SITE CHARACTERIZATION REPORT FOR THE UPPER ARKANSAS RIVER BASIN

October 31, 2002

EXECUTIVE SUMMARY

The following provides a brief summary of the key findings of this report with regard to the nature and extent of mining impacts to the natural resources of the Upper Arkansas River Basin (UARB) (Figure ES-1). This report was prepared in accordance with the parties to the Memorandum of Understanding (MOU) and corresponding "Work Plan for the Upper Arkansas River Basin Consulting Team: 11-Mile Reach, Downstream Survey, and Airshed Survey" (Work Plan). Consistent with the remainder of the report, a summary is presented for the following:

- **11-Mile Reach of the Arkansas River** – This area is defined as the 500-year floodplain from the confluence of California Gulch with the Arkansas River to a point approximately 11 miles downstream at its confluence with Two-Bit Gulch (Figure ES-2). In this area, the Arkansas River is a relatively steep, wandering gravel-bed river. The 11-mile reach of concern flows in a wide valley until it enters a canyon downstream of River Mile 11. For the purpose of this report, River Mile 0 is at the junction of California Gulch with the Arkansas River.

- **Arkansas River Downstream from the 11-Mile Reach** – The Downstream Area includes the 500-year floodplain from the end of 11-mile reach to the dam at Pueblo Reservoir (Figure ES-1).

- **Airshed** – The upland area surrounding Leadville, subject to historic smelter air deposition (Figure ES-1).

According to the Work Plan, the characterization effort is to fulfill the following objectives for the 11-mile reach:

- Description of the nature and extent of contamination;
- Maps of areas affected by mine-waste;
- Description of injuries to natural resources;
- Identification of potential contaminant pathways; and
- Definition of areas where restoration is needed to obtain a healthy, functioning ecosystem and to mitigate exposure pathways.

According to these objectives, the findings regarding target restoration areas for the 11-mile reach are also summarized. In addition, this report provides a literature review regarding potential injuries to natural resources within the Downstream Area, as well as potential injuries that result from the release of hazardous substances through smelter stack emissions and subsequent deposition in the surrounding

airshed. The purpose of this literature review is to determine the type of information that is available for evaluating the potential for injury to natural resources from the release of hazardous substances from mining and smelting activities and to conduct a preliminary evaluation of injury.

The 11-Mile Reach

Historic and ongoing releases from up-gradient sources within the California Gulch NPL site and historic releases of mine-waste now deposited within the 11-mile reach have resulted in past and present injuries to surface water and sediments, soils, and terrestrial and aquatic biological resources. These injuries were defined based on a comparison of conditions with the regulatory definitions, and by comparison with conditions of the Arkansas River and its floodplain upstream of California Gulch inflow. The Upper Arkansas River and its floodplain above the confluence with California Gulch was determined to provide an appropriate (point of reference) for evaluating the impacts of mining.

Review of the historical record indicates that current injuries can be traced to the original hydraulic placer mining activity of the late 1800s, with increasing levels of impact as hard-rock mining occurred over the first half of the 20th century. Examination of recent data indicates that response actions within the NPL site have reduced the magnitude of injury to surface water, within the 11-mile reach. There is corresponding evidence of recovery for components of the aquatic community in the 11-mile reach.

By far, the largest ongoing impacts within the 11-mile reach are to the waters of the Arkansas River. Although improved, current water quality immediately below the confluence with California Gulch (Reach 1) grossly exceeds the relevant Colorado Table Value Standards (TVSs) (Figures ES3A-E). The degradation of surface water quality for the 11-mile reach of the Arkansas River is primarily due to the metals load emanating from California Gulch.

Deposits of mine-waste in the floodplain are prevalent within the upper nine miles of the 11-mile reach. On average, the deposits extend approximately two feet below the current ground surface and are mostly isolated from contact with surface water and groundwater. Additionally, some surface soils within the 11-mile reach have been contaminated through irrigation. Deposits in the first few miles below California Gulch appear to be older, coarser mine-wastes, with higher concentrations of metals on average than deposits in the more downstream portions of the 11-mile reach. The mine-waste deposits have impacted soil function, inhibited or precluded riparian vegetation, and present a pathway for metals exposure to terrestrial biota. Evidence of erosion of these deposits during periods of bankfull and overbank flow was observed. However, studies examining the influence of these deposits on surface

water and groundwater quality demonstrated that Arkansas River surface water concentrations were not measurably influenced by the deposits. Metals loading from leaching of mine-waste deposits, resulting in exceedance of groundwater criteria, is limited to groundwater within and immediately adjacent to the deposits. This water appears to be a shallow locally perched system and impacts to domestic water supplies were not observed. The lack of impact is due to the small size of the mine-waste deposits relative to the large volume of surface water and groundwater flow during bankfull conditions, and the general condition of most mine-waste deposits not being in contact with surface water and groundwater during most flow regimes.

Further downstream from California Gulch, the water quality of the Arkansas River improves due to dilution from tributary inflows. Approximately three miles downstream, Lake Fork Creek joins the Arkansas River. Lake Fork carries significant natural flow, as well as large volumes of water diverted from the Western Slope for downstream use. The dilution effects of the augmented flow are significant, resulting in substantial reductions of metal concentrations in the Arkansas River. Water quality and, correspondingly, the condition of the aquatic communities continue to improve downstream as more tributaries bring additional clean flows to the Arkansas River. However, at times, the concentrations in the river still exceed the TVSs used to define injury.

Although beneficial from a water quality perspective, historically the highly increased flows due to augmentation coupled with prior deposition of hydraulic mining spoils, have resulted in a change in channel morphology, primarily a broadening of the active channel. The rapid flow increases and unseasonal peak flows associated with flow augmentation contributes to accelerated bank erosion and loss of irrigation head gates. This is most apparent below the confluence with Lake Fork, which receives west slope water through Turquoise Lake. Grazing of the riparian zone may also be contributing to this condition. Flow augmentation within the 11-mile reach has been reduced with the development of the Mt. Elbert Tunnel in 1981, which transfers flow further downstream to Lake Creek. However, flow augmentation of the Arkansas River continues both above California Gulch and through Lake Fork.

For the next several miles downstream of Lake Fork (Reach 2), the average metals concentration of floodplain mine-waste deposits drops and the floodplain broadens. The volume of tailings deposits per stream length is also less than upstream of Lake Fork. This is most likely due to the increased flow capacity of the channel in this area, which would reduce the frequency of overbank flow conditions. Lower average concentrations of metals in floodplain deposits is also evident in Reach 3 (approximately river miles 7, 8, and 9); however, the number of deposits increases as the wide, shallow channel through this area is more prone to overbank flow. Over the remaining length of the 11-mile reach, the floodplain

generally narrows. Only a few small deposits of mine-waste are present in Reach 4 due to the flushing effect of the more efficient channel.

Instream deposits of fine-grained sediments/mine-wastes are not readily identifiable within the 11-mile reach. Although elevated metals concentrations in instream sediments were measured and exceed typical threshold values for toxicity, the course gravel cobble river bed limits the potential for this exposure pathway. Because of the limited number of fine-grained, instream sediment samples for the 11-mile reach, it is difficult to discern any spatial trends within this relatively short area. However, it is expected that for the small amount of instream sediment in the system, a pattern of decreasing average concentration as one moves downstream would exist.

The condition of the aquatic biological resources tends to correspond to improvements in water quality. Although water quality improves substantially over the 11-mile reach, and fish and macroinvertebrates are present, metals concentrations, toxicity testing and field studies indicate that dissolved metals concentrations from California Gulch are still having a strong negative effect on macroinvertebrates and fish. These effects are directly due to the elevated concentration of metals in the water column, and also due to food chain pathways where periphyton accumulates water column metals, in turn serving as a food source for grazing benthic macroinvertebrates. These metals are then available for predatory macroinvertebrate species, as well as for larger predators such as fish.

Flow augmentation and ongoing flushing effects of amplified and extended peak flows can directly impact stream productivity. This occurs through alteration of the stream channel, which in turn causes destruction of habitat. It is difficult to separately quantify the effects on stream productivity due to metals from those due to stream augmentation; however, the impacts on the density and diversity of benthic macroinvertebrates and the numbers and health of brown trout are primarily due to the effects of elevated metals concentrations. Even though water quality improves over the 11-mile reach, injuries due to elevated dissolved metals concentrations in the Arkansas River continue.

Although the primary injuries within the 11-mile reach appear to be to the aquatic resources, injuries to terrestrial resources have been identified as well. Elevated metals concentrations in floodplain sediment deposits have impacted soil function and exceed concentrations that cause phytotoxicity. In turn, the lack of vegetation on these near-stream deposits reduces the productivity of riparian food sources to the stream, and also reduces habitat suitability through loss of shade and possible bank erosion. Although similar impacts can occur from grazing or road building, the loss of vegetation due to mine-waste deposits can be partially quantified through mapping efforts.

Food chain exposure pathways for injury were documented for two avian species within the 11-mile reach. Studies conducted by the U.S. Fish and Wildlife Service and U.S. Geological Survey show that benthic macroinvertebrates and their adult emergent forms have elevated metals-body burden and are a food source for dippers and swallows, respectively. Ingestion of the terrestrial form of the aquatic insects has resulted in injury due to elevated blood lead and decreased enzyme production in swallows. As with the aquatic species, it appears that the general trend in injury is a decrease with the dilution effects downstream.

Direct exposure to tailings deposits may be a concern for small mammals (e.g., mice or voles) or other species that have a home range small enough that they would spend a majority of their time in direct contact with a mine-waste deposit. However, no conclusive information was found describing this type of injury. Although information is limited, it is estimated that for larger species of predators (e.g., fox, coyote, etc.) and grazers (e.g., deer, etc.) the small amount of time spent in contact with the deposits, given the large range of movement, would limit the potential for injury. This may not be true for domestic livestock, where confined grazing occurs. However, it was not possible to distinguish impacts, such as osteochondrosis, to elevated metals in soils and vegetation from possible non-mining related nutrient imbalances.

The following lists some of the overall findings of the site characterization summary:

- Water quality within the 11-mile reach of the Arkansas River is severely degraded due to metals loading from California Gulch. Metals loading from California Gulch results in gross exceedances of the acute and chronic State of Colorado TVSs.

- Over the length of the 11-mile reach, water quality improves due to dilution from tributary flows and attenuation of metals. Large inflows approximately three miles downstream of California Gulch at the confluence with Lake Fork result in a halving of most metals concentrations. However, even with additional tributary inflows further downstream, exceedances of the TVSs are still measured.

- The productivity and diversity of aquatic organisms, such as benthic invertebrates, are linked to spatial trends in water quality. Large impacts on both diversity and abundance are observed immediately downstream of California Gulch due to the toxic effects of the metals load entering the river. However, at some downstream locations, species more sensitive to elevated metals concentrations (e.g., heptageniid mayflies) appear to have increased.

- The health and abundance of trout within the 11-mile reach can also be correlated with changes in water quality. Resident trout are prevalent upstream from the confluence with

California Gulch, absent immediately below California Gulch, and recover to some degree further downstream with improvements in water quality due to tributary inputs.

- Metals within the mine-waste deposits, adjacent soils, and the aquatic system are available for uptake by plant and animal life. Examination of other aquatic and avian species indicates that metals are moving from the dissolved form within the food chain. Metals concentrations within lower trophic levels (e.g., periphyton) result in elevated metals concentrations in aquatic insects that in turn serve as a food source for both aquatic and avian species. Elevated metals levels measured in trout organs may in part be attributable to food chain exposure. Studies on tree swallows and dippers indicate that metals in aquatic insects are accumulating and have measurable endocrine system effects.

- Mine-waste deposits along the 11-mile reach are numerous and cover an area of 2,829,911 ft^2, with an estimated volume of 2,698,514 ft^3. Mine-waste deposits are generally less than two feet in thickness. Metals-concentrations in these deposits range from 48,320 mg/Kg to 200 mg/Kg for zinc, 575 mg/Kg to 48 mg/Kg for cadmium, 1,200 mg/Kg to 46 mg/Kg for copper, and 11,525 mg/Kg to 85 mg/Kg for lead. Concentrations in many of the deposits exceed criteria for phytotoxic responses. Portions of these deposits are barren due to a combination of phytotoxic conditions and lack of the necessary organic material and soil nutrients.

- Floodplain soils peripheral to the mine-waste deposits also have elevated metals concentrations. Flood and irrigation water carrying dissolved metals and particulate mine-wastes have increased metals concentrations in the top several inches of floodplain soils. Although the concentration in floodplain soils is much less than in mine-waste deposits, these metals can still increase plant tissue concentrations of metals.

- The reported occurrence of osteochondrosis in foals can be associated with elevated cadmium or zinc interfering with copper metabolism, or a more direct effect of excessive zinc from elevated concentrations in soils and vegetation. However, no site-specific studies have been conducted to evaluate a cause and effect relationship between the disease and metal concentrations in forage.

- Although stream-bank deposits of mine-waste are eroding, the effect of these deposits on dissolved and total metals concentrations in surface water are not easily identifiable. This is in part due to the overwhelming effect of metals load from California Gulch and upstream areas on metals concentrations. However, the relatively small metals load contributed from these source materials is the primary reason for lack of observable effects.

- Localized effects on shallow groundwater are evident within and immediately adjacent to mine-waste deposits on the floodplain of the 11-mile reach. This observation is based on a number of wells associated with the mine-waste deposits placed in the very shallow

water table (1 to 10 ft in depth) near the river. It is probable that the elevated metals concentrations are due to a combination of infiltration of snowmelt and seasonal interaction with shallow groundwater. Deeper groundwater wells demonstrate that the effects of these source materials on groundwater quality rapidly dissipate with distance, due to the large volume of groundwater flow within the floodplain. Portions of the aquifer that provide a drinking water supply have not been injured.

- Non-mining influences on the condition of the resources were identified within the 11-mile reach. Flow augmentation of the Arkansas River via Lake Fork tributary (particularly prior to 1981) has impacted channel morphology and therefore instream habitat. Increased and unseasonal peak flows can also affect the fishery. Although the baseline influence of flow augmentation was identified, its role in reducing the productivity of the aquatic and terrestrial systems could not be quantified.

- Prior to mining in the Upper Arkansas River Basin, the Upper Arkansas River between California Gulch and Two-Bit Gulch was narrower than it is today. An attempt to determine channel width from General Land Office surveys in the 19th century was not successful, but nevertheless it is clear that the river was perhaps half its present width. The channel aggraded and widened most likely with the introduction of coarse sediment, which was a result of hydraulic placer mining. With the addition of water from trans-mountain diversions, the river widened further to its present dimensions. A reduction in flow augmentation should cause channel narrowing, and examination of aerial photographs suggests that the channel is less active at present.

The attached matrix provides a summary of SCR findings regarding injury sorted by resource category and by reach.

Target Restoration Areas

The results of this characterization effort were used as a basis for identifying areas that would benefit from restoration measures. This report presents the identification of the sources of hazardous substances in order to identify pathways for exposure, thereby providing a focus for mitigation and restoration.

California Gulch inflow has been identified as the primary pathway for exposure to elevated metals concentrations in the Arkansas River within the 11-mile reach; however, this area is beyond the scope of this report. California Gulch is currently being addressed through Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) actions, and it is recognized that restoration efforts within the 11-mile reach will only provide limited benefit without additional metals-

loading control measures in California Gulch. Any level of improvement in the water quality of California Gulch will in turn provide some benefit to the 11-mile reach.

Floodplain deposits of mine-waste have been targeted for restoration efforts. The lack of vegetation, potential for erosion, and potential for exposure to high metals concentrations are key factors in determining the need for restoration. USEPA has conducted analyses of the physical and chemical properties of the mining deposits. This information was utilized in a classification analysis based on the following criteria: erosion potential, vegetation cover, volume of material, and average zinc concentration. The information was analyzed using a Geographic Information System (GIS), the results quantified, and the deposits ranked according to priority level (Figure ES-4).

Floodplain soils have also been identified as a possible pathway for exposure to livestock. The need for restoration in areas of the floodplain with elevated concentrations has been recognized, but the level of injury to these resources is not easily defined. Therefore, these areas will be further analyzed in the Restoration Alternatives Analysis Report.

The Downstream Area

A substantial amount of information is available for the characterization of condtions in the Downstream Area. Water quality has been well documented at numerous downstream locations over the last 20 years. Injuries to surface water and associated aquatic biological resources were identified for portions of the Downstream Area. Injuries within the Downstream Area are directly related to the ongoing release of metals from historic mining sites within the headwaters and tributary drainages. The level of injury to aquatic resources diminishes with distance from the mining sources. Although instream metals concentrations have decreased since 1991, California Gulch continues to have the greatest influence on Downstream Area water quality.

The presence of floodplain mine-waste deposits was not identified as a significant source of injury within the Downstream Area. Discrete deposits of mine-waste are present only within a few very small areas of Reach 5. Channel morphology and steep gradient coupled with the large overall volume of sediment transport relative to mine-waste, limit the pontential for discrete floodplain deposits of mine-waste below Granite. Although Pueblo Reservoir provides a sink for sediments, concentrations of mining related metals are not at levels of concern. Based on the lack of discrete deposits and diminishing concentrations, injuries to floodplain terrestrial resources were not identified below Reach 5.

Exceedences of the Colorado TVS for Zinc are the most prevelant injury. Water quality in the Arkansas River upstream of the confluence with Lake Creek at Granite (Reach 5) is essentially the same as within Reach 4 of the 11-Mile Reach. As such, the level of injury to surface water and the aquatic resources are consistent with Reach 4. Water quality improves dramatically below Granite where dilution from Lake Creek reduces average metals concentrations to levels similar to Reach 0. Although exceedences of the TVSs are observed for Reach 6, they are primarily related to periodic runoff from California Gulch and other mined areas. The frequency and magnitude of TVS exceedences continues to diminish with further distance downstream and increased flow. No exceedences were noted for Reach 9.

Injury to aquatic biological resources follows a pattern similar to water quality and can be linked to releases from upstream sources. Injury to benthic macroinvertebrates due to poor water quality is consistent with water quality improvements within Reach 6, benthic macroinvertebrates generally recover to levels consistent with Reach 0 within Reach 6. A corresponding injury to migratory birds (depressed ALAD in dippers) due to elevated metals levels in benthic macroinvertebrates was also identified across Reaches 5 & 6. Brown trout are inferred to be injured within Reach 5, based on water quality. Brown trout recovery is not as obvious within the most upstream areas of Reach 6. However, the impacts of flow regulation and poor habitat, downstream of Granite, may not be separated from potential metals influences. Recovery of the brown trout fishery is evident further downstream (Reaches 7 & 8).

As for the 11-Mile Reach, the Downstream Area Reaches benefited from the control of upstream mining sources such as treatment of California Gulch and the Leadville Mine Drainage Tunnel discharge. Further recovery of the Downstream Area will be dependent upon additional improvements of water quality. Other than the presence of a few minor floodplain mine-waste deposits within Reach 5, there are no potential target restoration areas within the Downstream Area.

Airshed

A reasonable amount of information exists to assess the extent of metals deposition from historic smelter operations in and around Leadville. Information was compiled from a variety of RI/FS efforts, as well as from more recent efforts to characterize soil conditions throughout the UARB. The existing information includes data from sampling of surficial soils for metals concentrations. Several of the metals that were analyzed reflect a signature for smelter deposition. Using soil arsenic and lead concentrations, it was possible to delineate a general pattern of smelter deposition. In most cases the deposition pattern could be identified. At all locations, a trend of decreasing concentration with distance was evident. Based on these data, it does not appear that the distinct area of historic deposition extends much beyond

the area defined by the mapping effort. There is no indication that deposition would have extended across the divide to the east where suitable habitat and identified populations of penland alpine fen mustard (*Eutrema penlandii*) are present in the Mosquito Range.

FIGURES

Leadville
Granite
Buena Vista
Salida
Canon City
Colorado Springs
Pueblo
Pueblo Reservoir
Arkansas River
Royal Gorge
South Arkansas River
Tennessee Creek
East Fork Arkansas River
Turquoise Lake
Crystal Lakes
Halfmoon Creek
Mt. Massive Lakes
Lake Creek
Twin Lakes Reservoir
Clear Creek
Middle Cottonwood Creek
Chalk Creek
Browns Canyon
Badger Creek
Currant Creek
Fourmile Creek
Eightmile Creek
Beaver Creek
Turkey Creek
Texas Creek
Grape Creek
Hardscrabble Creek

EXPLANATION

Hydrology

- Arkansas River Below 11- Mile Reach
- Watershed Boundary
- River or Stream
- Lake or Open Water
- 11- Mile Reach 500- Year Floodplain

Transportation

- Primary Road
- Secondary Road

Other Features

- Mining Activity
- County Boundary
- NPL Site Operable Unit (OU) Boundary/ General Area of Airshed Study
- Town or Landmark

Colorado
Denver

SCALE IN MILES
2.5 0 2.5

UPPER ARKANSAS RIVER BASIN
SITE CHARACTERIZATION SUMMARY

FIGURE ES- 1

DRAINAGE BASIN,
LEADVILLE TO PUEBLO RESERVOIR,
500- YEAR FLOODPLAIN,
SUPERFUND SITE, AIRSHED,
11- MILE REACH, AND MINING ACTIVITY

PROJECT: 010004.3	DATE: OCTOBER 16, 2002
REV: 1	BY: MCP CHECKED: SAW

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22-OCT-2002 GRA: N:\ARCPRJ2\010004\GRA\REACHALL-ES.GRA * AML: N:\ARCPRJ2\010004\AML\REACHALL.AML

Reach 1
1A
1B
1C
Reach 2
2A
2B
Reach 3
3A
3B
Reach 4
4
California Gulch
Colo 300
HWY 24
Lake Fork
Halfmoon Creek
Crystal Lakes
Iowa Gulch
Thompson Gulch
Arkansas River
Empire Gulch
Dry Union Gulch
DERRY No. 1 DITCH
Mt. Massive Lakes
Big Union Creek
Box Creek
Spring Creek
CR 55
Kobe
Sawmill Gulch
Two Bit Gulch
Mt Elbert Forebay
Holmes

EXPLANATION

Hydrology

- River or Stream
- Lake or Open Water
- 11- Mile Reach 500- Year Floodplain
- Reach 0
- Reach 1
- Reach 2
- Reach 3
- Reach 4
- California Gulch at Arkansas River
- River Mile (from confluence with California Gulch)

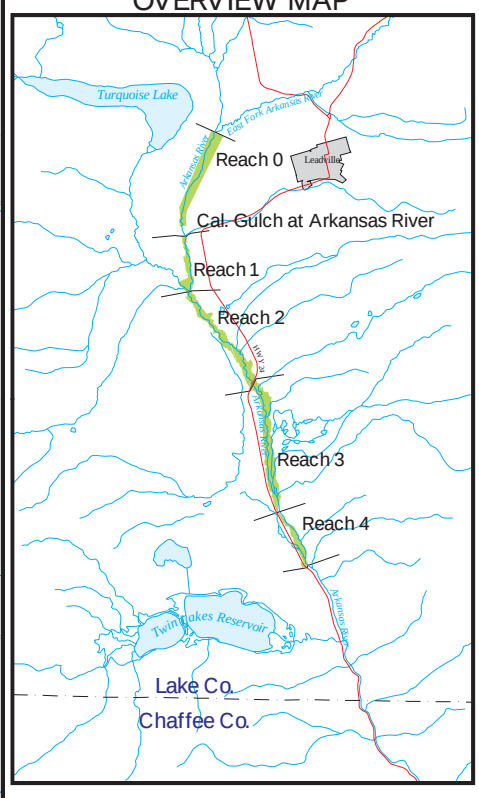
Transportation

- Minor Road
- Medium Duty Road
- Highway
- Railroad

Other Features

- Reach Boundary
- Subreach Boundary

OVERVIEW MAP



Reach Definitions:
1 - California Gulch to Lake Fork
2 - Lake Fork to HWY 24 Bridge
3 - HWY 24 Bridge to Narrows below Kobe
4 - Narrows below Kobe to above Two- Bit Gulch

0 - From EF Arkansas River to California Gulch

N

SCALE IN FEET

3000 0 3000

UPPER ARKANSAS RIVER BASIN
SITE CHARACTERIZATION SUMMARY

FIGURE ES- 2

SUBREACH MAP
SHOWING MAIN REACHES 1- 4
AND REACH 0

PROJECT: 010004.3	DATE: OCT 22, 2002	
REV: 1	BY: MCP	CHK: SAW

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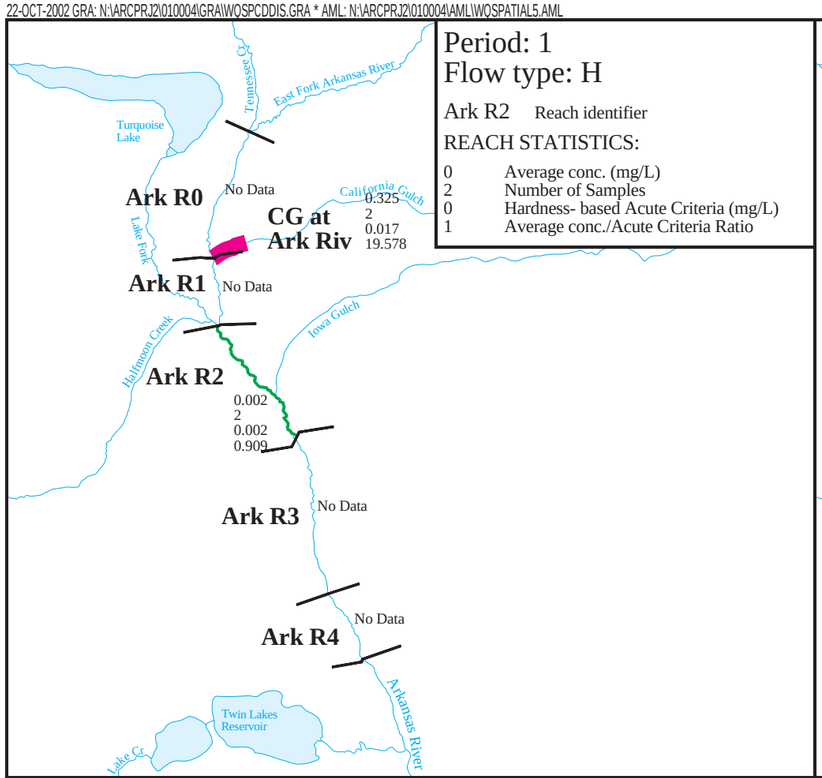

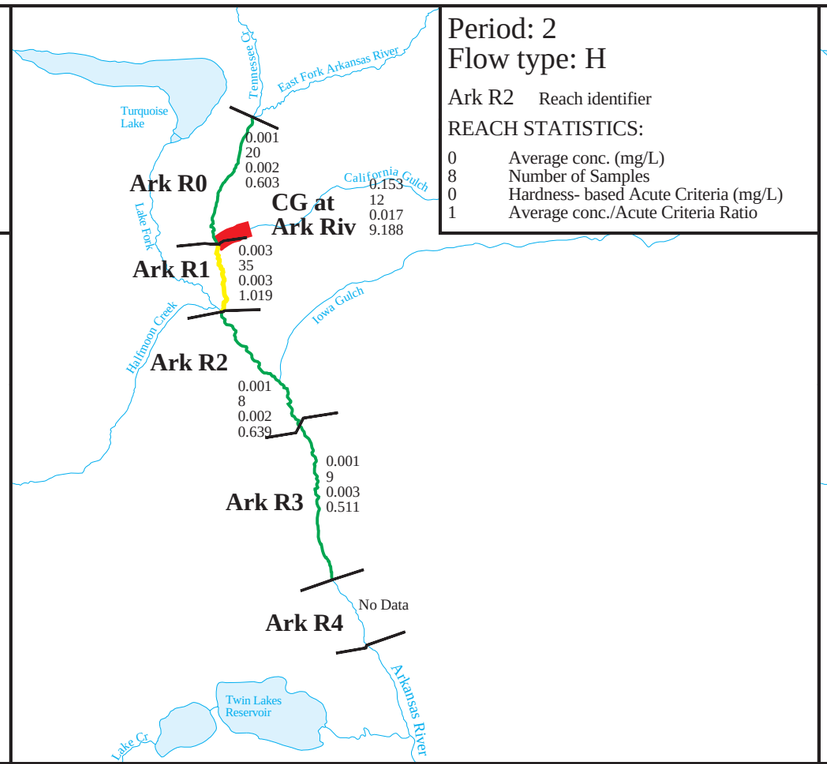

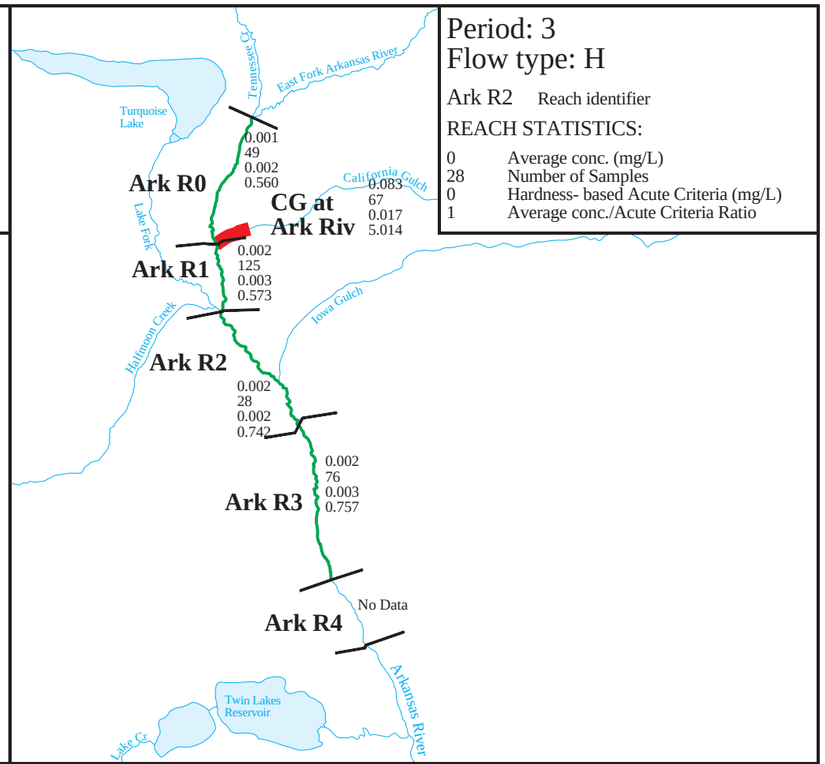

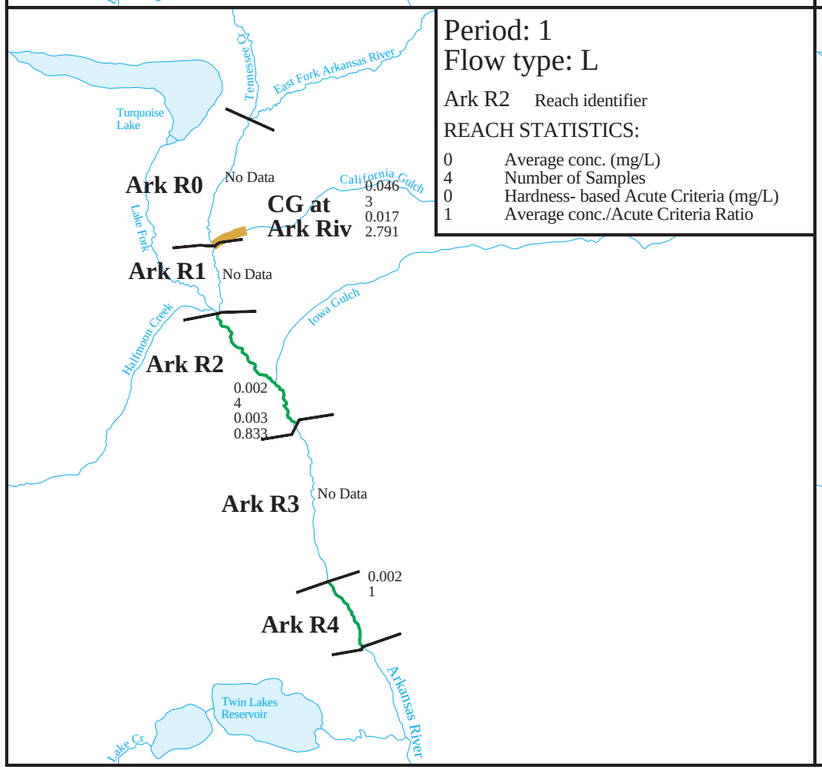

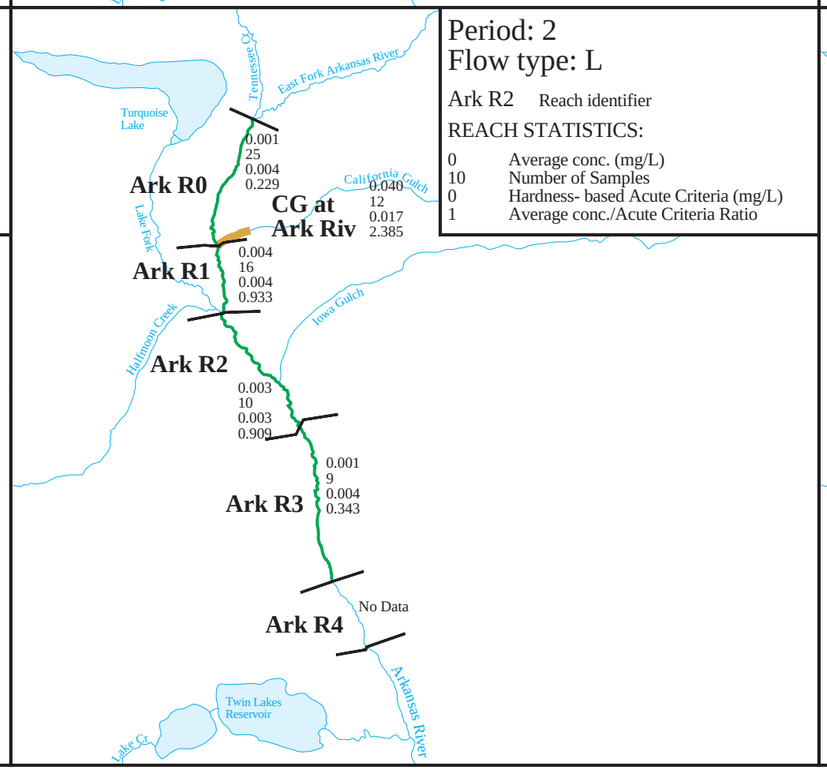

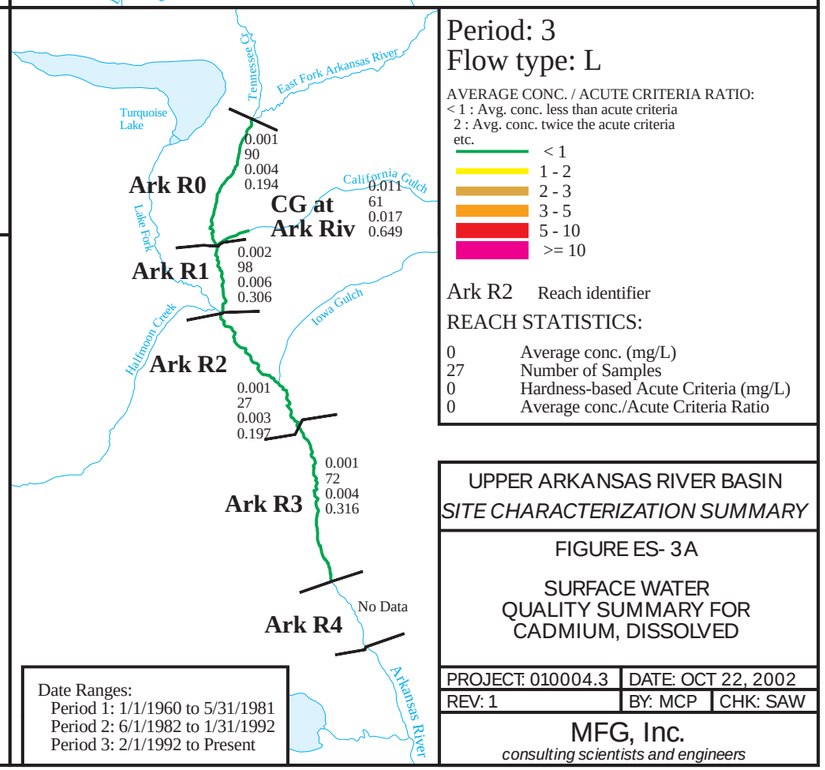

Date Ranges:
Period 1: 1/1/1960 to 5/31/1981
Period 2: 6/1/1982 to 1/31/1992
Period 3: 2/1/1992 to Present

UPPER ARKANSAS RIVER BASIN

SITE CHARACTERIZATION SUMMARY

FIGURE ES- 3A

SURFACE WATER QUALITY SUMMARY FOR CADMIUM, DISSOLVED

PROJECT: 010004.3	DATE: OCT 22, 2002	
REV: 1	BY: MCP	CHK: SAW

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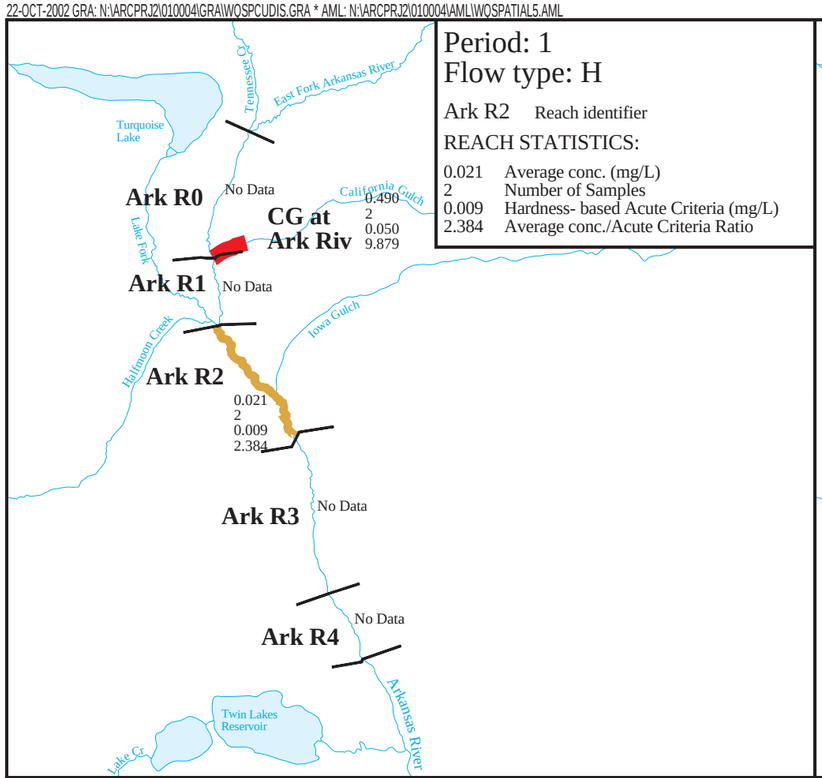
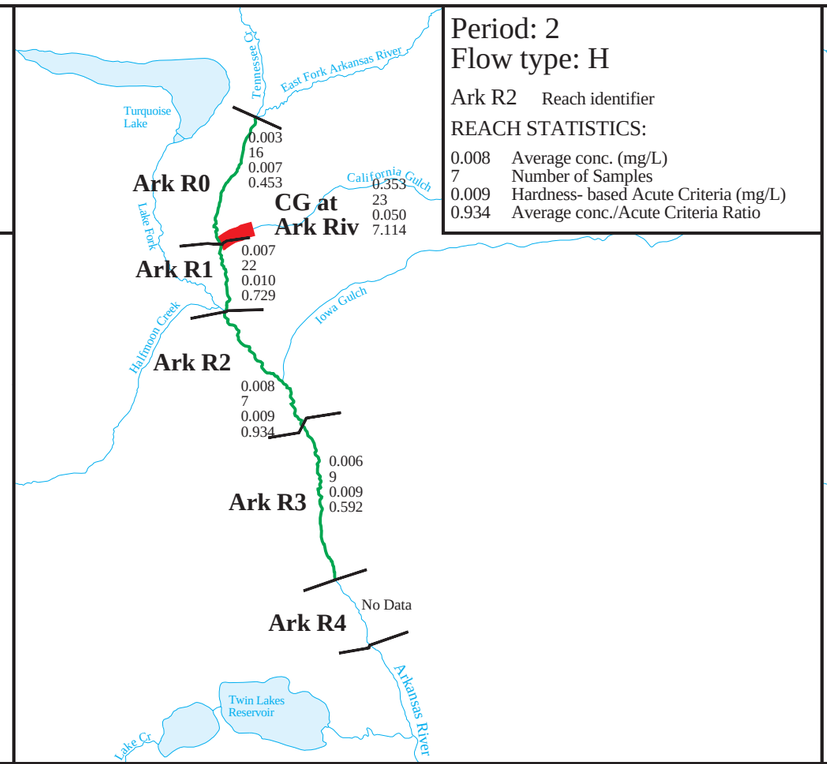


Period: 1
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.021	Average conc. (mg/L)
2	Number of Samples
0.009	Hardness- based Acute Criteria (mg/L)
2.384	Average conc./Acute Criteria Ratio

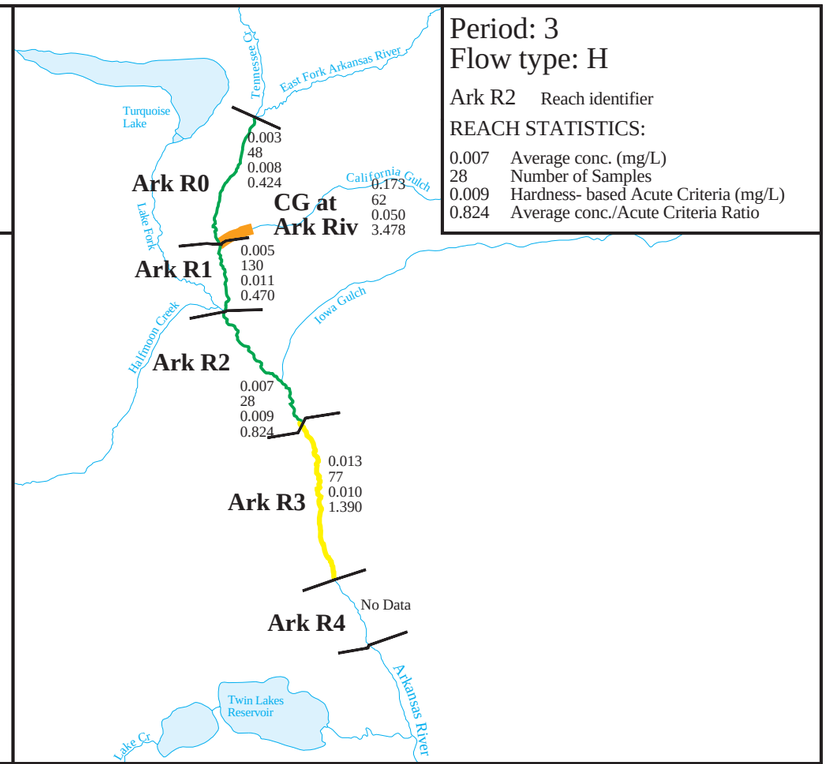


Period: 2
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.008	Average conc. (mg/L)
7	Number of Samples
0.009	Hardness- based Acute Criteria (mg/L)
0.934	Average conc./Acute Criteria Ratio

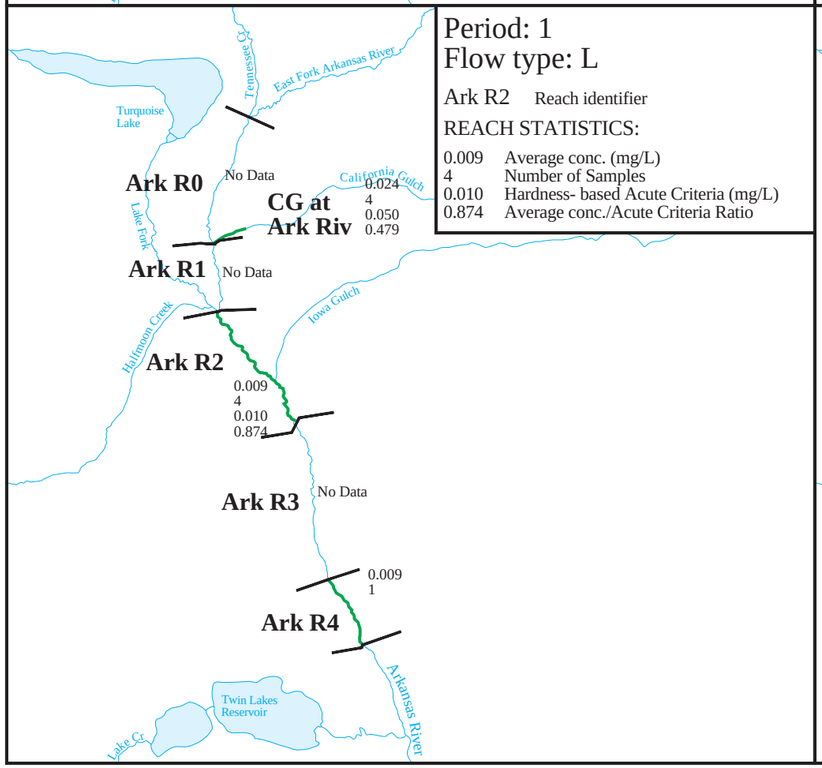


Period: 3
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.007	Average conc. (mg/L)
28	Number of Samples
0.009	Hardness- based Acute Criteria (mg/L)
0.824	Average conc./Acute Criteria Ratio

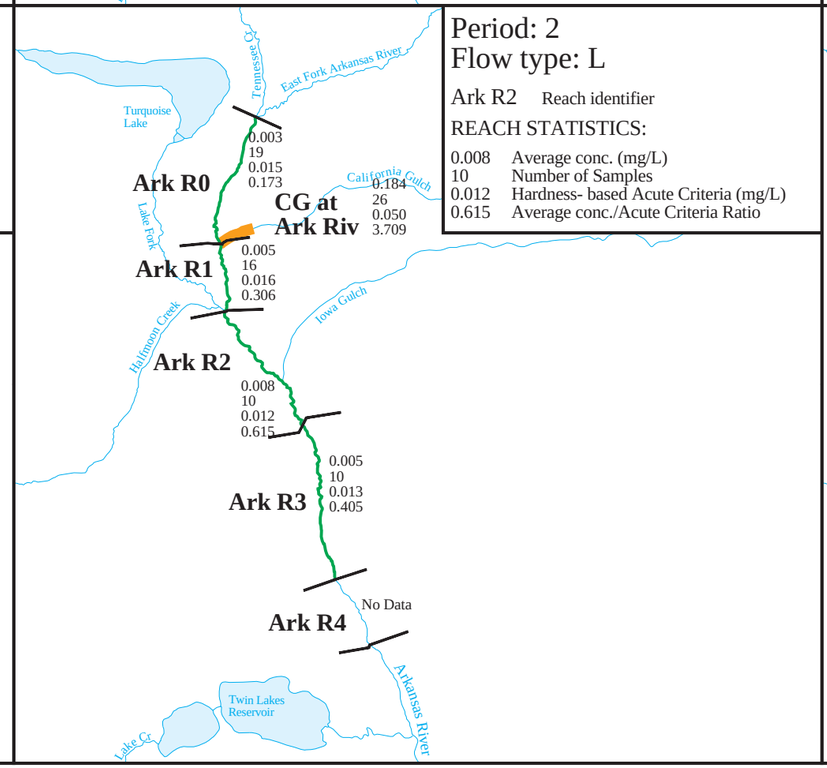


Period: 1
Flow type: L

Ark R2 Reach identifier

REACH STATISTICS:

0.009	Average conc. (mg/L)
4	Number of Samples
0.010	Hardness- based Acute Criteria (mg/L)
0.874	Average conc./Acute Criteria Ratio

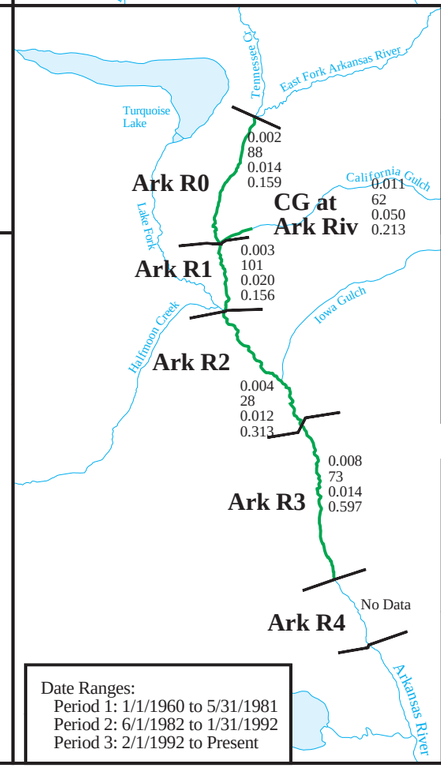


Period: 2
Flow type: L

Ark R2 Reach identifier

REACH STATISTICS:

0.008	Average conc. (mg/L)
10	Number of Samples
0.012	Hardness- based Acute Criteria (mg/L)
0.615	Average conc./Acute Criteria Ratio



Period: 3
Flow type: L

AVERAGE CONC. / ACUTE CRITERIA RATIO:
< 1 : Avg. conc. less than acute criteria
2 : Avg. conc. twice the acute criteria
etc.

- < 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 10
- >= 10

Ark R2 Reach identifier

REACH STATISTICS:

0.004	Average conc. (mg/L)
28	Number of Samples
0.012	Hardness-based Acute Criteria (mg/L)
0.313	Average conc./Acute Criteria Ratio

Date Ranges:
Period 1: 1/1/1960 to 5/31/1981
Period 2: 6/1/1982 to 1/31/1992
Period 3: 2/1/1992 to Present

UPPER ARKANSAS RIVER BASIN

SITE CHARACTERIZATION SUMMARY

FIGURE ES- 3B

SURFACE WATER
QUALITY SUMMARY FOR
COPPER, DISSOLVED

PROJECT: 010004.3	DATE: OCT 22, 2002	
REV: 1	BY: MCP	CHK: SAW

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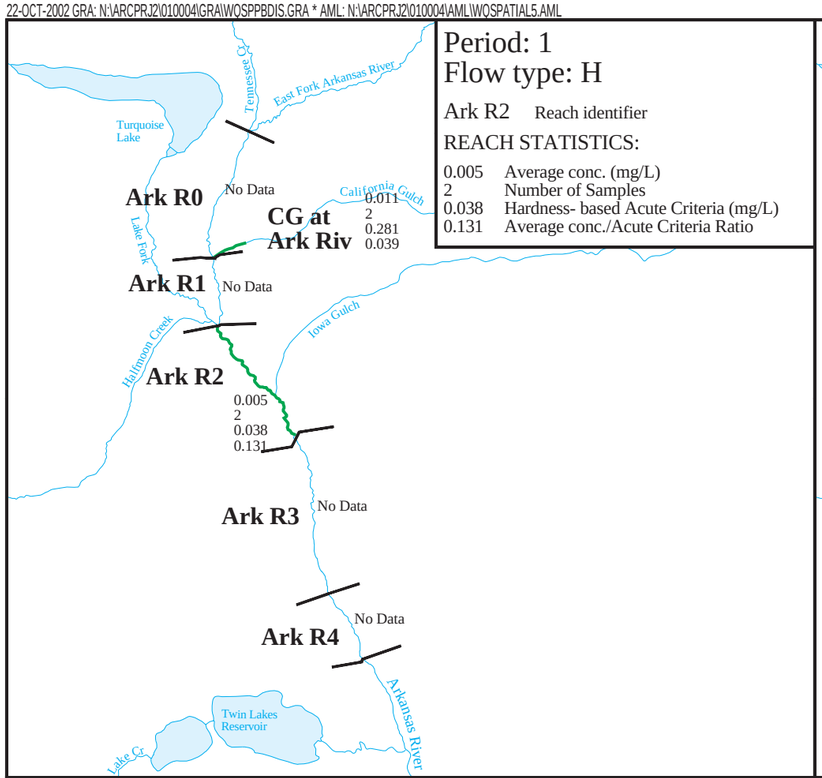
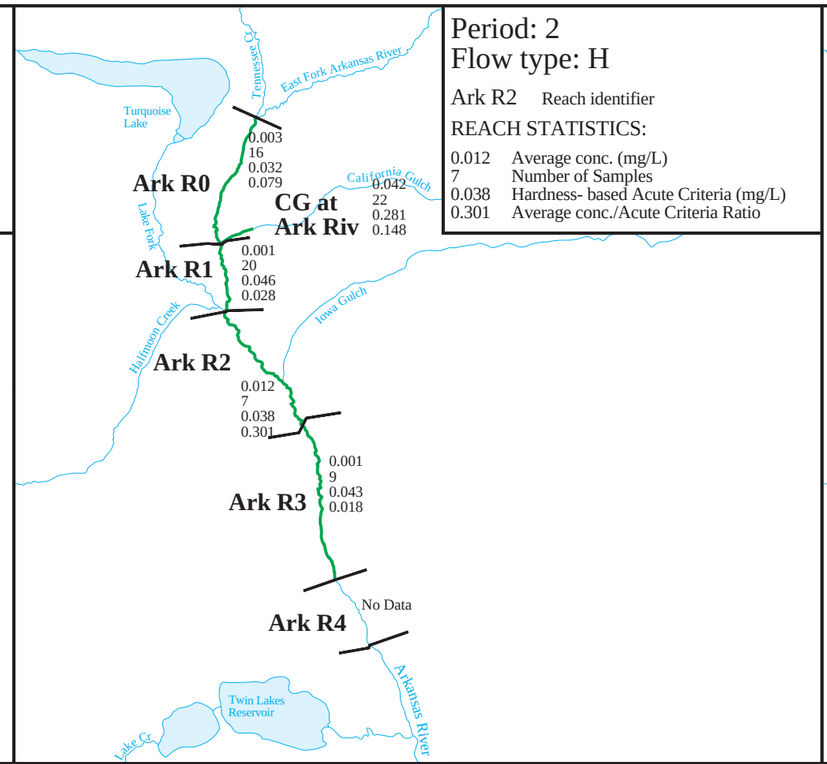


Period: 1
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.005	Average conc. (mg/L)
2	Number of Samples
0.038	Hardness- based Acute Criteria (mg/L)
0.131	Average conc./Acute Criteria Ratio

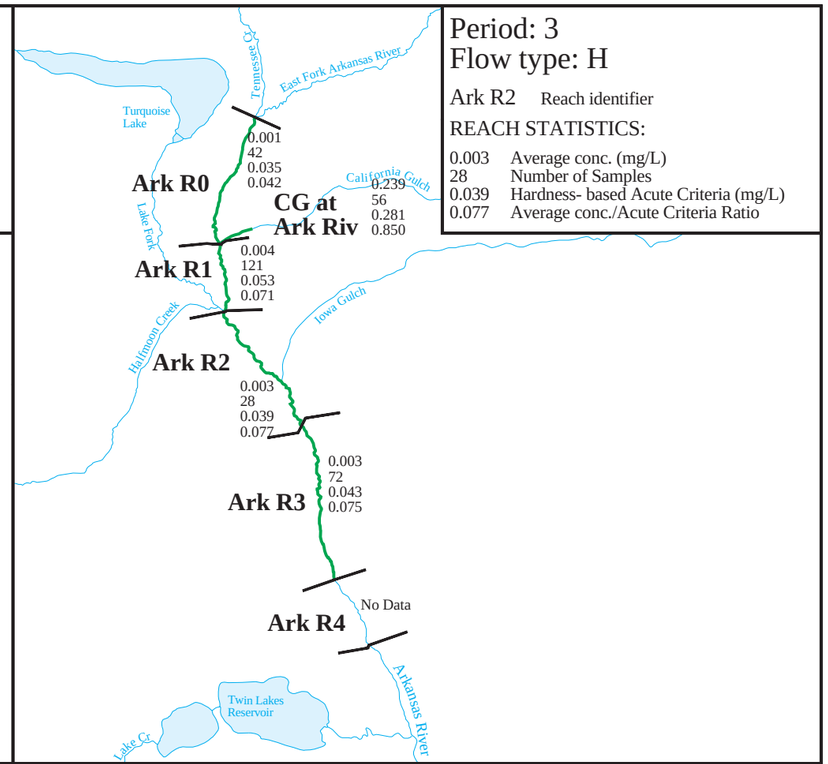


Period: 2
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.012	Average conc. (mg/L)
7	Number of Samples
0.038	Hardness- based Acute Criteria (mg/L)
0.301	Average conc./Acute Criteria Ratio

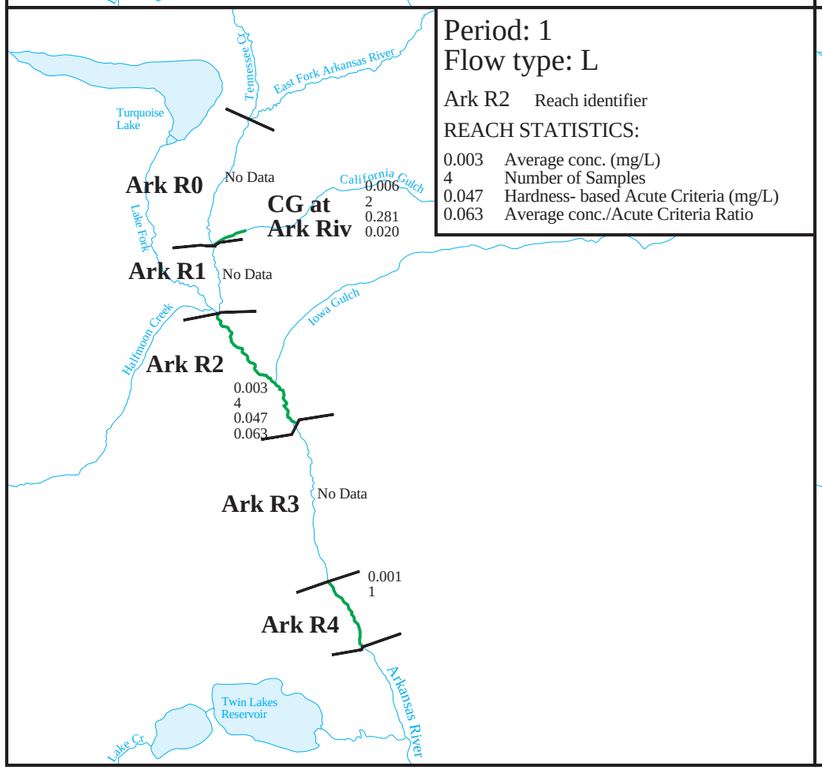


Period: 3
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.003	Average conc. (mg/L)
28	Number of Samples
0.039	Hardness- based Acute Criteria (mg/L)
0.077	Average conc./Acute Criteria Ratio

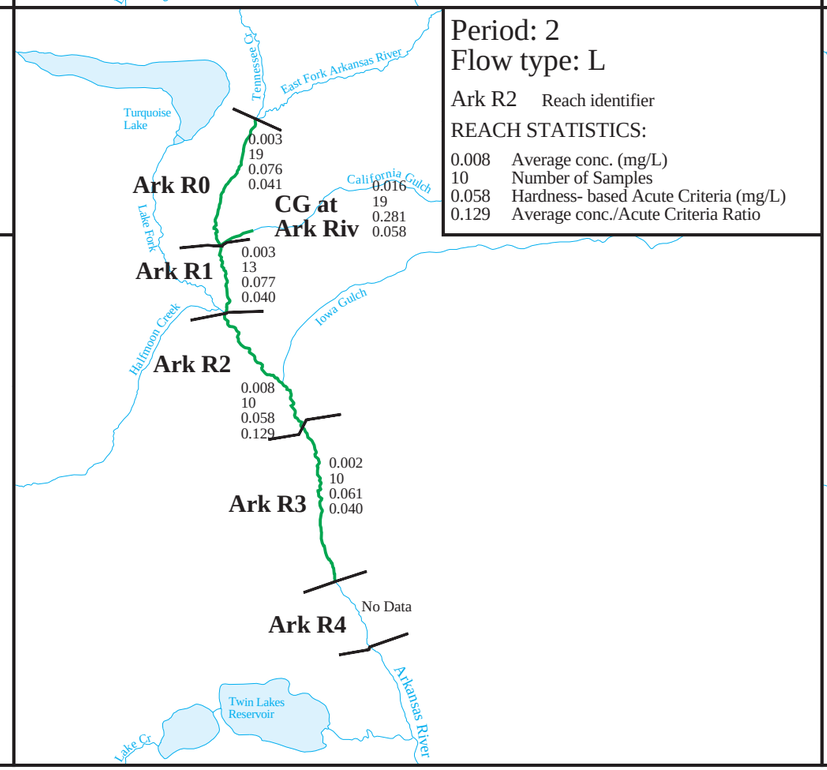


Period: 1
Flow type: L

Ark R2 Reach identifier

REACH STATISTICS:

0.003	Average conc. (mg/L)
4	Number of Samples
0.047	Hardness- based Acute Criteria (mg/L)
0.063	Average conc./Acute Criteria Ratio

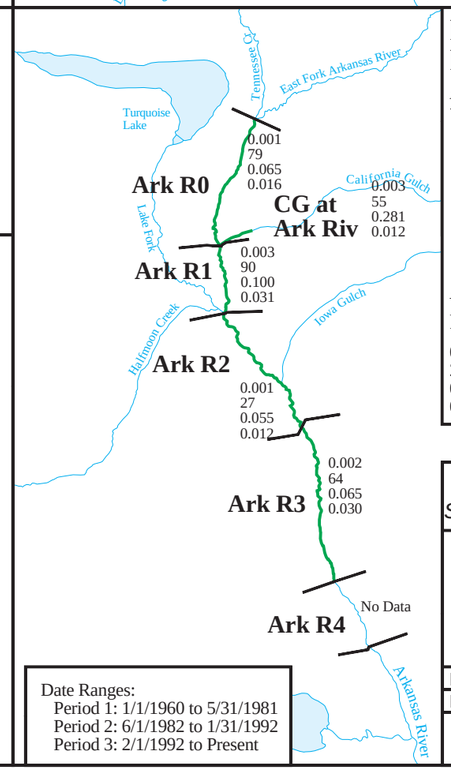


Period: 2
Flow type: L

Ark R2 Reach identifier

REACH STATISTICS:

0.008	Average conc. (mg/L)
10	Number of Samples
0.058	Hardness- based Acute Criteria (mg/L)
0.129	Average conc./Acute Criteria Ratio



Period: 3
Flow type: L

AVERAGE CONC. / ACUTE CRITERIA RATIO:
< 1 : Avg. conc. less than acute criteria
2 : Avg. conc. twice the acute criteria
etc.

	< 1
	1 - 2
	2 - 3
	3 - 5
	5 - 10
	>= 10

Ark R2 Reach identifier

REACH STATISTICS:

0.001	Average conc. (mg/L)
27	Number of Samples
0.055	Hardness-based Acute Criteria (mg/L)
0.012	Average conc./Acute Criteria Ratio

Date Ranges:
Period 1: 1/1/1960 to 5/31/1981
Period 2: 6/1/1982 to 1/31/1992
Period 3: 2/1/1992 to Present

UPPER ARKANSAS RIVER BASIN

SITE CHARACTERIZATION SUMMARY

FIGURE ES- 3C

SURFACE WATER
QUALITY SUMMARY FOR
LEAD, DISSOLVED

PROJECT: 010004.3	DATE: OCT 22, 2002	
REV: 1	BY: MCP	CHK: SAW

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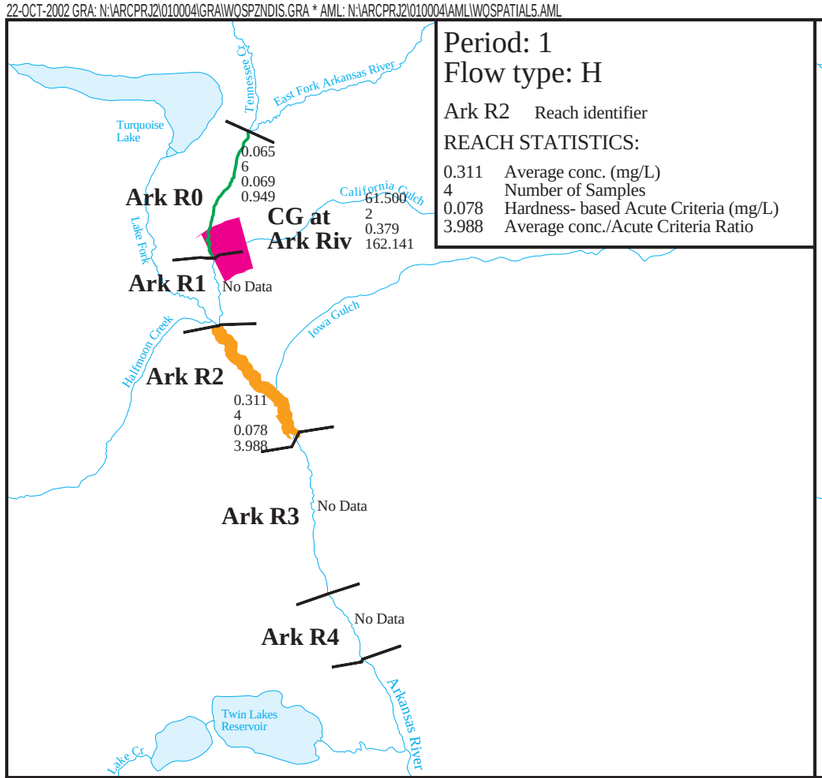
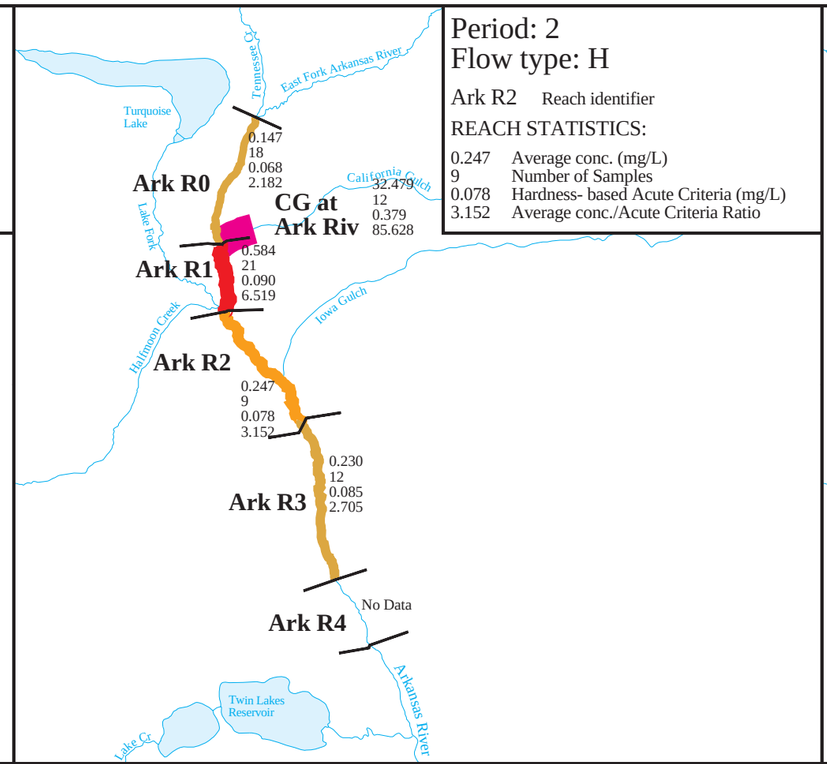


Period: 1
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.311	Average conc. (mg/L)
4	Number of Samples
0.078	Hardness- based Acute Criteria (mg/L)
3.988	Average conc./Acute Criteria Ratio

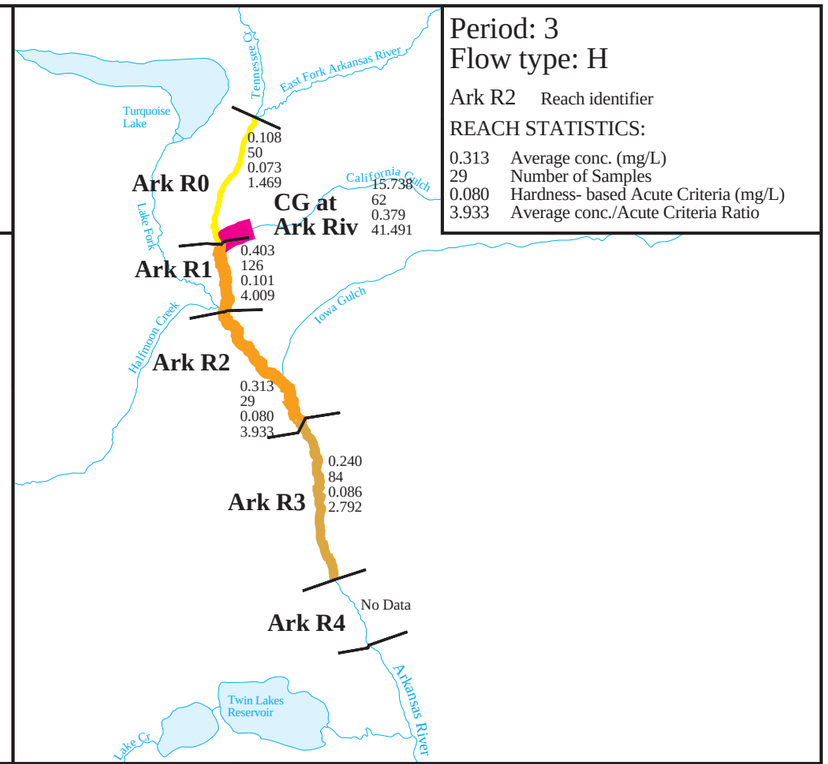


Period: 2
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.247	Average conc. (mg/L)
9	Number of Samples
0.078	Hardness- based Acute Criteria (mg/L)
3.152	Average conc./Acute Criteria Ratio

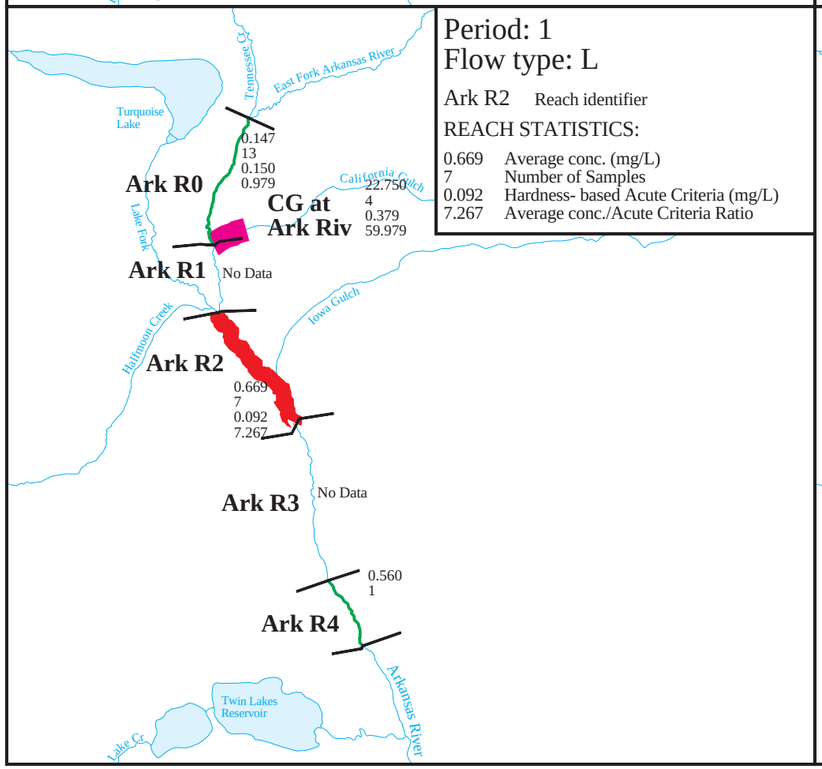


Period: 3
Flow type: H

Ark R2 Reach identifier

REACH STATISTICS:

0.313	Average conc. (mg/L)
29	Number of Samples
0.080	Hardness- based Acute Criteria (mg/L)
3.933	Average conc./Acute Criteria Ratio

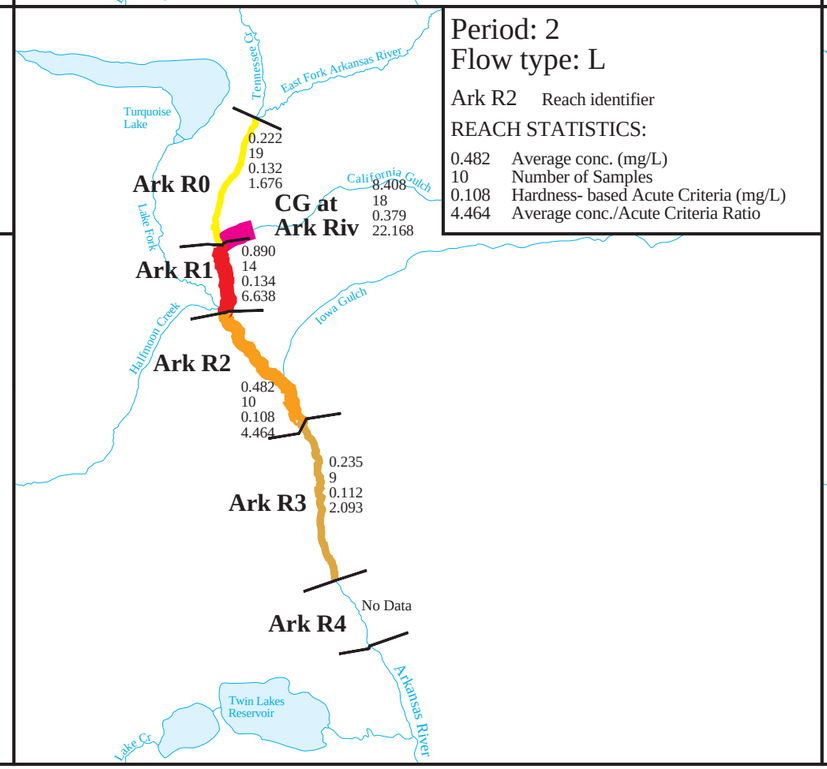


Period: 1
Flow type: L

Ark R2 Reach identifier

REACH STATISTICS:

0.669	Average conc. (mg/L)
7	Number of Samples
0.092	Hardness- based Acute Criteria (mg/L)
7.267	Average conc./Acute Criteria Ratio

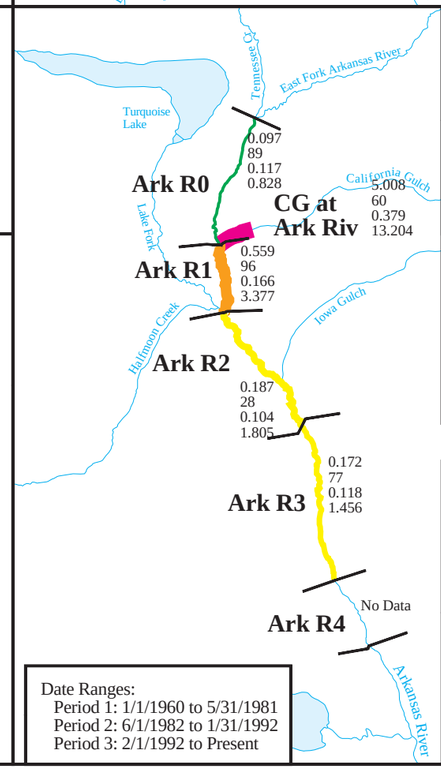


Period: 2
Flow type: L

Ark R2 Reach identifier

REACH STATISTICS:

0.482	Average conc. (mg/L)
10	Number of Samples
0.108	Hardness- based Acute Criteria (mg/L)
4.464	Average conc./Acute Criteria Ratio



Period: 3
Flow type: L

AVERAGE CONC. / ACUTE CRITERIA RATIO:
< 1 : Avg. conc. less than acute criteria
2 : Avg. conc. twice the acute criteria
etc.

- < 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 10
- >= 10

Ark R2 Reach identifier

REACH STATISTICS:

0.187	Average conc. (mg/L)
28	Number of Samples
0.104	Hardness-based Acute Criteria (mg/L)
1.805	Average conc./Acute Criteria Ratio

Date Ranges:
Period 1: 1/1/1960 to 5/31/1981
Period 2: 6/1/1982 to 1/31/1992
Period 3: 2/1/1992 to Present

UPPER ARKANSAS RIVER BASIN

SITE CHARACTERIZATION SUMMARY

FIGURE ES- 3D

SURFACE WATER
QUALITY SUMMARY FOR
ZINC, DISSOLVED

PROJECT: 010004.3	DATE: OCT 22, 2002	
REV: 1	BY: MCP	CHK: SAW

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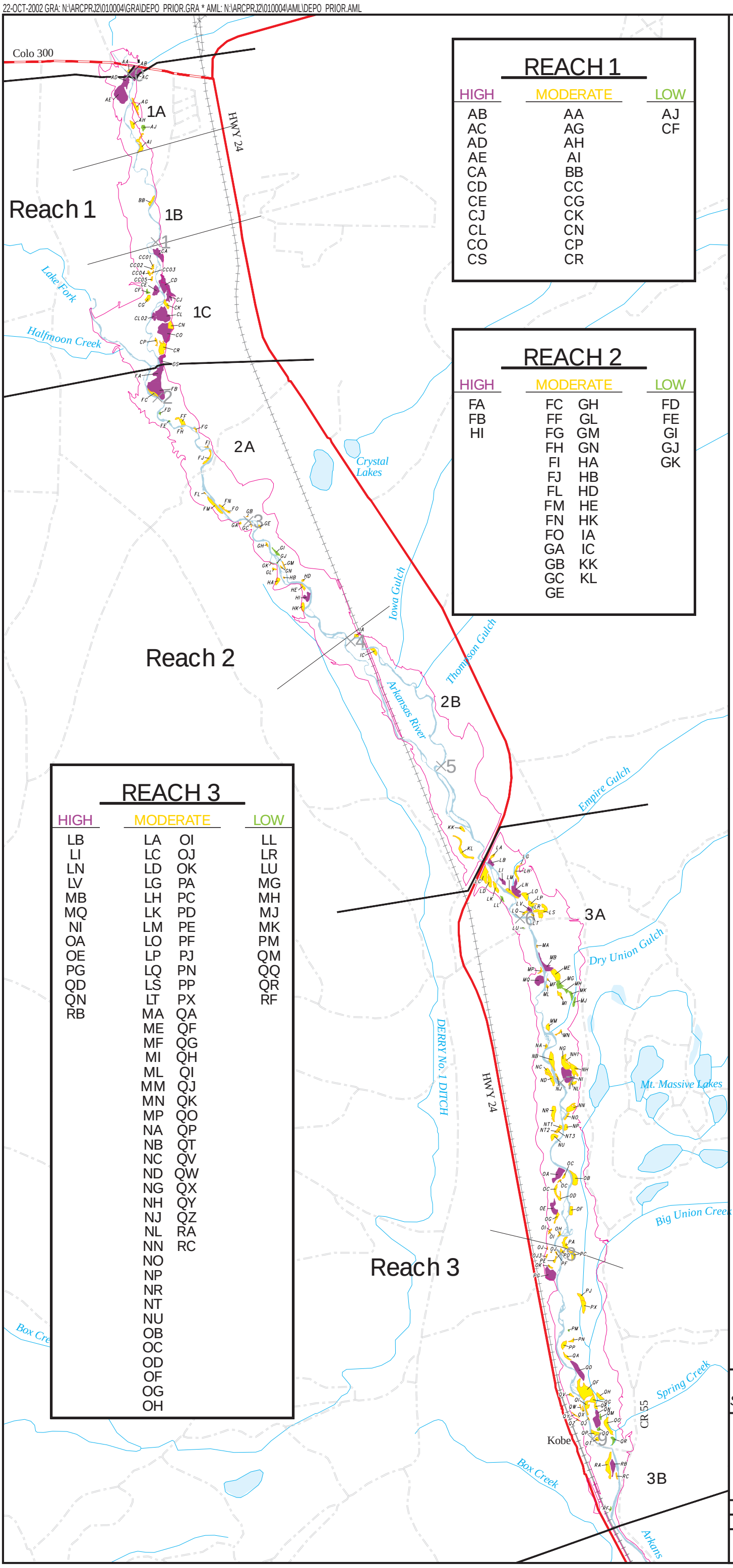
22-OCT-2002 GRA: N:\ARCPRJ2\010004\GRA\DEPO_PRIOR.GRA * AML: N:\ARCPRJ2\010004\AML\DEPO_PRIOR.AML



REACH 1

HIGH	MODERATE	LOW
AB	AA	AJ
AC	AG	CF
AD	AH	
AE	AI	
CA	BB	
CD	CC	
CE	CG	
CJ	CK	
CL	CN	
CO	CP	
CS	CR	

REACH 2

HIGH	MODERATE		LOW
FA	FC	GH	FD
FB	FF	GL	FE
HI	FG	GM	GI
	FH	GN	GJ
	FI	HA	GK
	FJ	HB	
	FL	HD	
	FM	HE	
	FN	HK	
	FO	IA	
	GA	IC	
	GB	KK	
	GC	KL	
	GE		

REACH 3

HIGH	MODERATE		LOW
LB	LA	OI	LL
LI	LC	OJ	LR
LN	LD	OK	LU
LV	LG	PA	MG
MB	LH	PC	MH
MQ	LK	PD	MJ
NI	LM	PE	MK
OA	LO	PF	PM
OE	LP	PJ	QM
PG	LQ	PN	QQ
QD	LS	PP	QR
QN	LT	PX	RF
RB	MA	QA	
	ME	QF	
	MF	QG	
	MI	QH	
	ML	QI	
	MM	QJ	
	MN	QK	
	MP	QO	
	NA	QP	
	NB	QT	
	NC	QV	
	ND	QW	
	NG	QX	
	NH	QY	
	NJ	QZ	
	NL	RA	
	NN	RC	
	NO		
	NP		
	NR		
	NT		
	NU		
	OB		
	OC		
	OD		
	OF		
	OG		
	OH		

EXPLANATION

Hydrology

- River or Stream
- Lake or Open Water
- 500- Year Floodplain
- × 1 River Mile (from confluence with California Gulch)

Transportation

- Minor Road
- Medium Duty Road
- Highway
- Railroad

Deposit Action Priority

- High Priority
- Moderate Priority
- Low Priority

Other Features

- Reach Boundary
- Subreach Boundary

N

SCALE IN FEET

2400 0 2400

UPPER ARKANSAS RIVER BASIN

SITE CHARACTERIZATION SUMMARY

FIGURE ES- 4

MINE- WASTE DEPOSIT PRIORITY

PROJECT: 010004.3	DATE: OCT 22, 2002	
REV: 1	BY: MCP	CHK: SAW

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MATRIX SUMMARIZING FINDINGS REGARDING INJURY SORTED BY RESOURCE CATEGORY AND BY REACH FOR THE 11-MILE REACH OF THE UPPER ARKANSAS RIVER BASIN

Summary of Injury Characterization

	Reach 1	Reach 2	Reach 3	Reach 4
SURFACE WATER RESOURCES				
Surface Water	1. Has the Resource Been Injured: Yes 2. Description of Injury: Exceedence of the TVSs[1] for Cd, Cu, Pb, and Zn. Average dissolved zinc concentrations during Period 3[2] are 4 and 5 times higher than TVSs during high and low flow, respectively. 3. Source of Injury: Runoff from historic mine sites contributes metals in Reach 0[3]. On average, water quality upstream of Reach 1 is typically near the TVSs. Inflow from California Gulch at the top of Reach 1 is responsible for large increases in instream metals concentrations measured throughout Reach 1. 4. Extent of Injury: Surface water is injured throughout Reach 1. Although substantial exceedences of the TVSs continue to occur, water quality has improved compared to pre-1992 conditions. Improvements are due to treatment of discharges from the Leadville Mine Drainage Tunnel on the East Fork of the Arkansas River, the Yak Tunnel on upper California Gulch, and ongoing remediation at the California Gulch Superfund Site.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Exceedence of the TVSs for Cd, Cu, Pb, and Zn. Average dissolved zinc concentrations during Period 3 are 4 and 1.5 times higher than TVSs during high and low flow, respectively. 3. Source of Injury: Ongoing metals releases from California Gulch. 4. Extent of Injury: Surface water is injured throughout Reach 2. Exceedences of the TVSs occur and the frequency and magnitude of those exceedences are a function of upstream sources. Some dilution of metals concentrations occurs in this reach due to the influence of flows from Lake Fork.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Exceedence of the TVSs for Cd, Cu, Pb, and Zn. Average dissolved zinc concentrations during Period 3 are 3and 1.5 times higher than TVSs during high and low flow, respectively. 3. Source of Injury: Ongoing metals release from California Gulch. 4. Extent of Injury: Surface water is injured throughout Reach 3. Exceedences of the TVSs occur and the frequency and magnitude of those exceedences are a function of upstream sources.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Exceedence of the TVSs for Cd, Cu, Pb, and Zn. Average dissolved zinc concentrations during Period 3 are 3and 1.5 times higher than TVSs during high and low flow, respectively. 3. Source of Injury: Ongoing metals release from California Gulch. 4. Extent of Injury: Surface water is injured throughout Reach 4. Exceedences of the TVSs occur and the frequency and magnitude of those exceedences are a function of upstream sources.
Sediments	1. Has the Resource Been Injured: Yes 2. Description of Injury: Elevated concentrations of cadmium, copper, lead, and zinc in sediments are found when compared to sediments in Reach 0. See benthic organisms for additional information. 3. Source of Injury: Metals are transported to the river by surface waters and through overland runoff and erosion of mine wastes. Primary source area is California Gulch. 4. Extent of Injury: Metals data in sediments are very limited. The 11-mile reach of the Arkansas River is considered to be a sediment-poor system. Fine sediments have a relatively short residence time in the 11-mile reach and only tend to be deposited in areas of reduced water velocities. Recent data indicate a reduction in sediment metals concentrations compared to prior periods. However, metals concentrations in fine-grained sediments continue to be elevated throughout Reach 1.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Elevated concentrations of copper and lead in Reach 2 sediments are found when compared to sediments in Reach 0. See benthic invertebrates for additional information. 3. Source of Injury: Metals are transported to the river by surface waters and through overland runoff and erosion of mine wastes. Primary source area is California Gulch. 4. Extent of Injury: Metals data in sediments are very limited. However, fine-grained sediments throughout the reach are expected to have elevated metals concentrations.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Elevated concentrations of lead in Reach 3 sediments are found when compared to sediments in Reach 0. See benthic invertebrates for additional information. 3. Source of Injury: Metals are transported to the river by surface waters and through overland runoff and erosion of mine wastes. Primary source area is California Gulch. 4. Extent of Injury: Metals data in sediments are very limited. However, fine-grained sediments throughout the reach are expected to have elevated metals concentrations.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Elevated concentrations of lead in Reach 4 sediments when compared to sediments in Reach 0. See benthic invertebrates for additional information. 3. Source of Injury: Metals are transported to the river by surface waters and through overland runoff and erosion of mine wastes. Primary source area is California Gulch. 4. Extent of Injury: Metals data in sediments are very limited. However, fine-grained sediments throughout the reach are expected to have elevated metals concentrations.
GROUNDWATER RESOURCES				
Groundwater	1. Has the Resource Been Injured: No 2. Description of Injury: Although concentrations of cadmium exceed the drinking water MCL and zinc exceeds the secondary MCL, the exceedences are not influencing drinking water supplies. Elevated metals concentrations in shallow groundwater are not causing injury to surface water. 3. Source of Injury: Contaminated surface water exchange between surface and subsurface flows. Leaching of metals has increased concentrations in groundwater adjacent to mine-waste deposits. 4. Extent of Injury: Elevated metals concentrations in shallow groundwater (<10 ft depth) decrease rapidly with depth and horizontal distance from a given mine-waste deposit. Discharge of shallow groundwater with elevated metals concentrations to the Upper Arkansas River has no measurable effect on in-stream concentrations.	1. Has the Resource Been Injured: No 2. Description of Injury: Although concentrations of cadmium exceed the drinking water MCL and zinc exceeds the secondary MCL, the exceedences are not influencing drinking water supplies. Elevated metals concentrations in shallow groundwater are not causing injury to surface water. 3. Source of Injury: Contaminated surface water exchange between surface and subsurface flows. Localized contamination adjacent to mine-waste deposits. 4. Extent of Injury: Elevated metals concentrations in shallow groundwater decrease rapidly with depth and horizontal distance from a given mine-waste deposit. Additional information on metals levels in groundwater below 10’ in depth should be obtained to confirm extent of injury.	1. Has the Resource Been Injured: No 2. Description of Injury: Although concentrations of cadmium exceed the drinking water MCL and zinc exceeds the secondary MCL, the exceedences are not influencing drinking water supplies. Elevated metals concentrations in shallow groundwater are not causing injury to surface water. 3. Source of Injury: Contaminated surface water exchange between surface and subsurface flows. Localized contamination adjacent to mine-waste deposits. 4. Extent of Injury: Elevated metals concentrations in shallow groundwater decrease rapidly with depth and horizontal distance from a given mine-waste deposit. Additional information on metals levels in groundwater below 10’ in depth should be obtained to confirm extent of injury.	1. Has the Resource Been Injured: No 2. Description of Injury: There are no significant mine-waste deposits within Reach 4. Only a few very small deposits have been identified within this reach. The volume of material is small and direct impact to the groundwater pathway is not a concern. 3. Source of Injury: No injury. 4. Extent of Injury: Not determined.

[1] TVS: Table Value Standards for State of Colorado surface water quality
[2] Period 3: Composite data record for 1992 to present
[3] Reach 0: Segment of Upper Arkansas River upstream of California Gulch

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

Summary of Injury Characterization

	Reach 1	Reach 2	Reach 3	Reach 4
GEOLOGIC RESOURCES: SOILS				
Floodplain Soils	1. Has the Resource Been Injured: No 2. Description of Injury: Total metal concentrations in floodplain (riparian) soils are substantially higher than concentrations found in Reach 0. However, plant-available concentrations are in a similar range to concentrations in Reach 0 and lower than concentrations considered to be toxic to plants (see vegetation). 3. Source of Injury: No injury, although metal concentrations are elevated in floodplain (riparian) soils and these metals are most likely from historic flooding and irrigation activities. 4. Extent of Injury: Soil metal concentrations are elevated throughout Reach 1, but below concentrations considered to be toxic to plants.	1. Has the Resource Been Injured: No 2. Description of Injury: Total metal concentrations in floodplain (riparian) soils are substantially higher than concentrations found in Reach 0. However, plant-available concentrations are in a similar range to concentrations in Reach 0 and lower than concentrations considered to be toxic to plants (see vegetation). 3. Source of Injury: No injury, although metal concentrations are elevated in floodplain (riparian) soils and these metals are most likely from historic flooding and irrigation activities. 4. Extent of Injury: Soil metal concentrations are elevated throughout Reach 2, but below concentrations considered to be toxic to plants.	1. Has the Resource Been Injured: No 2. Description of Injury: Total metal concentrations in floodplain (riparian) soils are substantially higher than concentrations found in Reach 0. However, plant-available concentrations are in a similar range to concentrations in Reach 0 and lower than concentrations considered to be toxic to plants (see vegetation). 3. Source of Injury: No injury, although metal concentrations are elevated in floodplain (riparian) soils and these metals are most likely from historic flooding and irrigation activities. 4. Extent of Injury: Soil metal concentrations are elevated throughout Reach 3, but below concentrations considered to be toxic to plants.	1. Has the Resource Been Injured: No 2. Description of Injury: There is no evidence to indicate injury to floodplain (riparian) soils in Reach 4. It is assumed that soil metal concentrations in Reach 4 are lower than in Reach 3. 3. Source of Injury: No injury, although if soil metal concentrations are elevated, it is assumed that these metals came from flooding. 4. Extent of Injury: No data available to define the extent of metals in floodplain (riparian) soils.
Soils where Floodplain Mine-Waste Deposits Exist	1. Has the Resource Been Injured: Yes 2. Description of Injury: Metal concentrations in mine-waste deposits exceed toxicity thresholds for plants and plant growth has been substantially reduced on most sites where mine-waste deposits occur. Of 24 deposits along Reach 1, 14 have poor vegetation cover (10% cover), 9 deposits have fair vegetation cover (10-50% cover), and 1 deposit has good vegetation cover (>50% cover). 3. Source of Injury: Fluvial deposition of mine-waste material during flood events. 4. Extent of Injury: Mine-waste deposits cover a surface area of approximately 18 acres, with a volume of approximately 887,000 ft^3. Of the 24 deposit groups in this reach, 11 are ranked as a high priority for restoration, 11 are ranked as moderate priority, and 2 are ranked as low priority. The potential for these deposits to influence metals concentrations in both surface water and groundwater is limited by the shallow thickness of the deposits and corresponding small loading potential relative to the large volume of surface and groundwater moving through the valley.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Metal concentrations in mine-waste deposits exceed toxicity thresholds for plants and plant growth has been substantially reduced on most sites where mine-waste deposits occur. Of 35 deposits along Reach 2, 2 have poor vegetation cover (10% cover), 19 deposits have fair vegetation cover (10-50% cover), and 14 deposits have good vegetation cover (>50% cover). 3. Source of Injury: Fluvial deposition of mine-waste material during flood events. 4. Extent of Injury: Mine-waste deposits cover a surface area of approximately 9 acres, with a volume of approximately 233,000 ft^3. Of the 35 deposit groups in this reach, 3 are ranked as a high priority for restoration, 27 are ranked as moderate priority, and 5 are ranked as low priority. The potential for these deposits to influence metals concentrations in both surface water and groundwater is limited by the shallow thickness of the deposits and corresponding small loading potential relative to the large volume of surface and groundwater moving through the valley.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Metal concentrations in mine-waste deposits exceed toxicity thresholds for plants and plant growth has been substantially reduced on most sites where mine-waste deposits occur. Of 94 deposits along Reach 3, 26 have poor vegetation cover (10% cover), 56 deposits have fair vegetation cover (10-50% cover), and 12 deposits have good vegetation cover (>50% cover). 3. Source of Injury: Fluvial deposition of mine-waste material during flood events. 4. Extent of Injury: Mine-waste deposits cover a surface area of approximately 37 acres, with a volume of approximately 1,578,300 ft^3. Of the 94 deposit groups in this reach, 13 are ranked as a high priority for restoration, 69 are ranked as moderate priority, and 12 are ranked as low priority. The potential for these deposits to influence metals concentrations in both surface water and groundwater is limited by the shallow thickness of the deposits and corresponding small loading potential relative to the large volume of surface and groundwater moving through the valley.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Some small mine-waste deposits exist in Reach 4, but they have not been quantified with respect to chemical properties and plant cover. 3. Source of Injury: Fluvial deposition of mine-waste material during flood events. 4. Extent of Injury: Not enough information exists to draw conclusions about injury to vegetation at locations where deposits occur. However, only several small accumulations of mine waste were observed in Reach 4.
BIOLOGICAL RESOURCES				
Vegetation	1. Has the Resource Been Injured: Yes 2. Description of Injury: Cover, biomass, and number of species of plants growing on floodplain (riparian) soils in Reach 1 are equal to or greater than Reach 0. All tissue metal concentrations are below thresholds considered to be toxic to perennial species. However, vegetation has been injured where most mine-waste deposits occur (see mine-waste deposits). 3. Source of Injury: Available data does not indicate injury to vegetation growing on floodplain (riparian) soils. Source of injury is limited to elevated metals in mine-waste deposits. 4. Extent of Injury: Injury to vegetation is limited to mine-waste deposits where vegetation cover is less than 50%.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Cover, biomass, and number of species of plants growing on floodplain (riparian) soils in Reach 2 are equal to or greater than Reach 0. Tissue metal concentrations of zinc are in the toxic range for grasses and forbs. Vegetation has been injured where most mine-waste deposits occur (see mine-waste deposits). 3. Source of Injury: Metal deposition on floodplain (riparian) soils from flooding and irrigation activities and elevated metals in mine-waste deposits. 4. Extent of Injury: Available data indicates that zinc concentrations in plant tissue are high enough to cause injury to plants growing on floodplain (riparian) soils. However, with existing data, it is not possible to determine the geographic extent or degree of injury. Injury also exists on mine-waste deposits where vegetation cover is less than 50%.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Cover, biomass, and number of species of plants growing on floodplain (riparian) soils in Reach 3 are equal to or greater than Reach 0. All tissue metal concentrations are below thresholds considered to be toxic to perennial species. However, vegetation has been injured where most mine-waste deposits occur (see mine-waste deposits). 3. Source of Injury: Available data does not indicate injury to vegetation growing on floodplain (riparian) soils. 4. Extent of Injury: Injury to vegetation is limited to mine-waste deposits where vegetation cover is less than 50%.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Field observations confirm that vegetation is productive and shows no signs of injury associated with elevated metal concentrations in floodplain (riparian) soils. 3. Source of Injury: Source of injury is limited to elevated metals in mine-waste deposits. However, there are several small mine-waste deposits that lack adequate vegetation indicating injury to vegetation in these locations. 4. Extent of Injury: Injury to vegetation is limited to a few small mine-waste deposits where vegetation cover is less than 50%.

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

Summary of Injury Characterization

	Reach 1	Reach 2	Reach 3	Reach 4
Benthic Organisms	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and species richness of benthic macroinvertebrates; elevated metal levels in periphyton. 3. Source of Injury: Elevated metal levels in water and periphyton from California Gulch. 4. Extent of Injury: Benthic macroinvertebrate communities are severely degraded in Reach 1. Greatest effects are observed during spring runoff.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and species richness of benthic macroinvertebrates; elevated metal levels in periphyton. 3. Source of Injury: Elevated metal levels in water and periphyton from California Gulch. 4. Extent of Injury: Benthic macroinvertebrate communities are moderately degraded in Reach 2. In particular, the reach is characterized by reduced abundance of metal-sensitive organisms. Greatest effects are observed during spring runoff.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and species richness of benthic macroinvertebrates; elevated metal levels in periphyton. 3. Source of Injury: Elevated metal levels in water and periphyton from California Gulch. 4. Extent of Injury: Benthic macroinvertebrate communities are slighty degraded in Reach 3. Greatest effects are observed during spring runoff. Improvement in community composition and abundance of metal-sensitive taxa has been observed since 1992.	1. Has the Resource Been Injured: Uncertain 2. Description of Injury: Insufficient data to determine injury. 3. Source of Injury: n/a 4. Extent of Injury: n/a
Brown Trout	1. Has the Resource Been Injured: Yes 2. Description of Injury: Greatly reduced abundance and biomass. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Fish populations in Reach 1 are characterized by reduced abundance, biomass and very poor recruitment. A recently published report by Nehring & Policky 2002 evaluated trends in trout populations over the last 16 years. This report indicates continued improvement in brown trout fishery. It states that if this trend continues over the next several years, it may be strong empirical evidence that the efforts at ameliorating heavy metal pollution are beginning to have a positive effect on the trout population.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and biomass. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Fish populations in Reach 2 are characterized by reduced abundance, biomass and poor recruitment. However, there is some improvement in conditions compared to Reach 1. A recently published report by Nehring & Policky 2002 evaluated trends in trout populations over the last 16 years. This report indicates continued improvement in brown trout fishery. It states that if this trend continues over the next several years, it may be strong empirical evidence that the efforts at ameliorating heavy metal pollution are beginning to have a positive effect on the trout population.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance and biomass. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Fish populations in Reach 3 are characterized by reduced abundance, biomass and poor recruitment. A recently published report by Nehring & Policky 2002 evaluated trends in trout populations over the last 16 years. This report indicates continued improvement in brown trout fishery. It states that if this trend continues over the next several years, it may be strong empirical evidence that the efforts at ameliorating heavy metal pollution are beginning to have a positive effect on the trout population.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Reduced abundance. 3. Source of Injury: Elevated metal concentrations in water and benthic macroinvertebrates from California Gulch. 4. Extent of Injury: Brown trout sampling in Reach 4 after 1992 is limited, and the extent of injury is difficult to determine. A recently published report by Nehring & Policky 2002 evaluated trends in trout populations over the last 16 years. This report indicates continued improvement in brown trout fishery. It states that if this trend continues over the next several years, it may be strong empirical evidence that the efforts at ameliorating heavy metal pollution are beginning to have a positive effect on the trout population.
Small Mammals	1. Has the Resource Been Injured: No 2. Description of Injury: Based on comparisons of exposure data (vegetation & soils) from Reaches 0, 2 and the NPL site; potential exposure in Reach 1 would not result in injury to small mammals. Tissue concentrations and pathology data from the NPL site and Reach 2 (representing higher areas of exposure) did not show indications of injury. . 3. Source of Injury: There are no specific data for Reach 1. Exposure would occur primarily via the food chain and soils. 4. Extent of Injury: Existing data are for herbivorous small mammals. Insectivorous small mammals may be exposed to higher metal concentrations, but they are also more tolerant of metals exposure and injury is not expected to occur.	1. Has the Resource Been Injured: No 2. Description of Injury: Metals concentrations do not exceed benchmark values. Histopathology shows no signs of injury. 3. Source of Injury: Exposure occurs primarily via the food chain and soils. 4. Extent of Injury: Existing data are for herbivorous small mammals. Insectivorous small mammals may be exposed to higher metal concentrations, but they are also more tolerant of metals exposure and injury is not expected to occur.	1. Has the Resource Been Injured: No 2. Description of Injury: Based on comparisons of exposure data (vegetation & soils) from Reaches 0-2 and the NPL site; potential exposure in Reach 3 would not result in injury to small mammals. 3. Source of Injury: There are no specific data for Reach 3. Exposure would occur primarily via the food chain and soils. 4. Extent of Injury: Existing data are for herbivorous small mammals. Insectivorous small mammals may be exposed to higher metal concentrations, but they are also more tolerant of metals exposure and injury is not expected to occur.	1. Has the Resource Been Injured: No 2. Description of Injury: Based on comparisons of exposure data (vegetation and soils) from Reaches 0-3, potential exposure in Reach 4 would not result in injury to small mammals. 3. Source of Injury: There are no specific data for Reach 4. Exposure would occur primarily via the food chain and soils. 4. Extent of Injury: Existing data are for herbivorous small mammals. Insectivorous small mammals may be exposed to higher metal concentrations, but they are also more tolerant of metals exposure and injury is not expected to occur.
Migratory Birds	1. Has the Resource Been Injured: Yes 2. Description of Injury: Possible elevated lead tissue concentrations and suppressed ALAD. 3. Source of Injury: Aquatic invertebrates. 4. Extent of Injury: Because birds move between reaches it is assumed that metals exposure in Reaches 2 and 3 is representative of the typical metals exposure throughout the 11-mile reach.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Lead concentrations in tissues are significantly higher than the Control Site and study Reference Area. 3. Source of Injury: Aquatic invertebrates. 4. Extent of Injury: All birds foraging on aquatic invertebrates in the 11-mile reach are potentially exposed to elevated metals concentrations and may experience ALAD inhibition.	1. Has the Resource Been Injured: Yes 2. Description of Injury: ALAD levels are significantly different than the study Reference Area and suppression is > 50%, lead tissue concentrations are significantly higher than the Control Site and study Reference Area. 3. Source of Injury: Aquatic invertebrates. 4. Extent of Injury: All birds foraging on aquatic invertebrates in the 11-mile reach are potentially exposed to elevated metals concentrations and may experience ALAD inhibition.	1. Has the Resource Been Injured: Yes 2. Description of Injury: Possible elevated lead tissue concentrations and suppressed ALAD. 3. Source of Injury: Aquatic invertebrates. 4. Extent of Injury: Because birds move between reaches it is assumed that metals exposure in Reaches 2 and 3 is representative of the typical metals exposure throughout the 11-mile reach.

The matrices provide a brief summary of the information contained in the Site Characterization Report (SCR). The matrices are not intended to be used as stand alone documents but rather are to be used in conjunction with the SCR.

PREFACE

Prepared by the MOU Parties

The environmental cleanup of mining related contamination in the historic California Gulch Mining District in and around Leadville, Colorado, has been ongoing for many years under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In March 1999, the federal and state governments and some private parties entered into a Memorandum of Understanding (MOU) to begin evaluating potential injuries to natural resources which may have been caused by mining related contamination from the California Gulch Superfund Site, and to evaluate alternatives for restoring, acquiring the equivalent of or replacing injured natural resources. The parties to the MOU are the federal and state trusties for natural resources (the U.S. Department of the Interior, acting principally through the U.S. Fish and Wildlife Service, the Colorado Department of Natural Resources, the Colorado Attorney General's Office), the U.S. Environmental Protection Agency (USEPA), and the mining companies (Resurrection Mining Company and Newmont Mining Corporation, ASARCO, Incorporated, and the Res-Asarco Joint Venture).

The MOU facilitated a cooperative process of: (a) assessing potential injuries to natural resources in the Upper Arkansas River Basin, (i.e., the Arkansas River from its headwaters downstream to the Pueblo Reservoir as further described in this report), attributable to historic mining activities in and around Leadville, Colorado, and developing restoration alternatives; and (b) coordinating the natural resource damage (NRD) process with investigations and potential response actions in that portion of the Upper Arkansas River immediately downstream of the confluence of the Arkansas River and California Gulch, which is referred to in this report as the "Eleven-Mile Reach." To further the development and exchange of information for settlement purposes, the MOU parties hired a team of experts (the "Consulting Team") from the fields of terrestrial biology, toxicology, aquatic biology/water quality, fluvial geomorphology, and habitat restoration/revegetation. The MOU parties directed the Consulting Team to complete two tasks: (1) compile and evaluate the data available for the Upper Arkansas River Basin downstream from the confluence with California Gulch; and (2) identify and evaluate alternatives for restoring impacted natural resources. The issuance of the Site Characterization Report (SCR) marks completion of the first task. The Consulting Team's second task is an analysis of alternatives for restoring thoses natural resources impacted by mining related activities as described in the SCR.

The analysis of the Consulting Team represents its own independent views, which are not necessarily shared or endorsed by any of the MOU parties. Furthermore, the federal and state government agencies retain their sole decision-making authorities regarding the determination of injuries to, and

restoration of, natural resources, and any other matters discussed in this SCR or the forthcoming restoration alternatives report. The governments will provide for an opportunity to comment on any proposed restoration plan. Finally, the participation by any party in the MOU process should not be considered an admission of responsibility or liability for any injury to natural resources.

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LIST OF ACRONYMS

AB-DTPA – Ammonium Bicarbonate – Diethylenetriaminepentacetic Acid

ALAD – Aminolevulinic Acid Dehydratase

ANOVA – Analysis of Variance

AV – Arkansas Valley

AVIRIS – Airborne Visible/Infrared Imaging Spectrometer

BLM – Bureau of Land Management

BOR – Bureau of Reclamation

CCU – Cumulative Criterion Unit

CDA – Canonical Discriminant Analysis

CDOW – Colorado Division of Wildlife

CDPHE – Colorado Department of Public Health and Environment

CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act

CFR – Code of Federal Regulations

CSU – Colorado State University

CWA – Clean Water Act

DNA – Deoxyribonucleic Acid

DOI – Department of Interior

DWS – Domestic Water Supply

USEPA – Environmental Protection Agency

EPT – Ephemeroptera Plecoptera Trichoptera Index

FS – Feasibility Study

GIS – Geographic Information Systems

HQI – Habitat Quality Index

ISCST – Industrial Source Complex Short Term

LIST OF ACRONYMS
Continued

LMDT – Leadville Mine Drainage Tunnel

MCL – Maximum Contaminant Level

MOU – Memorandum of Understanding

NPL – National Priorities List

NRCS – Natural Resource Conservation Science

NRDA – Natural Resource Damage Assessment

NURE – National Uranium Resource Evaluation

OU – Operable Unit

PHABSIM – Physical Habitat Simulation Modeling

POR – Period of Record

QA/QC – Quality Assurance/Quality Control

RAR – Restoration Alternatives Report

RI – Remedial Investigation

RI/FS – Remedial Investigation/Feasibility Study

RBP – Rapid Bioassessment Protocol

RNA – Ribonucleic Acid

SDWIS – Safe Drinking Water Information System

SMW – Shallow Monitoring Well

START – Superfund Technical Assessment and Response Team

STORET – Storage and Retrieval

TVSs – Colorado Table Value Standards

UARB – Upper Arkansas River Basin

USBLM – United States Bureau of Land Management

USBOR – United States Bureau of Reclamation

USFS – United States Forest Service

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

WUA – Weighted Usable Area

XRF – X-Ray Fluorescence spectrometry

GLOSSARY OF TERMS

500-Year Floodplain – Area of land that borders a stream and is subject to inundation under flood stage conditions associated with a 500-year flood event

Abundance – Density or number of organisms on a per unit or per volume basis

Airshed – Area of deposition of smelter-stack emissions

Alluvial – Pertaining to or composed of alluvium, or deposited by a stream or running water

Amalgamation Process – A process of gold or silver recovery in which the ore, finely divided & suspended in water, is passed over a surface of liquid mercury to form an amalgam that is subjected to fire for refining

Background – Refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring: substances present in the environment in forms that have not been influenced by human activity, or anthropogenic: natural and human-made substances present in the environment as a result of human activities (not specifically related to the release in question) (USEPA OSWER 9285.6-07P)

Baseline – Condition that would have existed at the assessment area had a release of a hazardous substance not occurred (43 CFR 11.14 (e))

Benchmark – A well-defined value or condition used as a point of comparison

Benthic Invertebrates, Benthic Macroinvertebrates, Macroinvertebrates – Invertebrates (primarily aquatic insects) generally associated with bottom habitats in lakes and streams. These organisms play an important role in regulating processes in aquatic systems and are an important component in the diet of fish.

Bioavailable – In a form that can be taken up by plants and animals

Biological Resources – All plants and animals

Biomass – Weight of living material (plant/animal), usually expressed as dry weight per unit area

Biota – All living organisms found within a certain area

Bryophyte –A group of organisms commonly found associated with hard-bottom substrate in high gradient streams. Because these organisms accumulate heavy metals and other contaminants, they are often used as indicators of potential exposure.

Colloids – Solids that remain suspended in the aqueous phase, but which influence the partitioning of metals through sorption and coprecipitation

Contaminant – Any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil (USEPA)

Control Area – Area or resource not affected by the release of a hazardous substance

DTPA (diethylenetriaminepentacetic acid) – Commonly refers to an analytical soil test developed to simultaneously extract macro and micro nutrients

GLOSSARY OF TERMS
Continued

Diatom – Unicellular primary producers generally found attached to hard substrate (e.g., cobble and boulders) in streams. These organisms are a major food source for many groups of aquatic insects

Ecosystem – All the interacting parts of the physical and biological world

Exposure – Occurs when a natural resource comes into physical contact with a hazardous substance

Floodplain – Area of land that borders a stream and is subject to inundation under flood stage conditions

Flotation Milling – A process to separate ore from host rock utilizing gravity separation within a fluid bath

Fluvial – Of or pertaining to a river or rivers

Gaging Station – The site on a stream, river, lake or canal where hydrologic data are collected

Geographic Information System (GIS) – A map based database that allows users to acquire, store, manipulate, analyze and display spatial data. Plots locations of information on maps using latitude and longitude

Geomorphology – The study of the history of geologic changes through the interpretation of topographic forms

Groundwater – The supply of fresh water found beneath the earth's surface (usually in aquifers) that is often used for supplying wells & springs

Habitat – Place where an animal or plant normally lives, often characterized by a dominant form or physical characteristic (e.g., stream habitat, forest habitat)

Hard Rock Mining – Mining that takes place in igneous & metamorphic rock by means of drilling & blasting to extract the ore

Hazardous Substances – By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least 1 of 4 characteristics (ignitability, corrosivity, reactivity or toxicity) or appears on special USEPA lists

Herbaceous –Non-woody plant species such as grasses and forbs (herbs)

Histopathology – A branch of pathology concerned with microscopic tissue changes characteristic of disease or exposure to a contaminant

Hydraulic Mining – Mining by washing sand and dirt away with water that leaves the desired mineral

Hydrology – The science of dealing with the occurrence, distribution and circulation of water

Injury – A measurable adverse change, either short- or long-term in the chemical, physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a release of a hazardous substance

Kriging Analysis – Interpretation of spatial data using geostatistical methods

Metals Loading – Mass of metals that are discharged into a receiving system

Mine-waste – Rejected mineral waste and unweathered geologic material that remains after such processes as mining and/or milling

Natural Resources –Land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976), any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe. These natural resources have been categorized into the following five groups: Surface water resources, ground water resources, air resources, geologic resources, and biological resources (43 CFR 14 (z))

Operable Unit (OU) – Term for a portion of or a separate activity undertaken as part of a Superfund site cleanup

Ore – A mineral containing a valuable constituent (e.g., metal) for which it is mined

Osteochondrosis – A bone formation disease where cartilage does not turn to bone as normally occurs during the time of bone formation. Because cartilage is retained, the shape of the forming bone may be altered and the joints become swollen, culminating in slight to severe lameness

Pathways – The route or medium through which a hazardous substance is or was transported from the source of release to the natural resource

Paucity – Scarce or smallness in quantity

Periphyton – Attached algae and associated biotic and abiotic materials in lakes and streams. This material is a major food source for many groups of aquatic insects

Physiological – Characteristics of or appropriate to an organism's healthy or normal functioning

Phytotoxicity – Causing a measurable reduction in plant growth or mortality

Placer Mining – Obtaining minerals from glacial or alluvial deposits of sand or gravel by washing or dredging

Plant-Available – In a form that can be absorbed by plants

Plant Cover – A measure of the percent of the ground surface covered with live vegetation

Plant Production – A measure of the plant mass expressed on a per unit basis (e.g., g/m^2 or lbs/acre)

Pyrometallurgical Process – Metallurgy dependent on heat (e.g., roasting & smelting)

Reach – Stream segment

Reference Site – A location used as a point of comparison for the purpose of establishing a baseline condition

GLOSSARY OF TERMS
Continued

Release – Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant)…(40 CFR 300.5 (22))

Remedial Investigation – An in-depth study designed to gather the data necessary to determine the nature & extent of contamination at a Superfund site; establish criteria for cleaning up the site; identify preliminary remedial alternatives for remedial actions; and support the technical & cost analyses of the alternatives

Riparian Zone – Area of land that borders a stream that is located between standing water and uplands. Plant growth in this area is influenced by additional water associated with the stream system

Services – The physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource (43 CFR 11.14 (nn))

Seston – Organic and Inorganic particulate materials suspended in the water column

Species Richness – Number of species at a particular place and time

Tailings – Rejected mineral waste that remains after milling

Terrestrial – Pertaining to the land, as distinct from air and water

Terrestrial Biota – Plants and animals that live on the land

Threshold Values – A concentration or value, below which a biological response cannot be detected

Total Dissolved Solids – The amount of material (e.g., inorganic salts and small amounts of organic material) dissolved in water and commonly expressed as a concentration in terms of mg/L

Total Suspended Solids – Particulate matter in the water column

Waste Rock – Non ore-bearing host rock separated from the ore at the mine-site