FINAL Workplan

Remedial Investigation at the
ASARCO LLC Hayden
Plant Site
Hayden, Gila County, Arizona

Prepared for
U.S. Environmental Protection Agency
Region IX

75 Hawthorne Street
San Francisco, CA 94105

September 2005
Remedial Investigation at the ASARCO LLC Hayden Plant Site
Hayden, Gila County, Arizona

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September 2005
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<td>Arizona Ambient Air Quality Guideline</td>
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<tr>
<td>AAS</td>
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<td>Alternative RCRA Information for States</td>
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<td>ASTM</td>
<td>American Society for Testing and Materials</td>
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<td>ATSDR</td>
<td>Agency for Toxic Substances and Disease Registry</td>
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<td>AWQS</td>
<td>Arizona Aquifer Water Quality Standards</td>
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<td>BERA</td>
<td>Baseline Ecological Risk Assessment</td>
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<tr>
<td>bgl</td>
<td>below ground level</td>
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<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation, and Liability Act</td>
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<tr>
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<td>cubic feet per second</td>
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<tr>
<td>cm/sec</td>
<td>centimeter per second</td>
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<td>Chain of Custody</td>
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ACRONYMS, CONTINUED

EPA U.S. Environmental Protection Agency
EPCRA Emergency Planning and Community Right-to-Know Act
ERA Ecological Risk Assessment
ERS Emergency Response Section
ESI Expanded Site Inspection
FASP Field Analytical Support Program
FEMA Federal Emergency Management Agency
FGDC Federal Geographic Data Committee
FPXRF Field Portable X-Ray Fluorescence
FS feasibility study
FSP Field Sampling Plan
GIS Geographic Information System
gpm gallons per minute
GPS Global Positioning System
HASP Health and Safety Plan
HEAST Health Effects Assessment Summary Table
HHRA Human Health Risk Assessment
HQ hazard quotients
HRS Hazard Ranking System
IDW investigation-derived waste
ISCST Industrial Source Complex Short Term
LUST leaking underground storage tank
MARSSIM Multi-Agency Radiation Survey and Site Investigation Manual
MCL maximum contamination level
mg/kg milligrams per kilogram
mg/L milligrams per liter
MRL minimum risk levels
MSHA Mine Safety and Health Administration
msl mean sea level
NAAQS National Ambient Air Quality Standards
<table>
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<tr>
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<td>NCEA</td>
<td>National Center for Environmental Assessment</td>
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<td>NOAELs</td>
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<td>NOECs</td>
<td>No observed effects concentrations</td>
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<td>Notice of Violation</td>
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<td>NPL</td>
<td>National Priorities List</td>
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<td>Occupational Safety and Health Administration</td>
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<td>PA</td>
<td>Preliminary Assessment</td>
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<td>PCAMP</td>
<td>Pollution Control and Mitigation Plan</td>
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<td>PDOP</td>
<td>position dilution of precision</td>
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<td>PHA</td>
<td>preliminary hazardous analysis</td>
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<td>photoionization detector</td>
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<tr>
<td>PM</td>
<td>particulate matter</td>
</tr>
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<td>PM$_{10}$</td>
<td>particulate matter smaller than 10 microns</td>
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<td>PM$_{2.5}$</td>
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<td>PPE</td>
<td>personal protective equipment</td>
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<td>ppm</td>
<td>parts per million</td>
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<tr>
<td>PPRTVs</td>
<td>Provisional Peer Reviewed Toxicity Values</td>
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<td>Quality Assurance</td>
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<td>Quality Assurance Manager</td>
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<tr>
<td>RA</td>
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<td>RAGS</td>
<td>Risk Assessment Guide for Superfund</td>
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<td>RAP</td>
<td>Risk Assessment Plan</td>
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<td>RCCC</td>
<td>Ray Consolidated Copper Company</td>
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<td>RD/RA</td>
<td>Remedial Design/Remedial Action</td>
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<td>RI</td>
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<td>RI/FS</td>
<td>Remedial Investigation/Feasibility Study</td>
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RMS  Root Mean Square
RPM  Remedial Project Manager
R-SRL Residential Soil Remediation Levels
SAP  Sampling and Analysis Plan
SCFM standard cubic feet per minute
SCS Supplementary Control Systems
SI  Screening Site Inspection
SLAMS State and Local Air Monitoring Station
SLERA Screening Level Ecological Risk Assessment
SM  Site Manager
SNR  signal to noise ratio
SO₂ sulfur dioxide
SOP  Standard Operating Procedures
SVOC semi volatile organic compound
TAL  Target Analyte List
TCLP Toxicity Characteristic Leaching Procedure
TDS total dissolved solids
TNC The Nature Conservancy
TOC total organic carbon
TPH Total Petroleum Hydrocarbon
TRI Toxics Release Inventory
TRVs toxicity reference values
TSP total suspended particulate
µg/L micrograms per liter
µg/m³ micrograms per cubic meter
USFWS U.S. Fish and Wildlife Service
USGS U.S. Geological Survey
UST underground storage tank
VOC volatile organic compound
WAAS Wide Area Augmentation System
XRF  x-ray fluorescence
1.0 Introduction

1.1 Purpose and Context of Workplan

The purpose of this workplan is to present the rationale and procedures for implementing a Remedial Investigation (RI) at the ASARCO LLC (ASARCO) Hayden Plant site (Site) in Hayden, Arizona. The workplan includes an investigation of air, surface and subsurface soil, groundwater, surface water, and sediments in areas of potential concern, and provides for screening level assessment of risks posed to human health and the environment.

This workplan was prepared for the U.S. Environmental Protection Agency (EPA) Region IX as Work Assignment No. 198-RICO-09JS under Contract No. 68-W-98-225. This final version of the workplan was prepared following a 30-day public comment period on the draft workplan provided in August 2005.

1.2 Statement of the Specific Problem

The Site consists of ASARCO’s crusher, concentrator, smelter and tailings deposition. The crusher is located on the north side of Highway 177, south of Hayden. The concentrator operation includes milling operations and two thickener tanks. An overhead conveyor, which is approximately 2,000 feet long, has an overhead portion (about 400 feet in length) that passes over some of Hayden’s streets and directs ore from the crusher to the concentrator operations. ASARCO’s smelting operations are located approximately 2,000 feet east-northeast of Hayden. Tailings from the concentrator operations are transported, as a slurry, to one of two multiple-tier tailings piles (Tailings Pile AB/BC and Tailings Pile D) located south and west of Hayden. Tailings Pile AB/BC is located south of Highway 177 and north of the Gila River, and is approximately two and one-half miles long, one mile wide at its widest point and 200 feet high. Tailings Pile D is located south of the Gila River, parallel to Tailings Pile AB/BC. This pile is approximately two miles long, 1,500 feet wide and 150 feet high. See Section 2.0 for a detailed Site description.

The operational history of the Site and investigations conducted to date indicate that contaminants (primarily metals) from smelter emissions, crushing and concentrator operations, the tailings piles, process water discharges to unlined ponds, and other process operations have migrated to the air, surface soil, sediments, and groundwater in the Hayden area:

a) **Air:** The Arizona Department of Environmental Quality’s (ADEQ) Air Quality Division maintains an air monitoring station in the abandoned Hayden Jail building, about one-half mile west of ASARCO’s smelting operations. The station monitors sulfur dioxide (SO₂) and particulate matter smaller than 10 microns (PM₁₀ only, and has been in operation since approximately 1969. PM₁₀ parameters monitored at the station include arsenic, lead, cadmium, copper, and nickel. SO₂ emissions were detected in excess of the National Ambient Air Quality Standards (NAAQS) in 1987, 1988, and 1989. Data from
ADEQ’s monitoring station also indicated that the 24-hour Arizona Ambient Air Quality Guideline (AAAQG) for arsenic was exceeded every year from 1991 to 2000, and the annual AAAQG for arsenic has been exceeded every year since 1991. There is no NAAQS for arsenic, and the AAAQG is not enforced.

b) **Soils**: The analysis of soil samples collected from residential yards in Hayden and Winkelman as part of the Expanded Site Inspection (ESI) and EPA Removal Assessment (RA) showed the presence of arsenic, lead, and copper above Arizona Residential Soil Remediation Levels (R-SRLs). In addition, the concentrations of cadmium, mercury and zinc were greater than three times average background levels in some soil samples (Expanded Site Inspection Report: ASARCO, Inc., Hayden Plant [ADEQ, 2003] and ASARCO Hayden Removal Assessment: Final Report [Ecology & Environment, 2004]).

c) **Sediments**: A 1993 flood washed approximately 292,000 tons of tailings into the Gila River directly from Tailings Pile AB/BC; analysis of the sediment collected adjacent to the tailings piles indicated copper and zinc at concentrations three times the levels detected in background samples. Analysis of river sediment samples collected as part of the ESI documented arsenic and copper levels above the R-SRLs (ADEQ, 2003).

d) **Groundwater**: Arsenic was detected in groundwater samples collected from monitoring wells located downgradient of containment pond CP-1 at the Site in 1992, at concentrations exceeding the Arizona Aquifer Water Quality Standards (AWQS). Arsenic and cadmium contaminant concentrations exceeding the AWQS were found in groundwater samples from monitoring well SM-2 (located downgradient of CP-1) in 1994 as part of the Aquifer Protection Permit (APP) Supplemental Investigation (SHB, 1994b). Elevated levels of arsenic and cadmium above AWQS were also found in monitoring wells as part of the ESI (ADEQ, 2003). Production wells serving Hayden and Winkelman are completed in the shallow alluvium adjacent to the Gila River and are generally downgradient of Site operations.

Therefore, impacts to air, surface soils, groundwater, and sediments have been documented. Other potentially impacted media include surface water (which may be impacted as a result of runoff from Site areas, tailings ponds, and as a result of impacted river sediments) and dust in residential dwellings. Both impacted and potentially impacted media will be further investigated as part of the RI.

The main problem at the Hayden site at this time is that the level of risk to community members and the environment is unknown. Additionally, an understanding of the extent of contamination in soil and water and ongoing in air emissions is incomplete.

Preliminary Conceptual Site Models (CSMs) that outline the primary and secondary sources and release mechanisms, potentially complete exposure pathways and routes, and potential receptors were developed for human and ecological receptors. These CSMs are presented in Figures 1-1 and 1-2 for human and ecological exposures, respectively.

As depicted in Figure 1-1, releases from current or historic Hayden smelter and concentrator operations are the primary source of offsite impacts from the Site. Together, the smelters and concentrator are the source of solid waste releases to soil, fugitive and stack emissions to air, and process wastewater releases. The primary release mechanisms are expected to be spills and releases from onsite operations, and fugitive and stack air emissions releases.
Secondary sources would be onsite and offsite soils and groundwater. Potential secondary release mechanisms would be infiltration (leaching and percolation) to groundwater and particulate and dust emissions to ambient air.

Dispersion transport media would include soil, groundwater, surface water, and wind. Potential human exposure routes would include soil (sediment) and dust ingestion, dermal contact, inhalation of particulates and vapors (if any) both indoors and outdoors, tap water ingestion, as well as ingestion of garden vegetables and sport fish caught in the Gila River.

Currently, potential applicable human receptors would be those of Hayden and Winkelman including adult and child residents, school children in schoolyards, pools, and parks, trespassers on tailings piles, and anglers in the nearby Gila River and San Pedro River, as appropriate.

For ecological receptors (see Figure 1-2), the primary sources are similar to those described above; namely, current or historic activities of the smelter and concentrator. Primary release mechanisms include air emissions from the smelter stacks and other process locations, as well as solid wastes (tailings) and wastewater associated with the processing of the copper ore. Secondary sources of potential contaminants are surface soils (including the tailings piles or ponds adjacent to the Gila River) and air. Release mechanisms include aerial deposition of stack emissions, discharge/runoff from the tailings piles to the Gila River or to adjacent soils, wind erosion, leaching to groundwater, and surface discharge from groundwater. Complete exposure pathways from contaminated surface soil, sediment, surface water (including ponded water located on top of the tailings piles), biota, and possibly groundwater, to ecological receptors exist at the Site.

Contaminants in soil may be directly bioaccumulated by terrestrial plants, soil invertebrates, or micro-organisms. Additionally, terrestrial plants may be exposed by uptake from contaminated groundwater or surface water sources or by aerial deposition on to foliage. Aquatic plants are primarily exposed by contaminated sediment. Benthic invertebrates are primarily exposed through sediment and fish and amphibians are primarily exposed through surface water. Terrestrial and aquatic wildlife, including reptiles, may be exposed directly to contaminants in surface water through ingestion and to contaminants in soil or sediment by incidental soil or sediment ingestion, dermal contact, or inhalation of wind-borne particles. Terrestrial and aquatic invertebrates and wildlife (i.e., amphibians, reptiles, birds and mammals) may also receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (e.g., plants to herbivores, plants and prey animals to omnivores, etc.).

As part of this workplan, gaps in the available site characterization data will be identified and data needs for the Human Health Risk Assessment (HHRA) and the Ecological Risk Assessment (ERA), which are parts of this RI, will be identified. The data collection proposed in this workplan will address the identified data needs.

For human receptors, the major environmental media associated with off-Site exposures to Site-related releases are expected to be soil and air, which will be supported by the major focus in sampling for the Site. Groundwater, drinking water, and sediments are expected to be relatively minor sources of risks and hazards, and will receive a comparatively lower level of sampling.
Soil, sediment, and surface water are the primary environmental media for ecological exposures; therefore, the sampling strategy will include samples of these media within areas of ecological habitat. It is unknown at this time whether groundwater is being adversely impacted by the smelter concentrator operations or leaching from the tailings piles; therefore, these pathways will be evaluated with limited sampling.

1.3 Overview of Areas of Potential Concern

For purposes of this workplan, several areas of potential concern have been identified and will be further investigated.

On-Site Areas:

These areas that are on or adjacent to the Site include:

1. Former Kennecott smelter area;
2. Concentrator operations;
3. Smelter operations;
4. Impoundments, drainage channels and washes;
5. Tailings Pile AB/BC; and
6. Tailings Pile D.

Off-Site Areas:

Areas of potential concern, which are off-Site but may be impacted by Site operations, include:

1. Residential yards and homes in Hayden and Winkelman;
2. Public areas such as schools in Winkelman and playgrounds in Hayden and Winkelman;
3. Gila River and San Pedro River floodplains and environs; and
4. Upland and background areas.

Note that the extent of sampling in the concentrator and smelter areas, as well as the tailings piles, will be dependent on degree of difficulty in accessing these active operational areas.

1.4 Objectives of Remedial Investigation

The overall purpose of the RI is to conduct a multi-media RI in the areas of potential concern to identify contaminants, pathways and potential threats to human and ecological receptors. Specific project objectives include:

1. Evaluate Site-related impacts on soils in selected areas;
2. Evaluate Site-related impacts on sediments in impoundments, surface water drainage channels, and the Gila and San Pedro Rivers;
3. Evaluate Site-related impacts on surface water along the Gila River, San Pedro River, and environs;
4. Evaluate Site-related impacts on groundwater quality, and better define groundwater flow conditions, at the Site and study area;
5. Evaluate Site-related impacts on air at the Site and study area;
6. Prepare combined baseline/screening-level HHRA;
7. Prepare screening-level ERA;
8. Identify preliminary remedial alternatives and assess the need for pilot testing; and
9. Prepare a comprehensive report of procedures and results.

1.5 Activities to be Conducted

The activities to be completed as part of the RI were developed in consideration of existing historic data, which is summarized in Section 2.0, and the identification of key data gaps, which is provided in Section 4.0. The RI activities include the following tasks:

Task 1 – Site Reconnaissance and Sample Location Confirmation
Task 2 – Mobilization and Demobilization
Task 3 – Field Investigation
  Task 3a – Prepare Site-Specific Plans
  Task 3b – Surface Soil Sampling
  Task 3c – Surface Water and Sediment Sampling
  Task 3d – Groundwater Investigation and Sampling
  Task 3e – Air Investigation and Dust Sampling
  Task 3f – Ecological Investigation
  Task 3g – Geotechnical Evaluation of Tailings Piles
  Task 3h – Surveying and Mapping
  Task 3i – Investigation Support Activities
Task 4 – Sample Analysis
Task 5 – Data Validation
Task 6 – Data Evaluation
Task 7 – Evaluation of Risk
  Task 7a – Combined Baseline/Screening Level HHRA
  Task 7b – Screening-Level ERA
Task 8 – Assess Needs for Treatability Studies and Pilot Testing
Task 9 – Remedial Investigation Report
1.6 Future Investigation Phases

The RI is intended to identify potential threats to human and ecological receptors resulting from Site operations. This current phase of the investigation will be relatively complete for soil, air and water. However, the data generated during this study may indicate the need for additional data collection. Future phases of work, if needed, will be conducted at the discretion of EPA in consultation with ADEQ.

1.7 Responsible Agency

The EPA is the lead responsible agency for the RI. However, the ADEQ Air Quality Division, Waste Program Division, Water Quality Division, and Tanks Program Division are expected to maintain ongoing state regulatory oversight for any open issues relative to each division.

Representatives from other agencies, such as the Arizona Department of Water Resources (ADWR), the Arizona Game and Fish Department (AGFD), and local municipalities and water providers (including the Arizona Water Company), may provide technical assistance and comments on documents prepared for the Site.

1.8 Project Organization

Table 1-1 includes the project organization. The overall responsibility for the project rests with the EPA Remedial Project Manager (RPM). Implementation and administration of the Quality Assurance (QA) Program for this project will be the responsibility of the Quality Assurance Manager (QAM). The QAM’s areas of responsibility include review and approval of the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) and any modifications to them, performance of quality audits and surveillance, performance or oversight of data management and data validation, preparation of quality assurance reports, and resolution of quality-related issues. The QAM will act as liaison between the project team and the laboratory. Any problems identified by the laboratory will be brought to the attention of the QAM through a Corrective Action Report. The QAM will then be responsible for coordination of corrective action under the direction of the Program Manager.

The CH2M HILL Site Manager (SM) will review the financials, schedules, and technical status of the work assignment. The SM will interface with the RPM, the task managers, and the QAM. The technical review team will review all deliverables and monitor the quality and delivery of the reviews. Where quality assurance problems or deficiencies requiring special action are uncovered, the SM, RPM, and the senior review team will identify the appropriate corrective action to be initiated by the SM.

1.9 Project Schedule

Section 9.0 contains a detailed description of the project schedule. The project schedule will begin with written notification to proceed from EPA. A month by month schedule of activities is included in Figure 9-1. The schedule includes major tasks starting with notice to
proceed and ending with submittal of a final summary report. Each task description includes beginning and ending dates.
2.0 Background

2.1 Site Location and Description

For purposes of this workplan, the Site incorporates the towns of Hayden and Winkelman, and surrounding areas along State Highway 177 in both Gila and Pinal Counties, Arizona. Generally, the Site is concentrated within several sections of Township 5 South, Range 15 East. Hayden is located approximately 100 miles southeast of Phoenix and 50 miles northeast of Tucson, Arizona. Winkelman is located approximately one mile southeast of Hayden. Figure 2-1 shows the general location of the Site; and Figure 2-2 shows the arrangement of residential, commercial, and industrial facilities; drainage patterns; and definition of the overall areas of potential concern.

The areas of potential concern for the RI are located on and in the vicinity of the Site, and generally include the following:

- Residential and public areas within the towns of Hayden and Winkelman;
- Selected process facility areas associated with ASARCO concentrator and smelter operations and the former Kennecott smelter areas;
- Gila River and San Pedro River floodplains and environs extending along the Gila River from approximately two miles upstream of Winkelman to five miles downstream of Last Chance Basin; and along the San Pedro River approximately two miles upstream of the confluence with the Gila River;
- Surface water drainages within Hayden that are in proximity to ASARCO process facilities, including Kennecott Avenue, Power House Canyon, and San Pedro Washes; and
- Upland and background areas.

Hayden has a population of approximately 900 residents (Arizona Department of Commerce, 2005). ASARCO operations including the active smelter, former Kennecott smelter, crushing, milling, concentrator, and tailings piles surround the Hayden community on the northern, southern and eastern edges of town. Residential areas are confined on the west edge of town by the San Pedro Wash, and are bisected by Kennecott Avenue Wash. Public areas including a playground and swimming pool are located adjacent to and west of ASARCO’s concentrator facilities.

Winkelman has a population of approximately 450 people (Arizona Department of Commerce, 2005). It is primarily a residential area, with a school complex on the north edge of town, commercial development along State Highway 177, and a community park along the Gila River on the east edge of town.

ASARCO’s overall process operations area includes the No. 9 conveyor extending from the crusher facilities on the north side of State Highway 177 to the concentrator facilities on the east edge of the residential areas, active smelting operations approximately one-half mile.
northeast of the town, a former Kennecott smelter area on the north edge of town and north of the concentrator complex, tailings slurry pipeline extending from the concentrator to Tailings Pile AB/BC and Tailings Pile D located adjacent to the Gila River, and process/storm water management facilities (ADEQ, 2003). Although closely related, ASARCO manages the concentrator and smelter operations separately, and each has a separate entrance. The active smelter is approximately 11 stories tall, and treated air emissions are released to the atmosphere through a 1,000 foot tall stack. Slag from active smelter operations is deposited in a dump located immediately southeast of the smelter. The former Kennecott smelter area is currently subject to demolition work, which consists of miscellaneous building debris, storage tanks, foundations, and an abandoned slag dump northwest of the former smelter; the former and inactive Kennecott smelter stack will not be subject to the currently planned demolition activity (ASARCO, December 15, 2004).

Tailings Pile AB/BC is located south of State Highway 177 and north of the Gila River; extending for a length of approximately two and one-half miles, maximum width of one mile, and height of 200 feet. Tailings Pile D is located south of the Gila River; extending for a length of approximately two miles, maximum width of 1,500 feet, and height of 150 feet. Process/storm water management facilities consist of multiple small surface water impoundments located throughout the concentrator and smelter areas, Power House Canyon Wash (bisecting the active smelter area and concentrator/Hayden residential areas), retention ponds located south-southeast of Tailings Pile AB/BC, a large retention pond (Last Chance Basin) at the northwest edge of Tailings Pile AB/BC, and containment berms in selected areas.

Hayden’s drinking water is supplied by a well field located south of Hayden, east of Tailings Pile AB/BC, and west of Winkelman. Winkelman’s water is supplied by three wells located east of town within the community park adjacent to the Gila River (ADEQ, 2003).

2.2 Operational History

The operational history of the ore processing operations in the Hayden-Winkelman area is described in several sources, including recent reports on investigations of multi-media contamination in the area. Further, a historical photographic analysis conducted to provide support to field investigations in the area is provided in Aerial Photographic Analysis of ASARCO Hayden Study Area, Gila and Pinal Counties, Arizona; U.S. Environmental Protection Agency; December 2004 (EPA, 2004a). The analysis documents environmental conditions and industrial activities on nine different dates over a period extending from 1958 through 2004.

The Ray Mine has been mined for copper since approximately 1880. One of the first owners of the mine was Ray Copper Company. This company transitioned to Ray Consolidated Copper Company (RCCC) with the acquisition of Globe Mines Exploration Company, Ltd. and Gila & Ray Copper Mines in 1898 and 1906, respectively. During this period, the Towns of Winkelman and Hayden were founded. Winkelman was founded in 1887, and Hayden was founded in 1909 as a company town to provide housing for workers supporting the mining and smelting operations (EPA, 2004a). ASARCO constructed its Hayden smelter in 1911 and began operations to process ore from the Ray Mine in 1912. In 1933, Kennecott Copper Company (Kennecott) bought the Ray Mine from RCCC. The ASARCO Hayden smelter stopped receiving ore from Ray Mine in 1958, at which time Kennecott began
2.0 BACKGROUND

ASARCO completed modernization of its Hayden smelter in 1983; including installation of an oxygen flash smelting furnace, construction of an oxygen plant to produce oxygen for the new furnace, construction of a second sulfuric acid plant to capture and re-use SO₂ emissions produced during smelting, and construction of a wastewater treatment plant to recover process water from the sulfuric acid plant for re-use. ASARCO’s smelter renewed processing of ore from the Ray Mine in 1983, and ASARCO bought the Ray Mines Division from Kennecott in 1986. The Ray Complex was created from control of both the mine and processing operations. In 1996, the Hayden concentrator modernization was completed (ADEQ, 2003).

In the current operations, sulfide ore is transported from the Ray Mine and off-loaded at the track hopper into the crusher facility. Crushed ore is transported by the No. 9 conveyor to the concentrator, where the ore is milled, mixed with a chemical solution, and aerated. The copper concentrates created from this process are transported to the smelter for further processing (the smelter also receives concentrates directly from the Ray Mine operations). The tailings waste is transported as a slurry to be deposited on Tailings Piles AB/BC and D. The concentrates transported to the smelter are unloaded and blended with fluxes, then transferred to fluid bed dryers where they are dried and stored prior to being introduced into the oxygen flash furnace and subsequently, converter furnaces to produce 98.5 percent pure copper. Copper is further processed in anode furnaces to produce copper anodes that are 99 percent pure. The anodes are shipped off-Site for final processing (ADEQ, 2003).

During the smelting process, sulfur from the ore is oxidized to form SO₂ gas, which is converted to sulfuric acid in the sulfuric acid plant. Slag from the smelter operations is transferred to stockpiles located southeast of the smelter operations area. Treated wastewater and other process waters are discharged to containment pond CP-1, located east of the smelter. Decant water from the tailings piles is discharged to retention ponds located east of Tailings Pile AB/BC, where it is reclaimed into the process operations (ADEQ, 2003).

2.3 Site Topography and Drainage

The ASARCO Site is located near the western edge of the Mexican Highland portion of the Basin and Range physiographic province (SHB, 1992). This province is characterized by north-northwest trending mountain ranges separated by sediment-filled valleys derived from erosion of the adjacent ranges. Major fault systems typically parallel the length of the uplifted mountain blocks. Hayden is located on the southwestern flank of the Dripping Spring Mountains, near the confluence of the Gila and San Pedro Rivers. The Tortilla Mountains, which form the western border of the Gila River Valley, are located several miles to the west of Hayden. Relief is moderately gentle in the Tortilla Mountains, transitioning to moderately steep slopes in the central and eastern portions of the Hayden area. Elevation ranges from 3,947 feet above mean sea level (msl) at Horse Hills in the Tortilla Mountains to about 1,800 feet msl at the Gila River in the northwest corner of the Site. The highest point in the area is Tornado Peak (located about three miles north of Hayden) at 4,484 feet msl. Drainage in the Hayden area is generally to the northeast of the Gila and San Pedro Rivers, and the Site contains one well-defined wash, Romero Wash, and
a number of poorly defined washes. There are two relatively small washes, known as Power House Canyon Wash and Kennecott Avenue Wash, that run southwest through the Site and Hayden. The Power House Canyon Wash runs parallel to the conveyor belt. San Pedro Wash is another small drainage feature located west of Hayden. A gently sloping alluvial surface slopes northeastward from the Tortilla Mountains to the Gila and San Pedro Rivers. The area east of the Gila and San Pedro Rivers is characterized by a dissected upland area that drains to the west.

The Hayden concentrator and smelters are located in Hayden near the base of the Dripping Spring Mountains, adjacent to and elevated above the floodplain of the Gila River. Elevations at the Site range from approximately 2,000 feet near Highway 177, to approximately 2,200 feet near the process water tank located north of the former Kennecott smelter area. The town of Winkelman is located southeast of Hayden. North of the main Hayden Site (smelter, concentrator, Tailings Pile AB/BC) is Tornado Peak; the western boundary follows a ridge located just east of Schneider Canyon that extends from Tornado Peak to the Tailings Pile AB/BC area. The eastern Site boundary follows a ridge located just west of O’Carroll Canyon that extends from Tornado Peak to the Gila River. Tailings Pile AB/BC is bounded on the north by the Southern Pacific Railroad tracks and on the south by the channel of the Gila River. Tailings Pile AB/BC extends west to the confluence of Keystone Canyon Wash with the Gila River (SHB, 1992). The Southern Pacific Railroad tracks terminate at Winkelman, and Highway 177 joins Highway 77, which follows the Gila River to the north and the San Pedro River to the south.

The area south of the Gila River includes Tailings Pile D and extends from the Tortilla Mountains on the west to the Gila and San Pedro Rivers on the east. This area is bounded on the northeast by the Gila and San Pedro Rivers, on the southeast by a ridge line, located just north of Swingle Wash, extending from the Tortilla Mountains to the San Pedro River, and on the northwest by a ridge line, located south of Smith Wash, extending from the Tortilla Mountains to the Gila River.

The topography and surface water flow conditions in the Hayden operations area on the north side of the river are complex. Recent topographic mapping performed by ASARCO indicates, in addition to numerous structures, roads, storage areas, and materials piles, a complex system of natural and man-made channels, pipes, ponds, and dikes are in place to control surface water flows in the area. ASARCO personnel indicate that all storm water runoff from the Hayden operations area is captured by this system before the storm runoff can enter the Gila River, with the exception of storm runoff from the downgradient/downstream edge of the berm/dike around Tailings Pile AB/BC (ASARCO, January 20, 2005).

Surface water hydrology is discussed in more detail in Section 2.4.

2.4 Surface Water Hydrology

The Site is located in the vicinity of two main rivers, the Gila River and the San Pedro River. The Gila River flows southwestward from the San Carlos Reservoir (created by the Coolidge Dam, about 30 miles upstream, which was completed in 1928) through the Mescal Mountains and southern portion of the Dripping Spring Mountains, turns northwestward at
Hayden, and flows through the valley between the Dripping Spring Mountains and the Tortilla Mountains. The Gila River then flows westward at Kelvin, traverses the Tortilla Range, and flows to the Ashurst-Hayden Dam where water is diverted into the canal system comprising the San Carlos Irrigation System. The San Pedro River flows northwestward from southeast Arizona and empties into the Gila River approximately one-half mile south of Hayden.

The ASARCO Hayden area north and west of the Gila River is drained by a series of intermittent streams unnamed on the U.S. Geological Survey (USGS) topographic quadrangle maps. The boundaries of the watershed in which the north Hayden area is situated were delineated using USGS 7-1/2 minute topographic quadrangle maps for Hayden and Winkelman (SHB, 1992). The watershed area was determined to be two and one-half square miles (APP Application Phase III, ASARCO, Inc. - Ray Complex, Gila and Pinal Counties, Arizona [SHB, 1994a]).

USGS stream gaging records are available for gages on the Gila River above and below Coolidge Dam and at Kelvin (about ten miles downstream from the confluence with the San Pedro River). Because the Gila River flows between Tailings Piles AB/BC and D, the flow region of primary interest is downstream of the confluence with the San Pedro River. Although systematic stream gaging records are not available for this flow region, USGS publications present estimates of flows during some historic large flood events (USGS, 2005).

Precipitation for the 100-year/six-hour design storm event was determined from the National Oceanic and Atmospheric Administration Atlas 14, Precipitation Frequency Atlas for the United States: Volume 1 - Semiarid Southwest. 2003 (NOAA, 2003) to be 2.92 inches. An estimated average curve number of 93 was selected based on the soil profile (a relatively thin layer of surface soils over bedrock) and the generally sparse vegetation in the undeveloped areas over the watershed, and the high percentage of relatively impervious areas, under buildings, roads, ponds, tanks, and other features, in the developed areas.

As described in Section 2.3, the topography and surface water flow conditions in the Hayden operations area on the north side of the river are complex. ASARCO maintains numerous structures, roads, storage areas, and materials piles, a complex system of natural and man-made channels, pipes, ponds, and dikes to control surface water flows in the area. ASARCO personnel indicate that all storm water runoff from the Hayden operations area is captured by this system before the storm runoff can enter the Gila River, with the exception of storm runoff from the downgradient/downstream edge of the berm/dike around Tailings Pile AB/BC.

Storm water at the plant and in surrounding areas drains to CP-1 (formerly known as Louie’s Lagoon). CP-1 is a pond, which, in addition to runoff from the smelter area storm drains, collects blowdown from the anode cooling tower, treated effluent from various treatment plants, process machinery cooling water, and air conditioner and swamp cooler blowdown as well. CP-1 was originally unlined. Excess water from Louie’s Lagoon was pumped to the three Terrace Ponds, the seven North Ponds, and Wimpy’s New Pond, which are located further to the north; however this practice was discontinued when CP-1 was constructed, and the sediments from the upper ponds were removed (ASARCO, September 2005). All of these ponds receive storm runoff. Surface runoff from the revert
stockpile area would likely drain toward the surface impoundment. A concrete lined sump is located at the southwest corner of containment pond CP-1. A lined containment pond is located southwest of the smelter, but does not currently receive process water from the smelting operations. There is another storm water retention pond located east of Tailings Pile AB/BC, south of Hayden. These retention ponds receive decant water from tailings ponds located on top of the tailings piles. (ADEQ, 2003)

Unlined depressions that collect storm water are located downhill from the slag pile. The East Storm Water Collection Area No. 1, principally contains storm water runoff, although some dust suppression and fire protection water for the slag pile may also be collected. The East Storm Water Collection Area No. 2 collects overflow from No. 1 and is normally dry. The south storm water collection areas contain storm water runoff only and are normally dry. The storage ponds north of the slag deposition area, including Louie’s Lagoon, have apparently received runoff and other waters for several years. A low permeability layer exists in the bottom of some of these ponds.

A diversion ditch has been constructed on the upstream (south) side of the Site to carry surface runoff from upgradient undisturbed ground into Romero Wash on the east and Smith Wash on the west. A small dike has been constructed directly north of the Site, between the tailings and the Gila River.

In 1993, a breach in Tailings Pile AB/BC caused by a flood event released 292,000 tons of tailings into the Gila River. This event was directly observed, and samples were collected as far as 11 miles downstream of the tailings piles. Sediment samples collected along the Gila River indicated that copper and zinc concentrations were elevated (ADEQ, 2003).

### 2.5 Terrestrial and Aquatic Systems

The Site is located in southern Arizona in and near the Towns of Hayden and Winkelman, Arizona. Hayden is at an elevation of about 2,100 feet and Winkelman is at about 1,970 feet in elevation above msl. Based on general climatological information obtained from the Hayden Community Profile provided by the Arizona Department of Commerce, Hayden has an annual average precipitation of 13.9 inches and temperatures range from a low of about 30°F in winter to a high of about 103°F in summer. The yearly average low is 46°F and the yearly average high is 84°F. Precipitation primarily occurs in two periods, winter (December to March) and summer/fall (July to October), with the most precipitation in July and August.

Descriptions of the terrestrial and aquatic systems in the Site study area are derived from literature. For example, general information on the terrestrial habitat in the area was obtained from *Biotic Communities: Southwestern United States and Northwestern Mexico* (Brown, 1994). More Site-specific descriptions of both terrestrial and aquatic (primarily the associated riparian areas) habitats were obtained from ecological studies conducted along the Gila and San Pedro Rivers ranging from southeast of Winkelman along the San Pedro River to northwest of Hayden past Kelvin along the Gila River.
2.5.1 Terrestrial Systems

The Site is located in the northeastern corner of the Sonoran desertscrub biome. This biome represents a large arid region that encompasses most of the Baja California Peninsula, the western half of the State of Sonora, Mexico, and large areas in southeastern California and southwestern Arizona (Brown, 1994). The Sonoran Desert has a bimodal rainfall pattern (rains in winter and summer), which allows it to have a greater structural diversity (i.e., large cacti and succulent plants in most regions and trees, tall shrubs, and succulents along drainages) than any of the other North American deserts.

Brown (1994) presents six subdivisions of this biome, including Lower Colorado River Valley, Arizona Upland, Plains of Sonora, Vizcaino, Central Gulf Coast, and Magdalena plain. The smelter is located in habitat characterized as Arizona Upland. This subdivision is also referred to as Arizona Desert, Paloverde-Cacti Desert, and Cercidium-Opuntia Desert. About 90 percent of this region is on slopes, broken ground, and multi-dissected sloping plains. It is the best watered and least desert-like desertscrub habitat in North America.

Upland communities are dominated by Paloverde (Cercidium spp.) and cacti (Opuntia spp.) desert associations (Hatten and Paradzick, 2003). Three series in the subdivision include Paloverde-Cacti Mixed Scrub series, the most extensive series, Jojaba-Mixed Scrub series, and Creosotebush-Crucifixion-thorn series (Brown, 1994). The Paloverde-Cacti-Mixed Scrub series is dominated by Paloverde, a leguminous tree, and the columnar cactus, Carnegiea gigantea. As indicated in the name, the Jojaba-Mixed Scrub series is dominated by Jojoba (Simmondsia chinensis), which is a very valuable forage plant for game and domestic stock. The Creosotebush-Crucifixion-thorn series is common near the San Carlos Reservoir, Arizona. The crucifixion-thorn (Canotia holocantha) is a low, spiny, leafless tree generally found on hillsides. It often grows with creosotebush (Larrea spp.). This series often shares many characteristics with the Mojave Desert.

The Arizona Upland subdivision has structural density and adequate winter precipitation to support a variety of wildlife species. Some large mammals include desert mule deer (Odocoileus hemionous crooki) and Javelina (Dicotyles tajacu), whereas smaller mammals in the area consist of species such as the California leaf-nosed bat (Macrotus californicus), California Myotis (Myotis californicus) black-tailed jackrabbit (Lepus californicus), desert cottontail (Sylvilagus audubonii), Arizona pocket mouse (Perognathus amplus), Bailey’s pocket mouse (P. baileyi), cactus mouse (Peromyscus eremicus), white-throated wood rat (Neotoma abigula), gray fox (Urocyon cinereoargenteus), and the endemic Harris antelope squirrel (Ammospermophilus harrissii) (Brown, 1994).

Brown (1994) also reports on common avian species of the Paloverde-Cacti-Mixed Scrub series within the Arizona Upland subdivision. These include the Harris’ hawk (Parabuteo unicinctus), white-winged dove (Zenaida macroura), Inca dove (Scardiafella inca), elf owl (Micrathene whitneyi), Wied’s crested flycatcher (Myiarchus tyrannulus), and pyrrhuloxia (Cardinalis sinuatus). Other species such as the cactus woodpeckers (Melanerpes uropygialis, Colaptes chrysoides, and Picoides scalaris), curve-billed thrashers (Toxostoma curvirostre), and cactus wren also utilize these communities.

Reptiles, especially lizards and snakes, are a common component of desert ecosystems. Within the Arizona Upland subdivision, there are many Sonoran and other desert reptiles, including some with more restricted ranges. For example, the regal horned lizard
(Phrynosoma solare), western whiptail (Cnemidophorus tigris gracilis), Gila monster (Heloderma suspectum), Arizona glossy snake (Arizona elegans noctivaga), Arizona coral snake (Micruroides euryxanthus), and tiger rattlesnake (Crotalus tigris).

Wildlife specific to the upland areas within the project area will be identified in conjunction with the United States Fish and Wildlife Service (USFWS) and AGFD.

2.5.2 Aquatic Systems

The Site is located near the confluence of the San Pedro and Gila Rivers. This area is within the Middle Gila River watershed, which spans from below the Coolidge Dam at San Carlos Reservoir to Gillespie Dam southwest of Phoenix (ADWR, 2005). From Coolidge Dam, the Gila River flows from the northeast along the east side of Winkelman, after which, it shifts to the west until it reaches the confluence with the San Pedro River (about one-half mile upstream of the Site) (ADEQ, 2003). The Gila River then flows northwest from the Site between the bermed Tailings Pile D and Tailings Pile AB/BC toward Kearny.

The Gila River and its tributaries are major lotic waters (i.e., actively moving) in the area and provide vital riparian habitat for wildlife in southeastern Arizona (Environmental Contaminants in Sediment and Fish of Mineral Creek and the Middle Gila River, Arizona [Andrews and King, 1997]). The Banding and Population Genetics of Southwestern Willow Flycatchers in Arizona - 1997 Summary Report (Paxton, et al, 1997) describe both rivers as perennial (i.e., contain water year-round), though it has been known to be dry during low rain periods (ADEQ, 2003). The Gila River is considered a fishery with flow characteristics from 100 cubic feet per second (cfs) to 1,000 cfs (ADEQ, 2003). It should be noted that flow in the Gila River between Coolidge Dam and Ashurst-Hayden Diversion Dam is attributed to releases from the San Carlos Reservoir and to natural flow in the river (ADWR, 2005).

The San Pedro River is of the calcium-bicarbonate type with an annual average concentration of total dissolved solids (TDS) of 676 milligrams per liter (mg/L) near Winkelman. Exceedances of water quality standards for turbidity, metals, bacteria, TDS, and nutrients have been reported along the Gila River (ADWR, 2005).

The riparian area near the confluence of the San Pedro and Gila Rivers consists of mixed exotic and native vegetation. Riparian areas along the confluence of these rivers have been described as varying from “monotypic tamarisk (Tamarix ramosissima) to stands of native Goodding’s willow (Salix gooddingii) and Fremont cottonwood (Populus fremontii),” with average canopy heights between 4 to 15 m as described in Southwestern Willow Flycatcher 2003 Survey and Nest Monitoring Reports (Smith, et al, 2004). Hatten and Paradzick (2003) indicate that this area is classified as Sonoran Riparian Deciduous Forest, with Fremont cottonwood, Goodding willow, mesquite (Prosopis spp.), seepwillow (Baccharis salicifolia), and the non-native species, tamarisk (also known as saltcedar). These authors also indicate that the riparian habitat occurred as spatially heterogeneous patches along the San Pedro and Gila Rivers.

Though these areas are dominated by cottonwood and willow, there are substantial amounts of dense saltcedar. Saltcedar may occur as a dense understory amidst the cottonwood, willow, ash, or boxelder overstory or it may border the edge of the native vegetation as stated in Status, Ecology, and Conservation of the Southwestern Willow Flycatcher (Finch and Stoleson, 2000). These riparian areas are surrounded by the Arizona Upland
subdivision vegetation as described above, though agricultural fields border the riparian habitat along some portions of the San Pedro River (Andrews and King, 1997).

There are several special status fish species in the Middle Gila River including the Gila topminnow (*Poeciliopsis occidentalis occidentalis*). Avian species supported by the riparian habitat along the Gila River include the federally endangered southwestern willow flycatcher (*Empidonax traillii extimus*), as well as other riparian species such as the yellow-billed cuckoo (*Coccyzus americanus*), common snipe (*Gallinago gallinago*), belted kingfisher (*Ceryle alcyon*), and various warblers. The southwestern willow flycatcher and bald eagles (*Haliaeetus leucocephalus*) have been documented in the ASARCO Hayden site vicinity (ADEQ, 2003).

A list of special status species (including plants, invertebrates, fish, amphibians, reptiles, birds, and mammals) within the Middle Gila watershed is provided in Table 2-1. This list is from the AGFD website containing species lists for the state (AGFD, 2005).

### 2.6 Geology and Hydrogeology

#### 2.6.1 Geology

A complete geologic/hydrogeologic description of the study area is beyond the scope of this workplan. Instead, this section provides a brief overview focused on aspects relevant to the primary workplan objective of identifying contaminants, pathways and receptors. The Site is regionally located within the Basin and Range physiographic province, an area characterized by upthrown blocks separated by alluvial basins, either of which are often cut by intrusive or extrusive volcanism. The geologic units exposed in the study area consist of a basement complex of older Precambrian metamorphic and igneous intrusives, which were then covered by a series of younger Precambrian through Paleozoic sedimentary rocks and minor igneous intrusives. Older Quaternary deposits such as alluvial fans and younger Quaternary alluvium are present along stream and river channels (SHB, 1994a). In the specific case of the Hayden site, the dominant feature is the alluvial basin formed by the Gila River, which trends in a southeast to northwest direction. On the Hayden side of this basin, adjacent to the Dripping Springs Mountains, are found Tertiary bedrock formations, with locally variable amounts of Holocene alluvium/colluvium.

Borings installed at the Site, either for subsurface soil investigation or for monitoring well construction, encountered three main geologic formations.

- **Gila River Alluvium**: These materials are found within the boundaries of the Gila River floodplain. Thickness varies from tens of feet at the edges to hundreds of feet in the center areas of the channel. Approximately the upper 100 feet of sediments are Holocene in age, with the deeper sediments being Tertiary in age. The sediments consist mainly of sand, gravel, and cobbles.

- **Big Dome Formation**: Tertiary age basin fill conglomerate, underlies the entire Hayden plant site. The formation has not been completely penetrated at the Site, so the exact thickness is unknown (Well H-7 encountered approximately 155 feet of Big Dome, and was completed in this formation).
• **Wash Alluvium**: These materials consist of Holocene alluvium, slag and artificial fill encountered in the various washes on Site. The materials range from slag deposits and artificial fill material to natural silts, sands, and gravels. The thickness of this material is normally in the few tens of feet, but can be much thicker when combined with slag deposits such as in the case of the area surrounding SM-2.

Table 2-2 presents summary information for the more recent on-Site borings (SHB, 1994a). Additional borings exist in other parts of the Site, but the quality control in the level of geologic interpretation was insufficient to give confidence to the specific subsurface geology encountered during their installation. Note that Paleozoic units consisting of alternating limestone, shale and marl of the Naco Limestone, Escabrosa Limestone, Percha Shale, Martin Formation, and Abrigo Formation are present in the eastern portion of the Hayden area; however these sediments are at higher elevations and were not encountered during drilling operations described herein.

### 2.6.2 Hydrogeology

Regionally, the Site is located within the Upper San Pedro groundwater basin. The major components of this system are the water bearing sands and gravels of the Gila and San Pedro River floodplains, with recharge from smaller tributary stream alluvium and bedrock seepage having localized impact. Water level measurements in wells located along the San Pedro and Gila Rivers indicate that the depth to groundwater is generally within tens of feet below the channel elevation (SHB, 1994a).

Local groundwater systems at the Hayden site largely divide along the same lines as the previously discussed geologic systems. The three systems are:

• **Gila River/San Pedro River Alluvial Aquifer**: This aquifer is composed of approximately the top 100 feet of alluvial sands and gravels within the river floodplain. Wells H-1, H-2, H-3, H-4, H-5, H-6, H-10, and H-11 are all screened within this aquifer, but none to a depth greater than 53 feet. As would be expected, fluctuations in water level within this aquifer are largely controlled by fluctuations in the river stage. Yields from this formation are generally large (200 to 1,200 gallons per minute [gpm]), and it comprises the area’s major water supply source. Both the Hayden Well Field and Winkelman Well Field are completed in this formation. The hydraulic conductivity for this aquifer, as obtained from APP field tests (SHB, 1994a), is approximately \(10^{-1}\) centimeters per second (cm/sec). The general direction of flow follows the direction of surface water flow.

• **Bedrock Aquifer**: Wells completed into the Big Dome Formation are considered to be completed into bedrock. Wells H-7, H-8, H-9, LC-1 and SM-2 are all screened within this formation. The hydraulic conductivity for this aquifer, as obtained from APP field tests (SHB, 1994a), is approximately \(10^{-5}\) cm/sec. The direction of flow is generally towards the alluvial floodplain aquifer.

• **Wash Alluvial Aquifers**: These disconnected aquifers are associated with the alluvium/colluvium found within the local Site drainages. While several wells are located within the spatial boundaries of the washes, only SM-2 is screened within the wash alluvium (61.5–70 feet of screen is within wash alluvium). On-Site borings seem to
indicate that these aquifers may be dry for most of the time, flowing only when there is significant precipitation or other runoff (i.e., ponds or storage basins). Limited Site information on specific field tests of hydraulic conductivity (SHB, 1994a) performed on wash alluvium yield an approximate value of $10^{-4}$ cm/sec. The direction of flow most likely follows topography, which would be toward the alluvial floodplain aquifer.

Table 2-3 contains the construction details for each of the monitoring wells completed at the Site (SHB, 1994a) and Table 2-5 summarizes available water quality data for selected wells.

Figure 2-3 presents a location map for the wells presented in Table 2-3. The remaining Hayden and Winkelman production well locations are also presented on this figure (although water quality data are not available for all of these wells).

## 2.7 Previous Investigations and Regulatory Involvement

### Previous Investigations

Previous investigations at the Site have been conducted by EPA and ADEQ (including primarily the Air Quality Division and the Water Quality Division). In addition, the Arizona Department of Health Services (ADHS) joined with the Agency for Toxic Substances and Disease Registry (ATSDR) to prepare a Public Health Assessment (ADHS and ATSDR, 2002). ASARCO has led investigations relating to leaking underground storage tanks (LUST) and other compliance-related matters at the Site. The following summarizes the major investigations at the Site:

- In 1988, EPA contracted with Ecology & Environment to conduct a Preliminary Assessment (PA) and Evaluation of the Site using the Hazard Ranking System (HRS) scoring. The HRS assesses the relative threat associated with actual or potential releases of hazardous substances at the Site. The HRS was adopted by EPA to help set priorities for further evaluation and eventual remedial action at hazardous waste sites. The HRS is the primary method of determining a site’s eligibility for placement on the National Priorities List (NPL). The NPL identifies sites at which EPA may conduct remedial response actions. Following this PA, a Screening Site Inspection (SI) was recommended for the Site.

- In 1991, ADEQ conducted a non-sampling SI and concluded that based on documented releases to the air and soil, the Site qualified for further consideration under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations (ADEQ, 1991).

- In January 1989, ASARCO removed a 1,000-gallon gasoline underground storage tank (UST) and a 1,000-gallon diesel UST located southwest of its smelting operations. During the removal, holes in the tanks and evidence of a release was noted. ASARCO installed and operated a soil vapor extraction system at the site of the gasoline release and initiated a quarterly groundwater monitoring and product removal program at the diesel release site. ASARCO is in the process of closing both UST sites (Hydrometrics, 1998).
• In September 1998, during the removal of two 5,000-gallon gasoline USTs located near the concentrator operations, holes in the USTs were noted and a gasoline release was reported. Contaminated soil was excavated and removed from the UST location. ASARCO is in the process of closing this UST site. According to ADEQ’s UST Corrective Action Section, groundwater contamination is not known to be related to the LUST releases at this Site (Hydrometrics, 1998).

• In 1999, ADHS conducted a preliminary hazardous analysis (PHA) for the study area, which consisted of obtaining environmental samples within Hayden and Winkelman to determine both background levels of metals and area levels of these metals. From June to October 1999, the University of Arizona conducted public health surveys of the residents of Hayden and Winkelman. Blood lead levels were evaluated for children 6 to 36 months and for some children up to 72 months of age and urinary arsenic levels were checked in adults and children. All test results were presented to the participants along with recommendations to seek follow-up care if levels were elevated above the standards used for this study. On March 16, 2000, findings of the health survey were presented during two meetings in Hayden and Winkelman with local residents. In 2002, ADHS presented the draft report for public comment and subsequently issued the final report. Conclusions of the report state that outdoor air in the Hayden and Winkelman area meets all federal and state air quality standards for criteria air pollutants including SO₂. Brief episodes of elevated SO₂ in air may cause short-term respiratory symptoms for sensitive asthmatics a few times per month. Levels of SO₂ in air are unlikely to cause respiratory symptoms in persons without pre-existing respiratory conditions. Exposures to water and soil pose no apparent public health hazard. The report noted, however, that conclusions drawn were based on data available at the time the document was released, and that conclusions could change if data indicate that exposure has increased or decreased based on further environmental investigation (ATSDR, 2002).

• In 2000, EPA contracted Ecology & Environment to review Site information and previously collected sampling data, to determine additional data needs, to recommend sampling to gather necessary data, and to develop a workplan to conduct the recommended sampling. Ecology & Environment determined additional data would be required for HRS scoring to adequately document the soil, groundwater, and surface water exposure pathways associated with the Site. Wind-blown dust from tailings piles, smelter smoke stack emissions, and dust from operation of the No. 9 conveyor belt (of which about 400 feet are overhead) in Hayden were all identified as potential sources of contamination associated with ASARCO operations. Soil sampling in the Towns of Hayden and Winkelman was recommended (ADEQ, 2003).

• In 2002, Weston (on behalf of ADEQ) performed an ESI, which included sampling around the ASARCO operations in and near Hayden. During the ESI, ADEQ collected surface soil samples from 23 private residences located in Hayden. Elevated levels of arsenic, cadmium, copper, mercury, and lead in surficial soil in both residential and public areas in Hayden were found, as well as from sampling locations in Kennecott Avenue Wash and Power House Wash. The residential areas were sampled due to the potential for the finer material on the conveyor belt that runs through town to be dispersed by wind into the residents' yards. Surface soil sampling locations at the private residences were divided into two priority areas: Priority One Area included the
private residences to the east of ASARCO’s conveyor belt, located on Smelter Road, Hillcrest Avenue, and Sunnyslope Road. Priority Two Area included the private residences located to the west of the conveyor belt, and on Ray/Velasco and Garfield Avenues. Surface soil samples were also collected from locations near the conveyor belt to determine if materials that fall off the conveyor belt are also a source of contamination (ADEQ, 2003).

- In 2004, the EPA Emergency Response Section (ERS) under the authority of CERCLA, contracted Ecology & Environment to perform additional sampling in the Hayden area to determine if levels of metal contaminants contained in the soil resulted from ASARCO operations. Analytical results from this RA effort document areas with concentrations of copper, lead, and arsenic above their respective R-SRLs (Ecology and Environment, 2004).

In addition to the above investigations, ADEQ’s Air Quality Division maintains an air monitoring station in the abandoned Hayden Jail building, which is located approximately one-half mile west of ASARCO’s smelting operations. The station monitors SO₂ and PM₁₀ only, and has been in operation since approximately 1969. PM₁₀ parameters monitored at the station include arsenic, lead, cadmium, copper, and nickel. SO₂ emissions were detected in excess of the NAAQS in 1987, 1988, and 1989. Data from ADEQ’s monitoring station also indicated that the 24-hour AAAQG for arsenic was exceeded every year from 1991 to 2000, and the annual AAAQG for arsenic has been exceeded every year since 1991. There is no NAAQS for arsenic, and the AAAQG is not enforced. In addition to the ADEQ air monitoring station, as a requirement of the air permits for the facility, ASARCO maintains ambient air monitoring stations at various locations in the Hayden area. These stations are located at the abandoned Hayden Jail, Globe Highway, Hayden Junction, Montgomery Ranch, and Garfield Avenue.

**Regulatory Involvement**

Both EPA and ADEQ have been involved with this Site from a regulatory standpoint. The Site was identified as a potential hazardous waste site and entered into the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) on December 1, 1979 and was given EPA ID No. AZD008397127. The Site is listed as a “Large Quantity Generator” in the Alternative RCRA Information for States (ARIS) database under EPA ID No. AXD008397127. On November 1, 1994, an inspection was conducted at the Site by the Hazardous Waste Inspections and Compliance Unit of ADEQ. Based on the inspection, a violation for “Generator Waste Determination” was issued to ASARCO. On August 14, 2000, an inspection was conducted at the Site by EPA. Based on the inspection, a violation for “Pre-transport Requirements” was issued to ASARCO (ADEQ, 2003).

ASARCO maintains two ADEQ Air Quality Class I (Major Source) operating permits for its Hayden operations: one for the concentrator (Permit Number M070399P1-99) and one for the smelter (Permit Number 1000042). ADEQ has performed numerous inspections at the Site. As a result of these inspections, numerous Notice of Violations (NOVs) have been issued to ASARCO, primarily in the 1990s. Most of the NOVs were issued to ASARCO for observed emissions from the smelter stack with opacities greater than 20 percent. A NOV was also issued in March 1991 for an observed release of dust from AB/BC Tailings Pile with an opacity of 78 percent (ADEQ, 2003).
In 1985, a Notice of Disposal (NOD) for discharging wastewater was filed with ADHS, the predecessor of ADEQ. The NOD outlines all wastewater discharges from ASARCO’s Hayden operations. Included in the NOD, untreated domestic sewage, along with the tailings slurry from the concentrator operations, is discharged over the top of the tailings piles. ASARCO was also discharging wastewater sludge, from the treatment of the smelter scrubber blowdown, to a lined impoundment south of the smelter (ADEQ, 2003).

ASARCO has filed two APP Applications with ADEQ’s Water Permits Section. The first application for an APP was submitted to ADEQ in 1992. A second application was filed in 1995 due to deficiencies noted in the 1992 application. To date, the 1995 application is still under ADEQ review. According to the ADEQ Mining Unit Manager, the application is currently in the technical review process, and the effort is focused at this time on the Ray portion of the Ray/Hayden Complex. Until the APP Application is approved, it is ADEQ’s understanding that ASARCO will continue to operate under the guidelines of the NOD. According to ADEQ’s APP Mining Unit, no current enforcement actions have been issued for the Site (ADEQ, 2004).

Twenty-seven (27) spill incidents have been documented at the Site from October 1990 to September 2002 according to the National Response Center database. Land was the most affected medium. The spilled materials included sulfuric acid, arsenic acid, arsenic compounds, cadmium compounds, and lead compounds. According to ADEQ’s Hazardous Materials Incident Logbook, no emergency response actions occurred (ADEQ, 2005).

On April 30, 1991, ADEQ’s inspection of ASARCO’s Slag Tunnel Wastewater System identified treated domestic wastewater being discharged to an unlined impoundment. This impoundment was formerly known as Louie’s Lagoon, and is now lined and known as containment pond CP-1. Analytical data was not available during the inspection, because the treatment plant was not required to perform any discharge monitoring. Due to excess rainfall that had filled a lined surface impoundment, which received process wastewater and sludge, ASARCO transferred over 1,000,000 gallons of water from it to the unlined surface impoundment (Louie’s Lagoon) in December 1990 and January 1991. Analysis of the wastewater sludge from the lined containment pond CP-1, submitted with the NOD, indicated concentrations of arsenic, barium, cadmium, mercury, selenium, and fluorine above their respective standards. Analysis of the transferred water, provided by ASARCO, indicated concentrations of arsenic, cadmium, fluorine, copper, and zinc above their respective standards (ADEQ, 2003).

### 2.8 Summary of Existing Data

#### 2.8.1 Available Soil Quality Data

The Hayden-Winkelman area has been subject to multiple investigations of surficial soil quality in recent years. These investigations were components of a broad effort by EPA and ADEQ to identify and address environmental impacts associated with the ASARCO LLC Hayden Facility. Investigations of surficial soils have yielded data that are useful in determining risk of exposure to residents of Hayden and Winkelman from concentrations of metal contaminants in soil.
Investigations of contaminant concentrations in surficial soils have included, in chronological order, the following:

- A non-sampling SI was performed by ADEQ in 1991. The SI concluded that the Site qualified for further evaluation under CERCLA (Ecology and Environment, Inc., 2004).

- Ecology & Environment, Inc. (under contract to EPA) performed a data review in 2000. From that review, a recommendation was made for further soil, groundwater, and surface water contaminant characterization to better document exposure pathways (Ecology & Environment, Inc., 2004).

- An ESI was performed by Weston (on behalf of ADEQ) in 2002. The project involved sampling of surficial soils and other media in the vicinity of ASARCO operations in and near Hayden to document levels of metals in residential and public locations (ADEQ, 2003).

- The ASARCO Hayden RA was performed by Ecology & Environment, Inc. (under the direction of the EPA Emergency Response Section) in 2004. This work involved sampling of surficial soils only in residential areas of Kearny, Hayden, and Winkelman to determine levels of metal contaminants resulting from ASARCO operations (Ecology & Environment, Inc., 2004).

- Sampling of surficial soils in selected school and playground areas in Winkelman and Hayden was completed by EPA in 2004, with the same purpose as the RA. These data were provided by EPA, but were not included in a previously published report.

The last three investigations cited above, which included collection of surficial soil samples, provide the basis for information included in this data summary section. The scope, results, and conclusions from each of these three investigative efforts are briefly summarized in the subsections below. Figures 2-4 and 2-5 show locations of surficial soil samples collected in Hayden and Winkelman, respectively, as these communities are within the area of focus of the proposed RI. Data from laboratory analyses are posted on these drawings for locations with one or more metal concentrations in soil that exceeded the respective Arizona R-SRL. Table 2-4 provides a summary from all three recent Site investigations, of surficial soil sample analyses showing metals concentrations above R-SRLs.

**Expanded Site Inspection**

Details concerning the scope of work, results, and conclusions from the ESI are provided in the Expanded Site Inspection Report (ADEQ, 2003). Generally, the goal of the ESI was to determine whether a release of hazardous substances had occurred as a consequence of ASARCO operations.

With respect to surficial soils, a total of 24 soil samples were collected from 23 private residences in Hayden (see Figure 2-4). These samples were grouped in two general areas including private residences in the Hillcrest area (identified as Priority One Area locations), located east of ASARCO’s No. 9 conveyor belt extending from the crushing facilities to the concentrator, and a separate area including a fewer number of private residences located west of the conveyor belt (identified as Priority Two Area locations). Both areas are in close proximity to ASARCO concentrator processing facilities, and together represent
approximately 15-20 percent of the total residential area of Hayden. In addition, seven samples were collected at four locations near the No. 9 conveyor belt, and a total of six locations considered as background (i.e., beyond the limits of influence of contamination sources) were collected. Surficial samples were collected at a depth of approximately three inches below ground level (bgl), field-examined, packaged, and submitted for laboratory analyses of total metals. Analytes were selected based on their association with the type of industrial activity at the Site, and their potential toxicity and mobility.

Of the 27 distinct locations sampled in Hayden, results of analyses revealed the following exceedances of R-SRLs in surficial soils (see Table 2-4):

- Arsenic levels exceeded the R-SRL of 10 milligrams per kilogram (mg/kg) at 26 locations;
- Copper levels exceeded the R-SRL of 2,800 mg/kg at 24 locations; and
- Lead levels exceeded the R-SRL of 400 mg/kg at three locations.

In addition, cadmium, mercury, and zinc levels in several samples were reported as elevated compared to the average background concentrations, but were not detected above their R-SRLs. Arsenic concentrations ranged from 3.0-67.4 mg/kg (average background = 7.9 mg/kg), copper concentrations ranged from 863-55,100 mg/kg (average background = 622.2 mg/kg), and lead concentrations ranged from 24.7-851 mg/kg (average background = 682.5 mg/kg).

In summary, the ESI concluded that the elevated concentrations of metals were the result of ASARCO operations, and that further assessment was necessary. Arsenic, cadmium, copper, and mercury in surficial soil samples were detected in concentrations exceeding three times the average background soil concentration, and a release of these metals from the Site to soil has been established. According to the ESI report, contamination is potentially attributable to sources including the crushed ore from the conveyor belt, deposition from smelting operations, surface water runoff from the concentrator operation, and airborne tailings during windy conditions.

**EPA Removal Assessment (RA)**

Specific details of the scope of work, results, and conclusions from the RA are provided in the *ASARCO Hayden Removal Assessment-Final Report* (Ecology & Environment, Inc., 2004). Generally, the goal of the project was to continue the initiative to identify and address levels of metals contaminants contained in soil resulting from operations at the Site, and specifically to evaluate impacts on the communities of Kearny, Hayden, and Winkelman. The investigation was focused on determining levels of metals contamination within residential, commercial, and public areas of the three towns. The summary in the following paragraphs focuses on the approach and results of sampling in Hayden and Winkelman.

Samples were collected at a total of 69 locations in Winkelman and 51 locations in Hayden (see Figures 2-4 and 2-5); one sample was collected from each grid node at a randomly selected location within each grid. Background samples were collected at six locations along State Highway 77 south of Winkelman. Surficial samples were collected to depths of approximately two inches bgl, field-examined, packaged, and submitted to laboratories for analyses of total metals by EPA Methods 6010B and 1311, and for Toxicity Characteristic
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Leaching Procedure (TCLP) Metals. The TCLP results for the samples collected in Winkelman and Hayden did not reveal concentrations above the TCLP limits; therefore, the following discussion is focused on total metals.

Of the 69 samples from Winkelman, the total metals analyses revealed the following exceedances of R-SRLs in surficial soils (see Table 2-4):

- Arsenic levels exceeded the R-SRL of 10 mg/kg at 16 locations;
- Copper levels exceeded the R-SRL of 2,800 mg/kg at seven locations; and
- Lead levels exceeded the R-SRL of 400 mg/kg at three locations.

In addition, antimony, beryllium, and thallium were also detected at concentrations above their R-SRLs in several samples; although antimony exceeded the R-SRL at only one location and through data validation the beryllium and thallium concentrations were determined to likely be biased high. Arsenic concentrations ranged from 1-320 mg/kg, copper concentrations ranged from 36.4-19,000 mg/kg, and lead concentrations ranged from 5.87-485 mg/kg. Sample locations showing exceedances of R-SRLs were concentrated near the northern and southern edges of the town (primarily southern). Locations showing copper and lead concentrations above R-SRLs also had arsenic concentrations above its R-SRL.

Of the 51 samples in the Hayden area, the total metals analyses revealed metals contamination above R-SRLs at 40 locations including the following:

- Arsenic levels exceeded the R-SRL of 10 mg/kg at 40 locations;
- Copper levels exceeded the R-SRL of 2,800 mg/kg at 29 locations; and
- Lead levels exceeded the R-SRL of 400 mg/kg at one location.

Arsenic concentrations ranged from 4.69-91 mg/kg, copper concentrations ranged from 418-11,400 mg/kg, and lead concentrations ranged from 19.1-463 mg/kg. Sample locations revealing elevated copper and lead concentrations generally coincided with locations showing high arsenic concentrations, with the highest concentrations typically concentrated close to ASARCO facilities, including particularly the No. 9 conveyor belt. Analyses of background samples revealed that concentrations of metals above their respective R-SRLs are not naturally occurring.

The RA concluded that surficial soil contamination is present in all three towns sampled. The study further concluded that the elevated concentrations of metals found throughout Hayden are likely the result of contamination dispersed from ASARCO operations. Elevated concentrations of metals in Winkelman are presumed due to the close proximity to ASARCO operations (exceedances in the northern portion of town), and proximity to tailings disposal areas, and aerial dispersion for vehicles traveling along State Highway 177, as well as rail transport facilities for copper ore (exceedances in the southern portion of town).

EPA School & Playground Sampling

In October 2004, samples were collected by EPA at five locations in Hayden and six locations in Winkelman; with the locations focused at school yards and play areas (see Figures 2-4 and 2-5). A formal report of this investigation has not been prepared, however,
the data has been subjected to all necessary quality assurance procedures. Therefore, the data are useful as a reference in planning future work.

The total metals analyses revealed the following exceedances of R-SRLs in surficial soils (see Table 2-4):

- Arsenic levels exceeded the R-SRL of 10 mg/kg at five locations, including four locations in Hayden and one in Winkelman; and

- Copper levels exceeded the R-SRL of 2,800 mg/kg at five locations in Hayden.

Arsenic concentrations ranged from 3-66.8 mg/kg and copper concentrations ranged from 122-16,900 mg/kg. Samples from Hayden containing exceedances of R-SRLs were collected at locations in the vicinity of the public pool and play structures west of and adjacent to the concentrator facilities. The sample from Winkelman that contained arsenic above the R-SRL was collected at a culvert near the indoor swimming pool. All other samples collected at the Winkelman school area contained arsenic below the R-SRL. Generally, sample locations where arsenic exceeded the R-SRL, also yielded an exceedance of the copper R-SRL.

The 2004 EPA school and playground study results reveal that surficial soil contamination is present in areas where public activities are concentrated in Hayden with arsenic concentrations above the R-SRL of 10 mg/kg in four of five samples, and copper concentrations above the R-SRL of 2,800 mg/kg in all five samples. The Hayden study results also reinforce the results from sampling of adjacent areas for the ESI and RA investigations. Within the Winkelman playground area, the levels of arsenic in soils sampled by EPA are comparable to arsenic levels found in nearby residential yards during the other investigations, with only one sample out of six exceeding the arsenic R-SRL of 10 mg/kg.

**Comparison of Existing Data to Human Health Screening Levels**

Soil sample collection and analysis for metals have been conducted in the Hayden/Winkelman areas as part of three recent Site investigation studies. The results of these studies have been compared to human health risk-based soil screening standards; including EPA Region IX residential soil Preliminary Remediation Goals (PRGs), (EPA, 2004b) and Arizona R-SRLs (Arizona Administrative Code. 2004b. Title 18, Ch. 7, Article 2. Soil Remediation Standards. March 31.), which are presented in Table 2-13:

- Hayden, Arizona, City Recreational Area Near Pool: Winkelman, Arizona, Elementary and High Schools, U.S. Environmental Protection Agency, October 18–19, 2004 (EPA, 2004c). Six soil samples were collected in Winkelman at the elementary and high schools, and five soil samples were collected in Hayden at the city recreational area near the pool. One of the soil samples from Winkelman, with an arsenic concentration of 12.7 mg/kg, slightly exceeded the Arizona R-SRL for arsenic (10 mg/kg, which is based on “natural background”). Four of the five soil samples collected in Hayden, with arsenic concentrations of 31.4 to 57.2 mg/kg exceeded the Arizona R-SRL for arsenic. All five soil samples from Hayden, with copper concentrations of 3,070 to 16,900 mg/kg, exceeded the R-SRL for copper (2,800 mg/kg).
E&E (2004). Fifty-one (51) surface soil samples were collected in Hayden as part of this study. Forty (40) samples exceeded the Arizona arsenic R-SRL, ranging from 11 to 44 mg/kg. One sample, containing 463 mg/kg lead, exceeded the Arizona R-SRL of 400 mg/kg. Twenty-nine (29) samples, ranging from 3,110 to 11,400 mg/kg, exceeded the Arizona copper R-SRL. The highest concentrations of arsenic and copper were typically found at locations nearest the ASARCO facility, in the vicinity of the No. 9 conveyor belt. Based on the active crushing, concentrating, and smelting operations occurring throughout the ASARCO facility, as well as tailings deposition, elevated soil concentrations of arsenic and copper found throughout Hayden are possibly contributed by aerially dispersed materials from these operations. Additional possible explanations for the high levels of arsenic are: process water discharges through the town, or discrete piles of tailings deposited in Hayden before the 1950's.

Sixty-nine (69) surface soil samples were collected in Winkelman. Sixteen (16) samples exceeded the Arizona arsenic R-SRL, ranging from 10 to 320 mg/kg. Three samples, containing from 403 to 489 mg/kg lead, exceeded the R-SRL. Seven samples, containing from 2,810 to 19,000 mg/kg copper, exceeded the R-SRL. One sample, containing 51 mg/kg antimony, exceeded the R-SRL of 31 mg/kg. Soil samples collected at several locations also exceeded the R-SRLs for beryllium and thallium (1.4 mg/kg and 6.1 mg/kg, respectively).

Three background soil samples collected between 12 and 17 miles south of Winkelman had arsenic, lead, and copper concentrations of 5.7 mg/kg, 586 mg/kg, and 30 mg/kg, respectively. All individual background sample concentrations were lower than the Arizona arsenic, lead, or zinc R-SRLs. This suggests that the levels of metals detected above their respective R-SRLs in Hayden and Winkelman may not be naturally occurring. However, these background samples, as well, may be impacted by historic smelter operations. The samples from south of Winkelman along the San Pedro River are downstream of the San Manuel smelter and mine and are within the air shed of the two smelters which experienced significant inversions before the Clean Air Act came into force. ADEQ (2003). Thirty-one (31) residential surface soil samples were collected in Hayden; 24 from private residences in the immediate vicinity of the smelter operations No. 9 conveyor belt, and seven from locations near the No. 9 conveyor belt. All soil samples exceeded the EPA residential PRG (0.39 mg/kg) and 28 samples exceeded the Arizona R-SRL for arsenic. Twenty-seven (27) samples exceeded the EPA residential PRG and Arizona R-SRL for copper. Three samples exceeded the EPA residential PRG and the Arizona R-SRL for lead. None of the samples exceeded the EPA residential PRG or the Arizona R-SRL for cadmium, chromium, mercury or zinc.

2.8.2 Available Groundwater Quality Data

This section summarizes available groundwater quality data from monitor wells and production wells in the Hayden and Winkelman areas. The Hayden well field is operated by ASARCO and consists of 19 production wells (ASARCO, January 20, 2005). The Winkelman well field is operated by the Arizona Water Company and consists of three production wells (ADEQ, 2003), although only two wells are currently in service (Arizona Water Company, September 2005). Additionally, ASARCO maintains a network of monitoring wells in the study area.
Fourteen (14) separate rounds of groundwater sampling have been reported in the recent past for the monitoring wells and water supply well fields located in the vicinity of the Hayden site. Sampling of a limited number of wells was conducted during each event. Nine sampling events were performed as part of the APP Part III application (July 1992 through June 1993) (SHB, 1994a), four sampling events were performed as part of the APP Supplemental Investigation (February 1994 through November 1994) (SHB, 1994b), and one sampling event was performed as a part of the ESI (May 2002 through June 2002) (ADEQ, 2003). Based on the Site visit/meeting of December 15, 2004, ASARCO also conducts quarterly groundwater monitoring; however, these data were not available prior to development of this workplan.

Summary data of all maximum contamination level (MCL) exceedances, which have included arsenic, cadmium, chromium, copper, lead, and mercury, are contained in Table 2-5. On this table, the wells involved have been separated into five related groups. Each group is discussed separately in the following paragraphs.

**Upgradient Gila River Alluvial Wells:** Well H-10 has been proposed as having background chemical concentration levels for the Gila River Alluvium. Well H-10 may be acceptable as an alluvial aquifer background monitor well, as it shows little contamination over time. Well H-6, although located upgradient from the smelter, appears to be greatly affected by the change in downgradient location from H-10. H-6 shows the highest levels of arsenic of any alluvial well in the study area, and as such, is not considered to be representative of upgradient conditions.

**Gila River Alluvial Wells Located Downgradient of the Tailings Impoundments:** These monitor wells show the effect that the tailings have upon the water quality of the Gila River Alluvium. Wells included are H-1, H-2, H-3, H-4, and H-5. Wells H-1, H-2 and H-5 are on the north side of the Gila River and generally downgradient of Tailings Pile AB/BC. Wells H-3 and H-4 are on the south side of the Gila River and generally downgradient of Tailings Pile D. The number of exceedance values found in this group of wells is significantly greater than H-10, but not as great as H-6. Overall, the proximity to the tailings piles does show an effect on these alluvial wells based on the sulfate and cadmium concentrations. Decant water samples from the tailings listed in the APP Part III application (SHB, 1994a) have an average value of 845 mg/L sulfate and 0.005 mg/L cadmium.

**Gila River / San Pedro River Water Supply Wells:** These production wells provide a means to assess the effect of potential contamination on human health. Wells included are HWF-09, HWF-15, HWF-21, HWF-25, GWF-355, and GWF-356 within the Hayden well field and S4A, and GWF-618 (Winkelman #4) within the Winkelman well field. Well H-11 was installed as a monitor well to measure the water quality in the Hayden well field area and so is included in this group. All wells are screened in the alluvium. The wells show almost no elevated levels of metals contamination, with the exception of S-4A, a San Pedro River alluvium water supply well for the town of Winkelman. Even this well only shows one exceedance out of five sampling events. However, groundwater quality data exist for only six of the 22 wells in the Hayden well field, and two of three wells in the Winkelman well field, and overall the data set is limited in size.

The lack of metals in this group of samples could be explained by reasons other than their location in non-affected areas. In the case of Hayden supply wells, wells are located close
together and usually operate simultaneously with anywhere from four to eight other wells (SHB, 1994b). If the sampled well is located behind the capture zone of other pumping wells, then little or no contaminated water would make it to the sampled well. Another way that contamination may be masked in these wells is through dilution within the floodplain alluvial aquifer. Since the pumping wells can yield 1,000 gpm or more each, the volume of contaminated groundwater delivered to the alluvium would have to be large to overcome being mixed in with the large amount of pumped supply water that is introduced from other portions of the basin. The hydraulic conductivity difference between the wash alluvial and the Gila River alluvial aquifers (three to four orders of magnitude) means this is highly unlikely except in the most highly concentrated cases of contamination.

**Bedrock Wells**: These monitor wells supply water quality information on the groundwater found within the bedrock. They are located upgradient, on-Site, and downgradient. Wells included are H-8, H-9, LC-1, and SM-2. The availability of sampling data for LC-1 and SM-2 (which is partially screened in the wash alluvium) is limited (one sampling event), and both of these wells are located near surface impoundments.

**Anomalous Response Wells**: Wells SM-2, H-6 and H-7 show levels of contamination that are anomalous to their surface or depth location. Well SM-2 provides a measure of both bedrock and wash alluvium groundwater chemistry, being screened both in the wash alluvium and underlying Tertiary basin fill materials. Well SM-2 is screened from 61.5 feet to 91.5 feet, where 61.5 to 70 feet is in alluvium and 70 to 91.5 feet is in the bedrock. The water level in this area is approximately 67 feet bgl, so some contribution could be made from the surficial aquifer. During the single sampling event in 2002, arsenic and mercury exceeded the MCL. As previously mentioned, the area in the vicinity of this well may be influenced by surface ponding and recharge.

Well H-6, although located upgradient from the smelter, appears to be greatly affected by the change in downgradient location from H-10. The response in this well could be related to contamination due to Site activities despite its location, and so is listed in the anomalous response section.

Well H-7 was originally installed to provide background data for the Hayden facility. From examination of the results in Table 2-5, this well contains higher levels of metals than those downgradient from it. It is unclear whether this is related to an upgradient source or is representative of background water quality conditions in this area, and thus it is listed in the anomalous response classification for wells.

One water quality aspect that is shared by all the wells at the Site is the potential for appreciable arsenic. While nine out of the 21 wells in the study area had at least one exceedance of the drinking water MCL for arsenic, eight out of the remaining 12 wells showed consistent occurrence of arsenic in the 0.003 to 0.007 mg/L range. This same level of arsenic was reported in both the 2001 (0.007 mg/L) and 2003 (0.004 mg/L) Water Quality Reports for the Arizona Water Company’s Winkelman Operations (AWC, 2001 and AWC, 2003). Arsenic is probably at an appreciable background level in this area, which will both increase the difficulty of identifying mineral process specific contamination while at the same time making any addition to the environment a potential exceedance amount.
Comparison of Existing Data to Human Health Screening Levels

ADEQ conducted groundwater sampling and analysis for metals content from three drinking water wells in Hayden.

- ADEQ (2003). Arsenic concentrations in the three wells ranged from 5.6 to 10 micrograms per liter (µg/L), which exceeded the EPA tap water PRG (0.045 µg/L), but not the EPA MCL, (10 µg/L) or the Arizona MCL (50 µg/L), (Arizona Administrative Code. 2004a. Title 18, Ch. 4, ADEQ Safe Drinking Water. March 31.). The maximum cadmium concentration was 5 µg/L, which was equal to the EPA and Arizona MCL of 5 µg/L and was less than the EPA tap water PRG of 18 µg/L.

Available Surface Water and Sediment Quality Data

A review of historical documents was conducted to summarize surface water and sediment quality data. Surface water and sediment samples were collected once in 1993 following a tailings spill event and during the ESI in 2002 (ADEQ, 2003). The 1993 sediment sampling event was used to document a spill of an estimated 292,000 tons of copper mine tailings that washed into the Gila River on January 17, 1993 (ADEQ, 1993). Six sediment samples were collected from the Gila River; including one near the town of Winkelman, upstream of the railroad bridge; two adjacent to the tailings near the Gila River; one five miles downstream; one seven miles downstream; and one sample from Kelvin, approximately 11 miles downstream. The sample results indicated an increase in zinc and copper concentrations in sediment downstream of the tailings spill. Soluble solids and leachable sulfate concentrations also increased downstream of the tailings discharge. The sediment sample results are summarized in Table 2-6. Only metals included in the EPA Total Metals Laboratory Method are summarized in the table. The ESI identified the potential for fines from the conveyor belt and other fugitive sources, sediment from the tailings pile, and particulates from the smelter stack to disperse throughout the stretch of the Gila River that spans the Site and the area downgradient of the Site. Therefore, sediment samples were collected from the Gila River, San Pedro River, Power House Canyon Wash, and Kennecott Avenue Wash. Samples were also collected from containment pond CP-1 (formerly Louie’s Lagoon), Tailings Pile AB/BC, Tailings Pile D, and the storm water pond. Samples from these locations are considered non-river sediment samples, and are discussed in Section 2.8.3. Note that sediment and surface water samples were also collected from Mineral Creek, but are not presented herein because of its distance from Hayden. A total of 15 river/wash sediment samples were collected from the Hayden area during the ESI; this total includes 12 from the Gila River, one from the San Pedro River, one from Power House Canyon Wash, and one from Kennecott Avenue Wash. A total of 20 surface water samples were collected from nine locations along the Gila River. Surface water samples were collected from locations along the Gila River only, as the San Pedro River, Power House Canyon Wash, and Kennecott Avenue Wash were dry at the time of sampling activities.

The sediment samples were collected as close as possible to their corresponding surface water samples, and at locations with fine texture sediments ranging from clay to medium sand. The sediment and surface water samples were analyzed for total metals. In addition, surface water samples were also analyzed for general water quality parameters, including chloride, sulfate, fluoride, nitrate, nitrite, total Kjeldahl nitrogen, hardness, alkalinity, TDS,
and total suspended solids. Figure 2-6 shows the sampling locations/results for both sediment and surface water.

The sediment and surface water sample results for the seven target metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc) are summarized in Table 2-7 and Table 2-8, respectively. Those values in bold type indicate an exceedance of Arizona R-SRLs (for sediment) or Arizona surface water quality standards MCLs.

The ESI differentiated sample results for HRS purposes. An analyte was considered to be present at a concentration significantly above background if one of the following two criteria were met: 1) the analyte is detected in the Site-related sample, but not in background samples, or 2) the analyte is reported at a concentration equal to or greater than three times the maximum or average background sample concentration. Background levels were determined based on samples collected from areas considered out of the influence of wind blown soil from the Site. For purposes of this workplan, the term “elevated concentrations” is used if one of the two criteria above were met.

Arsenic and copper were the two primary metals detected above the Arizona R-SRLs (10 mg/kg for arsenic and 2,800 mg/kg for copper) in the sediment samples. Arsenic in sediment samples ranged from 1.9 mg/kg (sample AHP-GR-SD-04 collected from the Gila River) to a maximum of 33.4 mg/kg (sample AHP-KC-SD-01 from the Kennecott Avenue Wash). Two samples met the criteria for “elevated concentration” for arsenic (AHP-PC-SD-01 from Power House Canyon Wash and AHP-KC-SD-01 from Kennecott Avenue Wash) but, did not have arsenic concentrations above the Arizona R-SRLs. The average background concentration for arsenic is 4.95 mg/kg.

Copper concentrations in sediment samples ranged from 14.9 mg/kg (sample AHP-GR-SD-09 from the Gila River) to 14,000 mg/kg (sample AHP-KC-SD-01 from Kennecott Avenue Wash). Two samples met the criteria for “elevated concentration” for copper (AHP-PC-SD-01 from Power House Canyon Wash and AHP-KC-SD-01 from Kennecott Avenue Wash) but, did not have copper concentrations above Arizona R-SRLs. The average copper background concentration is 74.9 mg/kg.

Cadmium, chromium, lead, mercury, and zinc were detected at concentrations below Arizona R-SRLs (38 mg/kg for cadmium, 2,100 mg/kg for chromium, 400 mg/kg for lead, 6.7 mg/kg for mercury, and 23,000 mg/kg for zinc) in all sediment samples from the ESI. The maximum cadmium concentration was detected in samples AHP-KC-SD-01 from Kennecott Avenue Wash. Two sediment samples (AHP-KC-SD-01 from Kennecott Avenue Wash and AHP-PC-SD-01 from Power House Canyon Wash) met the criteria of “elevated concentration” but, were below Arizona R-SRLs. The average background cadmium concentration is 0.42 mg/kg.

The maximum chromium concentration was 31.5 mg/kg in sample AHP-PC-SD-01 from Power House Canyon Wash. This sample was the only one to meet the criteria of “elevated concentration” for chromium. The average chromium background concentration is 9.7 mg/kg.

Lead was detected at a maximum concentration of 127 mg/kg in sample AHP-PC-SD-01 collected from Power House Canyon Wash. Two samples (AHP-PC-SD-01 from Power
House Canyon Wash and AHP-KC-SD-01 from Kennecott Avenue Wash) met the “elevated concentration” criteria for lead. The average lead background concentration is 14.3 mg/kg.

The maximum mercury concentration detected in sediment samples was 0.23 mg/kg in sediment sample AHP-KC-SD-01 collected along Kennecott Avenue Wash. Sample AHP-KC-SD-01 also met the criteria of an “elevated concentration” for mercury. The average background concentration for mercury is 0.1 mg/kg.

Zinc was detected at a maximum concentration of 469 mg/kg in sediment sample AHP-PC-SD-01 from Power House Canyon Wash. This sample also met the criteria of “elevated concentration” for zinc. The average background concentration for zinc is 60.7 mg/kg.

**Comparison of Existing Data to Human Health Screening Levels**

ADEQ conducted surface water sampling and analysis for metals content in the Site vicinity and downgradient (ADEQ, 2003). A total of 20 surface water samples were collected from nine sampling locations along the Gila River. None of the surface water samples had detections of any target compounds above the EPA Contract Required Detection Limit (CRDL).

A total of 12 sediment samples were collected from the Gila River, and one sample each from the Power House Canyon Wash and Kennecott Avenue Wash (ADEQ, 2003). All of these sediment samples exceeded the EPA residential soil PRG of 0.39 mg/kg and two samples exceeded the Arizona R-SRL of 10 mg/kg for arsenic. None of the sediment samples exceeded the EPA PRG or the Arizona R-SRL for cadmium, chromium, lead, mercury, or zinc.

**2.8.3 Available Non-River Sediment Quality Data**

In addition to sediment samples from the rivers and drainage washes in the Hayden area, non-river sediment samples were collected as well during the ESI (ADEQ, 2003). These non-river sediment sample locations include the containment pond CP-1, the storm water pond located upgradient from CP-1, Tailings Pile AB/BC, and Tailings Pile D. Figure 2-6 shows the locations of the non-river sediment samples and these results are summarized in Table 2-7. A total of 10 non-river sediment samples were collected during the ESI; two from CP-1, three from Tailings Pile AB/BC, three from Tailings Pile D, and two from the storm water pond.

CP-1 sediment samples were collected from the southwest corner of the containment pond, which is the location of the concrete lined sump. This sump was considered to be a potential contaminant source. Sediment samples collected from the storm water pond were collected as background samples since this pond is located upgradient of CP-1. Sediment samples collected from the two tailings ponds were located to evaluate if the tailings piles are a source of any mining related contaminants that might be detected in the water and/or sediment samples collected from the Gila River.

Arsenic, cadmium, copper, lead, and mercury each exceeded R-SRLs in one or more of the non-river sediment samples collected during the ESI. Chromium and zinc were the two target compounds that were not detected at concentrations above R-SRLs in any non-river sediment samples; however, chromium and zinc concentrations did exceed average
background levels. The maximum chromium concentration was 59.1 mg/kg from sediment sample SU-SD-01, collected from CP-1. The average background concentration for chromium is 9.7 mg/kg. Sediment samples TPD-SD-01, TPD-SD-02, TPD-SD-03 (all collected from Tailings Pile D), TPA-SD-03 (collected from Tailings Pile AB/BC, SU-SD-01 and its duplicate (collected from CP-1) meet the criteria of “elevated concentration” for chromium. Zinc concentrations in the non-river sediment samples ranged from 88.3 mg/kg in sample TPA-SD-02 (collected from Tailings Pile AB/BC) to 7,110 mg/kg in sample SU-SD-01 (collected from CP-1). The average background concentration for zinc is 60.7 mg/kg and all samples except TPA-SD-02 (collected from Tailings Pile AB/BC) meet the criteria of “elevated concentration” for zinc.

Arsenic concentrations in the non-river sediment samples ranged from 4.8 mg/kg in sediment sample TPA-SD-02 (collected from Tailings Pile AB/BC) to 4,960 mg/kg in sediment sample SU-SD-02 (field duplicate collected from CP-1). Six non-river sediment samples exceeded the R-SRL for arsenic of 10 mg/kg. The average background concentration for arsenic is 4.95 mg/kg, and four samples, SU-SD-01 & 02, its duplicate (both collected from CP-1), SP-SD-01 (collected from storm water pond), and SP-SD-02 (also collected from storm water pond) meet the criteria of “elevated concentration” for arsenic.

Cadmium concentrations in the non-river sediment samples ranged from 1.1 mg/kg in sediment sample TPA-SD-02 (collected from Tailings Pile AB/BC) to 722 mg/kg in sediment sample SU-SD-02 (collected from CP-1). Two non-river sediment samples exceeded the R-SRL for cadmium of 38 mg/kg. The average background concentration for cadmium is 1 mg/kg, and four samples, SU-SD-01 & 02, its duplicate (both collected from CP-1), SP-SD-01 (collected from storm water pond), and SP-SD-02 (also collected from storm water pond) met the criteria of “elevated concentration” for cadmium.

Copper concentrations in the non-river sediment samples range from 502 mg/kg in sediment sample TD-SD-01 (collected from Tailings Pile D) to 95,800 mg/kg in sediment sample SU-SD-01 (collected from CP-1). Four non-river sediment samples exceeded the R-SLR for copper of 2,800 mg/kg. The average background concentration for copper is 74.9 mg/kg, and all of the sediment samples met the criteria of “elevated concentration” for copper.

Lead concentrations in the non-river sediment samples range from 12.1 mg/kg in sediment sample TPA-SD-02 (collected from Tailings Pile AB/BC) to 9,750 mg/kg in sediment sample SU-SD-02 (collected from CP-1). Two samples exceeded the Arizona R-SLR for lead of 400 mg/kg. The average background concentration for lead is 14.3 mg/kg, and sediment samples SP-SD-01, SP-SD-02 (both collected from storm water pond), TPD-SD-03 (collected from Tailings Pile D), TPA-SD-03 (collected from Tailings Pile AB/BC), and SU-SD-01 and its duplicate meet the criteria of “elevated concentration” for lead.

Mercury concentrations in the non-river sediment samples range from non-detect to 808 mg/kg in sediment sample SU-SD-02 (collected from CP-1). Two samples exceeded the R-SRL of 6.7 mg/kg for mercury. The average background concentration for mercury is 0.1 mg/kg. SP-SD-01 (collected from storm water pond) and SU-SD-02 (collected from CP-1) and its duplicate meet the criteria of an “elevated concentration” for mercury.
Comparison of Existing Data to Human Health Screening Levels

One Site investigation study, which included non-river sediment sampling and analysis for metals, was conducted. The results of the sediment analysis for metals were compared to the EPA Region IX residential PRGs and Arizona R-SRLs.

ADEQ (2003). A total of 10 non-river sediment samples were collected, two each from the ASARCO facility CP-1 and the storm water pond, and six from Tailings Piles AB/BC and D. All sediment samples exceeded the EPA residential soil PRG of 0.39 mg/kg and the Arizona R-SRL of 10 mg/kg for arsenic. Two sediment samples exceeded both the EPA PRG and the Arizona R-SRL for copper. One sediment sample exceeded both the EPA PRG and the Arizona R-SRL for cadmium, lead and mercury. None of the sediment samples exceeded the EPA PRG or the Arizona R-SRL for chromium or zinc.

2.8.4 Available Air Quality Monitoring Data

Since the early 1970s, the EPA, State of Arizona (State), and ASARCO have collected ambient air monitoring data for SO2 and PM10 at various locations in the Hayden area. Selected PM10 samples have also been analyzed for elemental compositions. The following sections provide a summary of available air quality monitoring data. This summary is not an exhaustive listing of all available data, but is included to show the nature and concentration of pollutants in the ambient air in the Hayden area.

ASARCO submits annual discharges of toxic chemicals to EPA under the Federal Emergency Planning and Community Right-to-Know Act (EPCRA) program to inform communities and citizens of chemical hazards in their areas. Through EPCRA, Congress mandated that information on toxic chemical releases to the environment be collected into a database called the Toxic Release Inventory (TRI). The information submitted by ASARCO includes the releases to the air from slag dumping, smelter emissions and dust from crushing ore. The ASARCO copper smelter in Hayden has been one of the top releasers of TRI chemicals in the entire nation.

ASARCO also submits annual emission inventory of regulated air pollutants to ADEQ as a requirement of regulations adopted by State of Arizona and EPA under the Clean Air Act.

Both TRI data and emission inventory data will be reviewed as a part of the remedial investigation to evaluate impacts of historical emissions on Hayden/Winkelman residents. This is further described in Section 4.3.5.

SO2 Monitoring Network

Monitoring began in the Hayden area in 1970 by the State (Hayden Sulfur Dioxide Nonattainment Area State Implementation and Maintenance Plan, ADEQ, June 2002). ASARCO began continuous ambient SO2 air quality monitoring in the Hayden area in 1974. Since that time, an extensive monitoring network was established with spatial and temporal coverage intended to comprehensively evaluate the ambient impact of smelter emissions. More than 20 stationary and mobile monitoring sites were established throughout the area with as many as 12 monitors operating concurrently (See Table 2-9 and Figure 2-7). This ambient SO2 network, comprised of EPA, State, and ASARCO monitors, was developed as the result of extensive efforts to identify maximum ambient impact areas using diffusion
modeling, monitored atmospheric dispersion parameters, citizen observations, and ambient
SO₂ monitoring.

Installation of additional meteorological instrumentation at the network sites, measuring
wind speed and direction, air temperature, and humidity parameters, helped to further
define airflow and pollutant transport in the region. Utilization of mobile monitors allowed
evaluation and verification of ambient SO₂ concentrations over a greater area. Numerous
sites were monitored and subsequently relocated under the direction of State meteorologists
when no significant impacts were observed. All monitoring for SO₂ was reportedly
performed with guidance and dispersion modeling analysis from ADEQ.

The monitoring network was also developed in accordance with Supplementary Control
Systems (SCS). Prior to implementation of continuous control technology, SCS utilized
analysis of atmospheric conditions and monitored ambient concentrations to vary the rate of
smelter emissions to avoid any exceedance of NAAQS. In 1977, the State adopted rules that
codified requirements for concurrent operation of at least eight ambient monitors, including
a mobile monitor placed at points representative of observed maximum concentrations.

Following ASARCO’s compliance with emissions limits as defined in Arizona
Administrative Code R18-2-715(F), and based on continuous control technology, the number
of permanent monitors was gradually reduced to the current network of six. These are all
high impact ambient monitoring sites considered to be generally representative of air
quality for the area. These monitoring site decisions were made by ADEQ and ASARCO,
and are in accordance with EPA guidance. The locations of current SO₂ monitors are shown
in Figure 2-7.

Table 2-10 summarizes SO₂ monitoring data for the most recent five years (1999-2003) for
each of the six currently operating monitoring stations (Air Quality Annual Report, ADEQ,
meter (µg/m³), 365 µg/m³, and 1,300 µg/m³ on an annual, 24-hour and three-hour average
basis, respectively. There have been no violations of Ambient Air Quality Standards for SO₂
in the Hayden area since 1995. In June 2002, the State requested EPA to redesignate the
Hayden area from non-attainment area to attainment area for SO₂.

**Particulate Matter Monitoring Data**

ASARCO has provided information on regulated sources of particulate matter (PM)
emission to ADEQ in the air pollution permit application. ASARCO has submitted separate
Title V Permit applications for the Hayden concentrator and Hayden smelter. The PM
emission sources at the Hayden concentrator consist of track hopper, conveyor belts,
secondary crushing circuit, tertiary crushing circuit, fine ore bins, lime silo, and tailings
impoundments AB/BC and D. PM emission sources at the Hayden smelter consist of fluid
bed dryers, flash furnace, revert crushing system, converters, anode furnaces, and acid
plant. Emissions are exhausted through the 1,000 foot stack, exhaust stacks of individual PM
emission control devices for ore handling, as well as fugitives from smelter operation,
tailing piles and ore handling.

In addition to ASARCO smelter and concentrator operations, there are other sources of PM
emissions in the Hayden and Winkelman area. The PM₁₀ Nonattainment Area Plan (PM₁₀
State Implementation Plan for the Hayden Group I Area [ADEQ, 1989]), prepared by ADEQ and
submitted to EPA in 1992, lists automobile exhausts, roadway dust, wood burning stoves, locomotive exhaust and windblown dust as other sources of PM emissions. Relative contribution of each of these sources of PM emissions was estimated in the PM_{10} Nonattainment Area Plan. However, no analysis of relative contribution of emission sources has been prepared after the required PM_{10} controls were implemented in the Hayden area.

ADEQ has operated a PM_{10} sampler at the Hayden Jail monitoring site since February 1985, and has operated a Total Suspended Particulate (TSP) monitor at the same location for preceding years. This is the only station in the study area where PM_{10} measurements are collected.

Table 2-11 shows results of the most recent five years data reported by ADEQ for PM_{10} at the Hayden Jail site. The NAAQS for PM_{10} are 50 μg/m^{3} and 150 μg/m^{3} on an annual arithmetic mean and 24-hour average basis, respectively.

The PM_{10} Nonattainment Area Plan includes analysis of PM_{10} samples for elemental composition. Table 2-12 provides a summary of the elemental analysis.

Elemental composition of the major source profiles and apportionment calculation results indicated high correlation between emissions from some specific air pollution sources and PM_{10} collected on sample filter. These sources of air pollution included fugitive area dust sources, ore handling and processing, fugitive emissions from the smelting process, smelter dust and windblown dust from the smelting process. The recommended controls in the PM_{10} State Implementation Plan have been implemented in the Hayden area. There have been no exceedances of PM_{10} air quality standards after implementation of the proposed controls.

The ESI (ADEQ, 2003) indicates that data from the monitoring station also indicates that the 24-hour AAAQG for arsenic was exceeded every year from 1991 to 2000, and the annual AAAQG for arsenic has been exceeded every year from 1991 to 2000.

AAAQG levels were developed by ADHS to establish concentration of chemicals in ambient air that are protective of public health. These levels were derived by making an adjustment for the differences in the averaging times for exposure and applying a safety factor to limits originally established to protect individuals exposed in occupational settings. For example, occupational exposure levels are intended to be safe for individuals exposed to those levels 8 hours per day, 7 days per week for a working lifetime. They generally assume an 8-hour average exposure time; however, longer average times (e.g., 24 hours) are more appropriate for establishing community health guidelines. In addition, a safety factor is applied to provide adequate protection for the general public, which includes people who may be more sensitive than workers (e.g., children and the elderly).

The AAAQGs established by ADHS are for guidance purposes only and are not intended for use in deriving regulatory limits. However, AAAQGs provide a useful tool in evaluating concentrations of chemicals for the protection of public health. The AAAQGs are well suited for the screening analysis because they are likely to be conservative (i.e., err on the side of public health by setting levels well below what would be likely to cause adverse effects in the general population).

The AAAQGs established for arsenic are 0.28 μg/m^{3}, 0.0073 μg/m^{3}, and 0.00002 μg/m^{3} for one hour, 24-hour, and annual average exposures, respectively. Arsenic samples were
collected by ADEQ using 24-hour PM sampling equipment and filters were analyzed for arsenic content. The concentration of arsenic in samples collected by ADEQ at the Hayden Jail site are shown in Table 2-12. These concentrations are significantly higher than established 24-hour and annual AAAQGs.

Limited information is available regarding distribution of chemicals in coarse and fine fraction from each of the emission sources. As described in Section 4.3.2., samples will be collected from tailing piles, slag dump, and material deposited around crushers. The bulk samples as well as fraction less than 200 mesh size will be further analyzed for metals of concern, as it is generally expected that small soil particles are more likely to become wind borne and adhere to hands than coarse particles. For evaluation of inhalation pathway only chemicals contained in PM\textsubscript{10} fraction will be considered.

**Emission Sources in Hayden Area**

The initial Hayden smelter was constructed in 1911 and began operations to process ore from the Ray Mine in 1912. A 250 foot stack was built in 1918 to discharge gases from the copper smelter. In 1920, a Cottrell (form of electrostatic precipitator) was installed. In 1961, the Cottrel was converted to wire and plate configuration improving particulate removal efficiency to 99.7 percent. In 1965, furnace gases were also routed to the Cottrel. In 1970, construction began on the acid plant and electrostatic precipitator to treat gases from the converters. The acid plant began operating in 1971.

In 1974, the 1,000 foot stack was built to discharge exhaust gases from the smelting operations. ASARCO also started operating SCSs in 1974. In 1980, secondary hoods were installed on the converters to control fugitive emissions.

The Kennecott smelter was shut down in 1982, and the structures surrounding the stack are currently undergoing demolition by ASARCO.

ASARCO completed modernization of its Hayden smelter in 1983, including installation of an oxygen flash smelting furnace, construction of an oxygen plant to produce oxygen for the new furnace, and construction of a second sulfuric acid plant to capture and re-use SO\textsubscript{2} emissions produced during smelting.

The graph on the following page shows annual average concentrations of SO\textsubscript{2} in the Hayden area from 1969 to 2004. The NAAQS for SO\textsubscript{2} is 80 µg/m\textsuperscript{3}. The concentration of SO\textsubscript{2} started to decline with the installation of the acid plant in 1971. Installation of the 1,000 foot stack further reduced the annual average concentration. The NAAQS were not met until the oxygen furnace and flash smelting furnace were installed in 1983.

**Meteorological Data**

ASARCO has provided meteorological data for five years for the Montgomery Ranch, Globe Highway, and Hayden Junction monitoring sites (ASARCO, January 28, 2005). The data includes hourly data for wind speed, wind direction, and air temperature from January 2000 to December 2004.

Figures 2-8 to 2-10 provide a wind rose for each of these sites based on ASARCO provided meteorological data.
The EPA Emergency Response Team has also set up a monitoring station at the Hayden Jail site to collect one year of meteorological data. So far, only a few months of data have been collected at this site.

**Comparison of Existing Data to Human Health Screening Levels**

Information concerning the air quality in Hayden is available from three sources. ADEQ has conducted long-term air sampling at the Hayden Jail station and has monitored for particulate, arsenic, lead, and SO$_2$ levels. Hayden, Arizona is currently an air quality non-attainment area. The ASARCO Hayden facility is required to file yearly TRI Reports with the EPA.

- **ATSDR (2002), (EPA, 2005b).** ADEQ maintains an air particulate sampler at the Hayden Jail. The samples are analyzed for metals including lead, arsenic, cadmium and zinc, as well as SO$_2$. The arsenic annual average from 1991 to 1998 was reported to range from 0.080 µg/m$^3$ to 0.200 µg/m$^3$, all of which greatly exceed the EPA ambient air PRG of 0.00045 µg/m$^3$. The lead annual average from 1993 to 1997 was reported to range from 0.09 µg/m$^3$ to 0.37 µg/m$^3$, which is less than the NAAQS of 1.5 µg/m$^3$. The SO$_2$ three-hour maximum concentration from 1990 to 1998 ranges from 372 µg/m$^3$ to 1,137 µg/m$^3$, which does not exceed the NAAQS of 1,300 µg/m$^3$.

- **EPA (2005c), (EPA, 2005d).** Hayden is reported to be in an SO$_2$ and a PM non-attainment area, however, the State of Arizona is in the process of redesignating the Hayden area as attainment for SO$_2$ since there have been no reported exceedances of SO$_2$ ambient air quality standards since 1994.

- **EPA (2005a).** The ASARCO facility, under the EPCRA, reports annually on its releases of toxic chemicals. The EPA maintains this information in a database called the TRI.

The most recently available TRI report for the ASARCO smelter operations (reporting year 2003) includes an inventory of air emission (both fugitive [non-point] and stack [point] sources) releases, which are presented in Table 2-14. The following amounts (pounds per year) of metals were reported released in 2003 (fugitive/stack): copper (57,579 pounds/4,161 pounds), arsenic (4,811 pounds/490 pounds), lead (6,419 pounds/460 pounds), cadmium (2 pounds), zinc (21,318 pounds).
pounds/2,131 pounds), cadmium (77 pounds/502 pounds), zinc (3001 pounds/15,903 pounds), chromium (0 pounds/42 pounds), mercury (0 pounds/16 pounds), antimony (125 pounds/11 pounds), barium (0 pounds/921 pounds), cobalt (0 pounds/1 pound), manganese (0 pounds/906 pounds), nickel (0 pounds/4 pounds), selenium (790 pounds/12 pounds), and silver (176 pounds/13 pounds). Sulfuric acid releases were reported to total 1,381 pounds of fugitive emissions and 436,592 pounds of stack emissions (EPA, 2005a).

The TRI report for 2003 is an inventory of reported releases for one year and is a detailed inventory for air emissions. No releases to surface water or soils are reported. The reported emissions are a reflection of current in-place emission controls.

Off-Site impacts to soils and sediments from historic smelter metals releases are possible. The first emission controls were placed on the smelters in 1920 and were designed to remove PM from stack emissions. The acid plant was added in 1971 to reduce SO₂ and particulate emissions; additional controls were added in 1984 to further reduce SO₂ emissions (ATSDR, 2002). A summary of air standards for the primary constituents of concern is presented in Table 2-15.

On-Site Releases at ASARCO Complex

Regulatory oversight of releases of chemicals to soils, groundwater, sediments, surface water, and air at the operating ASARCO complex has been provided by ADEQ. Releases of petroleum hydrocarbons (gasoline and diesel) from USTs have been reported on the ASARCO complex (ADEQ, 2003). There is no documentation that those releases have migrated off-Site, and therefore will not be considered further in this workplan as part of the HHRA.

The RI Site investigation and characterization process is in the early stages for this Site. It is possible that other chemicals (for example volatile organic compound (VOCs), semivolatile organic compound (SVOCs), and other metals) have been released during normal smelter operations and equipment maintenance, which have not yet been reported or characterized. Such chemicals would need to be evaluated as they are reported and included in the RI, as appropriate.

2.8.5 Comparison of Existing Data to Human Health Screening Levels

Sections 2.8.1 through 2.8.4 provide a comparison of existing Site characterization data to federal and State of Arizona human health screening levels, as appropriate, for soils, sediments, surface water, groundwater, and air.

2.9 Potential Chemicals of Concern and Potential Environmental and Human Health Impacts

The following sections outline the potential chemicals of concern to human health and the environment based on existing chemical data collected at the Site (see Section 2.8), as well as expected chemicals of concern based on copper ore processing activities conducted at the Site.
The ASARCO site abuts the town of Hayden, Arizona (population 900) and is one mile north of the Town of Winkelman (population 450). As an operating copper smelter with a long history of copper metal production dating back to 1909, the ASARCO facility has historically released chemicals to the environment. The ASARCO Hayden operations consists of a 27,400 ton/day concentrator and a 720,000 ton/year copper smelter consisting of an oxygen flash furnace, converters, anode casting, oxygen plant, acid plant, and associated maintenance, warehouse and administrative facilities (ASARCO Hayden Website, 2005 [ASARCO, 2005]). The sulfuric acid produced at the acid plant is used in the leaching operations or sold into the market. A local railroad, Copper Basin Railway, transports ore from the Ray mine to the Hayden concentrator, concentrate from the Ray concentrator to the smelter, and sulfuric acid from the smelter to the leaching facilities. The smelter employs 375 people (nominal) and the concentrator employs 165 people (nominal). Smelter production in 2001 included (ASARCO, 2005):

- Copper in concentrate: 249,600,000 lbs
- Silver in concentrate: 684,374 oz
- Copper in cathodes: 102,959,000 lbs
- Copper in anodes: 438,308,000 lbs
- Acid: 571,800 tons

In addition to copper (Cu), the copper bearing ore processed on-Site contains other metals including: arsenic (As), lead (Pb), cadmium (Cd), zinc (Zn), chromium (Cr), and mercury (Hg). SO2, a byproduct of smelting, is recovered as sulfuric acid; 2,500 tons of sulfuric acid are produced each day. Air emissions from the facility include stack (point source), fugitive (non-point source), and particulate emissions. On-Site run-on and containment ponds and off-Site tailing piles are also part of the operations.

### 2.9.1 Chemicals of Concern Based on Existing Data

#### Human Health Risk Assessment

As part of the characterization of off-Site releases from the ASARCO operations facility to the Town of Hayden and nearby Winkelman, soil, sediment, groundwater, surface water, and air monitoring samples have been collected and analyzed for chemicals of potential concern (COPC). Based on available data, the currently known COPC for the ASARCO Hayden site include metals, which have been detected in soils, groundwater, and air samples, as well as SO2 and particulates in ambient air (PM10, PM2.5). The full list of metal COPC would include all the metal compounds in the TRI reports, for reporting year 2003, submitted by ASARCO to EPA (EPA, 2005a): copper, arsenic, lead, cadmium, zinc, chromium, mercury, antimony, barium, cobalt, manganese, nickel, selenium, and silver. The nature and extent of historic metal releases to adjacent properties and off-Site soils is unknown, but this list of COPC is a reasonable starting point based on existing data.

Additionally, radionuclides are associated with mining and ore processing activities and may be of concern in the direct vicinity of the smelter facility. Uranium, thorium, and radium are radionuclides associated with soils, while gross alpha and beta radioactivity, as well as uranium, thorium, and radium, can be found in groundwater.
For human health risk assessments, COPC are chemicals that are potentially Site related and for which data are of sufficient quality for use in the quantitative risk assessment (*Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, U.S. EPA [EPA, 1989]*)

Later, chemicals of concern are identified, which are chemicals that are retained for quantitative risk analysis after the COPC have undergone preliminary screening.

The Mine Safety and Health Administration (MSHA) would provide oversight of potential occupational exposures and potential health risks to the ASARCO work force by on-Site releases, and therefore, these exposure scenarios are not considered as part of this workplan.

**Ecological Risk Assessment**

Chemicals of potential ecological concern (COPEC) are those chemicals present at the Site in concentrations that may exceed toxicity thresholds for ecological receptors. These chemicals are identified by the evaluation of known site practices or analytical results. The Site is a copper ore processing facility that has operated since its founding about 90 years ago. The ore processing operations at the Site have resulted in large accumulations (about 1,700 total acres) of tailings, which have been deposited adjacent to the Gila River near the confluence with the San Pedro River. In 1993, flood waters washed about 292,000 tons of the tailings into the Gila River potentially impacting surface waters and sediment in the downstream areas (ADEQ, 2003). Air emissions from the smelting process have been deposited in surface soils and water in the terrestrial and aquatic areas around the plant. Based on the windroses developed for the Montgomery Ranch (west of the smelter) and Hayden Jail (in Hayden near the smelter) air monitoring stations, the primary deposition is likely to be in an east-west direction. In contrast, data from the Globe Highway air monitoring station (east of the smelter) indicate deposition in a primarily southwest-northeast direction, following the Gila River up the canyon located northeast of Winkelman.

Existing data indicates that arsenic and copper, and to a lesser extent, cadmium, lead, mercury, and zinc are at levels of potential concern. Therefore, all of these analytes are considered COPEC in soil, sediment, and surface water.

**2.9.2 Potential Chemicals of Concern**

**Human Health Risk Assessment**

Chemicals of concern are chemicals that are retained for quantitative human health risk analysis after the COPC have undergone preliminary screening. At the ASARCO Hayden site, investigation and characterization studies are still in their early stages. Therefore, it is still reasonable to collect soil, sediment, groundwater, and air monitoring samples for analysis for all of the COPC listed above.

The rationale for making the initial list of COPC identical to the metals identified in the TRI report (plus SO₂) is:

- The TRI metals are present on-Site
- The TRI metals are reported to be released from the Site

The TRI metals might occur off-site at concentrations that are of health concern to exposed humans. A formal selection of chemical of concerns for inclusion in the baseline HHRA will
be done after RI related Site characterization studies are performed and that data is evaluated. As an example, a COPC selection process based on RAGs (1989) can be applied:

- **Step 1: Eliminate Chemicals whose Maximum Value is Below a Level of Concern.**
  Comparison of maximum detected soil concentrations to EPA Region IX’s residential soil PRGs or Arizona R-SRLs can be used to eliminate metals which do not pose an unacceptable risk.

- **Step 2: Eliminate Beneficial Minerals.** In accord with EPA (1989), chemicals that are normal constituents of the body and the diet and are required for good health may be eliminated unless there is evidence that Site-specific releases have elevated concentrations into a range where intakes would be potentially toxic.

- **Step 3: Eliminate Chemicals whose Contribution is Minor Compared to the Others.** This can be performed on a metal by metal basis for the Site.

However, even at this stage in the RI, some contaminants identified in soil, groundwater, and air can be tentatively identified as potential risk drivers at the Site based on comparison of reported concentrations in soil, groundwater, and air samples to health based EPA and ADEQ standards. The concentrations of arsenic, copper, and lead in soils have been reported to exceed EPA and ADEQ human health risk-based screening criteria. Sediment samples have been reported to contain concentrations of arsenic and copper which exceed PRGs and R-SRLs. Available groundwater data from three of the drinking water wells in Hayden have been reported to contain arsenic concentrations that exceed the PRG for tap water (but are below the MCL). Air monitoring samples collected by ADEQ from 1991 to 1998 are reported to have exceeded the arsenic ambient air PRG. The Hayden area is reported to be in a non-attainment area for SO₂ and PM. These screening level exceedances indicate the potential for human health impacts from off-Site releases.

**Ecological Risk Assessment**

Although other classes of chemicals (e.g., VOCs, SVOCs, or radionuclides) are associated with mining and ore processing activities and may be of concern in the direct vicinity of the smelter facility, there is currently no evidence that these are chemicals of concern for ecological receptors. At this time, only metals are considered COPEC. In addition to those metals indicated in Section 2.9.1 (arsenic, cadmium, cooper, lead, mercury, and zinc), other metals including aluminum, antimony, barium, beryllium, boron, chromium, cobalt, iron, magnesium, manganese, molybdenum, nickel, selenium, silver, thallium, and vanadium are of potential concern. Though several of these have been recorded below levels of concern in previous investigations (ADEQ, 2003), many of the ecological habitats in the project area (e.g., upland areas within the air emissions deposition area) have not been well characterized. Therefore, all metals are considered COPEC.

The list of COPEC and the required detection limits are listed in Table 2-16. Each of these COPEC will be measured in soil, sediment, and surface water. It should be noted that measurement of both dissolved (filtered) and total (unfiltered) metals are required for surface water. For each medium type, there are additional data required for ecological risk interpretation (e.g., pH and total organic carbon [TOC] in sediment). The list of data requirements is provided in Table 2-17.
2.9.3 Potential Human Health Impacts

This section provides a brief discussion on potential human health impacts from exposures to Site related chemicals in soil (sediments, dust), groundwater, and air. For completeness, all metals listed in the TRI report are included. Potential exposure routes include inhalation, incidental ingestion, and dermal contact with those chemicals.

**Antimony and Compounds.** Exposures to high levels of antimony can result in several adverse health effects. Breathing high levels for a long period of time can irritate eyes and lungs and can cause heart and lung problems, stomach pain, diarrhea, vomiting, and stomach ulcers. Ingesting large doses of antimony causes vomiting. Exposure to antimony through drinking water can cause an increase in blood cholesterol and a decrease in blood sugar. Antimony can also irritate the skin if it is left on it (Agency for Toxic Substances and Disease Registry, Public Health Statements and TOXFAQs [ATSDR, 2005]).

**Arsenic.** Breathing high levels of inorganic arsenic can result in a sore throat or irritated lungs. Ingesting high levels of arsenic can result in death. Lower level exposures can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of “pins and needles” in hands and feet. Ingesting or breathing low levels of inorganic arsenic for a long period of time can cause a darkening of the skin and the appearance of small corns or warts on the palms, soles of feet, and torso. Ingestion of arsenic through drinking water also causes skin damage and problems with the circulatory system. Dermal contact with arsenic may also cause redness and swelling. Several studies have shown that arsenic increases the risk of lung cancer, skin cancer, bladder cancer, liver cancer, kidney cancer, and prostate cancer. EPA has identified inorganic arsenic as a human carcinogen (ATSDR, 2005).

The toxicity of arsenic is complicated due to the fact that arsenic can exist in different valence states. Most health effects from exposure to arsenic are associated with exposure to inorganic arsenic. The most common form of arsenic in air is arsenic trioxide (As$_2$O$_3$) and arsenates ([AsO$_4$]$^{3-}$) and arsenites ([AsO]$^{3-}$) exist in water, soil, and food. In general, the trivalent arsenites tend to be more toxic than pentavalent arsenates. It is difficult to determine the exact toxic effects of these forms of arsenic because in many cases of human exposure (intake from water and soil), the precise chemical speciation is not known (ATSDR, 2005).

**Barium and Compounds.** Adverse health effects from exposure to barium and compounds depend on how well the compound dissolves in water. In general, barium compounds do not dissolve well in water and are not harmful. Ingesting high levels of barium compounds that dissolve well in water over a short period of time can cause difficulties in breathing, increased blood pressure, changes in heart rhythm, stomach irritation, brain swelling, muscle weakness, and damage to the liver, kidney, heart, and spleen. The health effects from inhalation and dermal contact are currently unknown (ATSDR, 2005).

**Cadmium and Compounds.** Breathing high levels of cadmium severely damages the lungs and can cause death. Ingesting cadmium compounds in food and drinking water can severely irritate the stomach and causes vomiting and diarrhea. Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys and possible kidney disease. Other long-term effects are lung damage and fragile bones. Dermal contact with cadmium compounds is not known to cause health effects (ATSDR, 2005).
Chromium III. Chromium III is an essential nutrient that helps the body use sugar, protein, and fat. There are no major health effects from inhaling or ingesting it. Skin contact with chromium III may cause an allergic reaction consisting of severe redness and swelling of the skin (ATSDR, 2005).

Chromium VI. Breathing high levels of chromium (VI) causes irritation to the nose, such as a runny nose, nosebleeds, and ulcers and holes in the nasal septum. Ingestion of chromium (VI) can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death. Ingesting chromium through drinking water may cause allergic reactions of the skin such as dermatitis. Dermal contact with chromium (VI) can cause skin ulcers. Allergic reactions may also cause severe redness and swelling of the skin. The EPA has determined that chromium (VI) in air is a human carcinogen (increased risk of lung cancer) [ATSDR, 2005].

Cobalt. Breathing high levels of cobalt dust can cause difficulty in breathing, serious effects on the lungs, including asthma, pneumonia, and wheezing. High exposures in the workplace can also cause allergies resulting in asthma and skin rashes. Ingesting excessive amounts of cobalt may cause serious effects on the heart and in some cases death (ATSDR, 2005).

Copper and Compounds. Exposure to high amounts of copper can be harmful. Long-term exposure to copper dust by ingestion or inhalation can irritate the nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea. Ingesting drinking water with higher than normal levels of copper may cause vomiting, diarrhea, stomach cramps, and nausea. Intentionally high intakes of copper can cause liver and kidney damage and even death (ATSDR, 2005).

Lead. The health effects of lead are the same whether it is breathed or ingested. Exposure to lead can damage the central nervous system, especially in children. Lead also damages kidneys and the reproductive system. At high levels, lead may decrease reaction time, cause weakness in fingers, wrists, or ankles, and possibly affect the memory. Lead also causes anemia and can damage the male reproductive system. Exposure to lead through drinking water causes delays in physical or mental development in children and slight deficits in attention span and learning abilities. In adults, exposure to lead in drinking water can cause kidney problems and high blood pressure (ATSDR, 2005).

Manganese and Compounds. Breathing high levels of airborne manganese can affect motor skills and cause respiratory problems and sexual dysfunction. Exposure to very high levels of manganese for long periods of time can result in mental and developmental disturbances and slow and clumsy body movements (ATSDR, 2005).

Mercury and Compounds. Short-term inhalation of metallic mercury vapors may cause effects including lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation. Metallic mercury vapors are more harmful than other forms, because more mercury reaches the brain. Exposure to high levels of metallic, or inorganic mercury can permanently damage the brain, kidneys, and developing fetus. Effects on brain function include irritability, shyness, tremors, changes in vision or hearing, and memory loss. Damage to the lining of the mouth and lungs can occur from exposure to lower levels of mercury vapors over longer periods. Ingestion of drinking water with
inorganic mercury causes kidney damage. Skin contact with metallic mercury may cause allergic reactions (skin rashes) in some people (ATSDR, 2005).

**Nickel.** Breathing in high levels of nickel may cause chronic bronchitis and reduced lung function. Inhalation of nickel dusts can cause asthma attacks. Eating or drinking large amounts of nickel has caused lung disease in dogs and rats and has affected the stomach, blood, liver, kidneys, and the immune system in rats and mice. Direct dermal contact with nickel causes an allergic reaction to 10-15 percent of the population. The most common reaction is a rash at the site of contact. Because nickel causes cancer of the lung and nasal sinus, the EPA has determined that nickel refinery dust and nickel subsulfide are human carcinogens (ATSDR, 2005).

**Selenium.** Brief exposures to high levels of elemental selenium or selenium dioxide in air can result in respiratory tract irritation, bronchitis, difficulty in breathing, and stomach pains. Longer-term inhalation to either of these can cause respiratory irritation, bronchial spasms, and coughing. Short-term ingestion to high concentrations of selenium causes nausea, vomiting, and diarrhea. Chronic oral exposure to high concentrations of selenium can produce selenosis, which includes symptoms of hair loss, nail brittleness, and neurological abnormalities. Ingestion of drinking water with selenium also causes hair or fingernail loss, numbness in fingers and toes, and circulatory problems (ATSDR, 2005).

**Silver and Compounds.** Breathing in dust containing relatively high levels of silver compounds such as silver nitrate or silver oxide causes breathing problems, lung and throat irritation, and stomach pain. Several studies have been performed on animals that have ingested water with high levels of silver nitrate. Health effects included slight effects on the brain and hearts that were larger than normal. It is unknown if these health effects would occur in humans. Dermal contact with silver compounds has been found to cause mild allergic reactions such as rash, swelling, and inflammation (ATSDR, 2005).

**Sulfur Dioxide.** Exposure to very high levels of SO₂ can be life threatening. Most health effects result from inhalation of SO₂. Exposure to 100 parts per million (ppm) of SO₂ is considered immediately dangerous to life and health. Breathing in high levels of SO₂ also causes burning of the nose and throat, breathing difficulties, and severe airway obstructions. Long-term exposures can cause lung function changes. Asthmatics have also shown to be sensitive to respiratory effects of low concentrations of SO₂ (ATSDR, 2005).

**Vanadium and Compounds.** The major effects from breathing high levels of vanadium are on the lungs, throat, and eyes. Symptoms include lung irritation, coughing, wheezing, chest pain, runny nose, and a sore throat. These symptoms stop after there is no breathing in of contaminated air. The health effects of humans ingesting vanadium are unknown (ATSDR, 2005).

**Zinc.** Inhaling large amounts of zinc (as dusts or fumes) can cause a short-term disease called metal fume fever. It is unknown what the long-term effects of breathing in high levels of zinc. Large doses of zinc ingested for a short time causes stomach cramps, nausea, and vomiting. Over longer periods of time, it can cause anemia and decrease the levels of good cholesterol. Skin irritation occurs in animals after placing low levels of certain zinc compounds on the skin. Skin irritation would probably occur in humans from dermal contact with zinc (ATSDR, 2005).
2.9.4 Potential Environmental Impacts

At low levels, most organisms are able to accumulate and regulate intake of metals that serve as nutrients (i.e., chromium, copper, selenium, and zinc). However, these metals generally become toxic at certain levels. The mechanisms of ecotoxicity for each of the COPEC are presented in Table 2-18. Physical and chemical characteristics of, as well as interactions between, the medium and the COPEC are also important in understanding the potential environmental impacts. For example, organic carbon in soil and sediment often binds to metals, especially under alkaline conditions, and reduces their bioavailability to potential ecological receptors, thus reducing exposure. The environmental fate and transport information for each COPEC is presented in Table 2-19.

In addition to this general information regarding the mechanisms of ecotoxicity, four ecological studies have been conducted in or near the project area. One study evaluated contaminants in sediment, lizards, and fish collected from the Middle Gila River (Contaminants in Fish and Wildlife of the Middle Gila River, Arizona. U.S. Fish and Wildlife Service, Region 2, Contaminants Program. February. [King and Baker, 1995]) and a second study evaluated contaminants in sediment and fish of Mineral Creek and the Middle Gila River (Andrews and King, 1997). There are studies that document physical deformities in the willow flycatcher across the southwestern United States (A Summary of Observed Physical Deformities in the Willow Flycatcher: 1996 - 2000. U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Colorado Plateau Field Station, Flagstaff, AZ. November. [Sogge and Paxton, 2000]), and that also report contaminants in southwestern willow flycatcher eggs, nestlings, and prey items collected near several drainages in southeastern Arizona (Contaminants in Southwestern Willow Flycatcher Eggs and Prey Items, Arizona, 1998 - 2000. U.S. Fish and Wildlife Service, Region 2, Contaminants Program. July. [King, et al., 2002]).

King and Baker (1995) evaluated contaminants (Organochlorines [e.g., dichlorodiphenyltrichloroethane (DDT) and metabolites] and metals) in sediment, fish, and lizards collected from areas of the Middle Gila River from 1991 to 1992. Organochlorines were not detected in sediments, and were only found in fish and lizards at levels below those of concern for higher trophic birds. Copper in sediment was elevated at a majority of sampling locations, and molybdenum, selenium, and zinc were elevated only in the Mineral Creek sample. Despite equal effort, fish were only captured at one location. No fish were captured in areas of the river near the Site. Results of this study indicate that the highest concentrations of metals were from Mineral Creek and from the Gila River just downstream of Mineral Creek.

In the second study, fish population and diversity data and measurements of trace metals in sediment and fish were collected in 1995 from Mineral Creek upstream and downstream of Ray Mine and from the Gila River upstream and downstream of the confluence of the Gila River and Mineral Creek (Andrews and King, 1997). These were compared to similar data collected in 1993. Fish collected in the Gila River upstream of the Gila River and Mineral Creek confluence contained the highest concentration of aluminum, barium, and lead, though this location did not have the highest sediment concentrations of these analytes. The lead concentrations in fish at this location were greater than the threshold for potential reproductive and survival effects in fish. Copper was greatest in fish collected from Mineral
Creek downstream of Ray Mine, and was similar between the Gila River sampling location upstream of Mineral Creek than in those locations downstream of Mineral Creek.

Sogge and Paxton (2000) summarized deformities in 1,170 willow flycatchers captured in the United States from 1996 through 2000. A majority of these birds (86 percent) were captured in the southwestern states and 14 percent were captured in other areas of the contiguous United States. Fifteen (1.4 percent of total) of the birds collected had bill or eye deformities, with the percentage of deformed birds varying from about 1 to 2.6 percent per year. All of these beak and eye deformities were observed in birds collected from the southwest. Of these deformed birds, one was collected along the Gila River near Kearny (about 14.5 km downstream of the Site) and one was collected along the San Pedro River near Indian Hills (3 km south of the Gila River and San Pedro River confluence). Though bill deformities have been associated with elevated concentrations of some contaminants (e.g., selenium), the cause of the deformities in these areas is unknown. Therefore, this information is of limited use.

The last study, (King, et al, 2002), collected data on contaminant concentrations in eggs and food of southwestern willow flycatchers in the Hayden area. Sampling locations included one just west of Kearny along the Gila River and three south/southeast of the confluence of the Gila and San Pedro Rivers along the San Pedro River (as well as other sampling locations along the Salt, Verde, and Little Colorado Rivers, and Tonto Creek). These stretches of the Gila and San Pedro Rivers contain the greatest number of breeding southwestern willow flycatchers in Arizona. Addled eggs, dead nestlings, and potential prey items were collected at each sampling location and analyzed for organochlorines and metals. Additionally, nesting parameters (e.g., nesting success and fledging rate) were collected from 1996 to 2000. Dichlorodiphenyldichloroethylene (DDE) was the only organochlorine detected in egg samples and the concentration was below effects levels in birds. Of the 15 metals analyzed for, only selenium and boron were detected at concentrations of potential concern, though only one egg contained selenium levels greater than known toxic thresholds. Boron exceeded the lowest adverse effect level in two eggs. The average fledging success (<1.3 young/female) was lower than that known to maintain stable populations of other songbirds (usually 2.0 to 2.5 young/pair/season). Recruitment rates necessary for maintenance of a southwestern willow flycatcher population is unknown, but the observed rate suggested that the populations studied may not be stable. It should be noted that copper concentrations in eggs, nestlings, and invertebrates from the Kearny sampling location (downstream of the Site) were within the range of values collected at other locations.
3.0 Project Data Quality Objectives and Description of Companion Documents

The Data Quality Objectives (DQO) Process (based on Guidance for the Data Quality Objectives Process, EPA QA/G4, September 1994 and 2000) will be used to identify specific data needs for the project and to develop the appropriate sampling design and analyses to provide optimal data to meet project objectives. The DQO process is a seven-step iterative planning approach used to prepare plans for environmental data collection activities and is intended to help plan to collect data of the right type, quality, and quantity to support defensible site decisions. The seven steps are as follows:

1. State the Problem—Summarize the contamination problem that will require new environmental data and identify the resources available to resolve the problem. Update CSM.

2. Identify the Decision—Identify the decision that requires new environmental data to address the contamination problem.

3. Identify Inputs to the Decision—Identify the information needed to support the decision and specify which inputs require new environmental measurements.

4. Define the Study Boundaries—Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.

5. Develop a Decision Rule—Develop a logical "if . . . then . . ." statement that defines the conditions that would cause the decision maker to choose among alternative actions.

6. Specify Limits on Decision Errors—Specify the decision maker's acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data.

7. Optimize the Design for Obtaining Data—Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs.

The objectives of the RI at the Site are described in Section 1.4. Each objective will be considered through the DQO process to confirm needed data, data quality indicators (DQIs), and optimal sampling design and analyses.

These functional activities/procedures will be detailed in the Sampling and Analysis Plan (SAP, consisting of the QAPP, FSP and DMP), which will be submitted as a companion document to this RI workplan. All anticipated companion documents are described below.

The Quality Assurance Project Plan (QAPP) will present the policies, organizations, objectives, and functional activities/procedures for the remedial investigation to be carried out at the Site. The QAPP will be preceded with the DQO process described above, and the DQO process will be presented as an attachment to the QAPP.
This QAPP will follow EPA guidelines contained in *EPA Guidance for Quality Assurance Project Plans* (EPA 1998, 2002a), and *EPA Requirements for Quality Assurance Project Plans* (EPA 2001). The development, review, approval, and implementation of the QAPP is part of EPA’s mandatory Quality System, which requires all organizations to develop and operate management structures and processes to ensure that data used in agency decisions are of the type and quality needed for their intended use. The following sections of this document correlate with the subtitles found in the EPA guidelines (EPA 2001).

1. Introduction

2. Project Management (EPA Group A)
   2.1 Project/Task Organization (A4)
   2.2 Problem Definition/Background (A5)
   2.3 Project/Task Description (A6)
   2.4 Quality Objectives and Criteria (A7)
   2.5 Special Training/Certification (A8)
   2.6 Documents and Records (A9)

3. Data Generation and Acquisition (EPA Group B)
   3.1 Sampling Process Design (Experimental Design) (B1)
   3.2 Sampling Methods (B2)
   3.3 Sample Handling and Custody (B3)
   3.4 Analytical Methods (B4)
   3.5 Quality Control (B5)
   3.6 Instrument/Equipment Testing, Inspection, and Maintenance (B6)
   3.7 Instrument/Equipment Calibration and Frequency (B7)
   3.8 Inspection/Acceptance of Supplies and Consumables (B8)
   3.9 Non-direct Measurements (B9)
   3.10 Data Management (B10)

4. Assessment and Oversight (EPA Group C)
   4.1 Assessments and Response Actions (C1)
   4.2 Reports to Management (C2)

5. Data Validation and Usability (EPA Group D)
   5.1 Data Review, Verification, and Validation (D1)
   5.2 Verification and Validation Methods (D2)
   5.3 Reconciliation with User Requirements (D3)

6. References

   Appendix - Data Quality Objectives

The Field Sampling Plan (FSP) will elaborate on procedures presented in Section 4.0 of this workplan and will provide detailed field methods and procedures. The FSP is expected to contain the following sections:
1. Objectives
   1.1 Background
   1.2 Objectives

2. Site Background

3. Maps

4. Rationale for Sample Locations, Number of Samples, and Laboratory Analyses

5. Samples and Analyses

6. Field Methods and Procedures
   6.1 Sample Containers and Preservatives
   6.2 Sample Collection and Field Measurements
   6.3 Decontamination
   6.4 Containment and Disposal of Investigation-Derived Waste
   6.5 Sample Management Procedures and Documentation
      6.5.1 Sample Packaging and Shipment
      6.5.2 Sample Labeling
      6.5.3 Sample Documentation
   6.6 Quality Control Samples
      6.6.1 Field Duplicates
      6.6.2 Field Blanks
      6.6.3 Laboratory QC Samples
      6.6.4 Trip Blanks
      6.6.5 Temperature Blanks

7. References

The Data Management Plan (DMP) will address requirements for project management systems including tracking, storing, and retrieving data. The plan will also identify software to be used, minimum data requirements, data format, and backup data management. The plan shall address both data management and document control for all RI activities.

The Human Health Risk Assessment Plan (RAP) will be developed. A RAP will be prepared for the development of a human health risk assessment to determine whether Site contaminants of concern pose a current or potential risk to human health in the absence of any remedial action. The plan will include all assumptions and methods required to conduct a baseline risk assessment.

The Ecological RAP will be developed to help assess whether site contaminants of concern pose a current or potential risk to the environment in the absence of any remedial action. The plan will include all assumptions and methods required to conduct a screening-level ecological risk assessment.

The Pollution Control and Mitigation Plan (PCAMP) will be prepared to outline procedures to ensure that contaminants are not released off-site during RI implementation. The PCAMP will also describe procedures for managing IDW.
Finally, the Health and safety Plan (HASP) will be prepared to describe the safety procedures to be implemented for the project.
4.0 Remedial Investigation Field Procedures

4.1 Task 1—Site Reconnaissance and Sample Location Confirmation

This task will consist of conducting a Site reconnaissance of all areas in which field sampling is proposed. The work will consist of Site surveys including property, boundary, utility rights-of-way, and topographic information. The proposed sample locations will be physically visited to confirm they are accessible for sample collection. Some minor adjustments to sample locations may be needed, and if so, will be communicated to EPA. Obtaining access to sample locations is also included under this task.

4.2 Task 2—Mobilization and Demobilization

Mobilization will consist of coordination and consultation with the field team to execute the RI sampling activities at the Site. The field activities will be conducted concurrently to the extent possible, but separate mobilizations will likely be required for some activities, based on the schedule. Most field personnel will travel between Phoenix and Hayden, Arizona, and will confirm sample locations, request utility clearance either directly or through the subcontractors (and with ASARCO personnel as needed for on-Site work). Following mobilization, field personnel will conduct the initial sample collection, confirm field sample locations through Global Positioning System (GPS) or land surveying, and arrange for final investigation-derived waste (IDW) removal and Site restoration. The support equipment needed will vary from task to task and will consist of rental field and safety equipment. Equipment will be maintained either in the field vehicle or in a rented space (if needed). Designation of personnel and equipment decontamination area will be made. A list of expected field and safety equipment needs are as follows:

- Routine Field Equipment
  - Logbook
  - Waterproof pens
  - Mobile telephone
  - Site-Specific Documents
    - Workplan, SAP, and other companion documents
    - Historical reports
    - Reference documents (e.g., American Society for Testing and Materials (ASTM) Standards)
  - Contact list
  - Site maps
  - Access agreements
  - Permits
  - Laptop/GPS Unit
  - Paper towels
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- Marking tape and paint
- Rope/twine

• Health and Safety Equipment
  - Photoionization detector (PID) and other instruments as required by HASP
  - Nitrile gloves/leather gloves
  - Safety glasses/vests/steel toes
  - Tool bag
  - First aid kit
  - Fire extinguisher

• Sampling Equipment (actual equipment will vary according to each task)
  - Portable FPXRF instrument
  - Containers for soil, sediment, surface water, and groundwater samples
  - Chain of Custody (COC) Forms
  - Sample labels
  - Coolers and ice-packs

• Miscellaneous Equipment (as needed according to each task)
  - Generator
  - Power cords

It is expected that soil and sediment samples will be collected across a broad area and screened using a field portable x-ray fluorescence (FPXRF) instrument, as described in Section 4.3.2 and 4.3.3. Selected samples will then be collected and submitted to a fixed laboratory for analysis. Support from the EPA Region IX Field Analytical Support Program (FASP) laboratory is not anticipated for this investigation.

After completion of the initial sampling, the field team will demobilize and all temporary facilities will be removed. The Site will then be restored to its original state, to the extent practical.

4.3 Task 3—Field Investigation

4.3.1 Task 3a—Prepare Site Specific Plans

Prior to initiating any field work at the Site, CH2MHILL will generate a Site-specific HASP, SAP, PCAMP, and RAPs. The SAP, HASP, PCAMP, and RAPs will be prepared as companion documents prior to initiating any work at the Site.

The HASP will provide safety procedures allowing field personnel access to the Site and study area, and will therefore address appropriate Occupational Safety and Health Administration (OSHA) and MSHA requirements, as well as other requirements possibly imposed by ASARCO for work conducted on the concentrator, smelter and other company-owned properties.
The SAP will include the QAPP, FSP and DMP and will define soil, sediment, soil vapor, ambient air, water and groundwater sampling and analysis requirements associated with the field investigation activities. Sampling will be conducted in accordance with the QAPP, FSP, and associated Standard Operating Procedures (SOPs), which will be attached to the SAP. The DMP will be developed to describe all data management procedures to be used during the RI.

The PCAMP will be developed to help ensure that contaminants or pollutants are not released off-Site during the RI implementation. The PCAMP will include a waste management plan developed to outline how waste will be managed and disposed of.

The RAPs will be developed to guide data collection to support and prepare the Human Health Risk Assessment and Ecological Risk Assessment.

4.3.2 Task 3b—Surficial Soil Sampling

Purpose and Overview

Surficial soil sampling will be generally focused in areas that have been subject to minimal or no sampling activity in previous investigations. Exceptions include those soil areas where additional chemical data are needed or where changes in soil quality are anticipated to be occurring. As discussed in Section 2.0, previous investigations of surficial soil contamination have focused primarily on residential properties, school yards, and public gathering areas within the Towns of Hayden and Winkelman. The current investigation has two main purposes: 1) complement results of previous investigations and develop a better understanding of contaminant levels, potential contaminant source(s), and contaminant migration patterns over a broader area; and 2) collect sufficient data to support remedial actions, if necessary.

The area to be physically sampled for the RI is broadly defined as including:

1. Former Kennecott smelter area (including smelter yard, Smelter Last Chance Pond, slag pile, landfill, and other disturbed areas);
2. San Pedro, Kennecott Avenue, and Power House Canyon Washes, including side slopes adjacent to the washes and extending to the limit of residential yards;
3. Soils in the vicinity of the crusher facility, and on the western side of the concentrator facilities (adjacent to public areas in Hayden);
4. Developed land adjacent to the rail line and State Highway 177 (north of Tailings Pile AB/BC) and extending along the main highway through Winkelman);
5. Residential yards of all habitable homes (occupied and un-occupied) within Hayden and Winkelman, including homes that have been sampled during previous studies;
6. Ore and ore dust associated with No. 9 Conveyor;
7. Dust in attics and occupied areas of selected habitable homes within Hayden and Winkelman, as described in Section 4.3.5;
8. Upland areas representing different wind directions;
9. Winkelman school area;
10. Public park area east of Winkelman;
11. Golf course and access road east of AB/BC Ponds; and
12. Drainage areas immediately downstream of the slag dump located southeast of the active smelter.

These areas are shown in two shaded patterns on Figure 4-1. One shaded area depicts areas where confirmed sampling will be conducted at regular space intervals. Samples will be collected for analyses at approximately 300 feet intervals in areas including No. 9 conveyor, the area around the crusher, within the former Kennecott smelter area, low points along drainages, the toe of the slag pile near the active smelter, public areas near the facility (e.g., near the library), and along the railroad tracks which transport concentrate. The bulk and dust (i.e., soil fraction that passes the #200 sieve) fractions of samples from these areas will be analyzed by FPXRF; a field analytical technique described in greater detail in the procedures below.

Approximately 10 percent of the field samples will also be submitted for laboratory analysis. Additional sampling procedural information for both the FPXRF and soil sampling is included below. The percentage of samples submitted for laboratory analyses is subject to change following the initial phase of the site investigation, and during execution of the remainder of the site investigation. The surficial soil investigation will be divided into two phases. The initial phase will involve performing both FPXRF and laboratory analyses of approximately twenty samples collected from each of two test areas (areas to be determined). The purpose of completing this initial phase is to develop an understanding of the correlation between the data on metals concentrations derived from both types of analyses, to both determine the reliability of the FPXRF instrument and interpret the data collected from the subsequent second phase site investigation. The results of the initial phase of investigation will be used to adjust, as necessary, the frequency of samples submitted to a laboratory during the remaining portion of the investigation.

A second shaded area on Figure 4-1 depicts areas of potential sampling. These include the golf course and access road east of Ponds AB/BC, disturbed areas upslope of the level area within the former Kennecott smelter complex, and within and surrounding the active concentrator and smelter operations. The decision on whether to sample in these areas will be made during the RI field investigation, whereby sampling will be initiated if one or more contaminants are detected at concentrations above R-SRLs at confirmed sample sites adjacent to these areas. Sampling would be conducted at the same space intervals as described for other areas.

Sampling in residential areas will include habitable residential yards of all residences in Hayden and Winkelman, as well as dust from attics and occupied areas of selected homes from both towns. For the residential yard and school area soil samples, four samples will be collected; two surface soil samples (0-2") in high use areas; one subsurface soil (10-12") in one of the two same high use areas; and one surface soil sample (0-2") from a non-high use area. If the home has a small lot, only two surface and one subsurface samples may be required. If there is physical evidence of impacted soil (i.e. discoloration, odor, non-soil material present) at 2” depth at a particular location, sampling at 10-12” depth at that
location may be completed. One per 10 FPXRF samples collected from residential yards and the school area will be submitted to a laboratory for analysis, although this frequency may be changed based on the initial phase of the investigation.

Dust from attics and occupied areas of homes within Hayden and Winkelman will be sampled, as described in Section 4.3.5.

A gamma ray survey will be completed focusing on areas around the perimeter of the facility, around the large tailings piles and former in-town tailings piles (located within lower Kennecott Avenue and Power House Canyon Wash drainages), along the highway in Winkelman, along the railroad tracks, and along the San Pedro Wash as appropriate, using a Ludlum meter. In addition, selected residential yards will be included in the survey.

To support the HHRA and ERA, soil samples from areas representing different wind directions in upland areas not disturbed by human activities in the last 100 years, as well as areas that have been disturbed at various times in the past, will be collected to determine historic air emissions. As shown on Figure 4-2, a total of 13 soil samples will be collected at undisturbed ‘background’ sites that are arranged generally in a concentric pattern around the smelter stack. These samples of undisturbed soil will be evaluated to determine the effects of historic smelter smoke. At each of these locations, samples will be collected at 0-2” and 10-12” depth intervals and subject to FPXRF analyses. All upland soil samples will be collected for laboratory analyses.

Process facility areas including the active smelter area, and most of the concentrator facilities area, will not be subject to confirmed surficial soil sampling (per Figure 4-1). A key exception is the sampling of ore and ore dust area in the vicinity of No. 9 Conveyor. Access by the general public to process facility areas is restricted by ASARCO, with a corresponding reduction in risk associated with exposure to surficial contamination. Exposure to workers in these areas is monitored and controlled by ASARCO health and safety protocols. Soil contamination in these areas is also not of significant concern from an ecological risk perspective under current use conditions. Finally, it is expected that surficial soil in these areas constitutes variable contamination, contaminants will continue to variably accumulate due to ongoing operations, and remedial actions in these areas are most appropriately performed as part of any facility-wide remedial measures. Controls on operations to limit migration of contaminants from process areas may be recommended separately from the Remedial Investigation/Feasibility Study (RI/FS) process. However, additional soil sampling within process facility areas may be conducted if any of the following criteria are met based upon field observation during the RI field investigation phase:

- Residents (adult/child) have easy access via lack of fencing or actual/potential breaks in fencing;
- Off-Site transport is occurring (e.g., blown off-Site by wind or transport by water);
- People are moving the material off-Site; and
- Material (concentrate) is spilled onto railroad tracks.
An ore sample will be obtained in the vicinity of the crushing facilities and/or No. 9 conveyor. An ore sample should be requested from ASARCO if an ore sample is not obtained during the fieldwork. During the FPXRF sampling of the ore and ore dust, arsenic and copper concentrations in each media will be compared to determine if either metal is preferentially concentrated in one media over the other.

The areas defined above also encompass sediment sampling locations. For example, sediment deposits occur within San Pedro and Kennecott Avenue Washes. The sediment sampling program is discussed in Section 4.3.3.

Data "Gaps"/Data Needs

Current or historic Hayden smelter and concentrator operations are the primary source of off-Site impacts to the soil. The Preliminary CSM Diagram for Human Exposures is presented in Figure 1-1. The smelters and concentrator operations are the source of solid waste releases to soil. The primary release mechanisms are expected to be spills and releases from on-Site operations to on-Site soil. Secondary sources would be on-Site and off-Site soils.

Potential human receptor exposure routes would include soil (and dust) ingestion, dermal contact, and inhalation of particulates both indoors and outdoors. Potential applicable human receptors would be adult and child residents of Hayden and Winkelman, school children in schoolyards, pools, and parks, and trespassers on tailings piles, as appropriate.

The off-Site soil is anticipated to be one of the major environmental media associated with off-Site exposures to Site-related releases. As such, off-Site soil sampling (surface and subsurface) will be a major focus for RI Site characterization activities for the Site.

Soil sampling at all habitable residences in Hayden and Winkelman will address the need to characterize potential soil exposures of the adult and child residential population of Hayden and Winkelman, which is one of the major focuses of this RI workplan. Soil sampling at the public school complex in Winkelman will address the need to characterize potential soil exposures of children at schools. Additionally, the collection of soil samples near community facilities (parks, pools and libraries) will address the need to characterize potential soil exposures of children at public locations in Hayden and Winkelman.

Background surface and subsurface soil samples will be collected and analyzed, as well. Background samples will be collected in a concentric pattern around the present smelter stack. Samples will be collected of stable, undisturbed soil for the evaluation of old smelter emissions on native areas. The results of these samples will provide a reference point for potential background soil conditions for this study area.

The collection of soil samples at other inactive and active off-Site locations will address the need to characterize the potential soil exposures of trespassers (visitors) at these other locations.

As depicted in the ecological CSM (Figure 1-2), contaminants released from the smelter(s) and concentrator to air and soils are secondarily released to surficial soils by aerial deposition and discharge/runoff, respectively. Aerial deposition, in particular, has the potential to distribute contaminants over a wide area in the vicinity of the Site. The area surrounding the Towns of Hayden and Winkelman is mostly undeveloped and represents
potential ecological habitat. Because historic sampling did not include this habitat, the current sampling approach includes a combination of remote sensing of the entire subject area, x-ray fluorescence (XRF) sampling to ground truth the remote sensing and locate areas needing more focused sampling, and biased sampling in areas determined to be of concern based on potential ecological habitat and XRF results.

Procedures
Surficial soil sampling will be executed consistent with an RI. Four types of investigative techniques will be utilized including remote sensing, gamma ray survey, FPXRF, coupled with soil sample collection and laboratory analysis. These four techniques represent, in order of introduction, successively more focused investigation of surficial soils. Collectively, they represent a cost-effective and reliable approach to evaluating surficial soil contamination over a broad area. These techniques are described in more detail in the following subsections.

Remote Sensing
Remote sensing has been demonstrated to be an excellent, cost-effective method of mapping different mine/smelter waste materials transported by both voluntary placement and by the wind and surface water from the mine site into the surrounding ecosystem. Remote sensing records the reflected solar energy from specific mineral groups and specific minerals exposed on the surface of a scanned area. Each mine/smelter waste has a specific mappable mineralogical signature that differentiates each on-site specific mine/smelter waste transported by wind and surface water runoff over the similarly unique background signature(s). For example, satellite and overflight remote sensing data has been used successfully to map specific mine and process wastes at the rare-earth Mountain Pass Mine in the Mohave Desert of California, Coeur d’Alene Mining District in Idaho, Leadville Mining District in Colorado, Tri-State Mining District in Kansas, and the Butte Mining District in Montana. Both stream transported and particularly airborne tailings signatures were mapped for the site at the Mountain Pass Mine. Other mine and smelter sites have been similarly mapped by others and are described in literature.

Satellite remote sensing data collects significantly fewer channels of reflected light and at best can map at only about a 30 to 100 foot area of resolution, but provides about a 30 year record (from the early 1970s) of smelter waste dispersion from a site. Satellite data essentially maps discrete mineral groups (for example, clays, carbonates and iron minerals), but overflight data is used to map individual minerals present in the smelter wastes (for example, separately map copper sulfate, copper carbonate, etc.). Overflight data (using hyperspectral sensors) can map individual minerals on a scale of about a 10 foot area so it is capable of producing semi-quantitative and often quantitative estimates of specific minerals within individual smelter wastes at a scale that would be cost prohibitive using conventional surface mapping techniques. In other words, hyperspectral remote sensing data can map the average amount of individual minerals within every 100 foot square area of a site (a square 10 feet on each side, called a pixel).

A relatively broad area will be subject to remote sensing work. The remote sensing work will extend well beyond the limits of the shaded area shown on Figure 4-1. As a component of a screening-level assessment of contamination, remote sensing is beneficial in providing a large-scale understanding of sites impacted by mining and process operations in the vicinity
of Hayden, Winkelman, and areas upstream and downstream of these towns. The remote
sensing data is expected to yield not only a map of areas known or suspected to be
contaminated based on previous investigations, but perhaps additional contaminated sites
located a considerable distance from ongoing operations that may be subject to further
investigation. Further, this information should assist in defining ‘background’ levels of
constituents in soils within the area. One of the major advantages of this technology is the
mapping of both ‘background’ and mining-related materials where access is limited.

The subject area flown will be a rectangle trending generally northwest-southeast and
superimposed over the Gila and San Pedro River valleys. The overflight will incorporate the
Towns of Hayden, Winkelman, and associated ASARCO process facilities. The area flown
will extend five miles on both sides of a line extending from two miles east-southeast of
Winkelman, northwest to the town of Kearny.

Gamma Ray Survey
The gamma ray survey will include a walkover survey of the areas mentioned above using a
scalar ratemeter, such as the Ludlum 2221, which has been used at other mining sites. The
Ludlum 2221 contains an unshielded 3” x 3” sodium iodide detector that detects and counts
gamma rays and identifies radionuclides using an Exploranium GR-130 Gamma Spectrum
Analyzer. During the walkover survey, the detector will be suspended approximately three
inches above the surface to ensure accuracy and representativeness. Any anomalous areas
will be subjected to a 60 second count initially, and the counts would be verified using a 600
second count with the Ludlum meter as well as the Exploranium. Using both instruments
during the verification count provides both verification of the count as well as identification
of the radionuclides present. Additional information describing the gamma ray survey
procedure can be found in an EPA document titled Multi-Agency Radiation Survey and Site

Following completion of the gamma ray survey, areas with elevated gamma ray counts may
be included in the soil sampling program. The soil sampling procedures are described
below.

Field Portable X-Ray Fluorescence (FPXRF)
FPXRF has been used for semi-quantitative to more recently quantitative measurement of
elements, particularly metals, for both mining and environmental purposes over the last
20 years. FPXRF technology has been used over this period of time for remedial
investigations, feasibility studies and selected remedial actions to provide real time
concentrations of inorganic contaminants of concern. In addition to real time elemental
concentrations, the FPXRF documents representative sampling at a site. An example of
successful application of this technology is provided in Taylor et al, 2004, Environmental
Science and Technology (Vol. 38, pp. 6824-6831); 2004:

“It is objectively demonstrated that the in-situ method (portable x-ray fluorescence)
was three times more cost-effective than the ex-situ Atomic Adsorptive Spectroscopy
(AAS) method at characterizing a contaminated site.”

Use of the FPXRF instrument for environmental purposes is now formalized through EPA
Method 6200.
Five companies manufacture FPXRF instruments with variable capabilities. All five have FPXRF instruments that use radioisotope sources to determine the concentrations of inorganic contaminants of concern and two also provide the newer x-ray tube-sourced FPXRF instrument. These sources cause individual elements to produce unique photon energy levels that not only uniquely identify each element, but show amplitudes of each element’s signature that are directly proportional to their concentration in a sample. The FPXRF processes the energy level to individual element concentrations at detection limits that range from a few ppm to about 100 ppm for most contaminants of concern. The measured concentration is a true total concentration since no chemical preparation is necessary. They have been used to determine the element concentrations on essentially all media (soils, tailings, stream sediment, paint, vegetation, etc.), including filters from water samples. The FSP will describe the instrument to be used, and confirm the expected detection limits, for each inorganic contaminant.

The FPXRF will provide real-time measurements of concentrations of metals analytes. Of these, the concentrations of arsenic, copper and lead will be reported, since these are the analytes of highest concern based upon previous sampling work. The data on concentrations of other analytes will be stored, and reported at the discretion of EPA based on the occurrence of concentrations in excess of R-SRLs.

The results of FPXRF sampling will be quickly summarized and evaluated to identify specific areas where more focused sampling is desired, and to guide selection of samples to be submitted for laboratory analyses. This process will be enabled by using a hand-held GPS unit to record sample locations during sampling. Following review and discussion of data from the initial sampling, a second phase of FPXRF sampling may be initiated to better define specific areas of contamination, as noted on Figure 4-1.

**Soil Sampling**

FPXRF analyses will be performed on samples collected from 0-2” and 10-12” (depending on the location). Samples from locations where FPXRF screening indicates elevated concentrations will be submitted for laboratory analyses. Samples collected during the initial phase of investigation will be analyzed using both the FPXRF as well as laboratory techniques. Each sample collected during the second phase of the investigation will be analyzed using FPXRF, with 10 percent or greater of these samples submitted for laboratory analyses including TAL metals, cation exchange capacity, percent solids, grain size distribution, pH, and total organic carbon. If the FPXRF instrument detects elevated metal concentrations at 10-12” depth, a deeper sample (16-18” bgl) may also be collected from that location for laboratory analysis. No heavy equipment will be used to collect subsurface samples, and additional procedural information is included in Section 4.3.3.

The personnel performing surface soil sampling activities will have knowledge and experience in the sampling methods proposed, or will work under the direct field supervision of knowledgeable and experienced personnel.

The following materials and equipment may be necessary for surface soil sampling.

- Laboratory-supplied sample containers
- Bound field logbook
• Reference maps
• 100-foot tape measure
• Camera and film
• Surveying stakes or flags for marking of sampling locations and GPS receiver
• Monitoring equipment and personal protective equipment (PPE) as outlined in the HASP
• Decontamination equipment and supplies (e.g., high pressure sprayer/washer, wash/rinse tubs, brushes, Alconox, plastic sheeting, paper towels, sponges, baby wipes, garden-type water sprayers, large plastic bags, potable water, distilled water and/or deionized water)
• Stainless steel scoop or spoon, knife, pick and mixing bowl
• Mesh sieves to collect samples of ore dust fractions (dust fractions are that material which passes the 200 sieve)
• Sample collection supplies (e.g., plastic recloseable plastic bags or equivalent, waterproof markers, sample labels, COC forms, cooler for sample storage, ice or ice substitute, clear plastic and strapping tape, custody seals, trash bags)
• Approved containers for containing soil and water
• Other materials and equipment may be needed based on field conditions

At each sampling location, the top two inches of soil will be sampled following the removal of surface vegetation and other debris from the sampling area. Prior to sampling, the volume of sample material to be collected will be calculated. The sampling protocol is as follows:

1. Identify the sampling site and mark it with a flag, lath or surveying stake.

2. At each location, clear an area approximately 12-24 inches in diameter of surface vegetation and debris.

3. Use a decontaminated stainless steel spoon to collect the surface soil to a depth of two inches. A stainless steel pick may be used as needed to loosen the soil. To the extent possible, eliminate gravel or larger sized particles, organic matter or other debris based on visual observation. Record and document by photograph the vertical stratigraphy of the soil sample location. If windblown material overlies the natural soil, this material should be collected as a separate sample at the soil sample locations. Collect sufficient sample volume to enable analyses of the constituents listed above.

4. Place the sample in a stainless steel bowl. To the extent possible, eliminate gravel or larger sized particles, organic matter or other debris based on visual observation.

5. Thoroughly mix the sample material in the stainless steel bowl using a decontaminated stainless steel spoon.
6. Immediately fill the appropriate sample containers. Label and handle the containers as specified in Section 4.3.9. Soil samples collected at FPXRF-analyzed locations are to be thoroughly homogenized and analyzed by FPXRF. Laboratory instructions are to include a stipulation that all soil samples are to be thoroughly homogenized immediately prior to acquiring the sample for chemical analysis.

7. Decontaminate the sampling equipment in accordance with procedures provided in Section 4.3.9.

The following field notes will be documented in the field logbook using waterproof ink:

- Names of sampling personnel
- Weather conditions
- Date and time of sampling
- Sample location number
- Description of sampling location (e.g., surrounding Site description and sketch, observation of grain-size variability, soil layering characteristics, color differences, staining, odors, etc.)
- Soil color according to Munsel soil color chart and grain size (will be used to differentiate tailings, crusher dust, and other waste from typical native materials; whereby tailings typically have a different color and texture than native materials)
- Decontamination information
- Sampling method
- Sampler’s signature
- Observations of conditions that may affect sample quality

Following completion of sampling, restore the sampling location to match as closely as possible its pre-sampling condition.

Samples will be submitted under proper COC procedures for analysis of metals and other constituents. Detailed field sampling and laboratory procedures will be described in the FSP and QAPP, respectively.

4.3.3 Task 3c—Surface Water and Sediment Sampling

Purpose and Overview

Surface water and sediment sampling will be focused in established drainages and impoundment areas. The sampling will complement previous investigations, with minimal duplication in sampling locations relative to previous investigations. The data from this investigation will enable a better understanding of contaminant levels, potential contaminant source(s), and contaminant migration patterns over a broad area; as well as support remedial actions.

The area of interest for sediment and surface water sampling is generally defined as the:
1. Gila River extending from approximately two miles upstream of Winkelman to approximately five miles downstream of Last Chance Basin;

2. San Pedro River extending approximately three miles upstream from its confluence with the Gila River;

3. San Pedro, Kennecott Avenue, and Power House Canyon Washes;

4. Tailings Piles AB/BC and D; and

5. Stable and unstable riparian communities within the Gila River floodplain.

Data "Gaps"/Data Needs
The primary release mechanisms, which will impact off-Site surface water and sediments, are expected to be spills and releases from on-Site operations. The preliminary CSM for human exposures is presented in Figure 1-1. Dispersion transport media would include off-Site surface water flow and releases.

Potential human exposure routes would include sediment and surface water ingestion and dermal contact. Currently, potential applicable human receptors would be residents of Hayden and Winkelman, including adult and child off-Site trespassers, and anglers in the nearby Gila and San Pedro Rivers, as appropriate.

Surface water and sediments are expected to be relatively minor sources of risks and hazards, and will receive a comparatively, lower level of sampling. Surface water sampling locations include the Gila and San Pedro Rivers, and tailing pile pond samples. Sediment sampling locations include tailing piles (bulk and fine fractions), surface water sample collection locations, and nearby stable and unstable riparian area locations. Surface water and sediment samples collected at these locations will address the need to characterize the potential exposures of trespassers and anglers to these media.

Regarding potential ecological exposures, aerial deposition, as well as discharge/runoff from source soils (e.g., 1993 discharge from Tailings Pile AB/BC) are potential release mechanisms of contaminants to surface water and sediments (Figure 1-2). These releases create potential exposure pathways to ecological receptors. Although historic sampling has included collection of surface water and sediment, these data are not sufficient to characterize those areas of ecological habitat potentially affected by Site release.

These area limits are estimates based on the need for data to support a screening ecological risk assessment and subsequent remedial actions. The surface water and sediment sampling locations are shown on Figure 4-2. In addition to the discrete sampling locations shown on Figure 4-2, sediment sampling will occur within the San Pedro, Kennecott Avenue, and Power House Canyon Washes in the Town of Hayden (shown as shaded areas on Figure 4-1). As described in Section 4.3.2, process facility areas including the active smelter area, the concentrator facilities, and areas within the Towns of Hayden and Winkelman will not be subject to surface water or sediment sampling unless these areas can be accessed by the general public based on the criteria presented in Section 4.3.2. Access by the general public to these areas is restricted by ASARCO, and worker exposure to contaminants in these areas is monitored and controlled by ASARCO health and safety protocols.
Four types of investigative techniques will be utilized including remote sensing, electrical conductivity survey, FPXRF, and sample collection and laboratory analysis. The remote sensing and FPXRF techniques were introduced in Section 4.3.2. for surficial soil sampling, and these techniques are also prescribed for sediment sampling. In addition, procedures are described below for the electrical conductivity survey and collection of sediment and surface water samples for subsequent laboratory analyses.

The area of remote sensing coverage described in Section 4.3.2 will include areas containing soil, sediment and potential smelter-related airborne and waterborne materials. Remote sensing data may be beneficial in defining the nature and extent of sediment contamination along the Gila River associated with the uncontrolled discharge of tailings from Tailings Pile AB/BC in 1993, determining whether existing storm water/erosion controls are generally effective in containing sediment migration within ASARCO process facility areas, helping define ‘background’ concentrations of metals in sediments, and confirming the presence and extent of any previously-undisclosed sources of sediment contamination. Remote sensing allows extrapolation of documented materials from sampled sites into coverage in sites where access is a problem. This data will also assist in focusing the subsequent sampling effort utilizing the FPXRF.

In order to focus the surface water sampling, an electrical conductivity survey will be conducted prior to any sample collection. The results of the electrical conductivity survey will be used to refine as necessary, the surface water sampling locations. Electrical conductivity surveys are useful for identifying TDS source areas, such as around the tailings ponds, that may contribute to surface water contamination. The survey will extend through the project area (noted on Figure 4-2); including the length of the Gila River extending from Last Chance Basin to upstream of the Town of Winkelman. The survey will consist of collecting a grab water sample from near the banks of the Gila River at 100 foot increments, and measuring conductivity in each sample. Within the meanders of the Gila River, the sample spacing will be decreased to 50 feet, and if any seeps are visually located while in the field, these will also be sampled. The electrical conductivity of each sample collected along with the GPS coordinates of the sample location will be recorded. It is anticipated that this survey will be completed within one to two days.

The FPXRF sediment sampling locations in washes and other areas (as denoted on Figure 4-1) will initially be relatively evenly-spaced, with a large spacing between sample points. In addition, certain areas have been selected for biased sampling using FPXRF as denoted on Figure 4-5). All biased sample locations analyzed using FPXRF will also be submitted for laboratory analysis. The results of initial sampling in all areas will be assessed by the team to determine which, if any, areas should be subject to more focused FPXRF analyses and sampling. The proposed sample spacing for the initial sediment sampling effort in biased and non-biased areas is as follows:

1. Within the San Pedro, Kennecott Avenue and Power House Canyon Washes, approximately 300 feet along the lengths of the channels extending from State Highway 177 upstream to the former Kennecott smelter area (estimated 40-60 samples total);
2. Within the Gila and San Pedro River floodplains, a total of 13 biased/non-biased locations, whereby one sample each of surface water, stream sediment, and nearby
stable and unstable sediment in riparian areas will be collected (total of four samples at each location);

3. Within the Gila River floodplain, a total of five biased sediment samples collected from stable riparian communities located between the junction of the Gila and San Pedro Rivers and Last Chance Basin;

4. On Tailings Ponds AB/BC and D, a total of 10 biased sediment samples (seven from AB/BC and three from D) to be collected from relatively dry slopes below the crest of the embankments; and

5. On Tailings Ponds AB/BC and D, one biased surface water sample each from an area of ponded water.

The FPXRF will provide real-time measurements of concentrations in sediment of TAL metals. Of these, the concentrations of arsenic, copper and lead will be reported, since these are the analytes of highest concern based upon previous sampling work. The data on concentrations of other analytes will be stored, and reported at the discretion of EPA based on the occurrence of concentrations in excess of Arizona R-SRLs.

The extent of any subsequent sampling cannot be defined prior to performing the initial survey, though it is reasonable to estimate that an additional 100-150 FPXRF samples may be collected to further define and document the results of the initial sediment sampling. Recognizing that there may be access limitations and to allow some flexibility in sample site selection, specific additional sediment sample locations are not provided in this workplan, but areas of future potential sampling are noted on Figure 4-1. If supplemental sediment sampling is performed, sediment samples will be submitted for laboratory analyses following FPXRF analyses.

Sediment and surface water samples will be collected according to the procedures described below.

**Surface Water Sampling Procedures**

Prior to the start of surface water sampling, an electrical conductivity survey will be conducted, as described in the previous section.

The paragraphs below describe procedures for collection of surface water samples from the Gila and San Pedro Rivers, including both samples collected for laboratory analyses as well as field measurements of water quality parameters. Field measurements of parameters of specific conductivity, salinity, dissolved oxygen, pH, temperature, and turbidity will be completed. Laboratory analyses of surface water samples will include both total (unfiltered) and dissolved (filtered) TAL metals, total ammonia, hardness, alkalinity, total organic carbon, total dissolved solids, total suspended solids, sodium, calcium, and potassium.

Surface water flow conditions vary at the Site. Flows in the Gila River flow are largely controlled by releases from storage facilities located upstream, and the San Pedro River flows intermittently based largely on precipitation. Surface water flow conditions expected to be encountered at the Site include:

- Areas of standing water;
4.0 REMEDIAL INVESTIGATION FIELD PROCEDURES

- Flowing streams or ditches; and
- Low flow seeps and springs.

Separate sampling procedures are specified for each of the three flow condition types. Sediment samples will be co-located with surface water samples. Surface water samples will be collected prior to sediment samples to avoid effects from sediment disturbance. Sediment sampling procedures are specified below.

The personnel performing sampling activities will have knowledge and experience in the sampling methods proposed or will work under the direct field supervision of knowledgeable and experienced personnel.

A. Water Sampling for Laboratory Analyses—Materials and Equipment

The following materials and equipment may be needed for surface water sampling:

- Sample bottles (with preservatives added) obtained from the analytical laboratory. Several extra sample bottles will be obtained in case of breakage and for QA/QC samples
- Sample transfer containers of assorted sizes (extra sample bottles [without preservatives] from the analytical laboratory are acceptable)
- Bound field logbook
- Reference maps
- 100-foot tape measure
- Surveying stakes or flags for marking of sampling locations
- Stopwatch
- Camera and film
- Monitoring equipment and PPE as outlined in the HASP
- Sample collection supplies (e.g., disposable latex gloves, plastic recloseable plastic bags or equivalent, waterproof markers, sample labels, COC forms, cooler for sample storage, ice or ice substitute, clear plastic and strapping tape, custody seals, and trash bags)
- Other materials and equipment may be needed based on field conditions

Standing Water Sampling Procedures

Samples may be collected by direct submersion of the sample bottle in the standing water, if the sample bottles supplied by the laboratory do not contain preservatives. If the bottles contain preservatives, a transfer container must be used to initially collect the sample of the standing water prior to transferring the sample to the container submitted to the laboratory.

1. Rinse the laboratory-supplied sample bottle or transfer device three times with standing water before collecting the sample (discard rinse water well away from the sample location).
2. Submerge the laboratory-supplied sample bottle or decontaminated transfer container below the water surface, taking care to minimize disturbance of bottom materials. If possible, the sample should be collected from at least six inches below the water surface.

3. Fill the laboratory-supplied sample bottle to the required volume (either by submersion or from the transfer container). The filtering procedure for the dissolved metals/parameters is described in a separate section below. Cap and appropriately label the total and dissolved samples.

4. The laboratory will be supplying bottles with appropriate preservatives, but if necessary, add the appropriate preservative to the sample.

5. Place the samples for shipping to the laboratory in accordance with the sample handling procedures described in Section 4.3.9.

6. Collect a sample of the standing water in the transfer container and measure field parameters in accordance with Section B, below. Record field measurements in the field logbook, and discard the water.

**Flowing Water Sampling Procedures**

Samples may be collected by direct submersion of the sample bottle in flowing water if the sample bottles supplied by the laboratory do not contain preservatives. If the bottles contain preservatives, a transfer container must be used to initially collect the sample of the standing water prior to transferring the sample to the container submitted to the laboratory.

1. To avoid disturbing stream sediments, which may affect the sample, approach the sampling location from downstream. Always stand downstream of each individual sampling location while collecting the sample. When collecting samples at successive locations in the river, always proceed from downstream to upstream locations.

2. If a transfer container is to be used, triple rinse the container with flowing water prior to collection of the sample. Discard the rinse water downstream of the sampling location.

3. Fill the laboratory supplied sample bottle to the required volume (either by submersion or from the transfer container). If possible, the sample should be collected from at least six inches below the water surface. The filtering procedure for the dissolved metals/parameters is described in a separate section below. Cap and appropriately label the total and dissolved samples.

4. The laboratory will be supplying containers with appropriate preservatives, but if necessary, add the appropriate preservative to the sample.

5. Place the samples for shipping to the laboratory in accordance with the sample handling procedures described in Section 4.3.9.

6. Collect a sample of the water in the transfer container and measure field parameters in accordance with Section B, below. Record field measurements in the field logbook and discard the water.

**Low Flow Sampling Procedures**

1. Dig a small depression in the soil adjacent to and within the path of flow.
2. Place a decontaminated stainless steel bowl in the depression with the rim of the bowl positioned to intercept the flow.

3. Allow the bowl to fill and to overflow for several minutes (preferably until the water is no longer turbid).

4. Obtain water samples from the stainless steel bowl by submerging the sample bottle or using a decontaminated transfer container (triple rinse the sample container prior to collection of the sample). The filtering procedure for the dissolved metals/parameters is described in a separate section below. Cap and appropriately label the total and dissolved samples.

5. The laboratory will be supplying containers with appropriate preservatives, but if necessary, add the appropriate preservative to the sample.

6. Place the samples for shipping to the laboratory in accordance with the sample handling procedures described in Section 4.3.9.

7. Collect a sample of the standing water in the transfer container and measure field parameters in accordance with Section B, below. Record field measurements in the field logbook and discard the water.

**Filtering Procedures**

Samples for dissolved metals analyses will be filtered in the field using either an in-line 0.45-micron disposable filter unit and peristaltic pump or a disposable 0.45-micron filter unit (Nalgene or equivalent) and hand pump.

The following procedure is used for filtering samples using an in-line filter and peristaltic pump:

1. Assemble the filter and peristaltic pump according to the manufacturer’s instructions. Insert a new piece of tubing about six inches long through the pump head of the peristaltic pump. New tubing will also be used for each sample.

2. Place the unfiltered water sample into a decontaminated sample transfer device such as a large beaker. Place the inlet tube into the sample transfer device and turn on the pump.

3. Rinse and discard the first 25-100 milliliters of water that passes through the tubing and filter. The volume should be approximately three times the tubing volume.

4. Use the discharge line from the pump to fill the appropriate sample container(s) with filtered water.

5. Place the used filter and tubing in a suitable container and dispose of as investigation derived waste.

The following procedure is used for filtering samples using a hand pump:

1. Assemble the filter unit according to the manufacturer’s instructions. Use a new filter unit for each sample.

2. Pour the unfiltered water sample into the top portion of the filter unit. Use the hand pump to apply pressure to the filter unit to increase the rate of filtration.
3. Discard the first 25 milliliters of water that passes through the filter.

4. Transfer the filtered sample from the lower portion of the filter unit to the appropriate sample container(s) with filtered water.

5. Place the used filter unit in a suitable container and dispose of as investigation derived waste.

B. Field Measurements-Water Quality Parameters

The following materials and equipment may be necessary for measurement of field water quality parameters.

- Portable pH meter and pH 4, 7, and 10 buffer solutions
- Spare pH probe or electrolyte cartridge, as applicable
- pH electrode storage solution
- Conductivity meter and calibration solutions that bracket the expected range of measurements
- Portable dissolved oxygen kit and low and high range dissolved oxygen AccuVac ampuls (or equivalent)
- Two thermometers
- In-flow multi-measurement meter
- Tygon™ or silicone tubing
- Peristaltic pump
- 12-volt battery
- Extra batteries for all instruments
- Beakers of assorted sizes
- Deionized or distilled water
- Wash bottle
- Kimwipes® or equivalent

Several of the field parameters are physically or chemically unstable and may be tested using either an in-flow multi-measurement system or a field-test kit or instrument, immediately after sample collection. Examples of unstable parameters include pH, temperature, and dissolved oxygen. Although the conductivity of a substance is relatively stable, this characteristic needs to be measured in the field to compare with the laboratory measurement, to determine if significant dissolution or precipitation has occurred after sample collection. Most instruments measuring conductivity require temperature compensation. Therefore, the temperature of the samples should be measured at the time the conductivity is measured.
An unfiltered water grab sample (if not using an in-flow multi-measurement system) will be collected for measuring field parameters. One sample can be used to measure all field parameters, but field parameters need to be measured as soon as possible after collection and this unfiltered sample should not be submitted for laboratory analysis.

Field parameters will be measured in the following order, as applicable:

1. Temperature and pH
2. Conductivity and Salinity
3. Dissolved Oxygen
4. Turbidity

The in-flow multi-parameter monitoring system or similar multi-parameter instruments may be used for measuring pH, temperature, conductivity, and dissolved oxygen. The instrument operation and maintenance manual will be followed when operating or calibrating the instrument.

C. Documentation

Field personnel will document sample collection and field measurements in the field logbook. Generally, information to be documented includes instrument calibration checks, sampling conditions, sample location and identification, methods used, and results of field measurements of water quality parameters. Photographs should be taken at each sampling location to document both the sample point and sampling conditions. Specifically, the following field notes will be recorded in the field book:

- Names of sampling personnel
- Weather conditions
- Date and time of sampling
- Sample location number
- Parameters measured and values
- Description of sampling location (e.g., surrounding Site description and sketch, observation of staining, odors, etc.)
- Decontamination information
- Sampling method
- Sampler’s signature
- Observations of conditions that may affect sample quality

Sediment Sampling Procedures

The paragraphs below describe procedures for collection of sediment samples. All biased sediment samples will be analyzed for TAL metals, pH, percent solids, and total organic carbon, whereas the non-biased sediment samples will only be analyzed for Target Analyte List (TAL) metals.
Personnel performing sediment sampling activities will have knowledge and experience in the sampling methods proposed or will work under the direct field supervision of knowledgeable and experienced personnel. Personnel will also be qualified to perform this work in accordance with the project’s HASP.

**Materials and Equipment**

The following materials and equipment may be needed for sediment sampling:

- Laboratory-supplied sample containers
- Bound field logbook
- Camera and film
- Sampling site location maps
- 100-foot tape measure
- Surveying stakes or flags for marking of sampling locations
- Monitoring equipment and PPE as outlined in the HASP
- Decontamination equipment and supplies (e.g., high pressure sprayer/washer, wash/rinse tubs, brushes, Alconox, plastic sheeting, paper towels, sponges, baby wipes, garden-type water sprayers, large plastic bags, potable water, distilled water and/or deionized water)
- Stainless steel scoop or spoon, knife, pick and mixing bowl
- Sample collection supplies (e.g., plastic recloseable plastic bags or equivalent, waterproof markers, sample labels, COC forms, cooler for sample storage, ice or ice substitute, clear plastic and strapping tape, custody seals, and trash bags)
- Sample containers
- Other materials and equipment may be needed based on field conditions

**Sampling Protocol**

The sediment sampling protocol is as follows:

1. At each location, clear an area approximately 12 inches in diameter of surface vegetation and other non-representative debris.

2. Use a decontaminated stainless steel spoon to collect the sediment to the desired depth. A stainless steel pick may be used as needed to loosen the soil. To the extent possible, eliminate gravel or larger sized particles, vegetation or debris based on visual observation. Collect sufficient sample volume to meet analytical requirements.

3. Place the sample in a stainless steel bowl. To the extent possible, eliminate gravel or larger sized particles, vegetation or debris based on visual observation.

4. Thoroughly mix the sample material in the stainless steel bowl using a decontaminated stainless steel spoon.
5. Immediately fill the appropriate sample containers. Label and handle the containers as specified in the Section 4.3.9.

6. Decontaminate the sampling equipment in accordance with procedures presented in Section 4.3.9.

The following field notes will be recorded in the field logbook using waterproof ink:

- Names of sampling personnel
- Weather conditions
- Date and time of sampling
- Sample location number
- Photograph and describe the sampling location (e.g., surrounding site description and sketch, observation of grain-size distribution, degree of rounding, color, staining, odors, etc.)
- Decontamination information
- Sampling method
- Sampler’s signature
- Observations of conditions that may affect sample quality

Following sampling, each site will be restored as necessary to its pre-sampling condition.

4.3.4 Task 3d—Groundwater Investigation and Sampling

Purpose and Overview

Based on the review of groundwater quality data from previous sampling events, several questions remain relative to the potential effect of the Site on human health and the environment. Seven new monitoring wells are proposed to collect information to fill in these data gaps (Figure 4-3). The wells and justification are summarized as follows:

- Only one monitoring well has been completed within the wash alluvial aquifer on-Site, and this well is partially completed in the underlying bedrock aquifer (Well SM-2). Two locations that have shown elevated metals contamination are Well LC-1 at the head of the San Pedro Wash and Well SM-2 near Power House Canyon Wash. As part of the groundwater investigation, GW-1 and GW-6 will be installed in the wash alluvium at the mouth of the Kenneecott and Power House Canyon washes, respectively, prior to exiting into the larger Gila River alluvium. Also, GW-2 will be installed downgradient of the slag pile within the wash alluvium. The wash alluvium may only be fully saturated on a seasonal basis, so groundwater sampling of these wells may need to be timed with the presence of water in the well. The purpose of these wells will be to evaluate shallow groundwater quality impacts, which may occur in the source areas upgradient of these washes and to evaluate potential discharge to the Gila River alluvium from the Site.
Sampling of selected Hayden well field drinking water supply has taken place during normal operations of the production wells. These wells typically pump at more than 1,000 gpm, and may produce so much dilution that contaminants contributed from limited upgradient flowpaths may not be seen in water samples collected from the wellhead. GW-3 is proposed to collect water samples from within the well field, along a pathway between the well field and the nearby desiccant recovery pond. This well will be completed in the Gila River alluvium at a similar depth as the Hayden production wells. This well will also allow for measurement of water levels in the area to better complete a regional groundwater elevation contour map, and will serve as an observation well for the nearby production wells if refinement of aquifer hydraulic parameters is needed.

The water quality results from bedrock well H-7 and bedrock well LC-1 show elevated concentrations of arsenic. When installed, these wells are anticipated to be upgradient of the Site, so movement of Site groundwater could not easily explain the presence of contaminants. It is possible that the bedrock lithology (Tertiary volcanics) contributes to high background levels of arsenic. GW-4 will be installed into the bedrock in an area likely removed from the possibility of known metals processing contamination, to obtain information on the background bedrock water quality.

The tailings emplaced in Tailings Piles AB/BC and D are likely releasing affected water into the alluvial system, resulting in potential exposures to ecological receptors (Figure 1-2). The APP (SHB, 1994a) estimated that 10 to 20 percent of the flow in the Gila River alluvium downgradient of the tailings may be contributed from excess water in the tailings piles. There are several existing monitoring wells dedicated to sampling the alluvial aquifer in and around the tailings piles (H-1-H-5), which show occurrences of arsenic and cadmium in exceedance of MCLs, and which show continuously elevated TDS and sulfate concentrations. Once the affected waters leave the tailings area, it is not known how they travel. No information on the vertical gradients within the Gila River system are available, so it is not known whether the tailings contributions mingle with surface water or continue to flow in a subsurface fashion, and whether this flow pattern varies seasonally. GW-5a and GW-5b are proposed to evaluate the hydraulic vertical head gradient and groundwater quality, and are located downgradient of the tailings piles, within the Gila River alluvium. The exact location of this monitoring pair will be coordinated with the surface water sampling program to provide both groundwater and ecological sampling data.

Table 4-1 presents a summary of the proposed well construction details. Figure 4-4 presents a generalized monitoring well construction diagram.

Data "Gaps"/Data Needs

The primary release mechanisms, which may impact groundwater, are expected to be spills and releases from on-Site operations. A preliminary CSM for human exposures is presented in Figure 1-1. Secondary sources would be on-Site and off-Site soils and groundwater. Potential secondary release mechanisms would be infiltration (leaching and percolation) to groundwater.
Dispersion transport media would include groundwater flow. Potential human exposure routes would include tap water ingestion and dermal contact. Currently, potential applicable human receptors would be adult and child residents of Hayden and Winkelman, and school children.

It is unknown whether groundwater under the smelter discharges to the Gila River or whether there is leaching from the tailings piles to groundwater under the Gila River. As groundwater is a potentially complete exposure pathway to both human (Figure 1-1) and ecological receptors (Figure 1-2) this lack of groundwater characterization represents a gap in data.

Groundwater and drinking water are expected to be relatively minor sources of risks and hazards, and will receive a comparatively lower level of sampling. Groundwater sampling at existing domestic water supply well manifolds, groundwater monitoring wells, and tap water sources at community facilities such as schools, parks, pools, and libraries, will help to address the need to characterize potential tap water exposures to residents (adult and child) and school children in the towns of Hayden and Winkelman.

**Water Table Elevations**

Water table elevations will be collected contemporaneously from each of the monitoring wells during the groundwater sampling event. In addition, piezometers that were sampled for water table elevation during the APP Phase II study (SHB, 1994a), as presented in Drawing and Map Sheet 12 of this same report, will also be identified and water levels measured, if possible. This information will be used to construct a water table potentiometric surface covering as much of the Site as possible.

**Confirmation of Aquifer Properties**

A review of existing information pertaining to field derived aquifer properties will be made. The data will be categorized to support the hydrogeologic site model developed under this investigation. While existing test information may be re-analyzed, no new field tests will be performed under this task.

**Drilling Procedures**

A total of seven groundwater monitoring wells will be installed in six locations (Figure 4-3). It is anticipated that all wells will be drilled and installed using the mud rotary drilling method. The mud rotary drilling method utilizes a rotating tri-cone tooth bit to drill the borehole. Cuttings are displaced from the borehole by circulating drilling mud through jets in the bit up the annular space between the drill pipe and borehole. The drilling mud will be circulated through a portable mud pit where cuttings will drop out using a continuous water stream to cut the mud viscosity. Cuttings will be collected at five-foot intervals at the mud pit for lithologic logging.

The following preparations will be conducted prior to drilling,

- Select qualified driller
- Acquire permits and access
- Locate underground utilities
The selected driller will be licensed in Arizona. Access arrangements will be coordinated with the appropriate land owners. Drilling permits from ADWR will be acquired prior to initiating fieldwork. Public utilities will be marked using BlueStake. ASARCO will also be contacted to independently locate and physically mark private underground utilities that may be present at the selected drilling location.

The driller will supply the required equipment for drilling operations, including supplies necessary for IDW containment and decontamination of the drilling rig.

**Formation Logging and Documentation**

Documentation and lithologic logging of the formation will be performed to ensure representative data collection and analyses. Documentation will be compiled for each borehole and will include the following:

- Well completion and development report form
- Boring log of drill cutting samples in the field logbook
- Field notes compiled by the on-Site geologist during drilling operations
- Photographs, if available

The Site geologist will maintain a log of conditions encountered during drilling. Lithologic logs compiled during drilling activities will be evaluated and coupled with analytical data to enhance Site characterization. The log will include lithologic and hydrogeologic descriptions as well as notations on drill rig behavior and any anomalous conditions encountered during drilling. Field lithologic descriptions will be based on examination of undisturbed samples and drill cuttings with consideration of impacts of the drilling process on cuttings. An experienced hydrogeologist will supervise logging.

**Well Construction**

The wells will be installed in an 8” diameter borehole drilled using mud rotary technology. The wells will be constructed of 4-inch diameter schedule 40 PVC. The well screen will have a 0.040-inch slot opening to allow adequate laminar inflow of groundwater, with the filter pack sand being selected in conjunction with this slot size to hold back the formation materials. Final construction of monitoring wells will be similar to the depiction in Figure 4-4. Filter pack sand will be placed from the bottom of the boring to approximately five feet above the screen. The well may be initially developed at this point. All monitor wells may be initially developed following installation of the filter pack if substantial settling of the filter pack is expected. Initial development will be performed for a period of at least one to two hours using bailing or pumping. A filter pack will be added if settlement occurs during development. Five to 25 feet of fine filter pack sand will be placed above the filter pack to prevent the grout seal material from entering the filter pack. Well casing will be grouted from the top of the filter pack to land surface using Portland Type I or Type II cement, which will be tremied down the annular space of the borehole to ensure a competent surface seal. Centralizers will be placed approximately every 20 feet if deemed necessary by the Site geologist.

Depending on the location, the wells will be completed with either a locking above-ground steel surface casing or a grade-level manhole cover.
Surveyed locations for all sample points will be acquired either through existing information in the published literature or through field surveying. Field surveying of sampling point locations will be performed using hand-held GPS equipment. Where elevation information is required (such as for water table elevation points), land surveying will be performed.

**Groundwater Sampling**

The RI workplan calls for two comprehensive groundwater sampling events; the first after installation of the new monitoring wells and during a high flow event (January through March); the second after installation of new monitoring wells and during a low flow event (June through August). Low and high flow events are relative to the annual precipitation, and will be flexible enough to be adjusted to take advantage of the local conditions. Each sampling event will also include samples collected from each of the existing monitoring wells. At least three production wells from the Hayden well field, and two production wells from Winkelman water supply wells, will be sampled and analyzed during this sampling event. The Hayden wells will be selected from those operating during the sampling time frame (tentatively selected wells are HWF-15, HWF-21 and HWF-25), while Winkelman wells 3 and 4 will be sampled for comparison to historic information. Samples will be collected from the wellhead and from the manifolding where these water samples are composited into the distributed water supply. In addition to the well field samples, drinking water samples will also be collected from the tap within the elementary school in the Winkelman school complex, from the Hayden park water fountain, and from the tap within the Hayden Library.

The proposed sampling event would include TAL metals, which will include those metals found at elevated levels in previous sampling events (arsenic, cadmium, chromium and mercury) as well as metals found at elevated levels in soil samples and/or of possible human health or ecological concern (copper, lead and zinc), and the major cations. In addition, major anions (including sulfate), and field groundwater parameters (pH, dissolved oxygen, conductivity, and temperature) will be analyzed for. Selected wells will be analyzed for VOCs and SVOCs to evaluate whether these constituents are present as a result of upgradient Site-related operations. In addition, all groundwater samples will be analyzed for gross alpha radioactivity, gross beta radioactivity, total uranium, total thorium, and the radium isotopes 226 and 228. Selected wells will be analyzed for Total Petroleum Hydrocarbons (TPH).

Table 4-2 presents a list of the potential wells to be sampled and the target compounds. The actual wells available to be sampled will be determined during final Site reconnaissance, as some of the potential wells may no longer exist or may be deemed unrepresentative upon field examination.

Groundwater samples will be collected from each of the new monitor wells after fluid levels in the well have stabilized, and from selected existing monitor wells. Samples will be collected from the wells utilizing a portable submersible pump where higher permeability allows (Gila River alluvium), and bailing and recovery where permeability is low (wash alluvium and bedrock).
The sampling procedure for water samples collected from pumping wells and monitoring wells is as follows:

- The well construction logs will be reviewed.
- The depth to groundwater will be collected and total depth of the well will be confirmed prior to sampling (this may not be possible with the production wells, depending on the wellhead configuration).
- If needed, the portable pump will be set within the well’s screened interval, or a bailer will be lowered into the fluid column. Purging of the well will be accomplished at flow rates that do not over-stress the production capacity of the well, trying to maintain laminar flow and minimizing the turbulence within the water column.
- Water quality parameters will be monitored and recorded throughout the purging process. These parameters will include pH, temperature, DO, and specific conductance.
- Purging will continue until water quality parameters have stabilized to within 10 percent of the previous two readings and the water appears clear and free of sediment, or until three well volumes have been purged. Once stabilization of the groundwater parameters has been achieved (or three well volumes have been purged), the required samples will be collected.
- Observed field properties will be recorded throughout the purging process. In addition to the groundwater quality parameters, these properties will include the date and time of purging, pumping rate, total pumping time, total purged volume and notes regarding the clarity, odor and other physical attributes of the water.
- Collect samples in appropriate sample containers containing the appropriate preservative for the analysis required. No bubbles or headspace should remain in the sample container.
- Label the sample containers with a unique code for each sample.
- Cool and store samples with cold packs or on ice.
- Promptly ship sample to the lab for analysis following COC procedures.
- All samples must be analyzed within the holding times for the laboratory analytical method specified by EPA.

For samples collected from manifolds or from a drinking water tap, the following procedures will be used:

- Water samples will be collected from the cold water tap and any pre-treatment/treatment devices (such as aerators, screens or filters) will be detached prior to filtering.
- If the water source is used routinely (several times throughout the course of a day), then the tap will be allowed to run for a minimum of 15 minutes prior to sampling. If the water source is not in routine use, then the tap will be allowed to run for a minimum of 30 minutes.
4.0 REMEDIAL INVESTIGATION FIELD PROCEDURES

- During sampling, the flow rate will be set so as to cause the minimum amount of aeration or splashing.
- Observed field properties will be recorded throughout the purging process. In addition to the groundwater quality parameters, these properties will include the date and time of purging, estimated flow rate, estimated time, total purged volume and notes regarding the clarity, odor and other physical attributes of the water.
- Collect samples in appropriate sample containers containing the appropriate preservative for the analysis required. No bubbles or headspace should remain in the sample container.
- Label the sample containers with a unique code for each sample.
- Cool and store samples with cold packs or on ice.
- Promptly ship sample to the lab for analysis following COC procedures.
- All samples must be analyzed within the holding times for the laboratory analytical method specified by EPA.

More detailed sampling and analytical procedures will be presented in the FSP.

4.3.5 Task 3e—Air Investigations and Dust Sampling

Purpose and Overview

The purpose of this section is to describe air quality investigations necessary to assess human health and ecological risk associated with discharges of pollutants from the Site. This task proposes sampling of PM$_{10}$ and metals at three monitoring sites in the study area to identify concentrations of PM$_{10}$ and metals in ambient air, and proposes SO$_2$ measurements from existing ASARCO monitoring stations to assess the impacts of SO$_2$ emissions from the smelter. The data provided by ASARCO from SO$_2$ monitors will be reviewed for accuracy and usefulness. If data are suspect, then co-located monitors may be provided. In addition, dispersion modeling is proposed to identify concentrations in air at the desired receptor locations to quantify human health and ecological risks.

The air investigations will also include evaluation of wind direction and variation in night and day concentration of contaminants. Also, an attempt will be made to evaluate concentration of contaminants in dust from attics and occupied areas of selected homes in the Winkleman and Hayden areas to evaluate risks from air contaminants deposited in residential areas.

Data "Gaps"/Data Needs

Releases from current or historic Hayden smelter and concentrator operations are the primary source of off-Site impacts to the air. The preliminary CSM human exposures is presented in Figure 1-1. The smelter(s) and concentrator are the primary source of fugitive and stack emissions to air.

From an air quality perspective, there are three types of sources of emissions. The composition and nature of emissions also differs from each type of source:
The copper smelter, acid plant, and converters have emissions of acid gases, metals and PM.

The rock crushers and concentrators have PM emissions.

The tailing piles have PM emissions.

Additionally, the constituents of PM from smelting, concentrators and tailings piles differ from each other. The proposed air sampling is intended to identify the impacts of each of these sources.

Potential secondary release mechanisms would be particulate and dust emissions to ambient air. The wind is the dispersion and transport medium of releases to the air. Potential human exposure routes would include inhalation of particulates and vapors (if any) both indoors and outdoors.

Currently, potential applicable impacted human receptors would be adult and child residents of Hayden and Winkelman, school children in school yards, pools, and parks, trespassers on tailings piles, and anglers in the nearby Gila and San Pedro Rivers, as appropriate.

The outdoor air is anticipated to be a major environmental medium associated with off-Site exposures to Site-related releases. As such, air sampling and monitoring will be a major focus in environmental sampling for the Site. The proposed air sampling monitoring network will consist of four monitoring stations:

1. Town of Hayden Maintenance Yard (or elsewhere in the Hayden vicinity). This site was selected to characterize concentrations in the Hayden area. These air samples would address the need to characterize outdoor ambient air exposures to residents (adult and child) in the town of Hayden, which abuts the ASARCO site.

2. Winkelman High School (or elsewhere in the Winkelman vicinity). This site was selected to characterize concentrations in the Winkelman area. These air samples would address the need to characterize outdoor ambient air exposures to school children attending the only public schools in the study area, which are located in Winkelman.

3. Hayden Golf Club (or vicinity). This site was selected to measure concentrations predominately from the tailings piles. These air samples would address the need to characterize outdoor ambient air exposures to adult and child trespassers on tailings piles and anglers/recreators at the nearby Gila River.

Additionally, attic and occupied area dust samples will be collected from 10 homes each in Hayden and Winkelman. The results of the dust sample analysis will reflect the long-term impacts of particulate and dust emissions to ambient air in Hayden. The results of the dust analysis will help meet the need to address indoor dust exposures of the residents of Hayden and Winkelman.

Although ecological receptors may be exposed by inhalation, this exposure pathway is predicted to be insignificant compared to other exposure routes (e.g., ingestion of contaminated media or biota) (Figure 1-2). Additionally, toxicity data required for quantitative evaluation of ecological risk due to inhalation are limited.
Research on Historical and Current Operations

This subtask will consist of a detailed review of historical smelter/concentrator operations as related to air emissions, so that the air investigation activities (and related soil and sediment sampling activities) can be modified as needed. This task will consist of the following primary activities:

- Tabulate former and existing air emission sources, including stack and fugitive sources;
- Tabulate current and former air emission totals;
- Review historic aerial photographs and operational history information to ascertain locations of waste material piles;
- Review of wind rose diagrams presented in Figures 2-8, 2-9, and 2-10; and
- Obtain and review ADEQ data from analysis of particulate samples collected from the Hayden Jail PM monitor. The fine and course particulate fractions were collected using a dichot monitor over a several year period. These filter samples were analyzed for several metals by laboratory XRF and the data are tabulated electronically.

Air Quality Monitoring

This section addresses the monitoring objectives for the air borne particulate investigation for the populated areas of the study area. Specific topics discussed in this section are:

- Monitoring objectives
- Monitoring locations
- Sampling schedule

Monitoring Objectives

Windblown dust from Tailings Piles AB/BC and D, and PM and associated metals contained in the emissions from smelter stack and concentrator/smelter facility operations have been a concern as a potential source of human exposure and ecological risks. The tailings piles dust control measures, if not fully implemented, raise the concern that the NAAQS are being exceeded during high wind events.

Windblown PM is a major concern in the study area because of the potential for off-Site migration of hazardous PM and the public’s subsequent exposure to it. High levels of arsenic have been noted in air quality samples previously collected (ADEQ, 2003). Significantly higher than background level concentration of arsenic, lead, cadmium, copper, and mercury have been reported in soil samples collected from private residences in Hayden and Winkelman, and in soil samples from Power House Canyon Wash and Kennecott Avenue Wash.

Over the 93 years of operation of the copper smelting facilities in the area, accumulation and re-entrainment of metals discharged from the Site represent a potential source which, may result in exposure and possible health risk to local population.

This task will assess ambient air particulates and metals in the vicinity of suspected major windblown dust sources in the study area. The specific project objective is to physically and chemically characterize selected dust sources and measure concentrations of ambient PM$_{10}$ and selected metals.
Major sources currently under consideration are Tailings Pile AB/BC, smelter stack emissions, smelter building fugitive emissions, and concentrate building fugitive emissions (including associated ore crushing facilities). The metal laden PM is potentially harmful to people who live in the study area. This PM can act as an inhalation dust source, and can be transported into homes where, as house dusts, they are a contact exposure reservoir.

Currently, the State of Arizona and ASARCO operate five ambient SO$_2$ monitors in the study area. It is assumed that these data will be available for analysis of ambient SO$_2$ concentration and the HHRA. No additional ambient SO$_2$ monitoring is proposed in the area.

In addition, acid gases (primarily sulfuric acid, hydrochloric acid, nitric acid, and hydrofluoric acid) are associated with the smelter, converters and acid plant.

There are four key objectives to be fulfilled with this monitoring program:

**Objective 1:** To determine ambient PM$_{10}$ and metals concentrations. Although the area seems to be in compliance with NAAQS for PM$_{10}$ and lead, the PM may contain significant concentrations of several elements of concern including arsenic, cadmium, chromium, copper, lead, mercury, and zinc.

**Objective 2:** To assess relative contributions among the prime sources of windblown particulates by placing PM$_{10}$ sampler in optimal dust-impacted and sensitive receptor locations such as downwind residential areas.

**Objective 3:** To frequently sample and quantify dust concentrations during high wind conditions

**Objective 4:** To frequently sample and quantify acid gas concentrations.

**Objective 5:** To determine background ambient PM$_{10}$ and metals concentration in a similar desert environment.

**Monitoring Network**

The monitoring network will consist of three proposed monitoring stations:

- Hayden Golf Club (or vicinity)—this site was selected to measure concentrations predominately from the tailings piles;
- Town of Hayden Maintenance Yard (or elsewhere in the Hayden vicinity)—this site was selected to characterize concentrations in the Hayden area, and will be the site of the single acid gas monitor;
- Winkelman High School (or elsewhere in the Winkelman vicinity)—this site was selected to characterize concentrations in the Winkelman area.

In addition, a background monitoring station is proposed in the town of San Manuel, which is the location of a monitor currently operated by ADEQ. A collocated sampler will be operated at the Town of Hayden Maintenance Yard site to satisfy precision requirements for the network. These locations may be modified based on the results of the research on historical and current operations, as described above.
Each sampler will be sited and operated to comply with applicable portions of the State and Local Air Monitoring Station (SLAMS) requirements (40 CFR 58). The actual sampling locations are contingent upon access considerations and the ability to protect equipment from vandalism or theft. In addition, the EPA guidance document; Guidance for Ambient Air Monitoring at Superfund Sites (Revised), (EPA-451/R-93-007, May 1993. [EPA, 1993]), provides the following recommendations: “…programs designed for determining long-term concentration levels (e.g., annual or lifetime exposures) will require fewer monitoring locations than those intended to monitor compliance with short-term action levels. This is because the long-term prevailing wind directions are usually more predictable than day-to-day wind patterns and sampling sites therefore can be more accurately sited for measuring significant long-term effects. For example, the dispersion modeling of source emissions, using climatological wind data as input, can be performed to determine the most appropriate sampling locations (i.e., areas of maximum or significant effects.)” Based on this EPA guidance, a dispersion modeling task is recommended using existing particulate emissions data and emissions estimating methods for fugitive source(s). The modeling results, along with the historical SO$_2$ data and concentration of metals in soil already known, will be used to determine the final locations of monitoring stations.

By modeling to determine optimum site locations, the long-term monitoring data may also be useful for validating and substantiating the risk assessment modeling to be conducted using the monitoring data collected.

The specific locations outlined herein were chosen on the basis of several factors, but do not include modeling results since particulate modeling has not been done. One factor is: emissions of re-entrained dusts from Tailings Piles AB/BC and D that may impact populated areas need to be monitored adjacent to the tailings piles. As a result, one sampler is located at the Hayden Golf Club. Another factor is fugitive and stack PM$_{10}$ and metals emissions from the smelter that are assumed to behave similarly to SO$_2$ gases. Current SO$_2$ monitors that read highest concentrations from stack and fugitive emissions are located at Globe Highway and Montgomery Ranch. It is suggested that additional PM$_{10}$ monitors be located at the Town of Hayden Maintenance Yard and the Winkelman High School site, which were selected as sites that would represent potential receptors in the towns of Hayden and Winkelman, respectively. A background monitor is also proposed to be located in the town of San Manuel, located about 20 miles south of Hayden. This monitor will provide background concentration of PM$_{10}$ and metals.

**Sampling Schedule**

All samples are planned to be collected for a 24-hour period from midnight to midnight. Sampling is planned for a period of one year. One 24-hour sample will be collected every sixth day in accordance with EPA’s established schedule for particulate sampling. In addition, random samples will be collected on additional days and nights to the extent practicable. This schedule is designed to cover variations of meteorological conditions and Site conditions for every day of the week throughout an entire year and results in a total of 60 24-hour samples from each site. In all, for five monitoring sites, including one collocated site, for a total of six samplers will result in a total of 360 samples collected. Each of the samples will be gravimetrically analyzed for PM$_{10}$ concentration and analyzed for metals using FPXRF analysis or another appropriate method.
Selection of Methods
The selection of methods and equipment proposed for this monitoring program was made after reviewing available reference and equivalent methods. All equipment selected will meet the monitoring requirements as defined in the EPA publication Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) (EPA-450/4-87-07, May 1987 [EPA, 1987]), Quality Assurance Handbook for Air Pollution Measurement Systems Volume II-Ambient Air Specific Methods (EPA-600/R-94/038b, April 1994 [EPA, 1994e]), and Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV Meteorological Measurements (EPA-600/R-94/038d, April 1994 [EPA, 1994f]). Additional details will be provided in the QAPP and FSP.

PM$_{10}$ Sampling
The mass concentration of PM$_{10}$ will be measured by the high volume sampling method. Flow controlled high–volume samplers will be used. Air is drawn into a covered housing and through a filter by means of a high-flow rate blower at a flow rate of 30 to 60 standard cubic feet per minute (scfm) that allows particles having less than 10 microns to collect on the filter surfaces. The PM$_{10}$ samplers will be operated at 40 scfm. The mass concentration of PM$_{10}$ in the ambient air ($\mu$g/m$^3$) is computed by measuring the mass of collected particles and the volume of air sampled.

In order to collect samples on an every sixth-day cycle and also during high wind events, the samplers provided will be EPA Equivalent Method sequential filter samplers. These samplers hold 8-12 filters and are programmed to run routinely or can be remotely triggered based on high winds. Filters are 47 millimeters in diameter and can be analyzed by FPXRF and/or laboratory XRF for the target metals. Each individual filter runs for a preset period of time and then the sampler rotates the next unexposed filter into place for the next sampling event. These samplers reduce the number of trips needed to collect filter samples. The method used is based on the promulgated reference method published in 40 CFR 50.11.

Acid Speciation Sampling
The mass concentration of four different acids in the ambient air (HNO$_3$, H$_2$SO$_4$, HF, and HCl) is measured by drawing air into a covered housing and flowing through the sampling cartridges. The Speciation Sampler allows up to four sampling pathways to be active at once. All four pathways can run concurrently at up to 16.7 L/min (1 m$^3$/h). The mass concentration of acids in the ambient air ($\mu$g/m$^3$) is computed by measuring the mass of collected particles and the volume air sampled. Three samples (one hour peak and two 24-hr) will be collected every two weeks for each of the four gases.

Meteorological Instrumentation
The meteorological parameters of wind speed, wind direction, temperature, and relative humidity at the 10-meter (approximate) level will be collected at one or more of the monitoring stations. The number of stations will be determined based on the site selection for modeling results and an evaluation of whether one meteorological station can be representative of more than one particulate/metallic monitoring station. The meteorological data will be recorded by a datalogger, and the data will be retrievable by telephone. The dataloggers will be programmable so that air sampling can be triggered based on high wind events. For example, if wind speeds exceed a certain threshold, the samplers will be turned on and will run until the wind event subsides.
Installation of Equipment
Network installation of the monitoring sites includes all setup of scaffolding sets, setup of high-volume samplers, and setup of the meteorological station. The following steps should be followed for network installation.

PM\textsubscript{10} Air Sampler Installation
PM\textsubscript{10} samplers should be located at least two meters high; for example, on the roof of a shelter (< less than 15 meters above ground) or other above ground structure (scaffolding, etc.). If the site is a co-located sampler site, the samplers should be within four meters of one another, but at least two meters apart. All samplers should be placed at least 20 meters from any trees. Obstructions such as buildings should be avoided; the distance between obstacles and the sampler should be at least twice the height that the obstacle protrudes above the sampler. There should be unrestricted airflow in an arc at least 270° around the station and samplers.

The instrument shelters should be placed level and secure. The shelter should be sufficiently fastened to its base to avoid disturbance from high winds in the area. The instruments should be in a secure area, if possible out of public view, and not subject to vandalism or theft.

Acid Gas Sampler Installation
The EPA guidelines for speciation sampler are similar to the PM\textsubscript{10} air samplers. As a result, the speciation samplers will be installed at the same location as the PM\textsubscript{10} Samplers following the guidelines listed above.

The instrument shelters should be placed level and secure. The shelter should be sufficiently fastened to its base to avoid disturbance from high winds in the area. The acid gas sampler installation will be further described in the FSP.

Meteorological Station Installation
The wind speed and direction transmitters (one unit) should be placed on a flat surface. The cup and vane sets should be examined for damage. Connect the connector end of the cable to the transmitters and connect the other end of the cable to the recording unit. A simple diagnostic check of the instrument sensors should be made to verify that all sensors are operating and that no wires have been broken in shipment. After making and checking all connections, turn the recorder on. The wind speed transmitter is located at the end of the cross-arm with the connector, and the wind direction transmitter is at the opposite end. Rapidly spin the wind speed shaft and note that the recorder moves appropriately on the scale. Slowly rotate the wind direction shaft and note that the wind direction recorder again moves appropriately.

Place the cups on the wind speed transmitter and tighten the screws. The cross-arm is then installed on the tower. The cross-arm mounts on \( \frac{3}{4} \)-inch pipe, and should be aligned so that it points east–west, with the wind direction sensor on the eastward side. The cross-arm is aligned to true north and not magnetic north. The temperature sensor should be mounted below the cross-arm on the \( \frac{3}{4} \)-inch pipe. The sensor should point north. The relative humidity sensor is contained in the temperature sensor shield.

The datalogger will be installed at the base of the tower in a location easily accessible to the operator. The data output cable from the electronic weather station will be connected to the
micrologger. All cables should be connected to the sensors and the mainframe for operation. Meteorological data will be downloaded once per month from the datalogger.

**Collection and Analysis of PM\textsubscript{10} Samples for Metals**

The metals (including arsenic, cadmium, chromium, copper, lead, mercury, and zinc) concentrations will be established using FPXRF analyses (or another appropriate method) of filters from each of the PM\textsubscript{10} monitoring stations, as further described in the FSP.

**Dispersion Modeling**

**Model Selection**

The first step in establishing a database for dispersion modeling analysis is to determine the appropriate model to be used. An EPA approved model, Industrial Source Complex Short Term (ISCST), was selected for evaluating PM\textsubscript{10}, SO\textsubscript{2} and metals impact (modeling of acid gases is not called for at this time). This model was selected because of its ability to:

- Model point area and volume sources;
- Calculate combined impacts for selected source groups;
- Calculate short-term (1 to 24-hour) and long-term (annual) concentrations using hourly sequential meteorological data; and
- Calculate concentrations at designated receptor locations.

This model will allow for the evaluation of PM\textsubscript{10} impacts using an emission inventory of the study area (containing both area and point sources) and hourly meteorological data.

**Emission Inventory**

An emission inventory of the PM\textsubscript{10}, SO\textsubscript{2}, and metals sources within the study area must be compiled for input into the dispersion model. The inventory should contain source locations and emission rates for pollutants and release parameters of concern. Sufficient source data will be collected to model impacts from the 1,000 foot stack. The emission rates will be generally based on source test data, analysis of chemical constituents of PM, and other published emission factors and known or estimated activity levels.

**Meteorological Data**

Meteorological data representative of the study area must be selected for use in the dispersion modeling analysis. One year of Site-specific meteorological data is needed for this purpose. The meteorological parameters generally required for predicting short-term and annual average impacts with EPA guideline models are wind speed, wind direction, ambient temperature, atmospheric stability, and mixing height.

Wind speed, wind direction, and temperature data collected at the monitoring locations will be used in the dispersion modeling analysis. Upper air data will be obtained from the Tucson Airport. Tucson Airport is located approximately 100 miles southwest of Hayden. The on-Site wind data will be supplemented with cloud cover and mixing height data from Tucson to generate the atmospheric stability and mixing height profile. In addition, if practical, additional meteorological data will be collected to model impacts from the 1,000 foot stack.
Reconciliation of Receptor/Dispersion Model Results
The dispersion model will provide concentrations of PM\textsubscript{10} and associated metals at the identified receptors. The development of the HHRA depends on the ability of available modeling techniques to properly predict the contributions from each source at selected model receptors. Site-specific sampling data and dispersion models cannot be expected to show perfect agreement. The differences may be negligible, but on occasions they may be large enough to raise questions concerning validity of the model. The HHRA will be based on receptor concentrations established after systematically examining and reconciling the dispersion model estimates based on other EPA input and established EPA procedures.

Dust Sampling
The dust deposited in the attics and occupied areas of homes in Hayden and Winkelman will be sampled for contaminants of concern. The dust poses a potential health risk if it contains contaminants that may have been deposited over the years. The risk of health effects depends on the amount of time spent with dust exposure, the age and body weight of the person being exposed, and the concentration and amount of contaminants. The amount of dust loading is expected to vary based on location of the house relative to sources of PM emissions.

Ten (10) houses will be sampled in Winkelman and 10 houses will be sampled in the Hayden area. Seven out of 10 houses will be sampled in the areas closer to the Hayden operations where elevated soils concentrations were detected in previous investigations, while the remaining three samples will be collected in perimeter areas. One sample will be obtained from the attic of each house (near the center of the attic) and from occupied areas of the house. The samples will be analyzed for dust loading and concentration of contaminants of concern using FPXRF analysis. All samples will be submitted for laboratory analysis, as described in the SAP.

4.3.6 Task 3f—Conduct Ecological Investigation
The purpose of this task of the RI is to characterize the terrestrial and aquatic habitats in the project area. These characterizations will include general habitat mapping and wildlife observations. Methods for these ecological evaluations are described below.

Characterization of Terrestrial and Aquatic Habitat
Delineation of terrestrial and aquatic habitats will be based primarily on existing remote sensing data. Initial habitat delineation will be conducted using recent, high-resolution aerial photographs of the area, topographic maps, and National Wetlands Inventory maps. The resulting habitat maps will then be verified by field surveys. Habitat types will be classified broadly into four categories: river, stable riparian, ruderal (disturbed) riparian, and upland. Limited field surveys will be conducted to verify/ground-truth assigned terrestrial and aquatic habitat types, and to record characteristic vegetation and general wildlife utilization patterns within the project area, as well as within a reference area (i.e., an area with similar vegetation, geology, slope, etc., but that is not impacted by the Site).

As part of the field survey within each delineated habitat type at a selected location, a qualitative evaluation will be conducted in which the dominant plant species will be identified, any evidence of stressed vegetation (if present) will be recorded, and aquatic resources will be qualitatively described. In addition, visual and auditory observations of
wildlife species, as well as other indicators of wildlife use (e.g., burrows, tracks, scat, rubs, etc.) will be recorded during the field surveys. Photo-documentation of each habitat type will be compiled for reference and documentation of future changes or improvements in habitat quality for the Site. The photo-station locations of each habitat area will be mapped using a sub-meter accuracy GPS unit.

Generally, the project area includes all terrestrial and aquatic habitat within the rectangle trending northwest-southeast and superimposed over the Gila and San Pedro River valleys as shown in Figure 4-5. The project area spans five miles on both sides of a line extending from two miles east-southeast of Winkelman to northwest of Hayden about half way to the town of Kearny. This area also incorporates the towns of Hayden and Winkelman and associated ASARCO process facilities, though little ecological habitat is expected in these areas. The reference area will be selected from an area with similar terrestrial and aquatic habitats as the project area.

The terrestrial and aquatic habitat characterization of the project and reference area is expected to require one to two days effort. This estimate includes development of the habitat maps from aerial photographs and one to two days in the field to ground-truth the results and survey for wildlife.

Wildlife Observations

As indicated in the previous section, direct observation, calls, or sign of wildlife in the project area will be recorded during the terrestrial and aquatic habitat characterization field surveys. This sampling will be incidental to the habitat characterization efforts and is included in the time estimate provided in the previous section. Digital photos of signs will be taken and locations of direct observations and signs will be recorded in field logbooks. In addition to Site surveys, appropriate literature and database reviews and consultations with USFWS and AGFD will be conducted to determine the existence or potential utilization of the project area by species of special status, as designated by state or federal natural resource management agencies. Observations of any special-status species or sensitive habitat areas observed during the field surveys will be recorded using sub-meter GPS. Quantitative and/or focused wildlife surveys may be conducted in later phases of characterization as warranted.

Existing information indicates that the riparian areas near the confluence of the Gila and San Pedro Rivers (referred to as Winkelman Study Area) provides habitat for the largest concentration of southwestern flycatchers in Arizona (Smith et al., 2004). This species is a federal and state-listed endangered species, and has been studied extensively by the USGS, AGFD, and others. The following list of flycatcher-related studies are available for use in the risk evaluations for this species:

- **Southwestern Willow Flycatcher Survey and Nest Monitoring Reports for 2000 through 2003** (Paradzick et al., 2001; Smith et al., 2002; Smith et al., 2003; and Smith et al., 2004);
- **Southwestern Willow Flycatcher Breeding Site and Territory Summaries for 2000 through 2002** (Sogge et al., 2001; Sogge et al., 2002; and Sogge et al., 2003);
- **Physiological Condition of Southwestern Willow Flycatchers in Native and Saltcedar Habitats** (Owen and Sogge, 2002);
• A Quantitative Analysis of the Diet of Southwestern Willow Flycatchers in the Gila Valley, New Mexico (DeLay et al., 2002);
• Mapping and Monitoring Southwestern Willow Flycatcher Breeding Habitat in Arizona: A Remote Sensing Approach (Dockens and Paradzick, 2004);
• Banding and Population Genetics of Southwestern Willow Flycatchers in Arizona – 1997 Summary Report (Paxton et al., 1997);
• Food Habits of the Endangered Southwestern Willow Flycatcher (Drost et al., 2001);
• Survivorship and Movements of Southwestern Willow Flycatchers in Arizona – 2000 (Luff et al., 2000);
• Survivorship and Movements of Southwestern Willow Flycatchers at Roosevelt Lake, Arizona – 2001 and 2003 reports (Kenwood and Paxton, 2001; Newell et al., 2003);
• Status, Ecology, and Conservation of the Southwestern Willow Flycatcher (Finch and Stoleson, 2000);
• Nestling sex ratio in the southwestern willow flycatcher (Paxton et al., 2002); and
• A multi-scaled model of southwestern willow flycatcher breeding habitat (Hatten and Paradzick, 2003).

Additional ecological studies in the project area include a fish monitoring study being conducted by the AGFD (Voeltz, 2005), a herp (reptiles and amphibians) study being conducted by the Bureau of Reclamation (Messing, 2005), and the annual Christmas bird counts conducted in the area by the National Audubon Society (McCarthey, 2005). Brief descriptions of these three studies are provided below.

The AGFD is currently conducting a fish monitoring study that includes portions of the Gila River adjacent to and downstream of the Site and in areas within the San Pedro River (Voeltz, 2005). Two of the Gila River sites are located on ASARCO property, two are upstream of the property, two are downstream of the property, and one is upstream in the San Pedro River. This study is part of the annual sampling conducted in agreement with the Bureau of Reclamation to monitor 22 sites in the Gila River Basin. This study does not measure contaminant levels, but provides population/community data (e.g., species abundance and richness). It should be noted that the ASARCO property sites were dry during the November 2004 sampling, as were the sites in 2003. Information on species present in past years (1999 to 2002) is available.

The Bureau of Reclamation conducted a pilot study to compare the species diversity of herps (primarily lizards, but occasionally also toads) between mature Saltcedar habitat and mature cottonwood-willow habitat in southern Arizona (Messing, 2005). The Saltcedar site is located adjacent to the San Pedro River on ASARCO property and the cottonwood-willow habitat is located near The Nature Conservancy (TNC) preserve. There are three arrays (or sampling locations within each area). An array consists of a central five gallon bucket dug into the ground and three outer buckets about 25 feet away connected by a drift fence. The arrays were checked every other day beginning in May-September 2004. A second collection effort will be conducted May-September 2005, and some vegetation data will also be
collected. If approved by EPA, ASARCO, and TNC, metals analysis of surface soil and representative herps at each array (i.e., co-located soil and biota) would provide valuable information on COPEC concentrations in soil and biota in these areas, as well as limited information on contaminant uptake in reptiles. Arthropods (e.g., spiders) were also observed in the pitfall traps during the pilot study. Collection and chemical analysis of these terrestrial invertebrates is also recommended.

The National Audubon Society has been conducting nationwide Christmas bird counts in December and early January for over 100 years. For the past five years, Christmas bird counts have been done in the 15-mile radius area centered at Dudleyville, Arizona (McCarthey, 2005). This area includes the towns of Hayden and Winkelman and the ASARCO Hayden properties. Volunteers survey for one day and the data is compiled for the entire area. This information is useful for documenting avian species in the general project area during the winter, but may not provide information specific to the project area.

### 4.3.7 Task 3g—Geotechnical Evaluation of Tailings Piles

**Purpose**

The purpose of this task is to perform a reconnaissance-level general assessment of the overall stability of Tailings Piles AB/BC and Tailings Pile D. The assessment will be based on existing information and Site observations. The assessment will include a general evaluation on tailing impoundment overall stability, slope conditions, observed erosion features, and potential for additional slope erosion or failure. The assessment will also include recommendations for additional evaluation or improvements.

**Procedures**

This general stability will be accomplished by performing the following activities:

1. **Review of Existing Information.** Existing available information available from ASARCO and the EPA will be reviewed for use in the stability assessment. This could include information about the materials composition, engineering properties and deposition of the tailings materials, any previous evaluation performed for the tailings impoundment, geological and geotechnical information of the soils below the impoundments, current tailings piles operations, groundwater conditions within and below the impoundments, Site topography, and surface water hydrology.

   The information will be used to estimate and bracket engineering parameters used in the stability evaluation.

2. **Perform Site Reconnaissance.** A Site reconnaissance will be performed to observe the existing conditions of the impoundment slopes. The Site visit will include visual comparison of the existing slopes with available grading plans, observation of the general slope condition, observation of drainage features and erosion damage, and visual characterization of surface soils and slope vegetation. During the Site visit, slope locations that appear to be in the least stable condition will be identified for further evaluation. Information observed will be documented and photographed for use in the assessment. This task does not include any surveying of the tailings impoundment slopes, soil sample collection, or soil testing.
3. **Perform General Stability Analysis.** The overall stability of the impoundments will be assessed by performing a general stability analysis of the most critical locations identified during the Site reconnaissance. The stability analysis will be performed using the computer program Slide by Roc Science. Engineering parameters, Site geometry, and Site conditions used in the analysis will be estimated based on the data review and Site reconnaissance described above. This stability evaluation will be limited to four locations at each tailing impoundment for a total of eight cross-sections. Surface water hydraulic modeling to determine erosion effect on the tailings is not included in this workplan.

4. **Prepare Stability Assessment Results.** The RI report will include a stability assessment. The report will document the data review and Site reconnaissance tasks, provide the results of the stability analysis, and discuss limitation of the stability analysis based on available information. The report will also include a general overall assessment of the stability and erosion conditions of the impoundments and provide recommendations for additional investigations, evaluations, or improvements to the Site.

**4.3.8 Task 3h—Surveying and Mapping**

In order to improve accuracy and efficiency and reduce the RI cost, hand-held GPS units will be utilized to establish the locations of sampling points and permanent monitoring locations including groundwater monitoring wells. These units will reduce data gaps, reduce land surveying costs, eliminate post collection data entry and data entry errors, and standardize data collection. Use of the GPS units is particularly valuable for the surficial soil, sediment, and surface water sampling efforts to be conducted over a broad area and in difficult-to-access areas. GPS units used in conjunction with the FPXRF units for soil and sediment sampling, for example, are expected to provide the real-time flexibility to focus sampling efforts as data are collected.

The GPS units will contain a form for collecting field information. The form will be established prior to initiating field work, and will have menus and check boxes for many of the fields in order to reduce data entry error and to provide data uniformity. All field technicians will receive GPS training that addresses GPS fundamentals and proper field data collection techniques.

The hand-held GPS units utilized will either be Trimble ProXRS or GeoXT GPS Mapping System. These are high-end resource grade GPS mapping systems capable of collecting post processed differential GPS data with a specified accuracy of .5-meter or sub-meter root mean square (RMS), respectively. These units also employ Everest Multipath Rejection Technology, which reduces the chances of positional errors due to multipath.

The GPS units will be set to use the Trimble standard default configuration settings, which consist of a position dilution of precision (PDOP) of 6 or less, a signal to noise ratio (SNR) of 6 or more, an Elevation Mask of 15, and a logging interval of 1 second, with a 15 second minimum occupation time being collected to establish a single point feature, thus insuring synchronization of a minimum of 3 epochs with a base station operating at 5 second intervals. Caution will be taken to avoid and/or note areas where potential multipath events might occur. A real-time differential correction solution will be employed for navigation purposes utilizing the Wide Area Augmentation System (WAAS).
A post-processed differential correction procedure will be performed on all GPS data back in the office to increase the positional accuracy prior to exporting to Geographic Information System (GIS). Automated attribute settings for the export of quantitative data assessing accuracy will include PDOP, Standard Deviation, Horizontal and Vertical Accuracy, Minimum Number of Positions, and the Northing, Easting, and Elevation. This information will be used in the QA/QC procedure to ensure that the positional accuracy meets the required specifications of the project. All data will be exported to ArcGIS following EPA’s GIS data standards (to be determined) and will be Federal Geographic Data Committee (FGDC) compliant. Specifically, the metadata will be created using ESRI’s ArcCatalog using that program’s FGDC style sheet, which follows the FGDC’s Content Standard for Digital Geospatial Metadata (CSDGM).

### 4.3.9 Task 3i—Investigation Support Activities

The investigation support activities will be fully described in the SAP (consisting of the QAPP, FSP, and DMP), which will be provided as a companion document. The following sections present general guidelines for this work.

#### Sample Containers, Preservation and Storage

The EPA-contracted analytical laboratories will provide the required sample containers for all samples. All containers will have been cleaned and certified by the laboratory to be free of the analytes of concern for this project. No sample containers will be reused. Preservatives, if required, will be added by the contracted laboratory prior to shipment of the sample containers to the field. The adequacy of preservation will be verified by the laboratory upon receipt of the samples, and additional preservative will be added, if necessary. Generally, samples to be submitted for laboratory analysis will be placed in a cooler with ice and proper chain-of-custody documentation. All sample containers will be managed as outlined in the SAP, which will be submitted during the next phase of work.

#### Field Variances

As conditions in the field may vary, it may become necessary to implement minor modifications to sampling specifics and procedures as presented in this workplan and subsequent SAP. When appropriate, the EPA Quality Assurance Office will be notified and a verbal approval will be obtained before implementing the changes. Modifications to the approved workplan will be documented in the sampling project report.

#### Sample Documentation and Shipment

As conditions in the field may vary, it may become necessary to implement minor modifications to sampling specifics and procedures as presented in this workplan and subsequent SAP.

#### Field Notes

Field notes for Site sampling may consist of logbooks, COC forms, preprinted monitoring well sampling forms, and photographs.

#### Field Logbooks

All sampling activities will be recorded in a bound field logbook. Entries must be dated, legible, written in permanent ink, and contain accurate and inclusive documentation of
project activities. Language should be objective and factual. Entries must include (as applicable):

- Names of all personnel involved in the field activities
- Date of work
- Description of work to be performed
- General description of weather conditions
- Field instruments calibration information
- Subcontractors present
- Potential responsible party representatives names
- Visitors to the Site
- Reference to any photographs taken
- Signatures of persons making log entries
- Location of each sampling point
- Date and time of sample collection
- Observations of sampling procedure
- Type of blank collected and method of collection
- Duplicate and matrix spike sample locations
- Legible corrections, which will be single lines through the error, signed and dated by the person making the correction
- Name, address, and telephone number of the contracted analytical laboratory
- Field observations and descriptions of problems encountered or change made to the original plan

Photographs
For each photograph taken, the following information will be written in the logbook or recorded in a separate field photography log:

- Time, date, location, and weather conditions
- Description of the subject photographed
- Name of person taking the photograph

Labeling
Each sample container will be labeled with a sample number, date of collection, type of analysis, and preservatives. All sample numbers and locations (including blanks and duplicates) will be recorded in the field logbook.
Sample Chain of Custody Forms and Custody Seals
When samples are shipped to the laboratory, they must be placed in containers sealed with custody seals. One or more custody seals must be placed on each side of the shipping container (cooler). COC forms will be filled out for all samples collected.

COC procedures will be followed as described below to accomplish this task. The COC documentation will at a minimum include:

- Information from each sample label including the sample identification number to allow correlation of the sample with the boring location and depth obtained
- Date and time the sample was collected
- Samplers initials, signature and name, and affiliation
- Identification of any preservatives used (if applicable)
- Requested analytical method
- Any special instructions for the laboratory (e.g., MS/MSD, dilution may be necessary, etc.)
- Additional information included on the COC will include the contact address, phone number and fax number of the sampler and/or consultant project manager, along with any special instructions or warnings for the laboratory
- Each COC form will be signed by the sampler and again signed by the laboratory official once the samples have been delivered
- COC will be included with each sample it documents until such time the samples have been delivered to the laboratory

Decontamination Procedures

Equipment Decontamination

Heavy Equipment
A separate decontamination facility must be set up for heavy equipment. Heavy equipment will be provided by contractors who are directed to install a decontamination pad. Heavy equipment decontamination areas typically consist of a concrete pad and curbing or other containing structure, with a sump to contain wash water. IDW will be managed as outlined in the SAP, which will be submitted during the next phase of work.

Sampling Equipment Decontamination
When equipment used for sampling is not dedicated to a single location, it must be decontaminated between locations. Decontaminated equipment will not be allowed to touch potentially contaminated surfaces after drying and prior to use; if feasible, said equipment will be covered or placed away from the main work area to prevent accidental contact with contaminants.

Personnel Decontamination
Procedures for personnel decontamination will be described in the forthcoming HASP.
Management and Disposal of Investigation-Derived Waste

In the process of implementing this workplan, different types of potentially contaminated IDW will be generated that may include the following:

- Used PPE
- Disposable Sampling Equipment
- Decontamination Fluids
- Purged Groundwater, Well Development Water, Aquifer Test Water, and Excess Groundwater (collected for sample container filling)
- Drill Cuttings and Drilling Fluids

IDW will be managed as outlined in the SAP, which will be submitted during the next phase of work. In addition, other legal and practical considerations that may affect the handling of IDW will be considered.

- Used PPE and disposable equipment will be double bagged and placed in a municipal refuse dumpster. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE and disposable equipment that is to be disposed of which can still be reused will be rendered inoperable before disposal in the refuse dumpster.

- Decontamination fluids that will be generated in the sampling event will consist of deionized water, residual contaminants, and water with non-phosphate detergent. The volume and concentration of the decontamination fluid will be sufficiently low to allow disposal at the Site or sampling area.

- Purge water will be contained as specified in the SAP, which will be submitted during the next phase of work.

Excess soil, drilling fluids, and decontamination fluids generated during the drilling of monitor wells and exploratory borings for the collection of soil samples will be contained, labeled and disposed of properly.
5.0 Sample Analysis and Data Evaluation

5.1 Task 4—Sample Analysis
The purpose of this task is to provide analysis of the environmental samples collected during each field task. In accordance with the EPA Statement of Work, Section 4.0 and the associated SAP are to describe the sampling and analytical procedures. This task is only intended to present the costs for the sample analysis. The analytical costs will be provided separately upon confirmation of the complete sampling protocol with EPA.

5.2 Task 5—Data Validation
This purpose of this task is to arrange for validation of environmental samples collected during the RI. EPA will provide data validation for those samples analyzed as requested by the Region IX laboratory or its designated laboratory subcontractors. Data validation will be needed for those samples, which are not routed through the Region IX laboratory or its designated laboratory subcontractors.

The associated SAP will describe these data validation procedures.

5.3 Task 6—Data Evaluation
The purpose of this task is to organize and evaluate existing data collected during the RI. Data evaluation begins with the receipt of analytical data from the data acquisition task and ends with the submittal of the Data Evaluation Summary Report. Specifically, this task will include the following effort:

1. Perform Data Usability Evaluation and Field QA/QC. The usability of the data will be assessed.
2. Data Reduction, Tabulation, and Evaluation. The data will be evaluated, interpreted, and tabulated in an appropriate presentation format for final data tables.
3. Evaluate Non-Analytical Data (Geological Data). All non-analytical data, which will include geological data, hydrogeological data, geophysical data, and ecological data, will be evaluated.

The associated SAP will describe these data evaluation procedures.
6.0 Risk Assessment

6.1 Task 7—Assessment of Risk

An HHRA and a screening-level ERA will be developed to determine whether Site-related contaminants pose a current or potential risk to human health and the environment in absence of any remedial action. The risk assessment will be used to evaluate whether remediation is needed at the Site, provide justification for performing remedial action, and determine what exposure pathways need to be remediated.

6.1.1 Task 7.1—Human Health Risk Assessment

The development of the Site-specific RI HHRA will require the performance of the following tasks from the Scope of Work for the ASARCO Hayden Smelter RI/FS:

- Develop a Risk Assessment Plan for a Human Health Risk Assessment
- Develop a Human Health Risk Assessment (Task 7.1), including:
  - Draft Human Health Risk Assessment Report
  - Final Human Health Risk Assessment Report

Develop a Human Health Risk Assessment Plan (RAP)

A RAP will be prepared for the development of an HHRA to determine whether Site contaminants of concern pose a current or potential risk to human health in the absence of any remedial action. The plan will include all assumptions and methods required to conduct a baseline risk assessment. This document will be provided along with the other Site-specific plans (see Section 4.3.1).

Develop a Human Health Risk Assessment (HHRA)

An HHRA will be developed to determine whether Site contaminants pose a current or potential risk to human health in the absence of any remedial action. It is intended that the environmental media sampling proposed in Section 4.3, (Field Investigation), will address all known data needs and gather all the information needed to support the development of the HHRA. The assessment will evaluate and assess the risk to human health posed by Site-related contaminants. The risk assessment will address Site-related contaminant identification, toxicity assessment, exposure assessment, and risk characterization. The risk assessment will be used to determine whether remediation is necessary at the Site, provide justification for performing mitigation and/or remedial action, and determine what exposure pathways need to be mitigated or remediated.

For the HHRA, the major pathways associated with off-Site exposures to Site related releases are expected to be soil and air. For that reason, soil sampling and air monitoring will be the major focus of the RI Site characterization study. To evaluate exposures and risks to soil and air, an EPA baseline HHRA approach will be followed (e.g., based on the formal Risk Assessment Guide for Superfund (RAGs) paradigm (1989) exposure and risks calculations).
Groundwater, drinking water, and sediments are expected to be relatively minor sources of risks and hazards to off-Site human receptors, and will receive, comparatively, a lower level of sampling. Groundwater and surface water COPC concentrations will be compared to EPA MCLs and ADEQ's AWQS. Screening level human health risks and hazards for COPC in groundwater and surface water can be estimated using Region IX residential tap water PRGs and the step-wise screening approach described in the Region IX PRG User's Guide (2004). In a like manner, sediment COPC concentrations can be evaluated by comparison to residential soil PRGs using the step-wise screening level approach, as well.

To estimate cumulative health risks and hazards, the results for the screening level estimates for groundwater, surface water and sediments can be summed with the baseline calculations for soils and air, as appropriate.

The Site characterization and HHRA will focus on the potential hazards to the health of residents of the towns of Hayden and Winkelman. Currently, the selection of potential applicable receptors would focus on impacted residential dwellings and adult and child residents in Hayden and Winkelman, school children in school yards and parks, and to a lesser degree, adult and child trespassers on tailings piles, and anglers in the nearby Gila River, as appropriate. This approach will permit a quick evaluation of potential health risks to the most potentially exposed residential populations; those homes in Hayden and Winkelman with the most impacts. A Draft and a Final HHRA Report will be prepared.

**Draft HHRA Report.** A Draft HHRA Report will be developed using approaches and methodology based on EPA guidance documents including, as appropriate:


The Site-specific HHRA will include the following components:

- **Hazard Identification (Sources).** Available information on the hazardous substances present at the Site will be reviewed and the major Site-related contaminants of concern will be identified. For the ASARCO Hayden smelter, in addition to copper (Cu), the copper bearing ore processed on-Site contains other metals including, but not necessarily limited to: arsenic (As), lead (Pb), cadmium (Cd), zinc (Zn), chromium (Cr), and mercury (Hg). SO₂, a byproduct of smelting, is recovered as sulfuric acid; 2,500 tons of sulfuric acid is produced each day. Air emissions from the facility include stack (point source), fugitive (non-point source), and particulate emissions. On-Site run-on and containment ponds and off-Site tailings piles are also part of the operations.

COPC are defined in RAGS (EPA, 1989) as “Chemicals that are potentially site related and whose data are of sufficient quality for use in the quantitative risk assessment.” Based on available data, the currently known COPC for the Site include metals, which have been detected in soils, groundwater, and air samples, as well as SO₂ and particulates in ambient air (PM₁₀, PM₂.₅). The full list of metal COPC would include all the metal compounds reported released in the TRI reports submitted by ASARCO to EPA (copper, arsenic, lead, cadmium, zinc, chromium, mercury, antimony, barium, cobalt, manganese, nickel, selenium, and silver).

Since the RI process is just beginning for this Site, it is possible that other COPC (for example, VOCs, SVOCs, and other metals) have been released off-Site during normal smelter operations and equipment maintenance, which have not yet been reported or characterized. Such COPC would need to be evaluated as they are reported and evaluated in the HHRA, as appropriate. A final list of COPC will be prepared and carried through the HHRA process.

- **Dose-Response Assessment.** Contaminants of concern will be selected based on their intrinsic toxicological properties. Health risk-based screening values for soil, groundwater (tap water), and ambient air will be selected from the Region IX PRG Tables, ADEQ R-SRLs, federal and state drinking water MCLs, and NAAQS and ATSDR minimal risk levels (MRLs).
The human health toxicity values used to develop the HHRA will be obtained from the following updated EPA hierarchy of sources as presented in OSWER Directive 9285.7-53 (dated December 5, 2003):

- Tier 1—EPA’s Integrated IRIS
- Tier 2—EPA’s Provisional Peer Reviewed Toxicity Values (PPRTVs)
- Tier 3—Including additional EPA sources (e.g., historic Health Effects Assessment Summary Table (HEAST) and National Center for Environmental Assessment (NCEA) provisional values and non-EPA sources of toxicity information (e.g., California EPA toxicity values).

Although Site investigation and characterization studies are still in their early stages, some contaminants identified in soil, groundwater, and air can be tentatively identified as potential risk drivers at the Site based on comparison of reported concentrations in soil, groundwater, and air samples to health based EPA and ADEQ standards. These screening level exceedances indicate the potential for human health impacts from off-Site releases:

- The concentrations of arsenic, copper, and lead in soils have been reported to exceed EPA and ADEQ human health risk-based screening criteria.
- Sediment samples have been reported to contain concentrations of arsenic and copper that exceed PRGs and R-SRL.
- Groundwater samples from all three drinking water wells in Hayden have been reported to contain arsenic concentrations that exceed the PRG for tap water.
- Air monitoring samples collected by ADEQ from 1991 to 1998 are reported to have exceeded the arsenic ambient air PRG.

- **Conceptual Site Model, Exposure/Pathway Analysis, and Data Needs.** Critical exposure pathways (e.g., exposure of receptors to soils and ambient air, as well as to drinking water, surface water, and sediments) will be identified and analyzed. The proximity of contaminants to exposure pathways and their potential to migrate into critical pathways will be assessed. This information will be used to update a preliminary CSM diagram for the Site, which will be used to help insure that all relevant pathways, receptors and routes of exposure are considered in the risk assessment.

The preliminary CSM diagram for the Site is presented in Figure 1-1. The primary source of off-Site impacts from the Site are the smelter and concentrator operations related releases. The primary release mechanisms are expected to be spills and releases from on-Site operations and fugitive and stack air emissions releases. Secondary sources would be on-Site and off-Site soils and groundwater. Potential secondary release mechanisms would be infiltration to groundwater and particulate and dust emissions to ambient air.

Dispersion transport media would include soil, groundwater, and wind. Potential exposure routes would include soil (sediment) ingestion and dermal contact, inhalation of particulates and vapors (if any) both indoors and outdoors, and tap water ingestion. Additional exposure routes include ingestion of locally grown garden vegetables and
sport fish caught in the Gila and San Pedro Rivers.

Currently, potential applicable receptors would be adult and child residents in Hayden and Winkelman, school children in school yards and parks, adult and child trespassers on tailings piles, and anglers in the nearby Gila River, as appropriate.

Data needs for the development of the HHRA will be addressed by collection and analysis (for identified COPC) of the soil, air monitoring, drinking water (groundwater), surface water, and sediment samples described in Section 4. The proposed sampling for the potential area-wide human receptors include the following:

- **Soil.** Soil sampling at all habitable residences in Hayden and Winkelman will address the need to characterize potential soil exposures of the adult and child residential population of Hayden and Winkelman, which is one of the major focuses of this RI. Soil sampling at the public school complex in Winkelman will address the need to characterize potential soil exposures of children at schools. Additionally, the collection of soil samples near community facilities (parks, pools and libraries) will address the need to characterize potential soil exposures of children at public locations in Hayden and Winkelman.

  Background surface (0 to 2 inches bgl) and subsurface (10 to 12 inches bgl) soil samples will be collected and analyzed. Background samples will be collected at a total of 13 locations in a concentric pattern around the present smelter stack. Samples will be collected of stable, undisturbed soil for the evaluation of old smelter emissions on native areas. The results of these samples will provide reference values for potential background soil exposures for this study area.

  The collection of soil samples at other inactive and active off-Site locations will address the need to characterize the potential soil exposures of trespassers (visitors).

- **Air Monitoring.** The outdoor air is anticipated to be the other major environmental medium associated with off-Site exposures to Site-related releases. As such, air sampling and monitoring will be a major focus in environmental sampling for the Site. The proposed air sampling monitoring network will consist of four monitoring stations:

  - Hayden Jail (or elsewhere in the Hayden vicinity). This site was selected to characterize concentrations in the Hayden area. These air samples would address the need to characterize outdoor ambient air exposures to residents (adult and child) in the town of Hayden, which abuts the ASARCO site.

  - Winkelman Primary or Middle School (or elsewhere in the Winkelman vicinity). This site was selected to characterize concentrations in the Winkelman area. These air samples would address the need to characterize outdoor ambient air exposures to school children attending the only public schools in the study area, which are located in Winkelman.

  - Hayden Golf Club (or vicinity). This site was selected to measure concentrations predominately from the tailings piles. These air samples would address the need
to characterize outdoor ambient air exposures to adult and child trespassers on tailings piles, and anglers/recreators at the nearby Gila River.

- **Montgomery Ranch.** This site was selected to represent impacts from the smelter stack. Air monitoring samples from this location would address the need to estimate maximal impacts from ASARCO smelter emissions to the study area residents.

- Additionally, attic and occupied area dust samples will be collected from 10 homes each in Hayden and Winkelman. The results of the dust samples analysis will reflect the long-term impacts of particulate and dust emissions to ambient air in Hayden. The results of the dust analysis will meet the need to address indoor dust exposures of the residents of Hayden and Winkelman.

- **Groundwater (Drinking Water).** Local groundwater is the source of drinking water (domestic use water source) in the study area. Potential human exposure routes would include tap water ingestion and dermal contact. Currently, potential applicable human receptors would be adult and child residents of Hayden and Winkelman, and school children.

  Groundwater and drinking water are expected to be relatively minor sources of risks and hazards, and will receive, comparatively, a lower level of sampling. Proposed groundwater sampling at existing domestic water supply well manifolds, groundwater monitoring wells, and tap water sources at community facilities (such as schools, parks, pools, and libraries) will help to address the need to characterize potential domestic water supply (tap water) exposures to residents (adult and child) and school children in the towns of Hayden and Winkelman.

- **Surface Water and Sediments.** Surface water and sediments are expected to be another relatively minor sources of risks and hazards, and will also receive, comparatively, a lower level of sampling. Potential human exposure routes would include sediment and surface water ingestion and dermal contact. Currently, potential applicable human receptors would be those of Hayden and Winkelman, including adult and child trespassers, and anglers in the nearby Gila River, as appropriate.

  Surface water sampling locations include the Gila and San Pedro Rivers, and tailings pile pond samples. Sediment sample locations include tailings piles (bulk and fine fractions), locations of surface water sample collection, and nearby stable riparian area locations. Surface water and sediment samples collected at these locations will address the need to characterize the potential exposures of trespassers and anglers to these media.

- **Garden Vegetables and Fish Caught in Gila River.** Currently, the collection and analysis of samples of locally grown garden produce in the towns of Hayden and Winkelman and edible sports fish caught in the Gila River are not planned. Attendees at future, EPA sponsored, public information meetings can be polled to determine if these potential exposure pathways are relevant to the potentially impacted study area populations. At that time a decision can be made whether
vegetable and fish sampling and analysis need to be conducted to support the needs of the HHRA.

**Characterization of Site and Potential Receptors.** Human populations associated with the exposure pathways will be identified and characterized. The Site abuts the town of Hayden, Arizona (population 900) and is one mile north of the town of Winkelman (population 450).

Based on Site visits and information available concerning the residential population and land use in the towns of Hayden and Winkelman, such as schools, daycare centers, parks and playgrounds/golf course, and medical facilities, a list of potential adult and child, and sensitive receptors (such as retirees) will be compiled.

The Site is a currently operating copper ore processing and smelter facility. The MSHA and OSHA provide compliance oversight of potential occupational exposures and potential health risks to the on-Site ASARCO work force by on-Site releases at the concentrator and smelter, respectively. For that reason, it will be assumed that potential exposures and health risks to the on-Site work force from on-Site contaminants will not be part of the present HHRA.

If the ASARCO Hayden smelter facility should cease operations and close in the future, EPA may wish to consider having potential on-Site exposures and risks evaluated as a new task, separate from and unrelated to the present HHRA. At that time, EPA would need to consider potential Site closure options including future land use and associated receptor exposures and health risks.

**Exposure Assessment.** The exposure assessment will identify the magnitude of actual or potential human exposures, the frequency and duration of these exposures, and the routes by which receptors may be exposed. The exposure assessment will include an evaluation of the likelihood of such exposures occurring and will provide the basis for the development of acceptable exposure levels.

In developing the exposure assessment, reasonable maximum estimates of exposure for both current land use conditions and potential land use conditions at the Site will be evaluated. Residential exposure duration in the towns of Hayden and Winkelman will be assumed to include 9, 30, and 70 years, corresponding to the central tendency (average) residential duration default assumption for Superfund, the Superfund high-end residential duration exposure, and a lifetime of exposure.

**Risk Characterization.** During risk characterization, chemical-specific toxicity information, combined with quantitative and qualitative information from the exposure assessment, will be compared to measured levels of contaminant exposure levels in soil, groundwater, and air, and the levels predicted through environmental fate and transport modeling, as appropriate.

Using EPA based methodology as presented in guidance documents, cancer risks and non-cancer health hazards will be estimated for receptors in Hayden and Winkelman, including adult and child residents, school children in school yards and parks, adult and child trespassers on tailings piles, and anglers/recreators in the nearby Gila River, as appropriate. These comparisons will determine whether concentrations of contaminants near the Site in residential areas are affecting or could potentially affect human health.
Identification of Limitations/Uncertainties. Critical assumptions (e.g., background concentrations and conditions) and uncertainties in the report will be identified.

For example, the primary source of the residential soil and ambient air impacts is the operating ASARCO facility. However, minimal environmental sampling will be conducted at the ASARCO complex as part of this RI workplan. A major source of uncertainty concerning off-Site mitigation/remediation in the residential areas of Hayden and Winkelman is related to whether, and to what degree, the ASARCO complex will continue to impact soils and ambient air in nearby residential areas.

Conceptual Site Model. Based on contaminant identification, exposure assessment, toxicity assessment, and risk characterization, the preliminary CSMs of the Site will be updated.

Final Human Health Risk Assessment Report. The Draft HHRA Report will be reviewed and commented on by EPA. The EPA comments will be addressed and the Final HHRA Report will be submitted to EPA.

6.1.2 Task 7.2—Ecological Risk Assessment (ERA)

The following sections outline the methods and structure, as well as the phased approach for conducting an ERA. Additionally, the specific sub-tasks required for development of the ASARCO Hayden Site ERA are outlined.

Ecological Risk Assessment Methods and Structure

The ERA methods presented in this section are in general accordance with the following guidance provided by EPA:

- Framework for Ecological Risk Assessment (EPA, 1992a)
- ECO Updates, Volume 2, Numbers 1 through 4 (EPA, 1994a, 1994b, 1994c, 1994d)
- ECO Updates, Volume 3, Numbers 1 and 2 (EPA, 1996a, 1996b)
- Final Guidelines for Ecological Risk Assessment (EPA, 1998)
- Ecological Risk Assessment and Risk Management Principles for Superfund Sites (EPA, 1999b)
- The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments (EPA, 2001)

Ecological risk assessment is a process of collecting, organizing, and analyzing information to estimate the likelihood of undesired effects on plants and animals from human-induced changes. ERAs are developed within a risk management context for use in environmental
decision making. They are based on an iterative process (phases of risk assessment are discussed below in Section 6.1.2.2) that includes the following three components:

1. **Problem Formulation** is the planning and problem definition phase.
   - Integrating available information (sources, contaminants, effects, and environmental setting)
   - Identifying the COPEC at a site
   - Identifying assessment endpoints (environmental values to be protected)
   - Developing the ecological CSM (description of hypothesized relationships between contaminants and receptors)
   - Preparing an analysis plan (plan for obtaining and evaluating the necessary data)

The importance of the Problem Formulation phase in completing a successful ERA cannot be over emphasized. Inadequate development of the Problem Formulation phase is the most common cause for failure of an ERA to meet its intended purpose.

2. **Analysis** is the technical evaluation of exposure and effects data; it includes a characterization of exposure and a characterization of ecological effects.

   **Characterization of Exposure**
   - Measures of exposure (nature, distribution, and concentrations of contaminants at points of potential contact with receptors)
   - Exposure analysis (estimation of spatial and temporal contaminant distribution; typically will include estimation of dietary intake for avian and mammalian receptors; exposure for soil and sediment invertebrates, plants, fish, and other water column biota is estimated based on concentrations in the medium in which they live)
   - Exposure profile (summary of exposure analysis)

   **Characterization of Ecological Effects**
   - Measures of effects (results of measurements/observations indicating the responses of assessment endpoints to variation in exposure)
   - Ecological response analysis (quantitative analysis of effects data)
   - Stressor-response profile (relationship between magnitude and duration of exposure and relevant effects)

3. **Risk Characterization** integrates the Problem Formulation and the results of the exposure/effects analyses to estimate and describe the likelihood of risk to ecological receptors.
   - **Risk Estimation**—calculate risk based on results of exposure and effects characterization, usually by calculating hazard quotients (HQs), where HQ = (exposure measure/effects measure); when data are adequate, probabilistic exposure-effect evaluations may be conducted;
• **Risk Description**—description and interpretation of risk; and

• **Uncertainty Analysis**—uncertainties are inherent in all risk assessments, and may occur at all stages of the assessment (problem formulation, analysis, and risk characterization); the nature and magnitude of uncertainties depend on the amount and quality of data available, the degree of knowledge concerning site conditions, and the assumptions made to perform the assessment.

The culmination of this three-step process is a set of conclusions (sometimes with accompanying recommendations concerning ways of reducing uncertainties, whether further evaluation is needed, etc.) that are communicated to the risk manager, who can then choose an appropriate course of action (e.g., remediation, no remediation, or further refined assessment) and communicate the results to stakeholders.

### Phased Ecological Risk Assessment Approach

ERAs are usually prepared in phases (sometimes referred to as tiers or levels). This approach entails increasingly sophisticated levels of data collection and analysis, wherein the conservative assumptions of the initial evaluations are replaced by more site-specific data and more ecologically realistic assumptions. This serves to reduce conservatism and uncertainties in the risk assessment. There are generally three phases in ERA: scoping assessment, screening-level assessment, and baseline assessment.

Upon evaluation of the results from each phase, a review is conducted to determine whether risk management objectives can be achieved or whether more site-specific analysis is warranted. The results of each assessment phase are used to demonstrate whether the concentration of the COPEC in site media pose a threat to ecological receptors. Several actions can be taken upon completion of each assessment phase:

• **No Further Action.** If the COPEC concentrations at a site do not exceed the screening-level benchmarks developed in accordance with this approach, then no further remediation is warranted.

• **Perform a Higher Assessment.** If the COPEC concentrations at a site exceed the screening benchmarks, a refinement of the screening or the next assessment phase may be used with more rigorous (i.e., less conservative) analysis and/or the use of more site-specific data.

• **Collect Additional Data.** Additional data may be collected to provide more site-specific information and for the performance of more sophisticated analysis in a higher assessment phase.

• **Reduce Concentration Levels.** Reduction of COPEC concentrations through remedial actions (e.g., excavation and hauling, in-situ treatment, ex-situ treatment) to meet the ecological screening benchmarks.

• **Reduce Potential Exposure.** Use of management techniques to restrict exposure to COPEC concentrations in soil, sediment, surface water, or groundwater remaining at the site (e.g., engineering barriers).

• Any combination of above actions.
The components of each ERA phase, and how these will be applied to the Site are described below.

**Phase 1. Scoping Assessments**
Scoping assessments are performed to determine whether plants or animals may be exposed to Site contaminants and whether further ERA work is required. Risk can occur only when there is a chemical source, a receptor, and a route of exposure between the source and receptor. The following four questions should be answered by a scoping-level ecological risk assessment:

1. Is there a source of contaminants?
2. Are there currently, or might there be in the future, ecological receptors on the contaminated Site (i.e., does the Site provide suitable habitat for ecological receptors)?
3. What is the current and future land-use for the Site?
4. Could movement of the contaminants result in significant exposure of ecological receptors off the Site?

Answers to these questions must be integrated to determine whether further work is needed. A screening-level ecological risk assessment (SLERA) is recommended only if the scoping assessment has determined there is a source of contaminants, if receptors are or will be present, and land-use or off-Site contaminant migration dictates that receptors may be exposed.

It is already known that potential sources of contaminants (i.e., tailings piles and smelter air emissions) exist at the Site. Additionally, the Site is located adjacent to terrestrial and aquatic habitat where complete exposure pathways to ecological receptors (e.g., contaminated soil, sediment, or surface water) are likely. Therefore, a formal scoping assessment is not required, and this workplan represents the data collection and ERA methods for a screening-level assessment.

**Phase 2. Screening-Level Assessments**
Screening-level assessments take the assessment process one step further by determining whether toxicologically significant exposure could occur, by evaluating conservative estimates of exposure and conservative effects data to make preliminary risk conclusions. It is important to note that a SLERA is a one-tailed evaluation. It does not actually determine the presence of risks. Rather, it differentiates between data that can be definitively concluded to present no risks (i.e., they ‘pass’ the screen) and data that, due to the application of multiple conservative assumptions, are insufficient to support a no risk conclusion (i.e., they ‘fail’ the screen). Conclusions from a SLERA are that a set of analytes, receptors, and locations are not at risk or alternatively that information is insufficient to exclude potential for risk at areas that fail the screen. A screening-level ecological assessment allows the ERA team to exclude areas, media, or chemicals identified as presenting no risk from further evaluation. It also allows for the identification of data gaps, which helps to focus data collection efforts for subsequent analyses. In particular, data that would contribute most to a reduction in uncertainties (e.g., site-specific bioaccumulation information) should be identified.
In the initial screening evaluation for the Site, maximum contaminant concentrations (or dietary exposure estimates based on maximum concentrations) will be compared to conservative literature-derived toxicity values. These toxicity values will be based on no observed effects concentrations (NOECs) or no observed adverse effects levels (NOAELs) and may be referred to as toxicity reference values (TRVs).

If all analytes pass the screen, the ERA process is complete and no further ecological risk evaluation is recommended at the Site. However, if any analytes fail the screen, the SLERA may be expanded to include a refined screening evaluation. The refined screen does not include the collection of additional data, but rather, highly conservative assumptions used in the initial screening evaluation are refined or risk is evaluated qualitatively. Elements of the refined screening evaluation may include:

- **Background Screen** – A comparison of concentrations of inorganics to background concentrations may be conducted (according to EPA guidance) to exclude those inorganic COPEC that are less than background.

- **Comparison to Effects Levels/Magnitude of the HQ** - Compare exposure to both no and lowest effects levels. If exposure does not exceed either effect level, risks are absent. If exposure exceeds the no effect level, but not the lowest effect level, risks are unlikely. If exposure exceeds both effect levels, risks are likely.

- **Frequency of Exceedance** — A low frequency of exceedance may indicate low likelihood of risks.

- **Frequency of Detection** — A low frequency of detection may suggest that contamination is limited to a small area or single location.

- **Incremental Risk** — If the maximum concentration of an inorganic on-site is less than 10 percent greater than the background value and incremental HQ is less than 1, most of the risk may not be a direct result of site activities.

- **Bioavailability of COPEC** — Chemicals are generally not absorbed by biota with 100 percent efficiency; therefore, if data are available (usually literature-based in this assessment phase) on the bioavailability of the COPEC, the exposure estimate and therefore, the HQ may be reduced by incorporating bioavailability into the exposure calculation (it may also be noted in the discussion that toxicity tests reported in published literature usually use soluble salt forms of the chemical which have greater bioavailability than naturally occurring forms).

- **Area Use** — if the home range of a receptor is greater than the area of the site, the risk may be over estimated (the HQ can be recalculated using a more accurate estimate of exposure that incorporates an area use factor).

With the exception of the background screen where chemicals can be excluded from further evaluation if site concentrations are below background values, no individual refinement would likely be sufficient to eliminate the conclusion of potential risk. However, when these refinements are considered together they may provide a weight-of-evidence conclusion that risk is low and further evaluation in a baseline assessment may not be warranted. Although
the risk assessment report will make recommendations based on these refinements, the final decision will be made by the EPA risk managers.

If analytes fail the refined screen, the ERA process may be continued to the next, or baseline, phase. Although briefly described below, this workplan is not intended to support a baseline ecological risk assessment. Should a baseline ecological risk assessment be required for the Site, a supplemental workplan to support that effort will be necessary.

Phase 3. Baseline (Definitive) Assessments
Baseline ecological risk assessments (BERAs) use more ecologically realistic assumptions to estimate the presence, nature, and magnitude of risks associated with analytes retained at the conclusion of the SLERA. Conservative measures of exposure and effects used in the SLERA are replaced with ecologically more realistic and site-specific data. This may include collecting data to determine site-specific contaminant bioaccumulation and bioavailability, performing site-specific toxicity tests to determine toxicity of site media, using multiple tiers of TRVs, and performing biological surveys to complement the toxicity data. Strengths and weakness associated with these additional lines of evidence are integrated in a weight-of-evidence evaluation to decrease uncertainty and increase the realism of the risk determinations. As stated above, performance of a BERA is not included in this workplan or cost estimate. The need for a BERA at the Site will be determined following the conclusion of the SLERA, and would be scoped as a separate effort.

Sub-Tasks for the ASARCO Hayden Ecological Risk Assessment
Sub-tasks required for the ERA work at the Site are described below.

Sub-Task 1: Development of the Ecological Conceptual Site Model and Identification of Assessment Endpoints and Potential Ecological Receptors

- Under this RI sub-task, a CSM, including identification of assessment endpoints and potential ecological receptors, will be developed. This task will be completed using available historic Site data and information, as well as literature-based data as needed, and data collected during the RI investigation as described in this workplan.

A first step in developing the CSM is to identify the assessment endpoints and potential ecological receptors. Assessment endpoints are the ecological values to be protected (EPA, 1998) and are developed based on known information concerning the contaminants present, site conditions, and the risk management goals. Additionally, they must represent a property of the system that can be measured. The EPA identifies four criteria to consider when selecting assessment endpoints including societal value, environmental policy goals, ecological relevance, and susceptibility to the stressor (EPA, 1992a and 1998). Assessment endpoints for the Site will include terrestrial plants, soil invertebrates, soil microbial processes, reptiles, and terrestrial birds and mammals in the terrestrial habitats and aquatic plants, benthic invertebrates, fish, and aquatic birds and mammals in the aquatic habitats. In addition, any state or federal special-status species that occur within the vicinity of the Site will be included as assessment endpoints. As previously indicated, additional specific avian and mammalian receptors will be selected in consultation with appropriate federal and state agencies (e.g., USFWS and AGFD).
The CSM is a written and visual presentation of predicted relationships among stressors, exposure, and assessment endpoints. It includes a description of the complete exposure pathways and outlines the potential routes of exposure for each assessment endpoint. A preliminary CSM diagram for ecological exposures has been developed for the Site (Section 1.2, Figure 1-2). The primary sources are current or historic activities of the smelter and concentrator. Primary release mechanisms include air emissions from the 1,000-foot stack and other process locations, as well as solid wastes (the tailings) and wastewater associated with the processing of the copper ore. Secondary sources of potential contaminants are surface soils (including the tailings piles or ponds adjacent to the Gila River) and air. Release mechanisms include aerial deposition of stack emissions, discharge/runoff from the tailings piles (as occurred during flooding in 1993) to the Gila River or to adjacent soils, wind erosion, leaching to groundwater, and surface discharge from groundwater. Complete exposure pathways from contaminated surface soil, sediment, surface water (including ponded water located on top of the tailings piles), biota, and possibly groundwater, to ecological receptors exist at the Site. It is unknown at this time whether groundwater under the smelter discharges to the Gila River or whether there is leaching from the tailings piles to groundwater under the Gila River, therefore, these pathways will be evaluated with limited sampling.

Contaminants in soil may be directly bioaccumulated by terrestrial plants, soil invertebrates, or micro-organisms resident in Site soils. Additionally, terrestrial plants may be exposed by uptake from contaminated groundwater or surface water sources or by aerial deposition on to foliage. Aquatic plants are primarily exposed by contaminated sediment. Although benthic invertebrates, fish, and amphibians may be exposed to contaminants by surface water or sediment, benthic invertebrates are primarily exposed through sediment and fish and amphibians are primarily exposed through surface water. Terrestrial and aquatic wildlife, including reptiles, (e.g., herbivores, omnivores, soil invertebrate feeders, and predators) may be exposed directly to contaminants in surface water through ingestion and to contaminants in soil or sediment by incidental soil or sediment ingestion, by dermal contact, or by the inhalation of windborne particles. Terrestrial and aquatic invertebrates and wildlife (i.e., amphibians, reptiles, birds and mammals) may also receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (e.g., plants to herbivores, plants and prey animals to omnivores, etc.).

The specific wildlife receptors representing these exposure pathways will be finalized for the Site subsequent to the data collection described in this workplan and with agency consultation as described above.

**Sub-Task 2: Prepare Preliminary Screening-Level Ecological Risk Assessment for Review**

In the Site SLERA, conservative estimates of exposure for each receptor will be compared to conservative ecological screening benchmarks (NOECs and NOAELs as described above). For example, Ecological Soil Screening-Levels developed by EPA (EPA, 2005g) will be used as available, as will other published screening data for plants, soil invertebrates, and soil microbial processes (e.g., Efroymson et al., 1997a and 1997b). For the aquatic environment, published screening-levels for surface water (e.g., EPA, 2002; Suter and Tsao, 1996) and sediment (e.g., MacDonald et al., 2000; Jones et al., 1997) will also be used. Avian and mammalian toxicity values will be extracted from EFA West (1998), Sample et al. (1996), and published literature, as appropriate. Exposure estimates will be based on maximum media
concentrations measured at the Site. Bird and mammal receptors will be assumed to forage exclusively on-Site in the initial screening evaluation. An HQ of 1.0 or greater will represent a failure to pass the screening evaluation. As previously described, COPEC that fail to pass the initial screen will be re-evaluated in the risk characterization in a refined screen using biologically more realistic assumptions.

**Sub-Task 3: Respond to Comments and Prepare Draft Screening-Level Ecological Risk Assessment for Review by Appropriate Regulators**

This task includes participation in one conference call to discuss responses to client comments on the Preliminary Draft, and revision and preparation of the Draft SLERA.

**Sub-Task 4: Respond to Regulator Comments and Prepare Final Screening-Level Ecological Risk Assessment**

This task includes participation in one conference call to discuss responses to comments on the Draft, and revision and preparation of the Final SLERA.
7.0 Treatability Study Assessment

7.1 Task 8—Assess Need for Treatability Studies and Pilot Testing

Purpose and Overview

Remedial technologies that may be suitable to the Site should be identified as early as possible to evaluate whether there is a need to conduct treatability studies to better estimate costs and performance capabilities. Because the RI has not been implemented, it is presently unknown whether treatability studies will be necessary. However, the RI results will be used to help evaluate whether treatability studies will be needed.

The three tiers of treatability studies are laboratory screening, bench-scale testing, and pilot-scale testing. Either or all three tiers may be needed, depending primarily on whether the treatment technology is proven or innovative, and on the complexity of the media to be treated. The laboratory screening is used to establish the validity of a technology to treat waste and is normally conducted during the feasibility study (FS) stage. Bench-scale testing is used to evaluate the performance of the technology specific to a type of waste, and is often conducted during the FS. Pilot-scale testing is used to provide quantitative performance, cost, and design information for remediation and can be performed as part of the FS or during the Remedial Design/Remedial Action (RD/RA) stage.

This task will only include a general assessment of whether treatability studies are needed and will recommend next steps if they are deemed necessary or useful.

Procedures

This task will include the following step-wise approach:

- **Step 1**: Review of the analytical results for the various media components and comparison with regulatory cleanup levels and risk-based cleanup standards to generally evaluate whether remedial measures are likely needed for any media. If the data review indicates that remedial measures are likely not needed, then subsequent steps are not needed.

- **Step 2**: If remedial measures are likely needed, a literature review will be conducted to identify those treatment technologies that may be appropriate for the specific media of interest.

- **Step 3**: The treatment technologies will then be individually evaluated based on performance data from other sites to identify the two or three most promising technologies per media.

- **Step 4**: A general assessment will then be made regarding the need for treatability testing for the most promising technology(ies) per media. In addition, the suggested
treatability testing tier (laboratory screening, bench-scale testing, and/or pilot-scale testing) will be provided.

Treatability studies, if deemed necessary by EPA, must be guided by a Treatability Study workplan and results presented in a Treatability Study Report. These efforts would be performed subsequent to completion of this RI.
8.0 Remedial Investigation Reporting

8.1 Task 9—Remedial Investigation Report

8.1.1 Purpose and Overview
The purpose of this task is to provide a means for reporting periodic progress toward completion of the RI workplan, and to guide development of the draft and final RI Report.

8.1.2 Procedures
Periodic reporting will consist of electronic or hard copy status reports to EPA submitted at an appropriate interval consistent with the level of effort at the time of the update. During periods of active field work and reporting, weekly status reports will be provided. During periods when field work and reporting are generally inactive, bi-weekly status reports will be provided.

The RI Report will describe the procedures and results of the RI. A thorough description of Site characteristics such as media contaminated, extent of contamination, and the physical boundaries of the contamination will be provided. The RI Report will include identification of the key contaminant(s), which will be based on the analytical data and the screening-level human health and ecological risk assessments. The analytical data will be compared with existing standards and guidelines such as drinking water standards, water quality criteria, and other criteria accepted by the EPA as appropriate for the situation to evaluate effects on human and ecological receptors who may be exposed to the key contaminant(s) above appropriate standards or guidelines.

A draft version of the RI Report will be provided, which includes the following elements:

I. Site Background

II. Remedial Investigation Procedures
   • Field Investigation & Technical Approach
   • Chemical Analysis & Analytical Methods
   • Field Methodologies
     – Surface Water
     – Sediment
     – Soil Boring
     – Soil Sampling
     – Monitoring Well Installation
     – Groundwater Sampling
     – Hydrogeological Assessment
     – Air Sampling

III. Site Characteristics
   • Geology
   • Hydrogeology
- Meteorology
- Demographics and Land Use
- Ecological Assessment

IV. Nature and Extent of Contamination
- Contaminant Sources
- Contaminant Distribution and Trends

V. Fate and Transport
- Contaminant Characteristics
- Transport Processes
- Contaminant Migration Trends

VI. Screening-Level Risk Assessment
- Screening-Level Human Health Risk Assessment
- Screening-Level Ecological Risk Assessment

VII. Assessment of Need for Treatability Studies

VIII. Summary and Conclusions

After EPA review of the draft RI Report, EPA comments will be incorporated into a final RI Report.
9.0 Schedule

Figure 9-1 presents the tentative implementation schedule for the RI. This schedule assumes that access agreements will be obtained with ASARCO, and that field activities will be completed sequentially with minimal downtime between individual tasks.

The schedule will be updated as needed if delays are encountered due to access, adverse field conditions, weather delays, or for other unexpected reasons.
10.0 References


ASARCO, personal discussion between CH2M HILL/EPA and Jack Garrity, Technical Services Manager, during December 15, 2004 site visit.

ASARCO, personal discussion between CH2M HILL and Jack Garrity, Technical Services Manager, during January 20, 2005 site visit.


ASARCO LLC. September 6, 2005. Comments to draft Remedial Investigation Workplan, provided at close of 30-day public comment period.


Arizona Department of Environmental Quality (ADEQ), Air Quality Annual Report, 2000
Arizona Department of Environmental Quality (ADEQ), Air Quality Annual Report, 2001
Arizona Department of Environmental Quality, (ADEQ), Air Quality Annual Report, 2002
Arizona Department of Environmental Quality, (ADEQ), Air Quality Annual Report, 2003
Arizona Department of Environmental Quality, (ADEQ). Air Quality Annual Report, 2004


Voeltz, J. 2005. Personal communication between Jeremy Voeltz of the State of Arizona Game and Fish Department and Christine Arenal of CH2M HILL on January 27.