GM (ug/dL)	95th (ug/dL)	P11.1[a]
EU-1	2905	4.0	8.1	0.9%	12	25	59%
EU-2	2879	4.0	8.1	0.9%	12	25	58%
EU-3	9548	7.8	16	20%	35	71	99%
EU-4	1750	3.3	6.8	0.3%	8.3	17	25%
EU-5	2754	3.9	7.9	0.8%	12	24	55%
EU-6	2297	3.6	7.4	0.5%	10	21	42%
EU-7	2524	3.8	7.7	0.6%	11	22	48%

[a] P11.1 = probability of a worker exceeding a blood lead level of 11.1 ug/dL. For convenience, values above 5% have been shaded

TABLE 15 RISKS TO CHILDREN FROM LEAD IN SURFACE SOIL AND DUST

Exposure Area	Mean Lead Concentration (ppm)	Predicted Blood Lead Distribution in Children		
		GM (ug/dL)	95th (ug/dL)	P10[a]
EU-8	6177	28.6	50	**>99%**
EU-9	909	8.1	14	**26%**
EU-10	538	5.6	10	4%
EU-11	814	7.5	13	**19%**
ISZ-1	1299	10.4	18	**53%**
ISZ-2	241	3.4	5.9	0.1%
ISZ-3	768	7.2	13	**15%**
ISZ-4	391	4.6	8.0	0.9%
ISZ-5	426	4.8	8.0	1.4%
ISZ-6	657	6.5	11	**9.0%**
ISZ-7	1222	10.0	17	**48%**
ISZ-8	1062	9.0	16	**37%**

[a] P10 = probability of a child exceeding a blood lead level of 10 ug/dL (%). Shaded cells identify locations where the value of P10 is higher than EPA's goal of no more than 5%.

TABLE 16

CHEMICAL SPECIFIC ARARS

Requirement	Citation	Description	Notes
Utah Primary Drinking Water Standards	UAC R309-103-2	Establishes maximum contaminant levels of 0.015 mg/L for lead and 0.05mg/l for arsenic as primary drinking water standards	relevant and appropriate for groundwater at the Murray Smelter Site
National Primary Drinking Water Standards	40 CFR 141.11	Establishes the maximum contaminant level for arsenic of 0.05 mg/L	relevant and appropriate for groundwater at the Murray Smelter Site
National Primary Drinking Water Standards	40 CFR 141.80	Establishes a lead action level of 0.015 mg/L . Regulations establish a treatment technique triggered by exceedance of the action level in more than 10 percent of tap water samples collected during any monitoring period.	relevant and appropriate for groundwater at the Murray Smelter Site
Definitions and General Requirements of Utah Water Quality Act	UAC R317-1	Provides definitions and general requirements for water quality in the State of Utah	Applicable to ground water and surface water at the Murray Smelter Site
Administrative Rules for Groundwater Quality Protection	UAC R317-6-6.4C and R317-6-6.4D UAC R317-6-2	Establishes requirements for issuance of a groundwater discharge permit at an existing facility. Permit limits may be either groundwater quality standards or alternate concentration limits. Groundwater quality standard for arsenic is 0.05 mg/l, for lead is 0.015 mg/l . Alternate concentration limits are established on a site specific basis. The Alternate Concentration Limit for the Murray Smelter Site is 5.0 mg/L.	Substantive requirements are relevant and appropriate for groundwater at Murray Smelter. Note that the groundwater quality standard need not be met if it is demonstrated that an alternate concentration limit (ACL) is protective. At the Murray Smelter Site the ACL is the relevant and appropriate requirement for on site groundwater in the shallow aquifer.

TABLE 16

CHEMICAL SPECIFIC ARARS

Standards of Quality for Waters of the State	UAC R317-2-6, R317-2-7, R312-2-13, and R317-2-14	Establishes use designations of Class 2B, Class 3A, and Class 4 for the segment of Little Cottonwood Creek which borders the Murray Smelter site. Establishes water quality standards applicable to each class. Water quality standards for trivalent arsenic are 190 ug/l (4 day average) and 360 ug/l (1 hour average) for Class 3A. Water quality standard for dissolved arsenic is 100 ug/l for Class 4 Water quality standards for lead are 3 2 ug/l (4 day average) and 82 ug/l (1 hour average) for Class 3A and 100 ug/l for Class 4	Applicable to surface water of Little Cottonwood Creek

TABLE 17

ACTION SPECIFIC ARARS

Emission Standards	UAC R307-1-4	Establishes air quality standards for visible emissions, PM10, and internal combustion engines	Applicable to emissions generated during remedial activities
Fugitive Dust Emission Standards	UAC R307-12	Establishes air quality standards for fugitive dust emissions	Applicable to fugitive dust emissions generated during remedial activities
Ground Water Protection Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264.97 UAC R315-8-6 40 CFR Part 264.99	Establishes general ground water monitoring requirements for treatment storage and disposal facilities Establishes requirements for compliance monitoring program	Relevant and appropriate to ground water at Murray Smelter Site underlying any on site waste management units constructed as part of the remedial action
General Facility Standards: Construction Quality Assurance Program	40 CFR 264.19	Establishes requirement for a construction quality assurance program to ensure that constructed units meet or exceed all design criteria and specifications	Relevant and appropriate to construction of surface impoundment, waste pile, and land fill units constructed as part of the remedial action
General Facility Standards: Location Standards for Hazardous Waste Facilities	UAC R315-8-2.9 40 CFR 264.18	Establishes site characteristics which are unsuitable for location of hazardous waste management units.	Portions are relevant and appropriate t alternatives which include consolidation of wastes on site
Standards for Control of Installations, State Adoption of National Ambient Air Quality Standards (NAAQS)	UAC R307-1-3	Establishes NAAQS as requirements for air quality. NAAQS for PM10 is 50 ug/m^3 annual arithmetic mean, and 150 ug/m^3 24 hour maximum. NAAQS for lead is 1.5 ug/m^3 maximum quarterly average.	Relevant and appropriate to air emissions resulting from remedial activities at Murray Smelter
Off Site Management of CERCLA Wastes	40 CFR 300.440 UAC R315-5 40 CFR 262.10 through 262.44	Establishes requirements for off site management of CERCLA wastes Establishes hazardous waste generator requirements	Applicable to alternatives that involve off site management of hazardous waste
Well Drilling Standards	UAC R655-4	Establishes standards for drilling and abandonment of wells	Applicable to installation or abandonment of monitoring wells

TABLE 17

ACTION SPECIFIC ARARS

Definitions and General Requirements for Air Conservation	UAC R307-1-1 and R307-1-2	Outlines general requirements and provides definitions for Air Conservation Rules	Applicable to alternatives that may cause air emissions
Standards for Control of Installations	UAC R307-1-3	Requires implementation of Best Available Control Technology and specifies criteria for NAAQS	Relevant and appropriate to activities such as grading and excavation where fugitive dust could be generated
Definitions and General Requirements for Solid and Hazardous Waste	UAC R315-1 and R315-2	Outlines general requirements and provides definitions for Utah Solid and Hazardous Waste rules	Applicable to the management of hazardous wastes generated on site
Landfills	UACR315-8-14 UAC R315-8-7 40 CFR 264.310 40 CFR 264.301 40 CFR 264.303	Establishes standards for design and closure of landfills	Requirements are relevant and appropriate to alternatives which include consolidation of wastes on site
Land Disposal Restrictions	UAC R315-13 40 CFR Part 268	Outlines restrictions on land disposal of hazardous waste	Relevant and appropriate to on site placement of hazardous waste generated during remedial actions. Note that movement of waste with an area of contamination does not constitute placement.
Clean- up Action and Risk-Based Closure Standard	UAC R315-101	Establishes risk based closure standards for management of sites contaminated with hazardous waste or hazardous constituents	Relevant and appropriate to Murray Smelter
Corrective Action Clean Up Policy for CERCLA and Underground Storage Tank Sites	UAC R311-211-2, R311-211-3, R311-211-4, and R311-211-5(a) and ©	Establishes minimum standards for clean up of hazardous substances for water related corrective actions. The policy allows for establishment of clean up levels above the minimum standards under certain conditions.	Applicable to groundwater at Murray Smelter

ACTION SPECIFIC ARARS

Utah Pollutant Discharge Elimination System Requirements	UAC R317-8	Establishes general requirements, definitions, and standards for point source discharges of pollutants into surface water bodies in Utah and establishes pre-treatment requirements for discharge to a publicly owned treatment works	Applicable to point source discharges t Little Cottonwood Creek from the Murray Smelter site
Closure and Post-Closure: Post-closure Care and Use of Property	40 CFR 264.117	Establishes minimum requirements for monitoring, reporting, and maintenance of closed hazardous waste management units	Relevant and appropriate to consolidation units constructed as part of the remedial action
Closure and Post Closure: Post -closure plan	40 CFR 264.118	Establishes requirement for written plan identifying activities that will be carried on after closure of each disposal unit	Portions are relevant and appropriate t consolidation units constructed as part of the remedial action
Closure and Post Closure: Post -closure notices	40 CFR 264.119	Establishes requirement to record certification of closure via a notation on the property deed to the facility and notification that the land has been used to manage hazardous waste	Portions are relevant and appropriate t consolidation units constructed as part of the remedial action

TABLE 18

LOCATION SPECIFIC ARARS

Archeological and Historic Preservation Act	40 CFR Subpart C 6.301	Establishes procedures for preservation of historical and archaeological features which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable if such features are found on the Site
National Historic Preservation Act	40 CFR Subpart C 6.301O and 36 CFR 800	Requires Federal agencies to consider the effect of any Federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the national register of historic places.	Applicable if remedial activity affects property listed or eligible for listing on the National Registry of Historic Places
Executive Order on Protection of Wetlands	Executive Order 11990	Requires Federal agencies to avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists	Applicable to any areas classified as wetlands on the Murray Smelter site
Clean Water Act	40 CFR Parts 230, 231	Requires that actions not discharge dredged or fill material into wetlands without a permit.	Substantive requirements of permit are applicable for actions at the Murray Smelter site which involve discharge of dredged or fill material into classified wetlands.
Fish and Wildlife Coordination Act	40 CFR Part 83	Requires that actions taken in areas that may affect streams and rivers be undertaken in a manner that protects fish and wildlife	Applicable to activities conducted in Little Cottonwood Creek
Endangered Species Act	50 CFR Parts 17 and 401	Requires that Federal Agencies ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat.	No critical habitat or endangered species have been identified at the Murray Smelter site.

TABLE 18

LOCATION SPECIFIC ARARS			
Migratory Bird Treaty Act	16 USCS 703	Establishes that is unlawful to take or possess any migratory nongame bird or any part of such migratory nongame bird	Applicable to migratory birds at the Murray Smelter site

APPENDIX A

RESPONSIVENESS SUMMARY

PROPOSED PLAN FOR
MURRAY SMELTER PROPOSED NPL SITE

PART I:

COMMENTS RECEIVED FROM THE UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY (UDEQ)

UDEQ stated concerns that selenium has been detected in the shallow ground water at the Site in concentrations which exceed drinking water standards for that chemical.

EPA Response: The over-riding environmental concern associated with shallow ground water within the on-facility boundaries is arsenic which has been detected at levels 100-1000 times drinking water MCL. In comparison, selenium has been detected at various locations within the on-facility boundaries at levels twice the drinking water MCL. Unlike arsenic, the selenium in shallow ground water has not affected the quality of Little Cottonwood Creek. EPA's selected remedy includes continued monitoring of selenium in shallow ground water and institutional controls which will prevent exposure to selenium by prohibiting the installation of ground water wells except for the purpose of monitoring. The selected remedy is thus protective.

UDEQ also expressed concern about the arsenic loading of Little Cottonwood Creek as a result of a point discharge from the 48 inch reinforced concrete pipe culvert which runs along State Street.

EPA Response: The selected remedy requires control of the Site related source(s) of this arsenic discharge and further requires compliance with surface water quality standards for Little Cottonwood Creek. The details of the source control activities will be developed as part of remedial design.

UDEQ provided an evaluation of responses to comments they submitted on the draft Feasibility Study. The responses were prepared by Asarco. On the basis of Asarco's responses to UDEQ's and EPA's comments on the document, EPA approved the Final Feasibility Study. EPA notes that UDEQ was provided Asarco's responses on August 27, 1997.

UDEQ Comment 1: UDEQ requests numeric clean up levels and confirmatory sampling.

EPA Response: EPA established remediation levels in Section 8.3 of the ROD. The details of confirmatory sampling will be developed as part of remedial design.

UDEQ Comment 2: UDEQ is concerned about the remedy's ability to comply with the ground water MCL for arsenic given the long time (>150 years) for achieving the MCL predicted in the Feasibility Study.

<u>EPA Response</u>: In the ROD EPA provides the rationale for why the conditions at Murray Smelter meet those established in CERCLA Section 122 for the establishment of an Alternate Concentration Limit in lieu of the MCL for arsenic. The evaluation of how the selected alternative will meet this ACL within reasonable time-frame given the Site specific circumstances is contained in Section 9.1 of the ROD. EPA agrees with the statements in the final Feasibility Study that the MCL will ultimately be met. The mechanisms of natural attenuation will continue in perpetuity such that ground water quality will continue to improve resulting in the achievement of restoration albeit in a very long time.

Also in Comment 2, UDEQ requests more specific information about how ACLs will be established at the Site.

EPA has included the development of the ACL for arsenic as Appendix C to the ROD.

UDEQ Comment 3: UDEQ objects to Asaarco's statements which suggest that State ARARs were not identified in a timely manner.

<u>EPA Response:</u> EPA notes that UDEQ has never responded to EPA's September, 1996 formal request for an ARARs analysis from the State. While it is accurate to state that many discussions have occurred between the State and EPA on the identification of State ARARs, UDEQ has only provided a table with no indication of whether that table was to be considered official or final identification of State ARARs for this Site.

UDEQ also requested justification for why chemical specific RCRA ground water maximum concentration levels were not identified as ARAR.

<u>EPA Response:</u> EPA did not identify these standards because they ae not applicable (Murray Smelter is not a treatment storage or disposal facility) and are not relevant and appropriate given the Site circumstances are appropriate for establishing an ACL.

EPA included the following ARARs in the ROD in response to UDEQ' comments:

A. UAC R315-8-6 is identified as relevant and appropriate.

B. Utah's ground water protection rule is identified as relevant and appropriate.

C. EPA's off-site rule is identified as applicable.

D. UAC R315-5 is identified as applicable.

E. UAC R3158-14 is identified as relevant and appropriate.

F. UAC R311-211-2 is identified as applicable.

G. UAC R317-1 is identified as applicable.

UDEQ Comment 4: UDEQ is concerned about the lack of detail regarding the cover design for the on-Site repository system.

The requirements for the cover are identified in the ROD. The further development of the details of the cover is a remedial design activity.

UDEQ provided an evaluation of how well Asarco responded to UDEQ's comments on the draft Feasibility Study. This evaluation is noted by EPA. EPA considers the responses provided by Asarco to be adequate. It was on the basis of Asarco's responses to these comments as well as EPA's comments that EPA approved the Feasibility Study. We assume that this further evaluation by UDEQ is provided for the record and as such will be included as part of the Administrative Record for the Site.

PART II

COMMENTS RECEIVED FROM ASARCO

Asarco commented that the monitoring requirements included in the ROD to support efforts to reduce uncertainties in the ecological risk assessment may not be required if the wetlands area of the Site are filled during Site development. Asarco also suggests that there may be other options to monitoring which will reduce the uncertainties in the ecological risk assessment.

EPA Response: EPA agrees with the comment and has included language in the ROD indicating that in the event the wetlands are filled, the associated exposure pathways will be broken. The ROD also includes the requirement that if the wetlands remain, monitoring will be required. The majority of the ecological risk at the Site is associated with the wetlands. As development plans become more clear, monitoring will be incorporated into the remedial design or deleted as appropriate. Currently, there is not enough information to assess how the planned Site development will affect the wetlands.

Asarco also commented that the Proposed Plan was not clear in describing whether the proposed cover for slag is to be an interim or permanent cover. Asarco further questioned the basis for requiring a cover for slag. Asarco also enclosed the attached memorandum supporting their view that a cover for slag is not required.

EPA Response: EPA agrees with Asarco's comments. Language has been added to the ROD to clarify that there is no need to cover the slag as part of the remedy for the Site. The ROD also makes it clear that EPA expects the slag will be covered in the near future as part of Site development.

PTI
ENVIRONMENTAL SERVICES

Memorandum

To: Donald A. Robbins
From: Rosalind A. Schoof, Ph.D. Roz
Date: October 23, 1997
Subject: Weathering of Slag at the Murray Smelter Site

Recently a question has arisen regarding potential future human health risks for workers who might contact particles released from slag at the Murray Smelter Superfund Site in Murray, Utah due to weathering processes, prior to completion of final remediation activities at the site within the next 5 to 10 years (Lavelle 1997). This technical memorandum addresses the possibility that such risks might differ from those previously assessed by EPA in the baseline human health risk assessment for the site (Weston 1997).

The baseline risk assessment noted that there are extensive areas of the site where slag is exposed at the surface, but concluded that on-facility workers were unlikely to spend much time in areas of exposed slag. The only human receptors for whom slag exposure was determined to be of potential concern were teenagers who might spend time near the slag piles up to 50 times per year for 7 years. These teenagers were assumed to ingest 100 mg of slag at each visit. The fraction of lead and arsenic assumed to be absorbed from the slag was based on studies conducted using fine particles collected from the slag piles. The risk assessment concluded that these teenagers were unlikely to be at risk of adverse health effects from lead in the slag, and that incremental cancer risks associated with arsenic in the slag were within EPA's acceptable risk range (i.e., between 1×10^{-6} and 1×10^{-4}).

There are a number of reasons why continued weathering of the slag piles during an interim period prior to implementation of remedial actions is not likely to pose unacceptable human health risks. The purpose of the baseline risk assessment was to assess potential risks to workers and residents if no remedial actions were ever taken at the site. Consequently, risks from an interim period prior to implementing remedial action cannot exceed those evaluated and judged to be low in the baseline risk assessment unless there is some marked change in the nature of exposures to slag, or in the nature of releases of metals from slag that was not foreseen in the baseline risk assessment. The nature of exposures to slag is not expected to change for on-facility workers or for residents. Similarly, the nature of releases of metals from slag is also unlikely to change for reasons described below.

One mechanism for release of metals is by weathering and breakdown of chunks of slag into fine particles. In many areas of the site, slag that has been at the surface for 50 to 100 years doesn't show any marked signs of weathering. In areas where weathering may have occurred, the risk assessment already accounted for this process by assuming that the ingested slag was in fine particles that might adhere to hands prior to ingestion. Additionally, the bioavailability of fine particles collected from the slag piles was tested, and the results were used in the risk assessment. Consequently, the baseline risk assessment is already based on weathered material, and continued weathering is not likely to lead to increased risks. Indeed, as discussed below, further weathering may serve to reduce the risks by changing the arsenic and lead to less bioavailable forms.

To assess the risk posed by the exposed slag at the Murray site, the risk assessment used the bioavailability estimate for the composite Murray slag sample tested in the EPA swine study (Weston 1997). Greater than 70 percent of the lead mass in this sample (as determined by electron microprobe analysis) was associated with the highly bioavailable lead form, lead oxide (Figure 1). However, as the lead oxide weathers, it will form secondary weathering products including lead phosphate, iron-lead oxides, and iron-lead sulfates (Davis et al. 1993). Because these weathering products will have lower solubility than the lead oxide mineral upon which the risk assessment was based, the risk posed by the exposed slag will diminish as the lead oxide weathers and forms these secondary minerals.

While no information was presented in the risk assessment describing the arsenic mineralogy of the Murray slag sample, Dr. John Drexler of the University of Colorado has indicated that a large fraction of the arsenic was associated with the arsenic oxide phase (Drexler 1997). Assuming this is the case, then arsenic bioavailability would also diminish with time because the arsenic bound in soluble arsenic oxide will eventually repartition into iron oxide phases (PTI 1996), which have a lower bioavailability than arsenic oxide.

In conclusion, it appears that the evaluation of potential human health risks from exposure to slag in the baseline risk assessment for the Murray Smelter Superfund site was sufficiently comprehensive to ensure that no unforeseen risks will occur during an interim period prior to completion of remedial actions at the site.

References

Davis, A., J.W. Drexler, M.V. Ruby, A. Nicholson 1993. Micromineralogy of mine wastes in relation to lead bioavailability. Butte, Montana. Environ. Sci. and Tech. (27) 1415-25.

Drexler, J.W. 1997. Personal communication between J.W. Drexler, University of Colorado and Christopher Sellstone, PTI Environmental Services.

Lavelle, B. 1997. Personal communication between B. Lavelle, U.S. Environmental Protection Agency, Region VIII, Denver, CO and R. Schoof, PTI Environmental Services, Bellevue, WA.

PTI. 1996. Appendix O - Electron Microprobe Analysis Results. Included in: Draft Site Characterization Report for the Former Murray Smelter Site.

Weston. 1997. Baseline Human Health Risk Assessment for the Murray Smelter Superfund Site. Prepared by Roy F. Weston, Inc., Lakewood, CO. Prepared for U.S. Environmental Protection Agency, Region VIII, Denver, CO.

APPENDIX B

TECHNICAL MEMORANDUM

DERIVATION OF PRGS FOR ARSENIC AND LEAD IN SOIL AT THE MURRAY SMELTER SITE

1.0 INTRODUCTION

This document describes the calculation of human-health-based Preliminary Remediation Goals (PRGs) for arsenic and lead in soil at the Murray Smelter site in Murray City, Utah. PRG values were calculated for these chemicals based on the findings of the Baseline Human Health Risk Assessment for the Murray Smelter Superfund Site (WESTON, 1997), which indicated that concentrations of these chemicals in soil could be of concern to humans in some locations.

Health-based PRGs are site-, medium-, and chemical-specific concentration values such that the health risk to exposed humans does not exceed some specified upper limit. For noncancer risks, this target is usually a Hazard Quotient (HQ) of one (1E+00). For cancer risks, PRGs are usually calculated for a range of possible targets (usually 1E-04, 1E-05 and 1E-06). Health-based PRGs do not usually take additivity of risks across different chemicals or across different media into account. However, as discussed in the Baseline Human Health Risk Assessment (WESTON, 1997), additivity is not believed to be of concern at this site for either cancer or noncancer effects. PRGs also do not consider the cost or feasibility of achieving the PRGs. These factors are considered in the evaluation of potential removal actions and/or remedial alternatives.

2.0 PRGs FOR ARSENIC

2.1 Basic Equations

PRGs for arsenic in soil were calculated using the basic approach described in USEPA RAGS Part B (EPA, 1991d). As detailed in the Baseline Human Health Risk Assessment (WESTON, 1997), the basic equations for estimating noncancer and cancer risk from ingestion of soil and dust are as follows:

Noncancer Risk

$$\mathrm{HI} = (C_s \cdot \mathrm{cHIF}_s \cdot \mathrm{RBA}_s + C_d \cdot \mathrm{cHIF}_d \cdot \mathrm{RBA}_d)/\mathrm{oRfD}$$

Cancer Risk

$$\mathrm{Risk} = (C_s \cdot \mathrm{lHIF}_s \cdot \mathrm{RBA}_s + C_d \cdot \mathrm{lHIF}_d \cdot \mathrm{RBA}_d) \cdot \mathrm{oSF}$$

where:

C = concentration (mg/kg) of arsenic in soil (C_s) or dust (C_d)

cHIF = chronic human intake factor (kg/kg-day) for soil ($cHIF_s$) or dust ($cHIF_d$)

lHIF = lifetime human intake factor (kg/kg-day) for soil ($lHIF_s$) or dust ($lHIF_d$)
RBA = Relative bioavailability of arsenic in soil (RBA_s) or dust (RBA_d)
oRfD = Oral reference dose for arsenic (mg/kg-day)
oSF = Oral slope factor for arsenic $(mg/kg\text{-}day)^{-1}$

As discussed in USEPA (1995a), the contribution of arsenic in soil to the concentration of arsenic in indoor dust can be described by an equation of the form:

$$C_d = k_0 + k_{sd} \cdot C_s$$

where:

C_d = concentration in dust (ppm)
k_0 = contribution to indoor dust from non-yard soil sources (ppm)
k_{sd} = mass fraction of yard soil in indoor dust (unitless)
C_s = Concentration in yard soil (ppm)

Because the concentration k_0 is not due to site-specific sources, it is usually ignored when calculating PRG values. Thus, the following equation is used:

$$C_d = k_{sd} \cdot C_s$$

Substituting this expression into the equation above and solving for the value of C_s which corresponds to a Hazard Index of 1E+00 or a specified cancer target risk (1E-04 to 1E-06) yields the following:

$$PRG_{nc} = oRfD/[cHIF_s \cdot RBA_s + k_{sd} \cdot cHIF_d \cdot RBA_d]$$

$$PRG_c = (Target\ Risk)/[(lHIF_s \cdot RBA_s + k_{sd} \cdot lHIF_d \cdot RBA_d) \cdot oSF]$$

The overall PRG for soil is then the more stringent (lower) of these two values:

$$PRG = minimum(PRG_{nc}, PRG_c)$$

In the case of residents or workers exposed to arsenic in soil and dust, screening level calculations show that PRGs based on cancer risks of 1E-04 or lower are always more stringent than those based on an HQ of 1E+00. Therefore, all PRG calculations shown below for arsenic are based on cancer risk.

2.2 Input Values

The Baseline Human Health Risk Assessment (WESTON, 1997) presents and explains all of the exposure factors needed to evaluate the equation above for residents and workers, including both "contact-intensive" (CI) workers and "non-contact intensive" (NCI) workers. Most of the factors are standard defaults recommended by EPA (EPA, 1991a). Table 2-1 summarizes these standard input assumptions. Values for which there are site-specific data are discussed below.

k_{sd}

As described in the Baseline Human Health Risk Assessment (WESTON, 1997), paired soil-dust samples were collected from 22 off-facility locations, and these data were used to analyze the average relationship between levels of metals in soil and in dust. The parameters of the best-fit linear regression through the data are listed below:

k_0 = 16 ppm
k_{sd} = 0.17 ppm per ppm

However, as discussed in EPA (1995a), analysis of soil/dust relationships by linear regression is complicated by the problem of measurement error, which tends to lead to an underestimate of slope. On this basis, the best-fit slope (0.17 ppm per ppm) was rounded upwards to yield the following approximation of k_{sd}:

k_{sd} = 0.2 ppm per ppm

RBA Adjustment

At this site, the RBA of arsenic has been evaluated for a composite sample of surface soil. This sample was fed to young swine for 15 days, and the amount of arsenic excreted in the urine of animals exposed to soil was compared to that for animals exposed to a soluble reference material (sodium arsenate). Preliminary results indicate that the RBA of arsenic in the soil samples is 26%, with a 90% confidence interval from 21% to 33% (Weis et. al 1996). Although preliminary, this value (RBA = 0.26) was employed in the Baseline Human Health Risk Assessment (WESTON, 1997), and was also used in the calculation of the PRG for arsenic in soil.

2.3 Results

Based on the default exposure parameters shown in Table 2-1 and the site-specific factors discussed above, the PRG values for arsenic in soil for residential and commercial/industrial land use are as follows:

TABLE 2-1. SUMMARY OF PARAMETERS FOR ARSENIC EVALUATION

Parameter	Resident	NCI-Worker	CI-Worker
Soil/dust intake rate as child (mg/day)	200	–	–
Soil/dust intake rate as adult (mg/day)	100	50	240
Fraction of total that is dust	0.5	0.5	0
Relative bioavailability of arsenic in soil/dust	0.26	0.26	0.26
Body weight as child (kg)	15	–	–
Body weight as adult (kg)	70	70	70
Exposure frequency (days/yr)	350	250	250
Exposure duration as child (yrs)	6	–	–
Exposure duration as adult (yrs)	24	25	25
Averaging time for cancer (yrs)	70	70	70
Oral slope factor	1.5	1.5	1.5

Population	PRG for Arsenic in Soil* (ppm)		
	1E-04	1E-05	1E-06
Residential	290	29	2.9
NCI-Worker	1,200	120	12
CI-Worker	180	18	1.8

* All values expressed to two significant figures

2.4 Uncertainty in the PRG Values

It is very important to recognize that quantitative risk calculations and PRG derivations are both inherently uncertain due to lack of knowledge regarding a number of key parameters. These uncertainties (discussed in Section 6 of the Baseline Human Health Risk Assessment) include lack of knowledge regarding actual human exposure rates to soil, dust and slag, uncertainty in the extent of absorption (bioavailability) of arsenic from soil and slag, and uncertainty in the exposure levels of arsenic that are actually likely to cause significant adverse effects.

In most cases, conservative approaches are used to fill these knowledge gaps. Therefore, the PRG values calculated above are more likely to be low than high. Because of this, the PRG values should not be viewed as concentrations which form a clear boundary between acceptable and unacceptable soil levels. Rather, values below the PRG should be viewed as very likely to be protective, with a gradually decreasing probability of protection as soil values exceed the PRG.

3.0 EVALUATION OF LEAD

3.1 PRGs for Residents

Basic Approach

The USEPA has developed an Integrated Exposure, Uptake and Biokinetic (IEUBK) model for evaluating the risks of lead to children (age 0-7) exposed under residential circumstances. This model was used to calculate the concentration of lead in soil which would correspond to a 5% probability that a child living at a location with that concentration in soil would have a blood lead value greater than 10 ug/dL. All input assumptions to the model were those recommended by EPA as defaults (EPA 1994a), except for 1) the Geometric Standard Deviation (GSD), 2) the ratio of lead in dust compared to soil, 3) the relative bioavailability of lead in soil and dust, and 4) the amount of lead ingested in the diet. The basis for each of these site-specific values is detailed in the Baseline Human Health Risk Assessment (WESTON, 1997) and is summarized briefly below.

GSD

A study of blood lead levels in Sandy, Utah, indicate that variability between different children can be described by an individual geometric standard deviation of 1.4 (EPA 1995b). Because the population of Sandy is believed to be generally similar to the population of Murray, this value (a GSD of 1.4) is considered to be more relevant and a better approximation of the true site-specific value than the default value (1.6), so the site-specific value is used in place of the default value.

Soil/Dust Relationship

The normal assumption used in the IEUBK model is that the concentration of lead in indoor dust is 70% of that in outdoor soil (EPA 1994a). However, this assumption has been found to overestimate lead concentrations in dust at some mining-related sites. As described in the Baseline Human Health Risk Assessment (WESTON 1997), paired soil-dust samples were collected from 22 off-facility locations, and these data were used to analyze the average relationship between levels of lead in soil and in dust. The slope of the best-fit straight line through the data calculated by linear regression is 0.32 ppm per ppm. However, as noted above, analysis of soil/dust relationships by linear regression is complicated by the problem of measurement error, which tends to lead to an underestimate of slope and an overestimate of intercept. On this basis, the best-fit slope was rounded upwards to 0.35 ppm per ppm, and this value was used in place of the default of 0.70 in the IEUBK model.

RBA

The IEUBK model employs a default relative bioavailability factor of 60% for lead absorption from soil and dust (compared to that for water or food) (EPA 1994a). However, there are several studies which provide evidence that lead in soil from mining/smelting sites may be absorbed less-extensively than this default. The EPA has conducted a study of the bioavailability of lead in a composite soil sample from the Murray Smelter site (EPA 1996a). Preliminary results are summarized below:

RBA in Site Soil	Value
Plausible Range	0.67-0.84
Preferred Range	0.67-0.75
Suggested Point Estimate	0.71

As seen, although there is uncertainty in the estimate, the relative bioavailability for soil is probably about 70%, slightly higher than the default value used in the IEUBK model. Based on this value, and assuming that lead in food and water is about 50% absorbed by children (EPA 1990), this RBA value corresponds to an absolute bioavailability of 35% (0.35).

Dietary Lead Intake

As discussed in Appendix A, recent dietary data collected by the FDA support the view that dietary intakes are now lower than the default values provided in the IEUBK model. The revised values are as shown below, and these were used in the calculation of the soil lead PRG for residential land use.

Age	Intake (ug/day)
6-11 months	1.82
1 year	1.90
2 years	1.87
3 years	1.80
4 years	1.73
5 years	1.83
6 years	2.02

Results

Using the inputs discussed above, the IEUBK model was used to find the concentration of lead in soil which corresponded to a 5% risk of exceeding a blood lead value of 10 ug/dL in children age 0-84 months. The resulting value (the PRG for lead in soil) is about 630 ppm.

It is important to realize that this point estimate of the soil PRG for lead in residential areas is uncertain and that a range of other PRG values are plausible, depending which combination of input parameters are assumed to be most appropriate for the site. Appendix B presents a discussion of this uncertainty in the residential PRG, and indicates that values in the range of 600-1,200 ppm are plausible.

3.2 PRGs for Workers

Because the EPA IEUBK model was developed to evaluate young children exposed under long-term residential conditions (EPA 1994a), this model is not suitable for estimating PRG values for workers. There are several methods which have been proposed for evaluating lead exposure in adults, including models developed by Bowers et al. (1994), O'Flaherty (1993), and the State of California (CEPA 1992). Of these, the model of Bowers et al. is most nearly consistent with the approach employed in the IEUBK model, and is the EPA-recommended interim approach for evaluating leads exposures in adults (EPA 1996b).

Basic Equation

The Bowers model predicts a geometric mean blood lead level (PbB_{GM}) by summing the "baseline" geometric mean blood lead level ($PbB_{GM}0$) (that which would occur in the absence of any occupation exposures to soil or dust) with the increment in blood lead that is expected as a result of occupational exposure to soil or dust. The latter is estimated by multiplying the absorbed dose of lead from occupational soil/dust exposures by a "biokinetic slope factor" (BKSF). Thus, the basic equation is:

$$PbB_{GM} = PbB_{GM}0 + BKSF \cdot (C_s \cdot IR_s \cdot AF_s + C_d \cdot IR_d \cdot AF_d)$$

where:

PbB_{GM} = Geometric mean blood lead level (ug/dL) in a population of adults exposed to lead-contaminated soil/dust via occupational activities

$PbB_{GM}0$ = Geometric mean blood lead level in adults not exposed to lead-contaminated soil/dust via occupational activities

BKSF = Biokinetic slope factor (ug/dL increase in blood lead per ug/day lead absorbed)

C = Arithmetic mean concentration (ug/g) of lead in soil (C_s) or dust (C_d) at the workplace

IR = Mean daily intake rate of soil (IR_s) or dust (IR_d) at the workplace (g/day)

AF = Absolute absorption fraction (bioavailability) of lead in soil (AF_s) or in dust (AF_d).

The concentration of lead in dust is generally a highly variable parameter that depends in part on local soil concentrations, but also is influenced by area-wide concentrations as well as the amount and condition of indoor leaded paint. For the purposes of this analysis, the simplifying assumption was made that the contribution of lead in soil to lead in dust can be described as follows:

$$C_d = k_{sd} \cdot C_s$$

Substituting this expression into the equation above and solving for the value of C_s which corresponds to some specified target geometric mean blood lead value yields:

$$PRG = (PbB_{GM}target - PbB_{GM}0)/[BKSF \cdot (IR_s \cdot AF_s + k_{sd} \cdot IR_d \cdot AF_d)]$$

Input Parameters

All of the input parameters needed to evaluate this equation except for target PbB were presented in the Baseline Human Health Risk Assessment (WESTON 1997), and are summarized in Table 3-1. The value selected for target PbB is discussed below.

TABLE 3-1. SUMMARY OF MODEL PARAMETERS FOR EVALUATION OF LEAD RISKS TO ADULT WORKERS

Model Parameter	NCI-Workers	CI-Workers
95th Percentile PbB in fetus (ug/dL)	10	10
Mean ratio of fetal to maternal PbB	0.9	0.9
Individual geometric standard deviation (GSD)	1.54	1.54
Baseline blood lead value (PbB0) (ug/dL)	2.3	2.3
Biokinetic slope factor (BKSF) (ug/dL per ug/day)	0.4	0.4
Soil and dust ingestion rate (IR_{sd}) (g/day)	0.50	0.240
Fraction of total that is soil	0.5	1.0
Fraction of total that is dust	0.5	0
Ratio of concentration in dust to that in soil (K_{sd})	0.35	–
Exposure frequency (days/yr)	219	185
Oral absorption fraction for lead in soil/dust	0.07	0.07

PbB_{GM}target

The EPA has not yet issued formal guidance on the blood lead level that is considered appropriate for protecting the health of adults. However, both EPA and the Center for Disease Control (CDC) recommend that there should be no more than a 5% likelihood that a young child should have a PbB value greater than 10 ug/dL (CDC 1991, EPA 1994c). Since exposed workers could include pregnant women, and because the fetus is exposed to lead levels nearly equal to those of the mother, the health criterion selected for use in this evaluation is that there should be no more than a 5% chance that the fetus of a pregnant woman would have a PbB above 10 ug/dL.

This health goal is equivalent to specifying that the 95th percentile of the PbB distribution in fetuses does not exceed 10 ug/dL:

$$PbB_{95}\text{fetal} \leq 10 \text{ ug/dL}$$

The relationship between fetal and maternal blood lead concentration has been investigated in a number of studies. Goyer (1990) reviewed a number of these studies, and concluded that there was no significant placental/fetal barrier for lead, with fetal blood lead values being equal to or just slightly less than maternal blood lead values. The mean ratio of fetal PbB to maternal PbB in three recent studies cited by Goyer was 0.90. Based on this, the 95th percentile PbB in the mother is then:

$$PbB_{95}\text{maternal} = 10/0.90 = 11.1 \text{ ug/dL}.$$

Fixing 11.1 ug/dL as the upper 95th percentile of the blood lead distribution in exposed women, the geometric mean blood lead value is derived from the following equation:

$$PbB_{GM}\text{maternal} = 11.1/GSD_i^{1.645}$$

The GSD_i in this equation is intended to describe the individual variability between different people in the amount of environmental media which they ingest, in the fraction of the lead which they absorb from those media, and in the increment which that absorbed lead causes on their average PbB value. Normally, values of GSD_i are estimated from observed distributions of PbB values in a population. The observed GSD from the population is referred to as GSD_p. The relationship between GSD_p and GSD_i is usually difficult to resolve. Conceptually, a GSD_p value reflects variability of two main types: 1) variability in individual activity patterns and toxicokinetic factors, and 2) variability in the concentrations of lead in environmental media. The first component is equal to GSD_i. Thus, the empirical GSD_p represents an upper bound on the value of GSD_i.

Data collected during the NHANES III survey indicate that the GSD_p for all women is about 2.1 (Pirkle et al. 1994). Data collected during a study of the residents of Sandy, Utah (EPA 1995b) indicates the GSD_p for blood lead levels in adult women was 1.54. Because the residents of Sandy are likely to be more similar to the residents of Murray that the general population of the US, the GSD_p value of 1.54 from Sandy was assumed to apply at the Murray site. In order to be conservative, the value of GSD_i was taken to be equal to GSD_p. That is, a GSD value of 1.54 was used to estimate the full distribution of blood-lead values in the exposed population.

Based on this value, the target geometric mean PbB for the woman of child-bearing age is 5.46 ug/dL.

Results

Based on the parameters summarized in Table 3-1, the levels of lead in soil that will be protective for adult on-site workers are:

Population	PRG for Lead (ppm)
NCI-Workers	5600
CI-Workers	930

3.3 Uncertainty in the PRG values

As discussed above, it is important to stress that there is substantial uncertainty in the soil lead PRG values calculated for both residential children and for on-site workers. These uncertainties are related to lack of knowledge regarding true soil and dust intake rates, lack of certainty in the true absorption fraction for lead, and uncertainty in the true level of health risk posed by low level lead exposures to children and fetuses. In addition, there is uncertainty associated with the accuracy of the mathematical models used to make the calculations (the IEUBK model and the Bowers model). These "model uncertainties" arise because human exposure, absorption, distribution and clearance of lead are very complicated and dynamic processes, and any mathematical model which seeks to quantify the processes must always be an over-simplification. In addition, many of the pharmacokinetic parameters relating to lead metabolism in humans are difficult to study and measure, so there is uncertainty whether the values used in the models are accurate. Because of these uncertainties, the PRG values calculated for lead should not be thought of as a clear boundary between acceptable and unacceptable soil levels. Rather, values below the PRG should be viewed as very likely to be protective, with a gradually decreasing probability of protection as values exceed the PRG.

4.0 REFERENCES

Bowers TS, Beck BD, Karam HS. 1994. Assessing the Relationship Between Environmental Lead Concentrations and Adult Blood Lead Levels. Risk Analysis 14:183-189.

CDC. 1991. Preventing Lead Poisoning in Young Children. US Department of Health and Human Services, Centers for Disease Control.

CEPA. 1992. California Environmental Protection Agency, Department of Toxic Substances Control. Supplemental Guidance for Human Health Multimedia Risk Assessment of Hazardous Waste Sites and Permitted Facilities. Sacramento, California.

EPA. 1990. U.S. Environmental Protection Agency, Technical Support Document on Lead. ECAO-CIN-757. Cincinnati, OH: EPA Office of Environmental Criteria and Assessment Office. September.

EPA. 1991a. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors". Washington, D.C. OSWER Directive 9285.6-03.

EPA. 1991b. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. Washington, D.C. OSWER Directive 9355.0-30.

EPA. 1991d. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals). EPA Document EPA/540/R-92/003.

EPA. 1994a. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children. EPA Publication No. 9285.7-15-1.

EPA. 1994b. U.S. Environmental Protection Agency, Technical Review Workgroup for Lead. Comments and Recommendations on a Methodology for Estimating Risk Associated with Acute Lead Exposures at Superfund Sites.

EPA. 1994c. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Memorandum from Elliot P. Laws. Assistant Administrator. July 14, 1994.

EPA. 1995a. U.S. Environmental Protection Agency, Region 8 Superfund Technical Section. Standard Operating Procedure. Evaluating Exposure from Indoor Dust.

EPA. 1995b. U.S. Environmental Protection Agency, Region 8 Superfund Technical Section. Evaluation of the Risk from Lead and Arsenic. Sandy Smelter Site, Sandy, Utah.

EPA. 1996a. U.S. Environmental Protection Agency, Region 8 Superfund Technical Section. Bioavailability of Lead in Soil and Slag from the Murray Smelter Superfund Site.

EPA. 1996b. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead. U.S. Environmental Protection Agency, Technical Review Workgroup for Lead. December, 1996.

Goyer RA. 1990. Transplacental Transport of Lead. Environ. Health Perspect. 89:101-105.

O'Flaherty EJ. 1993. Physiologically Based Models for Bone-Seeking Elements. IV. Kinetics of Lead Disposition in Humans. Toxicol. Appl. Pharmacol. 118:16-29.

Pirkle JL, Brody DJ, Gunter EW, Kramer RA, Paschal DC, Flegal KM, Matte TD,. 1994. The Decline in Blood Lead Levels in the United States. The National Health and Nutrition Examination Surveys. JAMA 272:284-291.

Weis, CP, Henningsen G, Griffin S. 1996. Preliminary Bioavailability Values for Arsenic in Soil and Slag from the Murray Smelter Superfund Site. Memo from Christopher P. Weis, Gerry Henningsen and Susan Griffin to Bonnie Lavelle, dated 8/19/96.

Roy F. Weston, Inc. (WESTON). 1997. Baseline Human Health Risk Assessment for the Murray Smelter Superfund Site. Report prepared by Roy F. Weston, Inc. for the USEPA Region VIII. April, 1997.

APPENDIX A

REVISION OF DIETARY LEAD INTAKES IN IEUBK MODEL

MEMORANDUM

TO: Bonnie Lavelle
Remedial Project Manager
Murray Smelter Site

FROM: Susan Griffin, PhD, DABT
Regional Toxicologist
Program Support Group

SUBJECT: Revision of Dietary Lead Intakes in IEUBK Model

This memorandum is in response to ASARCO's request to update the dietary lead intake default values in the IEUBK Model for the Murray Smelter Site. As you are aware, the IEUBK dietary lead intake values are based on FDA Total Diet Study data from 1986 to 1988. A number of scientific papers have been published recently by Dr. Ellis Gunderson (Gunderson, 1995) and Dr. Michael Bolger (Bolger et al, 1996) of the U.S. FDA which contain more recent information from the FDA's Total Diet Studies. These papers list the mean daily intake of lead from the diet for the years from 1986-1991.

I spoke with Dr. Rob Elias of the USEPA who was responsible for the dietary lead intake component of the IEUBK model. He indicated it would be appropriate to use the more recent FDA data to update the dietary input values in the IEUBK model. As you may note from the FDA papers, dietary intakes are provided for children 6-11 months of age and 2 years of age. The next age group studied are teenagers 14-16 years of age. The IEUBK model contains age-adjusted dietary lead intakes for each year up to 7 years of age. This is because the age groups other than 6 months and 2 years were extrapolated. Originally, Dr. Elias did this by using the information from the FDA Total Diet Studies of 1986-1988 and the data from the Pennington studies of 1975 on food consumption rates for each age group. ASARCO is proposing to perform this extrapolation by a simpler ratio method between the older IEUBK model values and the more recent FDA data. Dr. Elias indicated that this was a satisfactory method and would probably not yield significantly different results from the more complicated method of combining the FDA data with food consumption rate data. Dr. Elias did indicate that he will be updating the dietary intake component of the IEUBK model in the near future. Those values may be slightly different from those proposed here, because he will be combining the most recent FDA data with a new 1996 study on food consumption rates in the U.S. which is just coming out. Using the more recent FDA data to update the IEUBK model values results in the following intakes:

Age	Dietary Lead Intake (ug/day)
6-11 mos	1.82
1 year^	1.90
2 years	1.87
3 years*	1.80
4 years*	1.73
5 years*	1.83
6 years *	2.02

^Derived from IEUBK 99d value for 1 year divided by the ratio of the IEUBK 99d value for 6 months/ 1990-91 FDA data for 6 months
*Derived from IEUBK 99d value for that age divided by the ratio of the IEUBK 99d value for 2 years/1990-91 FDA data for 2 years

When these more recent values are input to the IEUBK model the current PRG range of 550 -1100 ppm will be changed to 630-1260 ppm.

References

Bolger, PM, Yess, NJ, Gunderson, EL, Troxell, TC and Carrington, CD. 1996. Identification and Reduction of Sources of Dietary Lead in the United States. Food Additives and Contaminants, Vol. 13, No 1, 53-60.

Gunderson EL. 1995. FDA Total Diet Study, July 1986-April 1991, Dietary Intakes of Pesticides, Selected Elements, and Other Chemicals. Journal of AOAC International Vol. 78, No. 6, 1353-1363.

APPENDIX B

PRELIMINARY REMEDIATION GOALS FOR THE MURRAY SMELTER SITE

MEMORANDUM

TO: Bonnie Lavelle
RPM, Murray Smelter Site

FROM: Susan Griffin, PhD, DABT
Regional Toxicologist

SUBJECT: Preliminary Remediation Goals for the Murray Smelter Site

Development of risk-based preliminary remediation goals (PRGs) are part of the risk assessment process. The first step involves a baseline risk assessment which uses contaminant concentrations and exposure variables in conjunction with toxicity criteria, to estimate exposure and risk for a defined population at a site. At lead sites, a risk assessment is conducted by inputting contaminant concentrations into a simulation model, the Integrated Exposure Uptake Biokinetic (IEUBK) Model, which predicts blood lead levels in children 6 months to 7 years of age. If greater than 5% of those blood lead levels exceed 10 ug/dl, the risk is considered to be unacceptable. Risk-based PRG calculations are basically the reverse of the risk assessment calculations. These calculations use a selected acceptable risk (e.g., no more than 5% > 10 ug/dl) and exposure variables to estimate a desired contaminant concentration.

A single PRG could be estimated for the site using the IEUBK model with single values for both default and site-specific parameters. Using the data from the 1996 Baseline Risk Assessment for the Murray Smelter Superfund Site, (e.g., IEUBK model default values except for a site-specific Geometric Standard Deviation of 1.4, a soil/dust correlation coefficient of 0.35, and a soil/dust bioavailability of 35%) this single PRG would be 550 ppm. However, we know there is variability and uncertainty in both analytical measurements (e.g., bioavailability estimates, soil concentration. etc.), as well as population behavior and exposure. For example, all children do not ingest the exact same amount of soil, or spend 100% of their time in one location. Concentrations of lead in house dust are not identical for each home. These are examples of variability. Use of randomly collected soil samples to predict the true value of lead concentrations in the soil is an example of uncertainty. Therefore, development of PRG's which attempt to capture this uncertainty and variability convey more information about risk at a site, than a single PRG estimate.

EPA-Region 8 is currently in the process of quantitating this uncertainty in the risk estimate and PRG estimate for the Murray Smelter Site via a Monte Carlo analysis. This is a complex process, however, and will not be completed until late Spring 1997. In the interim, a more simplified approach may be useful. This approach looks at the variability around the estimate of the mean values which are used as inputs to the IEUBK model. As you are aware, the default inputs to the IEUBK model represent average or typical values for intake and uptake. Rather than evaluate <u>all</u> of the IEUBK model inputs, it is more efficacious to evaluate those which most significantly affect the outcome. At the Murray Smelter Site the lead in soil and house dust are the most significant sources of exposure. From this exposure pathway, the variables which impact soil and dust exposure the most are (1) bioavailability, (2) the correlation between lead in soil and house dust, and (3) soil ingestion rate. Based on site-specific data from the swine bioavailability study and the paired soil and dust concentrations, the variability around the mean estimates for (1) and (2) are fairly small. This variability would result in PRG's which ranged from 500 - 640 ppm. However, based on information from technical documents for the National Ambient Air Quality Standard (NAAQS) for lead, the Guidance Manual for the IEUBK Model and information from the Anaconda Childhood soil ingestion study, the variability surrounding the mean estimate for soil ingestion is fairly significant. At the Murray Smelter site it results in a range of PRGs from 550 -1100 ppm for lead in soil. As you are aware, the IEUBK model was utilized originally by the Office of Air Quality Planning and Standards (OAQPS) for the development of the lead NAAQS. Rather than utilizing a single value for soil ingestion, the model employed a range of average estimates. As part of the technical documentation of the NAAQS, these were reviewed and approved by the EPA's Science Advisory Board. These ranges are documented in the 1989 OAQPS report, "Review of the National Ambient Air Quality Standards for Lead: Exposure Analysis Methodology and Validation" and the 1994 Guidance Manual for the IEUBK Model for Lead in Children. It wasn't until the modification of the IEUBK model by the Superfund program, that the maximum value in that range was selected as the **single** soil ingestion input for the IEUBK model. In addition a recent soil ingestion study conducted by Dr. Edward Calabrese from the University of Massachusetts for children at the Anaconda Smelter site, yielded similar estimates of variability around a mean soil ingestion rate. The four best tracers resulted in average estimates ranging from 89 - 126 mg/day with upper and lower 95% confidence limits around the averages ranging from 15 to 218 mg/day.

In summary, the quantitation of variability surrounding the mean soil ingestion rate is based on technically sound scientific data. The precedence for it's use is the development of the NAAQS for lead. In addition, various points along the range have also been used on a site-specific basis at both the Leadville and Butte NPL sites. By using a range of PRGs which take into account the variability in mean soil ingestion rates, more realistic information is conveyed about the variability surrounding lead exposure and risk from soil and dust . The range does not imply that there is greater risk at the high end of the range, and less risk at the low end of the range. Instead, it suggests that any point on the range can represent EPA's risk goal of no greater than 5% exceedance of 10 ug/dl.

At Murray, the PRPs have suggested that the 1988 dietary default values of the model be updated and that an *in vitro* bioavailability study be conducted. In terms of how these new data may affect the PRG range of 550 - 1100 ppm, the updated dietary information will provide only a small impact. The new range will be 600 - 1200 ppm. Depending on the results of the *in vitro* study, the change could range from minimal to significant. Changes in bioavailability are linear with changes in PRG estimates, provided soil lead is the only or major source of exposure. For example a reduction in bioavailability from 30% to 15% will result in a doubling of the PRG estimate.

APPENDIX C

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2466

MEMORANDUM

DATE: November 5, 1997

FROM: Rich Muza, 8EPR-EP

TO: Bonnie Lavelle, 8EPR-SR

SUBJECT: Preliminary Determinations of Alternate Concentration Limits (ACLs) for Arsenic in Ground Water at the Murray Smelter Site, Murray, Utah

As per your request, I have taken a preliminary look at the determination of ACLs for arsenic in ground water at the Murray Smelter Site. I have focused my effort on arsenic as this analyte is the driver for any risk determinations from the ground-water pathway at the Site. ACLs for other analytes can easily be determined based on this work for arsenic.

I will provide a discussion of the concepts utilized in this ACL determination and then provide the prelimary ACL results based on various scenarios.

ALTERNATE CONCENTRATION LIMITS AS APPLIED TO THE SITE

Ground water at various locations on the Murray Smelter Site is contaminated with arsenic at ppm-levels. There are potentially three distinct plumes which have migrated a relatively short distance downgradient of the source areas. These plumes show zones of high arsenic concentrations with a significant drop-off in most cases to background levels over a relatively short distance. The plumes are present in the water-table aquifer of the terrace and fill deposits near Little Cottonwood Creek as well as within the floodplain deposits of the Creek. The ultimate fate of the arsenic-contaminated ground water is discharge to Little Cottonwood Creek.

Historically, impacts to the Creek from Site-specific contamination have been present. Monitoring over time has shown levels of arsenic approaching and exceeding the ambient water quality criteria (AWQC) of 190 ppb. However, recent studies have shown that this surface-water contamination can be attributed to discharges from a drainage conduit that is present at the State Street bridge. This conduit has been found to run southward along State Street and to have an arm that runs through the Site in the area of the former Baghouse where one of the arsenic plumes is present. Therefore, the mechanism for measurable contaminant migration to Little Cottonwood Creek looks to be ground-water seepage from the Baghouse plume into the drainage conduit with rapid tranport to its discharge point at the State Street bridge.

SARA allows for the setting of ACLs for contaminants where "1) there are known and projected points of entry of such ground water into surface water, 2) on the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such ground water in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream, and 3) the remedial action includes enforceable measures that will preclude human exposure to the contaminated ground water at any point between the facility boundary and all known and projected points of entry of such ground water into surface water". Since the impacts to Little Cottonwood Creek are presently believed to be attributable to the drainage conduit pathway, ACLs are applicable at the Site. However, it is recommended that a contingency plan be developed in the event that remedial actions to stop contaminant migration in the drainage conduit do not result in significant reductions in contaminant concentrations in Little Cottonwood Creek.

ACLs at the Site will then be developed for the protection of surface-water quality in Little Cottonwood Creek. The AWQC of 190 ppb will be applied to this determination. The logic behind this determination is to assure that arsenic-contaminated ground water upon discharge to Little Cottonwood Creek will be diluted by streamflow such that the AWQC is never exceeded in the Creek. The determination is simply a mass balance calculation based on theoretical ground-water and surface-water flow conditions.

If this ACL approach is accepted as the remedial action for contaminated ground water at the Site, then the point of compliance for maintanence of the ACL is within the water-table aquifer adjacent to Little Cottonwood Creek. That is a line of monitoring wells completed within the water-table aquifer will have to be installed on the floodplain along the Creek and be routinely monitored for the contaminants of concern.

PRELIMINARY ALTERNATE CONCENTRATION LIMIT DETERMINATION FOR THE SITE

I have looked at a number of hydrologic scenarios — all based on Site-specific data — in this preliminary ACL determination. In all scenarios I considered the zone of contaminated ground-water discharge potentially impacting the Creek to be the stretch from SW-2 downstream to SW-3 or a distance of approximately 3500 feet. This assumption is based on a combined analysis of the ground-water flow directions and contaminant plume distributions at the Site; if both the Baghouse and Arsenic Storage Bin plumes were to migrate to the Creek, based on the existing ground-water flow information, their discharge and impacts to the Creek would occur between SW-2 and SW-3 . Also, in all scenarios I have only considered ground-water discharge to the Creek from the Site or south side as the Site-specific database focuses on this ground-water flow system; this is a conservative assumption as based on the conceptual model for the area a component of ground-water flow from the north discharging to the Creek will exist. Lastly, a background arsenic level in surface water of 0.007 ppm was used; this was the maximum value detected in samples from SW-2 where most of the sampling results were below the detection limit of 0.005 ppm. I will summarize each scenario and the ACL for arsenic result.

Scenario 1

Under Scenario 1 the determinations of ground-water flow and surface-water discharge utilized in ground-water flow and solute transport modeling for the Site Characterization and Feasibility Study reports were input into a mass balance equation. The values for ground-water flow from the Site to the Creek range from 0.02 to 1.92 cfs based on this analysis. A low-flow discharge rate for Little Cottonwood Creek was estimated based on Site-specific data to be 3.0 cfs.

Using the above values for flow conditions, the background arsenic level, and the AWQC criteria, the ACL for arsenic under this scenario would range from 0.476 to 27.6 mg/l. (See attachment for calculations.)

Scenario 2

Under Scenario 2 determinations of ground-water flow and surface-water discharge to be utilized were based on my assessment of the Site-specific database. Data used included that from the Site Characterization and Feasibility Study reports as well as the quarterly monitoring program results. The evaluation focused on ground-water flow within the floodplain alluvium of the Creek. The hydraulic conductivity for MW-112 was used and the hydraulic gradient was determined based on ground-water flow between MW-112 and Well 2. The value for ground-water flow from the Site to the Creek was determined to be 0.0075 cfs based on this analysis. A low-flow discharge rate for Little Cottonwood Creek was estimated based on Site-specific data for SW-2 to be 2.5 cfs.

Using the above values for flow conditions, the background arsenic level, and the AWQC criteria, the ACL for arsenic under this scenario would be 61.2 mg/l. (See attachment for calculations.)

DISCUSSION OF ALTERNATE CONCENTRATION LIMIT RESULTS

The results of this exercise are ACLs for arsenic at the Site ranging from 0.476 to 61.2 mg/l. In theory these ACLs if attained at the POC should assure that the AWQC of 190 ppb is not exceeded in Little Cottonwood Creek due to contaminated ground-water discharge from the Site. These values are conservative in that no ground-water discharge from north of the Site was considered in this determination.

Based on the existing database for the Site, only the lowest determined ACL (0.476

mg/l) is exceeded in monitoring points (monitoring wells or hydropunch sample sites). The other values exceed any detected concentrations on-Site.

These ACLs show a range of over two orders of magnitude (0.476 to 61.2 mg/l). This range provides an indication of the levels of uncertainity in this type of determination. As a result, it is imperative that if this ACL approach is accepted as the remedial action for contaminated ground water at the Site, then a significant monitoring network needs to be established within the water-table aquifer on the floodplain along the Creek. This network will need to be routinely monitored for the contaminants of concern.

If you should have any questions, please feel free to contact me at x6595.

ACL CALCULATIONS

Scenario 1

AWQC: $C_{AWQC} = 0.19$ ppm

Background Surface-Water: $C_{BKG} = 0.007$ ppm (SW-2 maximum)

Ground-Water Flow: $Q_{GW} = KiA$ (FS modeling work)

$K = 5$ ft/d
$i = 0.008$ ft/ft
$A = 43{,}200$ ft^2

$Q_{GW} = 0.02$ cfs

$K = 154$ ft/d
$i = 0.028$ ft/ft
$A = 43{,}200$ ft2

$Q_{GW} = 1.92$ cfs

Surface-Water Flow: $Q_{SW} = 3.0$ cfs (Estimated)

ACL: $Q_{SW}C_{BKG} + Q_{GW}C_{ACL} = (Q_{SW} + Q_{GW})C_{AWQC}$

For $Q_{GW} = 0.02$ cfs

(3.0 cfs) X (0.007 ppm) + (0.02 cfs)C_{ACL} = (3.0 cfs + 0.02 cfs) X (0.19 ppm)
$C_{ACL} = 27.6$ ppm

For $Q_{GA} = 1.92$ cfs

(3.0 cfs) X (0.007 ppm) + (1.92 cfs)C_{ACL} = (3.0 cfs + 1.92 cfs) X (0.19 ppm)
$C_{ACL} = 0.476$ ppm

Scenario 2

AWQC: $C_{AWQC} = 0.19$ ppm

Background Surface-Water: $C_{BKG} = 0.007$ ppm (SW-2 maximum)

Ground-Water Flow: $Q_{GW} = KiA$

$K = 14$ ft/d (MW-112 slug tests)
$i = 0.0012$ ft/ft (1/97 ground-water flow between MW-112 and Well-2)
$A = 38{,}500\ \text{ft}^2$ ($A = b \times l = 11$ ft X 3500 ft)

$Q_{GW} = 0.0075$ cfs

Surface-Water Flow: $Q_{SW} = 2.5$ cfs (Estimated)

ACL: $Q_{SW}C_{BKG} + Q_{GW}C_{ACL} = (Q_{SW} + Q_{GW})C_{AWQC}$

(2.5 cfs) X (0.007 ppm) + (0.0075 cfs)C_{ACL} = (2.5 cfs + 0.0075 cfs) X (0.19 ppm)
$C_{ACL} = 61.2$ ppm

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET · SUITE 500
DENVER, COLORADO 80202-2466

MEMORANDUM

DATE: February 25, 1998

FROM: Rich Muza, 8EPR-EP

TO: Bonnie Lavelle, 8EPR-SR

SUBJECT: Determination of an Alternate Concentration Limit (ACL) for Arsenic in Ground Water at the Murray Smelter Site, Murray, Utah

As per your request, I have taken a final look at the determination of an ACL for arsenic in ground water at the Murray Smelter Site. ACLs for other analytes can easily be determined based on this work, if necessary.

I will not provide a thorough discussion of the concepts of the ACL determination as this information is detailed in my memorandum on this subject to you dated November 5, 1997. I will provide the ACL results based on the various scenarios detailed in that memo.

AN ALTERNATE CONCENTRATION LIMIT FOR ARSENIC AS APPLIED TO THE SITE

An ACL for arsenic at the Site will be developed for the protection of surface-water quality in Little Cottonwood Creek. The Utah Agricultural Water Standard of 0.1 ppm for arsenic will be applied to this determination. The logic behind this determination is to assure that ground water contaminated with arsenic upon discharge to Little Cottonwood Creek will be diluted by streamflow such that the 0.1 ppm concentration is not exceeded in the Creek. The determination is simply a mass balance calculation based on theoretical ground-water and surface-water flow conditions.

ALTERNATE CONCENTRATION LIMIT DETERMINATION FOR THE SITE

I have looked at a number of hydrologic scenarios — all based on Site-specific data — in the ACL determination. In all scenarios I considered the zone of contaminated ground-water discharge potentially impacting the Creek to be the stretch from SW-2 downstream to SW-3 or a distance of approximately 3500 feet. This assumption is based on a combined analysis of the ground-water flow directions and contaminant plume distributions at the Site; if both the Baghouse and Arsenic Storage Bin plumes were to migrate to the Creek, based on the existing ground-water flow information, their discharge and impacts to the Creek would occur between SW-2 and SW-3 . Also, in all scenarios I have only considered ground-water discharge to the Creek from the Site or south side as the Site-specific database focuses on this ground-water flow system; this is a conservative assumption as based on the conceptual model for the area a component of ground-water flow from the north discharging to the Creek will exist. Lastly, a background arsenic level in surface water of 0.007 ppm was used; this was the maximum value detected in samples from SW-2 where most of the sampling results were below the detection limit of 0.005 ppm. I will summarize each scenario and the ACL for arsenic below.

Scenario 1

Under Scenario 1 the determinations of ground-water flow and surface-water discharge utilized in ground-water flow and solute transport modeling for the Site Characterization and Feasibility Study reports were input into a mass balance equation. The values for ground-water flow from the Site to the Creek range from 0.02 to 1.92 cfs based on this analysis. A low-flow discharge rate for Little Cottonwood Creek was estimated based on Site-specific data to be 3.0 cfs.

Using the above values for flow conditions, the background arsenic level, and the Agricultural Standard, the ACL for arsenic under this scenario would range from 0.245 to 14.05 mg/l. (See attachment for calculations.)

Scenario 2

Under Scenario 2 determinations of ground-water flow and surface-water discharge to be utilized were based on my assessment of the Site-specific database. Data used included that from the Site Characterization and Feasibility Study reports as well as the quarterly monitoring program results. The evaluation focused on ground-water flow within the floodplain alluvium of the Creek. The hydraulic conductivity for MW-112 was used and the hydraulic gradient was determined based on ground-water flow between MW-112 and Well 2. The value for ground-water flow from the Site to the Creek was determined to be 0.0075 cfs based on this analysis. A low-flow discharge rate for Little Cottonwood Creek was estimated based on Site-specific data for SW-2 to be 2.5 cfs.

Using the above values for flow conditions, the background arsenic level, and the Agricultural Standard, the ACL for arsenic under this scenario would be 31.1 mg/l. (See attachment for calculations.)

DISCUSSION OF ALTERNATE CONCENTRATION LIMIT RESULTS

The results of this exercise are ACLs for arsenic at the Site ranging from 0.245 to 31.1 mg/l. In theory these ACLs if attained at the POC should assure that the Utah Agricultural Standard for arsenic of 0.1 ppb are not exceeded in Little Cottonwood Creek due to contaminated ground-water discharge from the Site. These values are conservative in that no ground-water discharge from north of the Site was considered in this determination.

The arsenic ACLs show a range of over two orders of magnitude (0.245 to 31.1 mg/l). This range provides an indication of the levels of uncertainity in this type of determination. As a result, it is imperative that if this ACL approach is accepted as the remedial action for contaminated ground water at the Site, then a significant monitoring network needs to be established within the water-table aquifer on the floodplain along the Creek. This network will need to be routinely monitored for the contaminants of concern.

If you should have any questions, please feel free to contact me at x6595.

ARSENIC ACL CALCULATIONS

Scenario 1

Utah Agricultural Standard: C_{AG} = 0.1 ppm

Background Surface-Water: C_{BKG} = 0.007 ppm (SW-2 maximum)

Ground-Water Flow: Q_{GW} = KiA (FS modeling work)

K = 5 ft/d	K = 154 ft/d
i = 0.008 ft/ft	i = 0.028 ft/ft
A = 43,200 ft^2	A = 43,200 ft2
Q_{GW} = 0.02 cfs	Q_{GW} = 1.92 cfs

Surface-Water Flow: Q_{SW} = 3.0 cfs (Estimated)

ACL: $Q_{SW}C_{BKG} + Q_{GW}C_{ACL} = (Q_{SW} + Q_{GW})C_{AG}$

For Q_{GW} = 0.02 cfs

(3.0 cfs) X (0.007 ppm) + (0.02 cfs)C_{ACL} = (3.0 cfs + 0.02 cfs) X (0.1 ppm)

C_{ACL} = 14.05 ppm

For Q_{GW} = 1.92 cfs

(3.0 cfs) X (0.007 ppm) + (1.92 cfs)C_{ACL} = (3.0 cfs + 1.92 cfs) X (0.1 ppm)

C_{ACL} = 0.245 ppm

Scenario 2

Utah Agricultural Standard: $C_{AG} = 0.1$ ppm

Background Surface-Water: $C_{BKG} = 0.007$ ppm (SW-2 maximum)

Ground-Water Flow: $Q_{GW} = KiA$

$K = 14$ ft/d (MW-112 slug tests)

$i = 0.0012$ ft/ft (1/97 ground-water flow between MW-112 and Well-2)

$A = 38{,}500$ ft^2 ($A = b \times l = 11$ ft $\times$ 3500 ft)

$Q_{GW} = 0.0075$ cfs

Surface-Water Flow: $Q_{SW} = 2.5$ cfs (Estimated)

ACL: $Q_{SW}C_{BKG} + Q_{GW}C_{ACL} = (Q_{SW} + Q_{GW})C_{AG}$

(2.5 cfs) X (0.007 ppm) + (0.0075 cfs)C_{ACL} = (2.5 cfs + 0.0075 cfs) X (0.1 ppm)

$C_{ACL} = 31.1$ ppm