Total Maximum Daily Load For:
Boulder Creek

Parameters: Arsenic, Copper and Zinc

July 2004

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act requires each state to develop Total Maximum Daily Loads (TMDLs) for surface waters that do not meet and maintain applicable water quality standards. A TMDL establishes the amount of a given pollutant that the waterbody can withstand without creating an impairment of that surface water's designated use. The TMDL by definition (40 Code of Federal Regulations Part 130) is the sum of all point and non-point sources with the inclusion of a margin of safety and natural background considerations.

Boulder Creek, from Wilder to Burro Creek, located near Bagdad, AZ, in west central Yavapai County, appeared on the Arizona Department of Environmental Quality's1998 List of Water Quality Limited Waters for exceedances of surface water quality standards for arsenic, beryllium, copper, lead, manganese, and zinc. Specific surface water quality standards for these parameters are listed in Title 18, Chapter 11 of the Arizona Administrative Code (AAC). For this TMDL investigation, samples were collected to discern pollutant sources, the extent of impairment, and allow for the calculation of pollutant loads and allocations. Sample results supported delisting beryllium, lead, and manganese for the entire reach; copper and zinc from Butte Creek to Burro Creek and arsenic from Copper Creek to Burro Creek. The TMDLs for copper and zinc from Wilder Creek to Butte Creek and for arsenic from Wilder Creek to Copper Creek can be found in Table 4-6.

The sources of pollutants are three tailings piles, the upper tailings pile, the middle tailings pile, and the lower tailings pile, and an adit discharge from the abandoned Hillside Mine. The tailings piles are located on land owned by three different entities: Bureau of Land Management (BLM), private, and State of Arizona, respectively. In October 1999, BLM hired a contractor to conduct a site characterization of the tailings piles in preparation for remediation efforts. BLM and its contractors drafted a remediation/reclamation plan for the upper and middle tailings piles. In early 2001, the U.S Environmental Protection Agency (EPA) became involved in remediation by offering financial assistance and by offering to manage the project under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Currently, the Hillside Mine is not on the National Priorities List (NPL) and its non-NPL status is considered a "removal only" site. In late summer 2001, EPA entered discussions with the private landowner to review the landowner's proposal to reprocess and remediate the upper and middle tailings piles. Since then, the owners of the middle tailings pile have rescinded their offer to reprocess the tailings piles. BLM is moving forward on their plans to remediate the upper tailings pile. The Arizona Department of Environmental Quality (ADEQ) is assisting both the private entity and the Arizona State Land Department (ASLD) in applying for federal 319(h) grants to coordinate remediation of the middle and lower tailings piles, respectively, with BLM's effort.

LIST OF ABBREVIATIONS

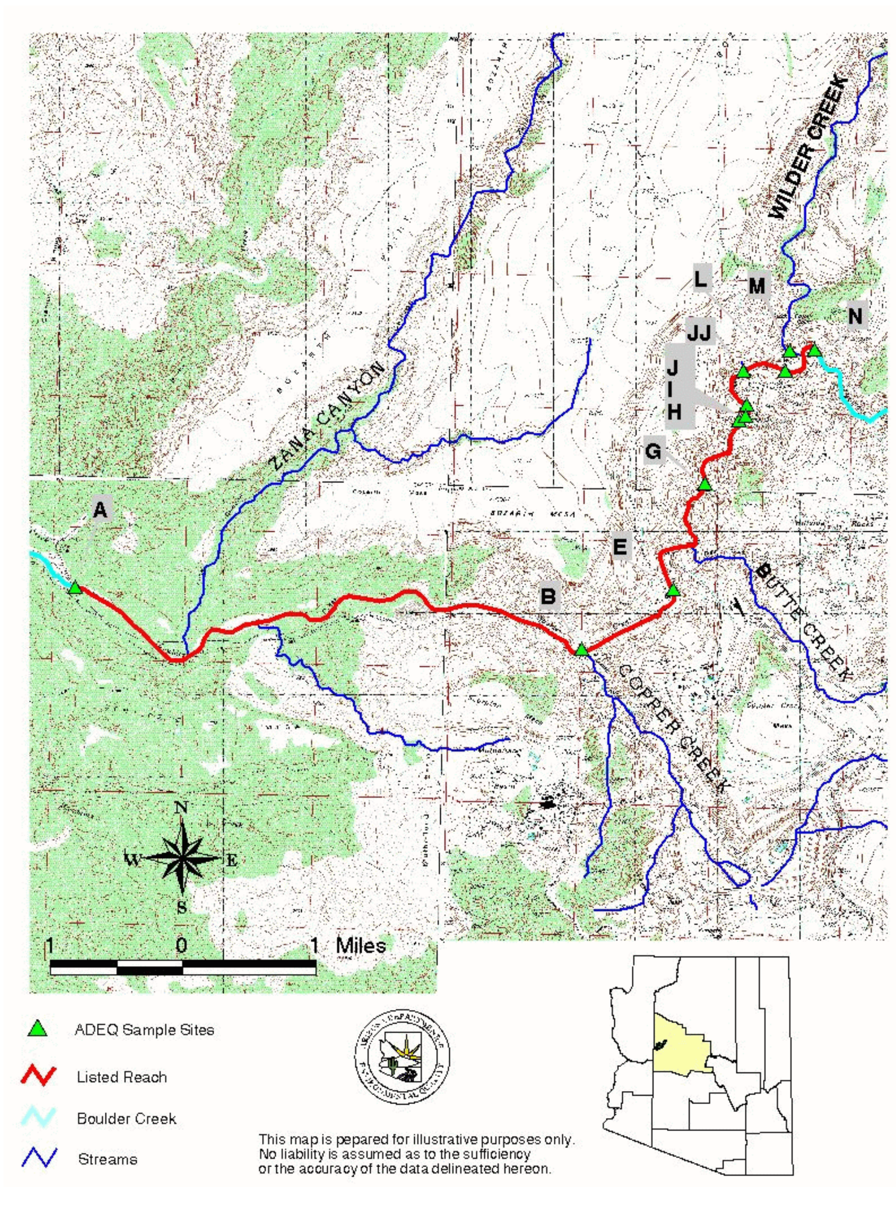
AAC	Arizona Administrative Code
A.A.R.	Arizona Administrative Register
A&Ww	Aquatic and Wildlife, warmwater
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
AgI	Agriculture Irrigation
AgL	Agriculture Livestock Watering
AMEC	AMEC Earth and Environmental
ASLD	Arizona State Land Department
BLM	Bureau of Land Management
BMP	Best Management Practices
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFS	Cubic Feet per Second
EPA	Environmental Protection Agency
F	Fahrenheit
FBC	Full Body Contact
FC	Fish Consumption
ft msl	Feet above Mean Sea Level
GIS	Geographic Informational Systems
mg/L	Milligrams per Liter
MGD	Millions of Gallons per Day
MOS	Margin Of Safety
NPL	National Priorities List
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WLA	Waste Load Allocation

1 BACKGROUND

1.1 Geography

Boulder Creek is located in western Yavapai County, near Bagdad, AZ. It is predominantly an intermittent watercourse which flows 37 miles from its headwaters near Camp Wood Mountain, 7000± feet above mean sea level (ft msl), to its confluence with Burro Creek at 2460± ft msl. The listed reach, HUC# 15030202-005, runs from the confluence with Wilder Creek to just above the confluence with Burro Creek (Figure 1-1).

Figure 1-1 Project Area



1.2 Climatology

The listed reach lies at elevations between 3150 ft msl and 2460 ft msl. A meteorological station in Bagdad has recorded precipitation data which are representative of the conditions for the Boulder Creek watershed. The station is located 3704 ft msl and it has recorded daily precipitation continuously from January 1928. The average annual precipitation over the period 1928 to 2000 was 15.0 inches. Annual precipitation ranged from a low of 3.0 inches in 1956 to 29.2 inches in 1978 (Tetra Tech, 2002). Daily temperature data for the period 1929 to the present is also available from this station. The average annual temperature for the Boulder Creek area as measured at Bagdad is 63.1E Fahrenheit (F), varying from an average monthly temperature of 45.7E F in January to 82.7E F in July (Tetra Tech, 2001).

1.3 Hydrology

The Boulder Creek watershed drains approximately 138 square miles. Flow is dependent on winter storms and spring snowmelt. Boulder Creek flows mainly from late October or early November until late May, with the highest flows occurring from late January through early March (Figure 1-2). From June until early November or December, Boulder Creek consists of a number of independent pools separated by long stretches of dry streambed.

There are no USGS or county stream gage stations on Boulder Creek. The nearest USGS gage, #09424447, is located on Burro Creek at the US Highway 93 Bridge near Bagdad, AZ. Daily and monthly streamflow data are available at this location from August 1980 through February 1994 (Tetra Tech, 2002). Stream flow measurements taken by ADEQ in support of this TMDL investigation ranged from 0.01 cfs to 11.6 cfs. Flow was not measured in February 2001 due to high flow conditions. Estimated flow at this time was >50 cfs. The only measurable flow from May 2001 until December 2001, was from site I, which is adit discharge. Flow measurements for the sampling locations are shown in Appendix A.

Figure 1-2 Boulder Creek's flow regimes are contrasted in these two pictures. The top picture is from February 2001, and the bottom one is the same location in November of the same year.

1.4 Geology

The geology of the project area is complex. The rocks exposed in this region are predominantly of Precambrian and Tertiary age. The older Precambrian rocks of this area consist of metamorphosed volcanic and sedimentary rocks that have been intruded and deformed by plutons of granitic to gabbroic composition. These were later covered by late Cretaceous or early Tertiary rhyolite tuffs and subsequently intruded by rhyolite dikes and quartz monzonite stocks and related dikes. Quaternary lava flows were later carved into the mesas present today (Anderson *et al.* 1955).

In the project area, Boulder Creek cuts a steep canyon through mesas capped with Quaternary basalt flows and the underlying basement rock. In the vicinity of the abandoned Hillside Mine, the creek cuts through a section of the Hillside mica schist, a metamorphosed sandstone and shale complex. The schist is intruded by the Lawler Peak granite to the west. Small sills and dikes of granodiorite gneiss and pegmatite dikes also cut through the schist. In the vicinity of the lower tailings pile, the creek flows over the Butte Falls tuff, a bedded, water lain, metamorphosed (probably from the Lawler Peak intrusion) tuff that grades upward into the Hillside mica schist (Anderson *et al.* 1955). Shortly after flowing over Butte Falls, in the vicinity of Butte Creek, the gradient decreases and the topography is less steep and constrictive. Here, Boulder Creek cuts through and flows over outcrops of gabbro, Gila conglomerate, and Quaternary gravels (Anderson *et al.* 1955).

In the project area, the minerals of economic importance include gold, silver, sphalerite, galena, chalcopyrite, and pyrite (Anderson *et al*. 1955). The minerals are found in vein deposits that parallel the Hillside Fault.

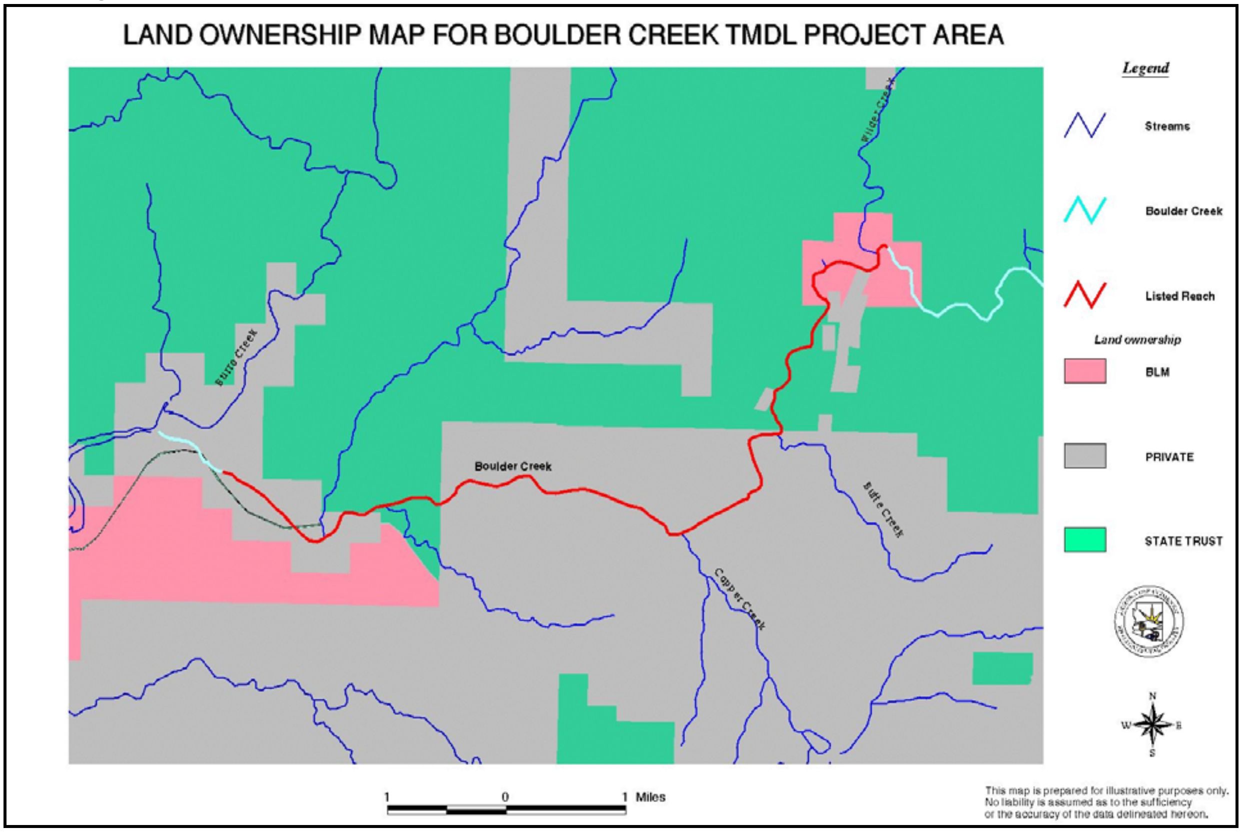
1.5 Vegetation/Wildlife

Vegetative communities range from Sonoran Desert and chaparral at the lower and mid elevations, through juniper and oak woodland, to Ponderosa pine and Douglas fir at higher elevations near the headwaters. The listed reach runs through the mid to lower elevations. Wildlife in the area include deer, javelina, mountain lions, small mammals, and various bird species. Boulder Creek is home to a variety of native fish, most notably *Gila robusta* (Roundtail Chub) and *Catostomus insignis* (Sonora Sucker). There have been no federally threatened or endangered fish species sighted in Boulder Creek (Unmack, 2002).

1.6 Land Ownership/ Use

The majority of the land in the project area is private and state trust land (Figure 1- 3). A small portion is BLM land. Land use is predominantly ranching, mining, and open range.

Figure 1-3



2 NUMERIC TARGETS

2.1 Clean Water Act Section 303(d) List

Section 303(d) of the Clean Water Act requires states to compile a list of surface waterbodies that do not meet applicable water quality standards. TMDLs must be developed for every waterbody on the 303(d) List. TMDLs set the amount of given pollutant(s) that the waterbody can withstand without creating an impairment of that surface water's designated use(s).

This TMDL investigation was performed because Boulder Creek, from Wilder Creek to Burro Creek, appeared on Arizona's 1998 list of water quality limited waters (ADEQ, 2000). Exceedances of the surface water quality standards for arsenic, beryllium, copper, lead, manganese, and zinc were found in nine samples collected in the vicinity of the abandoned Hillside Mine in October 1992, by ADEQ. These data are summarized in Appendix B.

2.2 Beneficial Use Designations

ADEQ codifies water quality regulations in AAC Title 18, Chapter 11 (ADEQ, 1996). Designated beneficial uses, such as fish consumption, recreation, agriculture, and aquatic biota, are described in AAC R18-11-104 and are listed for specific surface waters in

Appendix B of AAC R18-11. Boulder Creek is currently protected along reach HUC# 15030202-005 for the following designated uses: Aquatic and Wildlife warm water fishery (A&Ww); Fish Consumption (FC); Full Body Contact (FBC); Agricultural Livestock Watering (AgL); and Agricultural Irrigation (AgI).

2.3 Applicable Water Quality Standards

Title 18, Chapter 11, Article 1 of the AAC defines water quality standards for surface waters as a numeric constituent concentration or a narrative statement representing a quality of water that supports a designated use(s) of the waterbody. Table 2-1 shows the applicable water quality standards for Boulder Creek. The A&Ww water quality standards for copper, lead, and zinc are hardness dependent. The Boulder Creek TMDLs are based on the most stringent standard for each designated use (indicated by bold font) For arsenic, the most stringent standard is FBC and for copper and zinc, the most stringent standard is A&Ww (chronic).

Table 2-1 ADEQ Use Designations and Corresponding Water Quality Standards

Parameter Fg/L	Fish Consumption		Full Body Contact		Agricultural Irrigation		Agricultural Livestock Watering		Aquatic & Wildlife warmwater (acute)		Aquatic & Wildlife warmwater (chronic)	
Arsenic	1,450	T	**50**	**T**	2,000	T	200	T	360	D	190	D
Beryllium	1,130	T	2,800	T	NNS		NNS		65	D	**5.3**	**D**
Copper	NNS		1,300	T	5,000	T	500	T	A (3.64 - 49.62)	D	E **(2.74 - 29.28)**	**D**
Lead	NNS		15	T	10,000	T	100	T	B (13.9 - 280.9)	D	F (**0.54 - 10.94**)	**D**
Manganese	NNS		196,000	T	**10,000**		NNS		NNS		NNS	
Zinc	69,000	T	420,000	T	10,000	T	25,000	T	C (36.2 - 379.3)	D	J **(36.2 - 379.3)**	**D**

T = Total recoverable metal concentration
D = Dissolved metal concentration
NNS = No numerical standard

A = Aquatic & Wildlife warmwater (acute) standard for Copper: $(e^{(0.9422\ [\ln(hardness)]\ -\ 1.7)}) * (0.96)$
B = Aquatic & Wildlife warmwater (acute) standard for Lead: $(e^{(1.2730\ [\ln(hardness)]\ -\ 1.460)}) * (1.46203 - \ln(hardness) * (0.145712))$
C = Aquatic & Wildlife warmwater (acute) standard for Zinc: $(e^{(0.8473\ [\ln(hardness)]\ +\ 0.884)}) * (0.978)$
E = Aquatic & Wildlife warmwater (chronic) standard for Copper: $(e^{(0.8545\ [\ln(hardness)]\ -\ 1.702)}) * (0.96)$
F = Aquatic & Wildlife warmwater (chronic) standard for Lead: $(e^{(1.2730\ [\ln(hardness)]\ -\ 4.705)}) * (1.46203 - \ln(hardness) * (0.145712))$
J = Aquatic & Wildlife warmwater (chronic) standard for Zinc: $(e^{(0.8473\ [\ln(hardness)]\ +\ 0.884)}) * (0.978)$
**A-F: Hardness, expressed as mg/L $CaCO_3$, inserted into the equation where it says "Hardness". Hardness for the Aquatic & Wildlife warmwater standards are based on the hardness of the receiving water body from a sample taken at the same time that the sample for the metal is taken, except that the hardness may not be below 25 mg/l nor exceed 400 mg/L as $CaCO_3$. On the table, the numbers in the parentheses show the range of the standards based on hardness values from 25-400 mg/L as $CaCO_3$.*

3 SOURCE ASSESSMENT

A wide range of data and information was used to develop these TMDLs, including physiographic data that describes the physical conditions of the watershed; environmental data that identify potential pollutant sources and their contributions; and, in-stream water quality monitoring data. The in-stream monitoring data used to determine impairment for the 1998 303(d) listing were collected on October 22, 1992 in support of the goals of other programs. (Appendix B.) These results were insufficient to isolate sources or to characterize the impacts of weather, physical conditions or seasonal variation on the stream water quality. As part of this project, the ADEQ TMDL Program collected data specific to the goals of source identification and TMDL calculation. Water quality samples were collected on a monthly basis from October 2000 until August 2001 at 11 sites to systematically monitor conditions along the listed reach to determine the extent, frequency and conditions under which impairment occurs as well as identify background water quality. Sites were established at the beginning and end of the reach; upstream and downstream of potential point and non point sources; and at several other accessible monitoring locations. Site locations are shown on Figure 1-1.

Flow data from the USGS gage on Burro Creek at the US Highway 93 Bridge was used in estimating seasonal flow variations and the response to precipitation within the Boulder Creek Watershed. Additional USGS flow estimates made during monthly sampling events between 1977 and 1979 for locations on and near Boulder Creek were used. ADEQ flow measurements from the early 1990's (two locations on Boulder Creek) and flow measurements or estimates made by ADEQ during 2000 and 2001 sampling events on Boulder Creek were also used. (Tetra Tech, 2002)

Water quality data from fourteen ADEQ monitoring locations (November 2000 to August 2001) and EPA's STORET database were used to determine the extent, frequency, and conditions under which the stream impairment occurs, as well as to define background water quality. In total, data from four sources, Bureau of Land Management (BLM) study of Burro Creek in 1982-83, ADEQ sampling near Hillside Mine in 1992-93, USGS sampling in Boulder Creek in 1977-79, and samples collected by BLM in 2000 at and near the Hillside Mine tailing piles were used to support water quality analysis for the Boulder Creek watershed. The most recent water quality data collected by ADEQ is summarized in Appendix A. (Tetra Tech, 2002)

3.1 Segmenting Boulder Creek

Data from the ADEQ TMDL sampling effort are presented in Appendix A. Sample results show that portions of the listed reach were not impaired at the times sampling occurred. The model used in this investigation corroborated the identification of non-impaired stretches. The model took into account historic sample results as well as the sample results generated through this investigation.

Based on recent sampling results and modeling, ADEQ supports removing certain pollutants ("delisting") from specific segments of the stream. Tables 3-1, 3-2, and 3-3 provide the sampling results which support delisting beryllium, lead, and manganese from Wilder Creek to Burro Creek; copper and zinc from Butte Creek to Burro Creek; and, arsenic from Copper Creek to Burro Creek. Segmentation at these locations was chosen based on the location of sampling points and it is supported through modeling. These delist decisions are based on the WQS standards approved by EPA on November 13, 2002.

For lead, the laboratory reporting level was at times higher than the standard. This made direct comparison with the water quality standard impossible in some cases. However, modeling results, which were derived from historic data sets as well as the data collected in support of this TMDL, resulted in no projected exceedances of the surface water quality conditions, under all flow regimes. (In the model, one-half the laboratory reporting limit of 5 ug/L was used for instances where the standard was lower than the laboratory reporting level.) Based on these factors, ADEQ proposes to delist lead from the entire reach, Wilder Creek to Burro Creek.

Table 3-1 Summary of Delist Data From Wilder Creek to Butte Creek

Site	Parameter	# Samples	Mean (Fg/L)	Min (Fg/L)	Max (Fg/L)	Standard (Fg/L)	# of Exceedances
N	Be (D)	8	<2	<2	<2	5.3	0
L	Be (D)	4	<2	<2	<2	5.3	0
JJ	Be (D)	4	<3.0	<2	12	5.3	1
J	Be (D)	6	<2	<2	<2	5.3	0
H	Be (D)	13	<2	<2	<2	5.3	0
G	Be (D)	7	<2	<2	<2	5.3	0
N	Mn (T)	8	22.5	<20	70	10,000	0
L	Mn (T)	4	17.5	<20	40	10,000	0
JJ	Mn (T)	4	5942.5	30	23,400	10,000	1
J	Mn (T)	6	61.7	30	120	10,000	0
H	Mn (T)	13	2835.4	40	11,800	10,000	2
G	Mn (T)	7	130	50	260	10,000	0
N	Pb (D)	8	<5	<5	<5	0.84-4.52[1]	U
L	Pb (D)	4	<5	<5	<5	1.31-6.15[1]	U
JJ	Pb (D)	4	<5	<5	<5	2.38-10.94[1]	U
J	Pb (D)	6	<5	<5	<5	1.23-5.31[1]	U
H	Pb (D)	13	<5	<5	<20	1.23-10.94[1]	U
G	Pb (D)	7	<5	<5	<5	1.23-5.52[1]	U

% Exceedances: Be, 2%; Mn, 7%; Pb, 0%

1: Based on hardness values taken at time of sampling.

U: Laboratory reporting level at or higher than the calculated water quality standard making direct comparison difficult.

Table 3-2 Summary of Delist Data From Butte Creek to Copper Creek

Site	Parameter	# Samples	Mean (Fg/L)	Min (Fg/L)	Max (Fg/L)	Standard (Fg/L)	# of Exceedances
E	Be (D)	6	<2	<2	<2	5.3	0
E	Cu (D)	6	<15	<15	<15	6-13	U
E	Mn (T)	6	81.7	40	160	10,000	0
E	Pb (D)	6	<5	<5	<5	1.36-3.99[1]	U
E	Zn (D)	6	50	<20	70	73-168	0

%Exceedances: Be, 0%; Cu, 0%; Mn, 0%; Pb, 0%; Zn, 0%

1: Based on hardness values taken at time of sampling.

U: Laboratory reporting level at or higher than the calculated water quality standard making direct comparison difficult.

Table 3-3 Summary of Delist Data From Copper Creek to Burro Creek

Site	Parameter	# Samples	Mean (Fg/L)	Min (Fg/L)	Max (Fg/L)	Standard (Fg/L)	# of Exceedances
A	As (T)	6	16.5	14	25	50	0
B	As (T)	7	39	11	52	50	1
A	Be (D)	6	<2	<2	<2	5.3	0
B	Be (D)	7	<2	<2	<2	5.3	0
A	Cu (D)	6	<15	<15	<15	6-24[1]	U
B	Cu (D)	7	<15	<15	<15	6-19[1]	U
A	Mn (T)	6	105.0	<20	510	10,000	0
B	Mn (T)	7	44.3	<20	150	10,000	0
A	Pb (D)	6	<5	<5	<5	1.44-8.69[1]	U
B	Pb (D)	7	<5	<5	<5	1.44-6.49[1]	U
A	Zn (D)	6	5.0	<20	30	76-314[1]	0
B	Zn (D)	7	17.1	<20	50	76-248[1]	0

% Exceedances: As, 8%; Be, 0%; Cu, 0%; Mn, 0%; Pb, 0% Zn, 0%

1: Based on hardness values taken at time of sampling.

U: Laboratory reporting level at or higher than the calculated water quality standard making direct comparison difficult.

3.2 Hillside Mine

The Hillside Mine is an abandoned gold-silver-zinc-lead mine and mill site. The mine was operated from 1887 to 1951. The main shaft was sunk along the Hillside vein at the site of the current middle tailings pile. The Hillside vein is a typical quartz-sulfide fissure vein that follows the Hillside Fault. The vein was worked approximately 2,700 ft. along strike and 900 ft. down dip (Anderson *et al.* 1955). Gold, silver, and lead were the sole metals produced from 1887 to 1933. Copper and zinc production began in the mid 1930s. Copper was a minor constituent, contributing approximately 1% of the value of the metals produced (Anderson *et al.* 1955). A custom mill built in 1946 in the vicinity of the upper tailings pile treated ore from the Hillside Mine and other custom ores, such as tungsten, copper, and gold from nearby mines. The mill operated until around 1954.

Figure 3-1 The top photo (courtesy of Arizona Department of Mines and Mineral Resources) shows the Hillside mine in January 1940. The bottom photo is the same location in January 2001.

The site now consists of the head frame, primary and secondary shafts, three tailings piles (Figure 3-1), and the former mill site. Massive sulfides ore in mine tailing are being weathered and oxidized at an accelerated rate due to a reaction with water and oxygen. This chemical reaction produces high concentrations of metals and acidic water, which eventually leach into Boulder Creek. (Tetra Tech, 2002)

There is also a discharge that emanates from a collapsed adit near the toe of the middle tailings pile. The adit has a continuous discharge, approximately 5 gpm, and is a main source of dissolved metals including arsenic, manganese, and zinc.

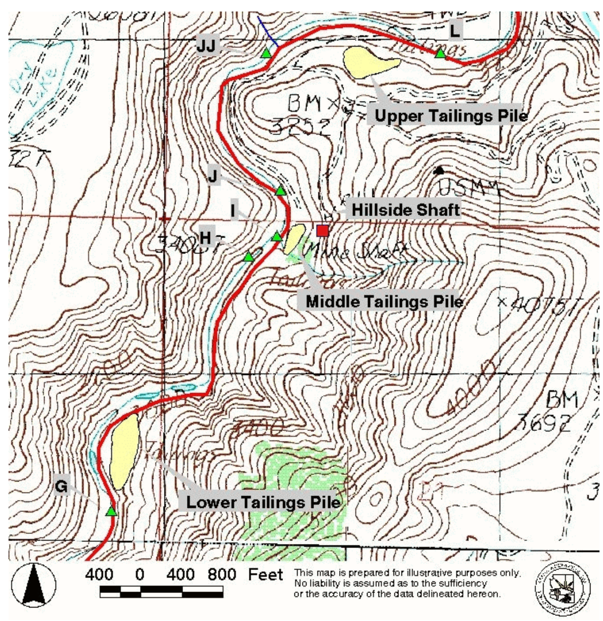


Figure 3-2 Overview of Hillside Mine Complex.

3.2.1 Upper Tailings Pile

The upper tailings pile is located on BLM land and is composed of two piles in the vicinity of the custom mill site (Figure 3-

3)[1]. The eastern lobe covers approximately 1.72 acres and has an approximate volume of 26,362 cubic yards. The western lobe covers approximately 0.91 acres and has an approximate volume of 17,618 cubic yards (BLM, 2000). The mill, located immediately south of the tailings pile, processed ores from the Hillside and custom ores from other mines in the area.

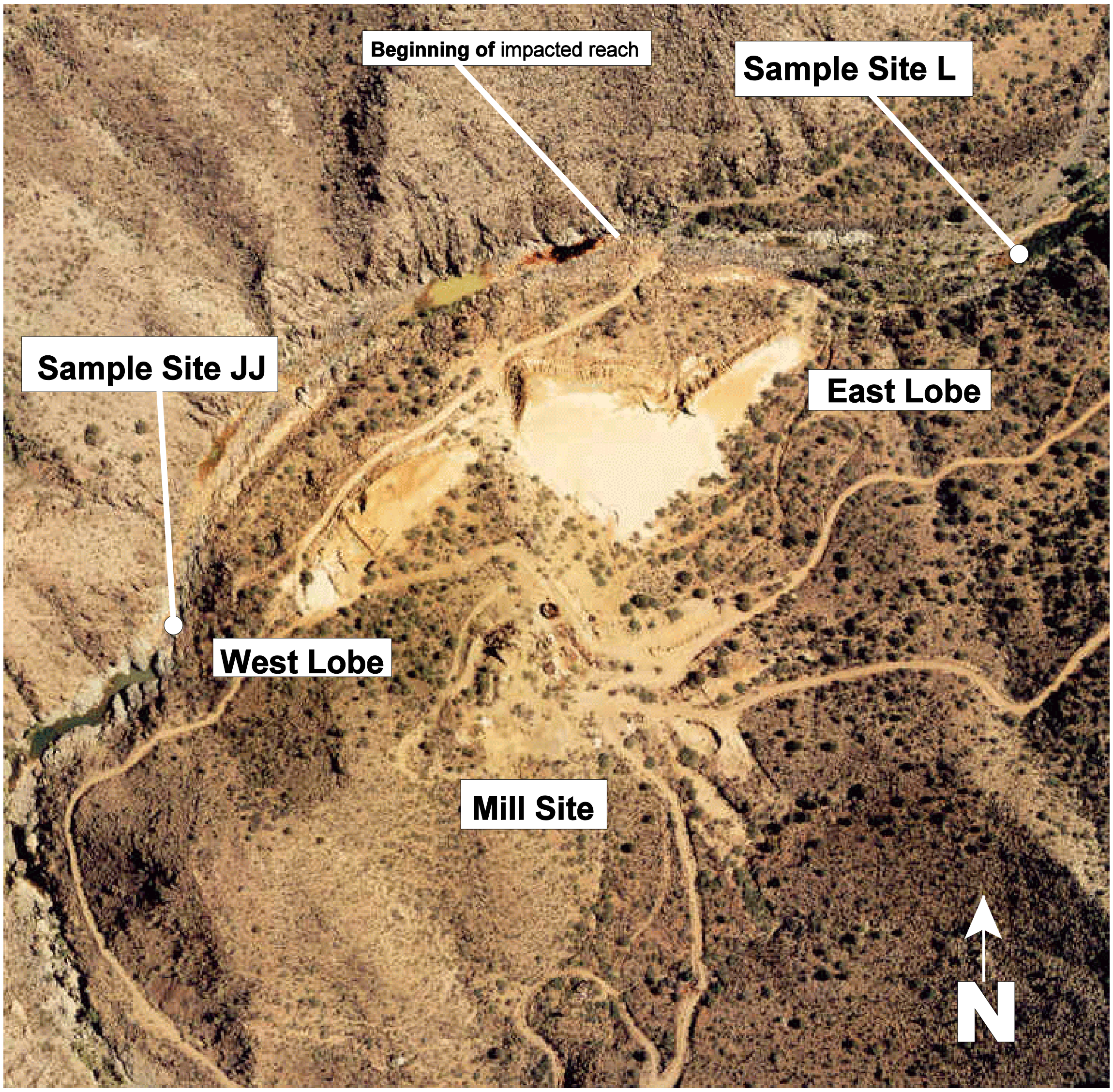


Figure 3-3 Upper Tailings Pile and Mill Site (photo courtesy of BLM, July 1999)

[1]Sample sites referenced in the images correspond to the data in Appendix A.

3.2.2 Middle Tailings Pile

The middle tailings pile is located on patented mining claims at the site of the main shaft of the Hillside Mine (Figure 3-4). This property is owned by KFX Building Company, Inc. This tailings pile covers approximately 1.72 acres and has an approximate volume of 41,624 cubic yards (BLM, 2000).

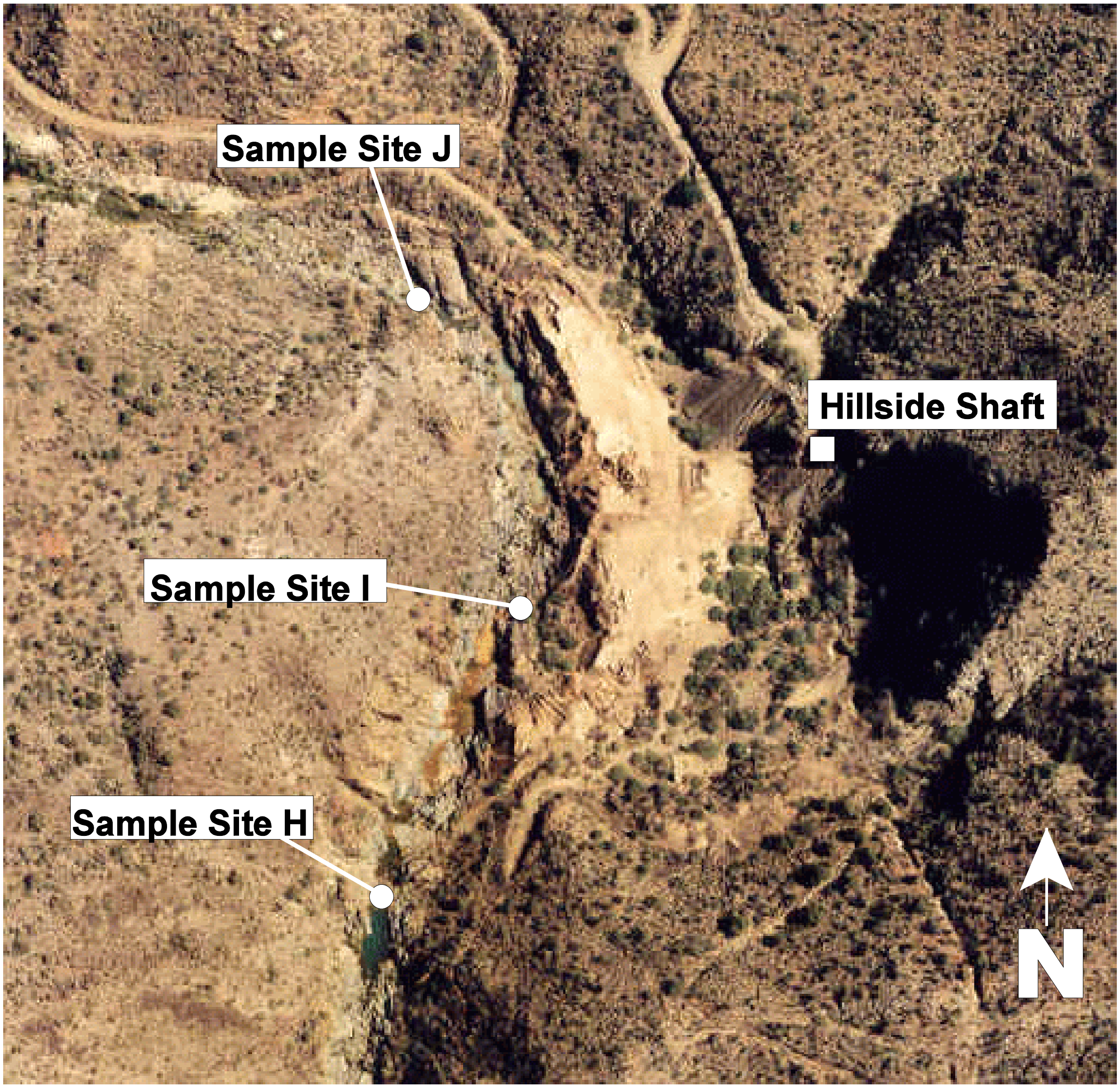


Figure 3-4 Middle Tailings Pile (photo courtesy of BLM, July 1999)

3.2.3 Lower Tailings Pile

The lower tailings pile is located on State Trust land approximately 0.6 stream miles downstream of the middle tailings pile (Figure 3-5). The lower tailings pile covers approximately 2.41 acres and has an approximate volume of 54,434 cubic yards (BLM, 2000). The tailings materials were slurried in a pipeline from the Hillside Mine to this location.

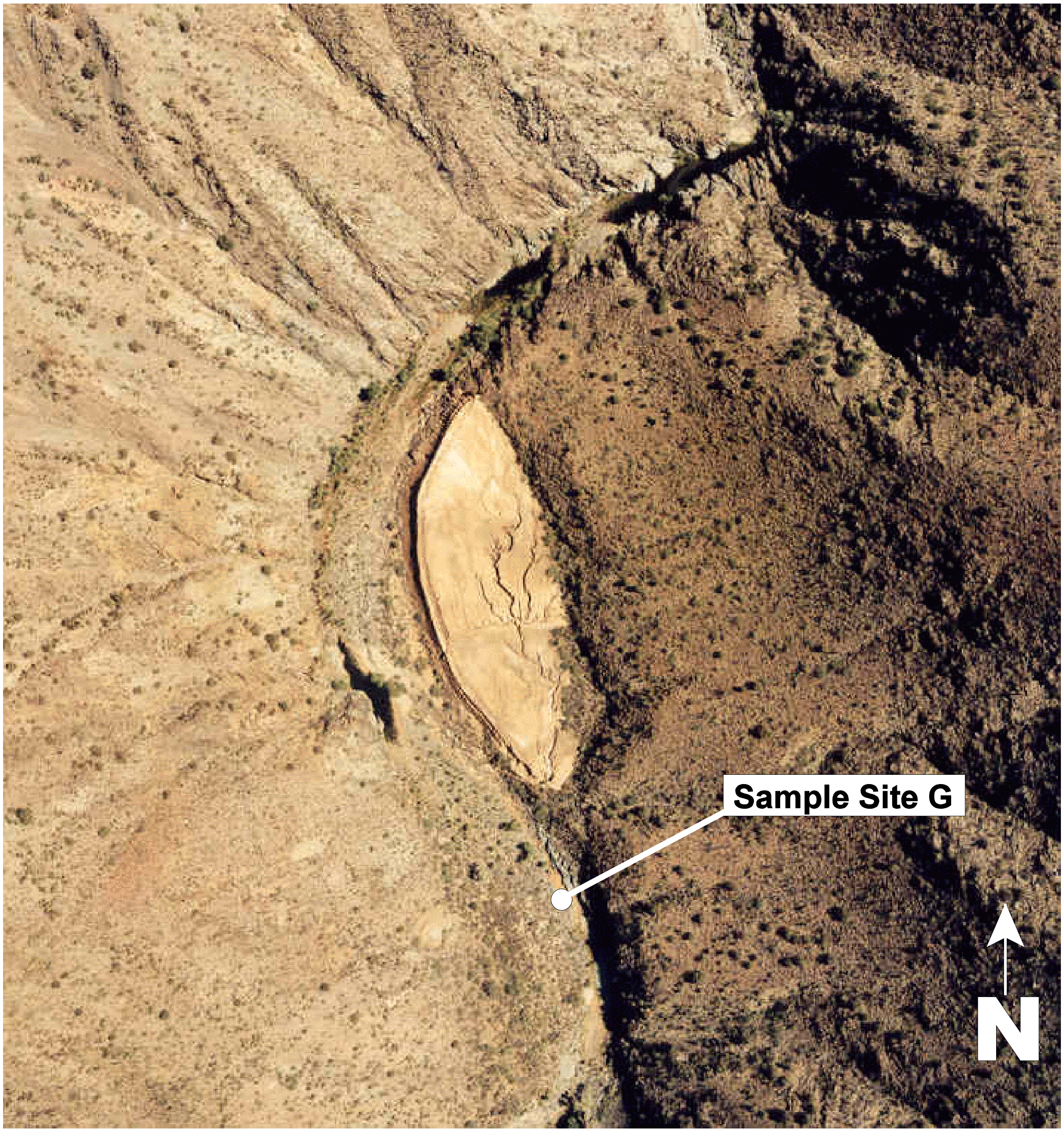


Figure 3-5 Lower Tailings Pile (photo courtesy of BLM, July 1999)

3.2.4 Discharge From Collapsed Adit

The adit discharge is located near the toe of the middle tailings pile (Figure 3-6). The flow from the adit is constant at approximately 0.011 cfs (5 gpm). After exiting the adit, the discharge flows about 30 feet before entering into Boulder Creek. The adit discharge is reported to have appeared in June, 1982 (ADHS, 1984). The discharge is slightly acidic, having a pH of 6. The water is clear, but the channel in which it flows is lined with an orange precipitate. The channel is also host to finger-like colonies of iron-oxidizing bacteria (ADHS, 1984).

Figure 3-6 Adit discharge (December 2001)

3.3 Existing Loadings in Watershed

3.3.1 Adit Discharge

Existing loadings for the pollutants of concern in the adit discharge are presented in Table 3-4. These loads are based on field measurements. The flow from the adit is constant at approximately 5 gpm.

Table 3-4 Existing Loadings from Adit Discharge (g/day)

As	Cu	Zn
164.17	0.40	57.59

3.3.2 Nonpoint Source Loadings

3.3.2.1 Natural Background

Natural background concentrations of alkalinity, calcium, magnesium, and sulfate were calculated based on available historic data for unimpaired segments of the upper Burro Creek watershed, including Boulder Creek (Figure 3-7). Because a statistical analysis of the data showed the geometric mean of each chemical has a consistent concentration, the geometric mean was used to define natural background. The background concentrations of Butte and Copper Creek were also derived in the same way using available historic data. When recent observation data were available, they were used instead of the geometric mean of historic values. (Tetra Tech, 2002)

The background concentrations for arsenic, copper, lead, and manganese were set at one half of the detection limit that was reported for samples collected at Site N (Figure 3-7). The reported detection limits were <5 ug/L for arsenic; <15 ug/L for copper; <5 ug/L for lead; and, <20 ug/L for manganese. At half of the limit, arsenic is 2.5 ug/L; copper is 7.5 ug/L; lead is 2.5 ug/L; and, manganese is 10 ug/L. The background concentrations for beryllium and iron were derived based on historic observation data and the best professional judgement from the site visits. For beryllium the concentration is 0.1 ug/L and for iron it is 3.5 ug/L. (Tetra Tech, 2002)

The existing loadings for each pollutant is listed by segment in Table 3-5 (Tetra Tech, 2002).

Table 3-5 Existing Loadings from Natural Background (g/day)

	As	Cu	Zn
Upstream Boundary Conditions	7.9	23.7	31.6
Butte Creek Watershed	1.7	N/A	N/A

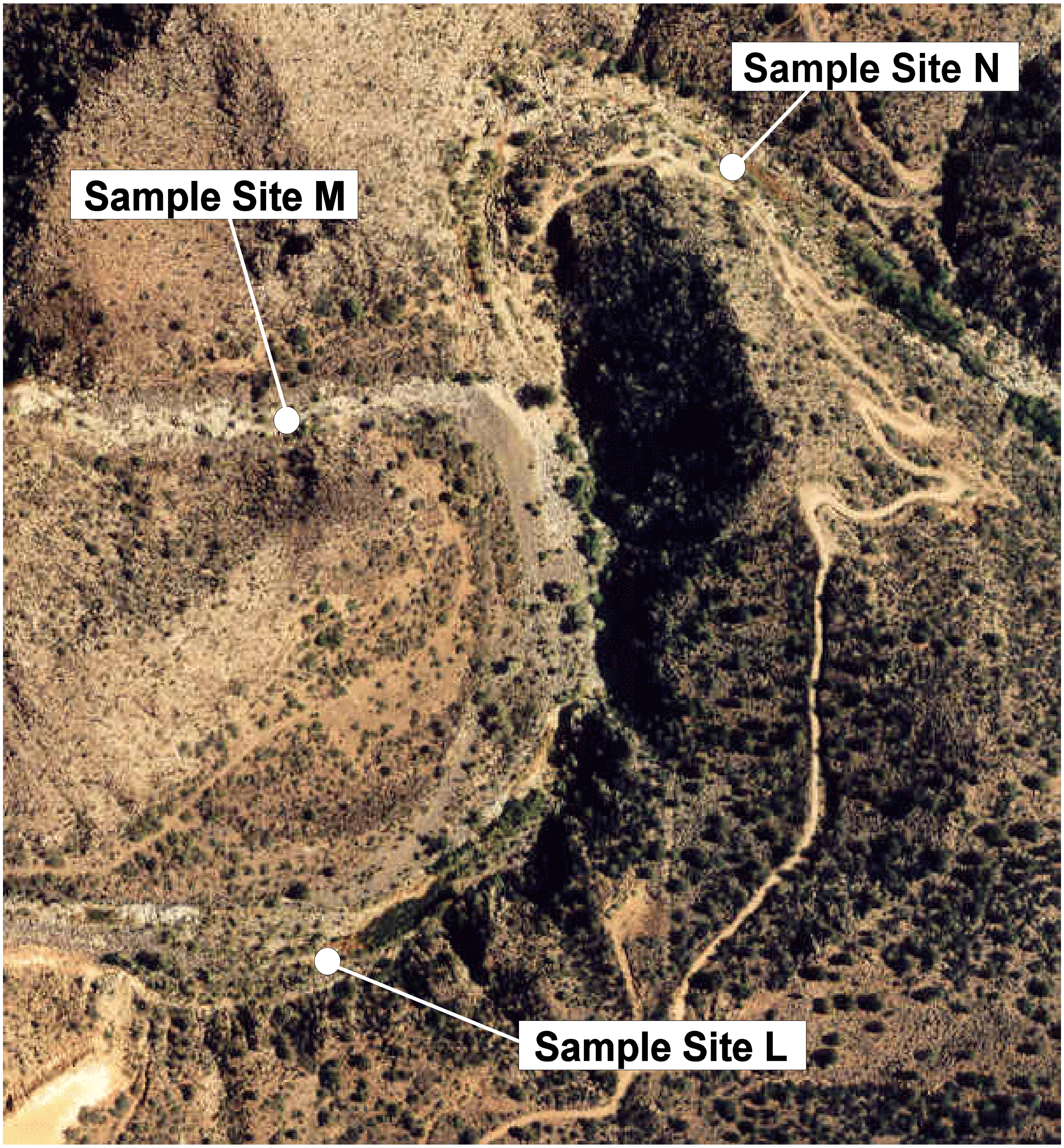


Figure 3-7 Sample sites above impacted reach (photo courtesy of BLM 1999).

3.3.2.2 Copper Creek Watershed

Phelps Dodge, Bagdad, Incorporated (PDBI) has the only permitted point source discharge within the Boulder Creek watershed. PDBI holds an individual NPDES permit (AZ0022268) to discharge from three outlets to Copper Creek, a lower tributary to Boulder Creek. The NPDES permit contains limits for arsenic, cadmium, copper, lead, mercury, nickel, zinc, and pH. This permitted source no longer discharges into Copper Creek as a catchment basin and subsurface cut-off walls were installed in the drainage to prevent runoff from ultimately entering Boulder Creek (Appendix C). A subsurface cut-off wall and retention basin were constructed in 1982 and a second sub-surface soil cut-off wall was constructed between the retention basin and Boulder Creek in 1992 (personal communication, Jeff Campbell, PDBI, August 4, 2003). Because flows from Copper Creek are captured in the retention basin, the modeled loads attributed to Copper Creek, which were based on pre-basin/wall data, are not be listed here and were not considered in the final TMDL calculation. PDBI also has a general NPDES multi sector stormwater permit to discharge from a limited drainage between Butte and Copper Creeks. Modeling shows that no allocations for industrial stormwater discharges are necessary, that such discharges are therefore consistent with this TMDL, and that no permitting restrictions should be placed on such discharges, at this time.

3.3.2.3 Upper, Middle and Lower Tailings Piles

Sampling conducted in support of this TMDL clearly shows the impact of each tailings pile on Boulder Creek. The existing loadings for each metal are presented in Table 3-6.

Table 3-6 Existing Loadings from Tailings Piles (g/day)

	As	Cu	Zn
Upper Tailings Pile	43.2	61.4	605.8
Middle Tailings Pile	<1	<1	2.8
Lower Tailings Pile	<1	<1	217.1

4 ALLOCATION ANALYSIS

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. (Tetra Tech, 2002) This definition is expressed as:

$$TMDL = 3WLA + 3LA + MOS$$

To develop TMDLs for Boulder Creek, the following approach was taken.

1. Collect and review recent and historic data
2. Select model(s)
3. Define TMDL endpoints
4. Simulate existing conditions
5. Assess source loading alternatives
6. Determine the TMDL and source allocations

Water quality data from fourteen ADEQ monitoring locations and EPA's STORET database were used to determine the extent, frequency, and conditions under which stream impairment occurs, as well as to define background water quality. Additional data from ADEQ, BLM, and USGS were also used to support water quality analysis. (Tetra Tech, 2002)

4.1 Model Framework

The Mining Data Analysis System (MDAS) was applied to simulate watershed hydrological processes. MDAS is a system designed to support TMDL development for areas impacted by acid mine drainage. The system integrates the following:

- Graphical interface
- Data storage and management system
- Dynamic watershed model

(Tetra Tech, 2002)

The graphical interface supports basic geographic information systems (GIS) functions, including electronic geographic data importation and manipulation. Key data sets include stream networks, landuse, flow and water quality monitoring station locations, weather station locations, and permitted facility locations. The data storage and management system functions as a database and supports storage of all data pertinent to TMDL development, including water quality observations, flow observations, permitted facilities, as well as stream and watershed characteristics used for modeling. The system also includes functions for inventorying the data sets.

The Dynamic Watershed Model, also referred to as the Hydrological Simulation Program C++ (HSPC), simulates nonpoint source flow and pollutant loading as well as in-stream flow and pollutant transport, and it is capable of representing time-variable point source contributions. (Tetra Tech, 2002)

Because there was insufficient continuous in-stream water quality data to accurately calibrate the model for simulating source loadings, MDAS was not applied to simulate water quality conditions. In order to simulate the required stream flow and chemical processes of total and dissolved quantity of metals, an in-stream chemical speciation model was developed and applied to Boulder Creek. (Tetra Tech, 2002)

The In-stream Chemical Speciation and Transport Model consists of two components. The first component is a physical transport model that assumes a steady-state flow condition. The second component is a chemistry module based on MINTEQA2 and MINEQL geochemical equilibrium speciation models in order to simulate in-stream chemical speciation. This model considers a variety of chemical processes including acid-base reactions, complexation, precipitation/dissolution, and sorption/desorption. The model calculates simultaneous solutions of nonlinear mass action expressions and linear mass balance relationships. These methods are frequently referred to as the "equilibrium constant method." These reactions are solved for set conditions within segments of a modeled stream in order to predict equilibrium systems in the water column. Each time the equilibrium calculation is performed, a new equilibrium status will be achieved, and the total concentration is redistributed into the three different components: dissolved, adsorbed, and precipitated. These components are then categorized as mobile and immobile. The dissolved component resides in the water column and is subject to transport to the next segment. The amount that will be transported to the next segment among adsorbed and precipitated components will be based on the settling rates of each component. The remaining components in the segment can be thought of as mass that adsorbed on the streambed, such as hydrous ferric oxide or aquatic biota in the stream channel. (See the orange precipitate in Figure 3-6.) These components are immobile and are not transported. (Tetra Tech, 2002)

4.1.1 MDAS Hydrology Calibration

The hydrology calibration involved a comparison of model results to in-stream flow observations at selected locations and the subsequent adjustment of hydrologic parameters. Temporal comparisons (daily and monthly) and comparisons of high flows and low flows were developed to support calibration. The calibration involved adjustment of the infiltration, subsurface storage, evapotranspiration, surface runoff, and interception storage parameters. (Tetra Tech, 2002)

After calibration, parameter values were validated for an independent, extended time period (between 1988 and 1998). Validation involved comparison of model results and flow observations without further adjustment of parameters. (Tetra Tech, 2002)

4.1.2 In-stream Chemical Speciation Calibration

Boulder Creek was segmented into 1415 discrete cells. Each cell represents a 10 meter stream segment. Tributaries such as Wilder Creek, Butte Creek, Copper Creek and others flow into the specified cells of Boulder Creek. Each discrete cell required flow, and several chemistry parameters. The flow inputs, upper boundary, tributaries, and tailings pile flows were determined from MDAS. For chemistry inputs, the model required total concentrations of each metal of concern (arsenic, zinc, manganese, copper, beryllium, and lead), alkalinity, atmospheric CO_2 pressure, other relatively conservative chemicals (calcium, magnesium, and sulfate), and the amount of iron which related to hydrous ferric oxide for adsorption. More than one hundred different chemical species were considered. (Tetra Tech, 2002)

The calibration was first conducted for a low flow condition (0.70 cfs). During the calibration, source loading characteristics and in-stream settling rates of metals were adjusted. Once this low flow calibration was complete, the same source loading characteristics and in-stream settling rates were transferred to a different low flow condition (0.80 cfs) for model validation purposes. After calibrating the model for low flow conditions, the high flow conditions (11.6 cfs) sampled by staff were simulated. (Tetra Tech, 2002)

4.2 Critical Condition
The critical condition of Boulder Creek occurs during low flow (0.75 cfs). At, or below, this flow, the concentration of metals in the water column rises. There is also an increase in pH in the immediate vicinity of the sources (Tetra Tech, 2002). During low flow, waters from the adit seepage comprise a significant portion of the flow in Boulder Creek below the source. At higher flows, un-impacted waters provide dilution to the adit discharge and the model shows little to no negative water quality impacts.

4.3 Seasonal Variation
Stream flow in Boulder Creek responds dramatically to seasonal conditions. Flow ranges from spatially interrupted, independent pools in the summer to raging floods in response to large winter or summer monsoon storms. In this study, seasonal variation was considered in the formulation of the modeling analysis. By using low and high flow conditions, seasonal hydrologic and source loading variability was inherently considered (Tetra Tech, 2002). The independent pools which are the remnants of the stream during low flow conditions are not sources of pollutants but act as a sink for those metals during the low flow periods. Calculating the TMDL based on the critical condition will ensure protection of Boulder Creek's designated uses throughout the entire stream reach during all flow regimes.

4.4 Margin of Safety
An implicit MOS was included in TMDL development through application of a dynamic model for simulating daily flows over a wide range of hydrologic conditions, and through the use of conservative assumptions in model calibration and scenario development. In additional to this implicit margin of safety, a 5% explicit MOS was used to account for the difference between modeled and monitored data.

4.5 TMDL Endpoints for Water Quality Modeling
TMDL endpoints represent the in-stream water quality targets. Different TMDL endpoints are necessary for each parameter. Arizona's numeric water quality criteria for metals (Table 2-1) and an explicit margin of safety (MOS) were used to identify endpoints for TMDL modeling. To assure compliance of all applicable water quality standards, the most stringent water quality criteria among the specified use designations (e.g., chronic standards) were selected as TMDL endpoints, which will apply at all times (Tetra Tech, 2002).

4.5.1 Arsenic
The TMDL endpoint for total arsenic was selected as 47.5 μg/L (based on a 50 μg/L criteria for FBC minus a 5% MOS) (Tetra Tech, 2002).

Table 4-1 The Arsenic Endpoint

PARAMETER	MOST STRINGENT STANDARD	TMDL ENDPOINT WQS - 5% MOS
As	50 ug/L for FBC	50 - 2.5 = 47.5 ug/L

4.5.2 Copper and Zinc

The endpoints for dissolved copper and zinc were selected as the hardness-based chronic criteria for the A&Ww use designation minus a 5% MOS (Tetra Tech, 2002). The loading capacity for these two metals will vary throughout the stream because the surface water quality standards for these pollutants vary with hardness (not to exceed 400 mg/L). As noted in Section 4.1, the model calculates simultaneous solutions to mass action and mass balance equations. The model inputs calcium and magnesium values at each segment, and calculates the hardness. The hardness values for each day and reach segment were then averaged and compared to the appropriate calculated water quality standards at that location given the hardness values. As the model is run, it is determining the appropriate surface water quality standard at each segment with the appropriate hardness values. Reductions in loads are based on bringing the concentration levels into conformance with surface water quality standards throughout the listed reach. Based on the ADEQ sampling data collected for this TMDL, the in-stream hardness for the entire reach from Wilder Creek to Burro Creek, averaged 225 mg/l as $CaCO_3$. This average hardness value is used below *to illustrate* the loading for each pollutant on Boulder Creek. [Note: These tables are *for illustration purposes only*. The final TMDL values presented in Table 4-6 are based on the dynamic modeling which accounts for ongoing changes throughout the stream].

Table 4-2 Copper and Zinc Endpoints

PARAMETER	MOST STRINGENT STANDARD (based on hardness = 225 mg/l)	TMDL ENDPOINT Chronic WQS - 5% MOS
Cu	A&W warm, chronic = 17.91 ug/l	17.91 - 0.90 = 17.01 ug/l
Zn	A&W warm, chronic = 232.9 ug/l	232.9 - 11.64 = 221.26 ug/l

4.5.3 Loading Capacity

Using the TMDL endpoints identified in the sections above and the critical flow of 0.75 cfs, the loading capacity per pollutant can be calculated. The TMDL endpoint and the loading capacities, per pollutant are shown in Table 4-3, after applying a unit conversion factor. As noted in section 4.5.2, the values are presented *for illustration purposes* based on an average in-stream hardness value of 225 mg/L. The actual load allocations, presented in section 4.7, are based on the modeling results which simulated varying hardness values and calculated appropriate SWQS based on those values.

Table 4-3 An Illustration of the Loading Capacity per Pollutant at Critical Flow

PARAMETER	TMDL ENDPOINT	LOADING CAPACITY
As	47.5 ug/l	87.03 g/day
Cu	17.01 ug/l	31.19 g/day *
Zn	221.26 ug/l	405.75 g/day *

***** Average stream hardness was used for Cu and Zn calculations**.**

4.6 Allocations and TMDLs

As discussed in section 3.1, ADEQ proposes to remove all pollutants on the 303(d) list from that portion of Boulder Creek below Copper Creek as the data collected in support of this TMDL shows insufficient signs to warrant those pollutants remaining on the 303(d) List.

The following allocations are for arsenic from Wilder Creek to Copper Creek and for copper and zinc from Wilder Creek to Butte Creek. These allocations were based on the model results which looked at reductions of all the pollutants simultaneously in order to meet the appropriate surface water quality standards. To conduct a strict arithmetic exercise, on a per-pollutant basis, to try and meet surface water quality standards may result in slightly different reduction values. It should also be noted that remediation strategies for the sources (i.e., moving and/or capping the tailings piles) will likely address all pollutants simultaneously rather than on a pollutant specific basis. Applying the reduction values to all pollutants at each source will assure that all parameters will meet the appropriate water quality standards.

4.6.1 Wasteload Allocations

In the model, the flow from the adit was represented conceptually as a constant 5 gpm. The existing loadings for each metal are presented in Table 3-4. Table 4-4 shows the WLAs. The WLAs are presented as daily loads, in terms of grams per day (Tetra Tech, 2003).

Table 4-4 WLAs (g/day)-Adit Discharge

As	Cu	Zn	Reduction (%) from Existing Loadings
24.6	0.1	8.6	85

4.6.2 Load Allocations

The daily load allocations (LA) for each metal are presented in Table 4-5 in terms of grams per day (Tetra Tech, 2003). Load allocations apply to flows at, or below, the critical condition of 0.75 cfs. At higher flows, un-impacted waters provide dilution and there is little to no negative water quality impacts. Since concentration data from precipitation-induced washoff from the tailings piles are not available, these values were adjusted based on source loading characteristic variables in the model. ADEQ has placed the tailings piles in the LA portion of the TMDL. If, upon further investigation, it turns out the piles will require point source permitting, the allocations would shift to the WLA column, but the overall TMDL numbers would not change.

Table 4-5 Load Allocations (g/day) for Tailings Piles

	As	Cu	Zn	Average Reduction (%) from Existing Loadings
Upper Tailings Pile	9.5	13.5	133.3	78
Middle Tailings Pile	*	*	1.7	40
Lower Tailings Pile	*	*	97.7	55

* Allocations are not necessary.

4.6.3 Boulder Creek TMDL

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL contains a 5% explicit MOS (discussed in section 4.4) to account for differences between modeled and monitored data. Conceptually, this definition is denoted by the equation:

$$TMDL = 3WLA + 3LA + MOS$$

The TMDLs for Boulder Creek identify the total amount of pollutant that can be assimilated by the receiving system while still achieving water quality standards. These TMDLs are for copper and zinc from Wilder Creek to Butte Creek and for arsenic from Wilder Creek to Copper Creek (Tetra Tech, 2003).

Table 4-6 Boulder Creek TMDLs

	Wilder Creek to Butte Creek		Wilder Creek to Copper Creek
	Cu (g/day)	Zn (g/day)	As (g/day)
LA	37.2	264.3	19.1
WLA	0.1	8.6	24.6
MOS	1.8	13.6	2.2
TMDL	39.1	286.5	45.9

5 IMPLEMENTATION

In September 1999, AMEC Earth & Environmental (AMEC), in cooperation with the BLM, conducted a site characterization of the mine tailings and adit seep (AGRA, 2000). BLM used the data obtained from the site characterization to prepare an Engineering Evaluation/Cost Analysis (EE/CA) of the upper site (BLM, 2000). Due to the proximity of the middle tailings pile to the upper site, BLM included the middle tailings pole in their initial remediation plans. The lower pile was not considered, at the time, due to accessibility issues. The EE/CA provided an alternatives analysis for remedial actions at the sites.

During a meeting in February, 2001, representatives from EPA's Emergency Response Office clarified their intent to assist BLM with the project. EPA was willing to provide financial assistance to manage the project under CERLA, if necessary, and take enforcement action against the private owners of the middle tailings pile. By September, 2001, the EE/CA was finalized and the chosen remedial action was to leave both the upper and middle tailings piles in place, re-grade them and cap in place (AMEC, 2001b). Although there are site accessibility issues, the remedy for the lower tailings pile would be similar – re-grade and cap the pile and install runon/runoff controls to prevent degradation of the capping material through subsequent erosion.

About this time, KFX, owners of the middle tailings pile, submitted to EPA a mining and remediation proposal for their site. KFX proposed to excavate the tailings, process them, redeposit the materials and cap them. EPA stipulated that KFX would have to enter a three party agreement with EPA and BLM, post adequate financial surety and complete the process within 15 months. BLM put its project on hold pending resolution of the KFX proposal. KFX has since rescinded the proposal to reprocess the tailings piles.

In September, 2003, staff from BLM, ADEQ, ASLD, and AMEC visited all three sites to discuss the remediation strategies for the piles as well as the adit. The best strategy for all three tailings piles remains to re-grade and cap the piles and stabilize the slopes. The adit discharge could be addressed with an evaporation pond equipped with a solar powered lift station. Access to the lower pile is currently by foot. In order to bring in the heavy equipment needed, either a road would have to be cut in from the mesa above the stream or equipment could be airlifted in by helicopter.

In November, 2003, BLM offered to fund complete engineering design for the middle and lower tailing piles in exchange for a coordinated cleanup by all parties. ADEQ is committed to providing 319 funding to assist in the cleanup and is working closely with ASLD to develop the necessary match using state resources and private contributions. ADEQ continues to try and work with KFX by exploring match opportunities for remediation of the middle tailings pile and by encouraging KFX to pursue an AZPDES permit for the adit discharge. ADEQ may pursue an enforcement action if a permit is not acquired and the discharge remains in violation of surface water quality standards.

6 MONITORING

ADEQ intends to conduct follow-up monitoring five years after the approval of this TMDL. ADEQ continues to work in the area in support of the Alamo Lake mercury TMDL and possibly other metals TMDLs attributable to historic mining in the area. Once the Hillside Mine tailings piles are re-graded and capped, further monitoring will help assess the effectiveness of implemented remediation strategies.

7 PUBLIC PARTICIPATION

Stakeholder and public participation was encouraged and received throughout the development of this TMDL. Numerous meetings have been held during this process. Involved parties include EPA, BLM, US Army Corps of Engineers, ADEQ, ASLD, Arizona Game and Fish Department, KFX, Phelps Dodge, and representatives from contractors involved with all levels of the projects mentioned previously. The draft TMDL report was made available for a 30-day public comment period starting July 12, 2002. Public notice of the availability of the draft document was made via a posting in a newspaper of general circulation *The Daily Courier*; via email notifications; via phone calls; and via webpage postings. The draft Boulder Creek TMDL was presented in a public meeting in Bagdad, AZ, on July 23, 2002. Comments received during the public notice period were addressed in a public notice posted in the Arizona Administrative Register (A.A.R.) on October 25, 2002. After the 45-day public comment period following the A.A.R. notice was completed, the EPA encouraged ADEQ to re-model the loads and allocations based on the new water quality standards which were approved by the EPA on November 13, 2002. This report presents the findings of the re-modeled loads and allocations. A 30-day public comment period for the re-drafted report began on June 2, 2003 and was completed July 1, 2003. This draft will now be submitted to the A.A.R. and a 45-day public comment period will follow the notice. After completion of the 45-day public comment period, this report will be submitted to the EPA for final approval. Responses to questions and comments received during the public notice phase will be submitted to the EPA with this report.

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APPENDIX A
TMDL PROGRAM SAMPLING DATA

Site ID: A	Topo Quad:	Grayback Mtn	Lat:	34 36 46.322	Long:	113 14 56.695
Sample Date	30 November 2000	4 January 2001	28 February 2001	28 March 2001	24 April 2001	23 May 2001
TDS mg/l	438	466	67	220	307	330
TSS mg/l	<1	<1	146	1	<1	<1
Hardness mg/l	255	320	60	168	126	217
As(T) µg/l	16	15	19	25	17	14
As(D) µg/l	17	13	7	28	15	13
Be(T) µg/l	<2	<2	<2	<2	<2	<2
Be(D) µg/l	<2	<2	<2	<2	<2	<2
Cu(T) µg/l	<15	<15	36	<15	<15	<15
Cu(D) µg/l	<15	<15	<15	<15	<15	<15
Pb(T) µg/l	<5	<5	34	<5	<5	<5
Pb(D) µg/l	<5	<5	<5	<5	<5	<5
Mn(T) µg/l	40	30	510	50	<20	<20
Mn(D) µg/l	40	20	<20	50	<20	<20
Zn(T) µg/l	<20	<60	270	20	<20	Error
Zn(D) µg/l	<20	<20	30	<20	<20	<20
Sulfate mg/l			13.9	8.6	55	68
A&Ww						
WQS(D)						
As	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3
Cu	20	24	6	14	11	17
Mn	10000	10000	10000	10000	10000	10000
Pb	7	9	1.4	4.4	3.2	6
Zn	259	314	76	76	143	226
Date	30-Nov-00	04-Jan-01	28-Feb-01	28-Mar-01	24-Apr-01	23-May-01
Time	1115	1000	945	915	815	800
Q (cfs)	0.696	0.79		5.667	2.533	0.483
Q(gpm)	312	355		2544	1137	217
MGD	0.450	0.511		3.663	1.637	0.312
pH	7.92		7.35	7.6	7.42	7.12
Tw(ºC)	10.33	6.14	7.69	14.54	15.65	20.87
Tw(ºF)	50.59	43.05	45.84	58.17	60.17	69.57
SpecCon	649.2	795.7	85.7	472.1	589.3	638
DO mg/l	7.69		10.54	8.6	8.39	3.94
DO%	105.1		98.8	91.1	100.02	48
ORP	366	462	492	362	326	270

Site ID: B	Topo Quad:	Bagdad	Lat:	34 36 26.369	Long:	113 13 54.452	
Sample Date	30 November 2000	4 January 2001	31 January 2001	28 February 2001	28 March 2001	24 April 2001	23 May 2001
TDS mg/l	331	368	128	81	183	296	484
TSS mg/l	<1	<1	<1	32	1	<1	<1
Hardness mg/l	187	242	60	60	73	115	155
As(T) µg/l	44	**52**	18	11	39	48	29
As(D) µg/l	42	**50**	19	6	36	45	27
Be(T) µg/l	<2	<2	<2	<2	<2	<2	<2
Be(D) µg/l	<2	<2	<2	<2	<2	<2	<2
Cu(T) µg/l	<15	<15	<15	17	<15	<15	<15
Cu(D) µg/l	<15	<15	<15	<15	<15	<15	<15
Pb(T) µg/l	<5	<5	<5	6	<5	<5	<5
Pb(D) µg/l	<5	<5	<5	<5	<5	<5	<5
Mn(T) µg/l	50	30	30	150	30	<20	20
Mn(D) µg/l	40	30	20	20	20	<20	<20
Zn(T) µg/l	40	<60	60	90	30	<20	Error
Zn(D) µg/l	20	20	50	30	<20	<20	<20
Sulfate mg/l			20.1	12.2	34.9	54	138
A&Ww							
WQS(D)							
As	50	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Cu	15	19	6	6	7	10	13
Mn	10000	10000	10000	10000	10000	10000	10000
Pb	5	6.5	1.4	1.4	1.8	3	4
Zn	199	248	76	76	90	132	170
Date	30-Nov-00	04-Jan-01	31-Jan-01	28-Feb-01	28-Mar-01	24-Apr-01	23-May-01
Time	1645	1430	1230	1530	1300	1130	1400
Q (cfs)	0.956						
pH	8.07		7.69	6.64	8.16	8.31	7.87
Tw(ºC)	11.94	9.12	6.06	7.22	19.92	21.2	31.6
Tw(ºF)	53.49	48.42	42.91	45.00	67.86	70.16	88.88
SpecCon	495.9	659.6	200.1	92	339.6	588.4	847.3
DO mg/l	9.93		11.65	10.73	8.51	8.43	10.42
DO%	101.5		102.5	98.6	101.5	112.7	157
ORP	357	453	394	480	357	258	236

Site ID: E	**Topo Quad:**	Bagdad	**Lat:**	34 36 50.847	**Long:**	113 13 11.501
Sample Date	30 November 2000	4 January 2001	31 January 2001	28 February 2001	28 March 2001	24 April 2001
TDS mg/l	273	328	118	100	139	268
TSS mg/l	2	<1	<1	36	<1	<1
Hardness mg/l	153	118	57	60	106	100
As(T) µg/l	**58**	**72**	16	11	47	**76**
As(D) µg/l	**52**	**68**	16	<5	51	73
Be(T) µg/l	<2	<2	<2	<2	<2	<2
Be(D) µg/l	<2	<2	<2	<2	<2	<2
Cu(T) µg/l	<15	<15	<15	<15	<15	<15
Cu(D) µg/l	<15	<15	<15	<15	<15	<15
Pb(T) µg/l	<5	<5	<5	<5	<5	<5
Pb(D) µg/l	<5	<5	<5	<5	<5	<5
Mn(T) µg/l	90	60	40	160	90	50
Mn(D) µg/l	80	60	30	20	70	50
Zn(T) µg/l	100	70	70	70	60	50
Zn(D) µg/l	70	50	60	<20	40	50
Sulfate mg/l			15.2	11.3	17.7	31.2
A&Ww						
WQS(D)						
As	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3
Cu	13	10	6	6	9	9
Mn	10000	10000	10000	10000	10000	10000
Pb	4	3	1.4	1.4	2.7	2.5
Zn	168	135	73	76	123	117
Date	30-Nov-00	04-Jan-01	31-Jan-01	28-Feb-01	28-Mar-01	24-Apr-01
Time	1530	1345	1145	1345	1145	1045
Q (cfs)	1.192					
pH	7.92		7.16	7.5	7.97	8.16
Tw(ºC)	11.22	10	5.36	6.73	19.3	20.33
Tw(ºF)	52.20	50.00	41.65	44.11	66.74	68.59
SpecCon	415.1	586	180.6	92.3	293.9	511.8
DO mg/l			11.45	10.92	8.03	9.3
DO%			99.1	99.5	95	122.2
ORP	366	303	404	438	310	275

Site ID: G	Topo Quad:	Bozarth Mesa	Lat:	34 37 32.971	Long:	113 12 57.431	
Sample Date	30 November 2000	3 January 2001	30 January 2001	27 February 2001	27 March 2001	25 April 2001	22 May 2001
TDS mg/l	304	326	122	58	148	265	338
TSS mg/l	<1	<1	<1	9	<1	<1	<1
Hardness mg/l	175	211	55	52	103	100	106
As(T) µg/l	**57**	**63**	11	<5	31	**74**	**66**
As(D) µg/l	50	60	12	<5	32	72	66
Be(T) µg/l	<2	<2	<2	<2	<2	<2	<2
Be(D) µg/l	<2	<2	<2	<2	<2	<2	<2
Cu(T) µg/l	<15	<15	<15	<15	16	<15	<15
Cu(D) µg/l	<15	<15	<15	<15	<15	<15	<15
Pb(T) µg/l	<5	<5	<5	<5	<5	<5	<5
Pb(D) µg/l	<5	<5	<5	<5	<5	<5	<5
Mn(T) µg/l	260	260	60	50	110	100	70
Mn(D) µg/l	260	210	40	<20	100	90	50
Zn(T) µg/l	240	190	80	30	110	140	Error
Zn(D) µg/l	180	140	60	<20	60	90	**190**
Sulfate mg/l			16.2	12.8	15	28.4	91
A&Ww							
WQS (D)							
As	50	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Cu	14	17	5	5	9	9	9
Mn	10000	10000	10000	10000	10000	10000	10000
Pb	4.6	5.6	1.3	1.2	2.6	2.5	2.7
Zn	188	221	71	67	120	117	123
Date	30-Nov-00	03-Jan-01	30-Jan-01	27-Feb-01	27-Mar-01	25-Apr-01	22-May-01
Time	1615	1030	0930	1100	1045	945	1145
Q (cfs)	0.983	0.960	15.680		3.751	1.154	0.158
Q(gpm)	441	431	7038		1684	518	71
MGD	0.635	0.620	10.134		2.424	0.746	0.102
pH	7.55	7.04	6.95	7.35	7.77	8.35	7.51
Tw(ºC)		5.54	4.93	7.17	16.01	18.53	24.91
Tw(ºF)		41.97	40.87	44.91	60.82	65.35	76.84
SpecCon	455.7	569.6	167.3	95.1	272.1	507.4	635.9
DO mg/l			11.13	10.61	7.68	8.17	5.86
DO%			89.9	98	86.6	103.7	80.1
ORP	318	699	371	513	385	227	268

Site ID: H		Topo Quad:	Bozarth Mesa	Lat:	34 37 57.904	Long:	113 12 42.161						
Sample Date	29-Nov-00	03-Jan-01	30-Jan-01	27-Feb-01	27-Mar-01	25-Apr-01	22-May-01	26-Jun-01	18-Jul-01	15-Aug-01	28-Aug-01	2 November 2001	31 December 2001
TDS mg/l	305	336	116	71	145	233	432	1500	1520	986	1740	1670	444
TSS mg/l	<1	<1	<1	10	<1	<1	2	14	<1	13	2	2	<1
Hardness mg/l	179	216	55	52	106	100	163	1010	1090	320	961	1084	276
As(T) µg/l	**55**	**67**	9	<5	28	**79**	39	**188**	**223**	**256**	**250**	**287**	**73**
As(D) µg/l	45	56	9	<5	29	75	25	116	138	70	136	96	46
Be(T) µg/l	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Be(D) µg/l	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Cu(T) µg/l	16	<15	<15	<15	<15	<15	<15	<15	<15	30	<10	<10	150
Cu(D) µg/l	<15	<15	<15	<15	<15	<15	<15	<15	<15	20	<10	<10	**80**
Pb(T) µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<50	<5	<10
Pb(D) µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<20	<5	<5
Mn(T) µg/l	310	180	50	40	120	230	1160	2580	2120	**10700**	**11800**	6870	700
Mn(D) µg/l	290	280	40	<20	120	220	1110	2370	2280	9940	12000	6540	620
Zn(T) µg/l	220	220	70	30	110	110	Error	260	200	6820	2400	780	1790
Zn(D) µg/l	150	140	60	<20	60	50	90	170	180	**4460**	**2340**	**700**	**1370**
Sulfate mg/l			14.6	14	14.9	23.9	154	960	1040	242	965	965	74.2
A&Ww													
WQS (D)													
As	50	50	50	50	50	50	50	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Cu	15	17	5	5	9	9	14	29	29	24	29	29	21
Mn	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Pb	4.7	5.8	1.3	1.2	2.7	2.5	4.3	11	11	8.7	11	11	7.5
Zn	192	225	71	67	123	117	177	379	379	314	379	379	272
Date	29-Nov-00	03-Jan-01	30-Jan-01	27-Feb-01	27-Mar-01	25-Apr-01	22-May-01	26-Jun-01	18-Jul-01	15-Aug-01	28-Aug-01	02-Nov-01	31-Dec-01
Time	1715	1130	1030	1230	1145	1030	1045	930	820	1600	1130	1030	1125
Q (cfs)	0.773	0.847	11.601		3.357	1.125	0.113	0.013	0.011	0.134	0.012	0.012	
Q(gpm)	347	380	5207		1507	505	51	5.83	4.94	60.00	5.23	5.17	
MGD	0.500	0.547	7.498		2.170	0.727	0.073	0.008	0.007	0.087	0.008	0.008	
pH	7.78	8.26?	7.23	7.55	7.84	8.26	7.4	7.57	7.77	7.76		7.35	8.29
Tw(ºC)		6.54	4.75	7.62	16.43	18.8	23.95	23.78	24.13	29.77	28.21	15.05	8.7
Tw(ºF)		43.77	40.55	45.72	61.57	65.84	75.11	74.80	75.43	85.59	82.78	59.09	47.66
SpecCon	468.6	555	165.9	93.8	281.1	518.3	800.2	2259	2379	1175	1794	2111	765.7
DO mg/l			11.5	10.42	7.75	8.59	8.14	6.1	7.15	7.02	6.68	7.81	
DO%			92.5	97.1	88	114.2	107.6	76	93.1	92.9	95.9	85.3	
ORP	313	657	359	438	332	265	255	250	325		425		

Note: These samples were taken from a seep emanating from a collapsed adit at the middle tailings pile. These were not taken from Boulder Creek.

Site ID: I		Topo Quad:	Bozarth Mesa	Lat:	34 37 59.941	Long:	113 12 38.886					
Sample Date	29-Nov-00	03-Jan-01	30-Jan-01	27-Feb-01	27-Mar-01	25-Apr-01	22-May-01	26-Jun-01	18-Jul-01	15-Aug-01	28-Aug-01	2-Nov-01
TDS mg/l	1510	1260	1360	1180	1120	1190	1220	1370	1570	1390	1530	1500
TSS mg/l	78	60	23	18	32	4	6	2	4	69	34	114
Hardness mg/l	909	902	897	1049	989	593	587	961	895	942	981	969
As(T) µg/l	6100	4650	3640	3140	6100	5440	5360	6670	4840	7210	5480	10800
As(D) µg/l	**3120**	**2540**	**3380**	**2160**	**3980**	**4960**	**5360**	**6280**	**4550**	**4810**	**4440**	**3180**
Be(T) µg/l	5	5	5	6	6	5	6	6	4	5	6	8
Be(D) µg/l	4	5	5	4	**6**	**6**	**6**	5	5	5	5	5
Cu(T) µg/l	< 15	<15	<15	<15	<15	<15	<15	<15	<15	< 10	<10	10
Cu(D) µg/l	<15	<15	<15	<15	<15	<15	<15	<15	<15	< 10	<10	<10
Pb(T) µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<10	24	<25	15
Pb(D) µg/l	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Mn(T) µg/l	14800	13100	12420	13900	15800	14520	13700	12400	12400	15700	12200	10300
Mn(D) µg/l	**13800**	**13700**	**14300**	**13600**	**15700**	**14370**	**12850**	**12800**	**13800**	**13000**	**11700**	**11400**
Zn(T) µg/l	2140	1820	1740	1920	2510	2320	2180	1900	1660	2000	1850	1590
Zn(D) µg/l	**1710**	**1750**	**1710**	**1590**	**2480**	**2240**	**1880**	**1740**	**1860**	**1900**	**1880**	**1240**
Sulfate mg/l			895	765	885	865	940	895	935	875	1030	905
A&Ww												
WQS (D)												
As	50	50	50	50	50	50	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Cu	29	29	29	29	29	29	29	29	29	29	29	29
Mn	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Pb	11	11	11	11	11	11	11	11	11	11	11	11
Zn	379	379	379	379	379	379	379	379	379	379	379	379
Date	29-Nov-00	03-Jan-01	30-Jan-01	27-Feb-01	27-Mar-01	25-Apr-01	22-May-01	26-Jun-01	18-Jul-01	15-Aug-01	28-Aug-01	02-Nov-01
Time	1730	1215	1145	1300	1230	1115	1230	1115	1110	1700	1430	1130
Q (cfs)								0.011				0.009
Q(gpm)								4.90				4.22
pH	6.69			6.94	5.6	6	6	5.74	6.42	6.05	6.32	5.88
Tw(ºC)				20.42	22	25.77	26.4	23.89	24.11	26.48	24.8	23.24
Tw(ºF)				68.76	71.60	79.39	79.52	75.00	75.40	79.66	76.64	73.83
SpecCon	1697			1989	2012	2007	1923	2067	2080	2161	2059	1960
DO mg/l				5.82	1.02	0.72	2.79	2.41	4.85		3.5	0.51
DO%				72	12.8	9.9	38.5	30	64		47.2	5.3
ORP	175			179	228	172	59	35	149	84		

Site ID: J	Topo Quad:	Bozarth Mesa	Lat:	34 38 04.369	Long:	113 12 38.542
Sample Date	29 November 2000	3 January 2001	30 January 2001	27 February 2001	27 March 2001	22 May 2001
TDS mg/l	271	309	129	84	146	261
TSS mg/l	<1	<1	<1	7	<1	1
Hardness mg/l	168	200	55	52	103	90
As(T) µg/l	21	18	5	<5	9	34
As(D) µg/l	13	15	<5	<5	9	32
Be(T) µg/l	<2	<2	<2	<2	<2	<2
Be(D) µg/l	<2	<2	<2	<2	<2	<2
Cu(T) µg/l	18	<15	<15	<15	<15	<15
Cu(D) µg/l	<15	<15	<15	<15	<15	<15
Pb(T) µg/l	<5	<5	<5	17	<5	<5
Pb(D) µg/l	<5	<5	<5	<5	<5	<5
Mn(T) µg/l	120	60	30	70	50	40
Mn(D) µg/l	100	50	20	<20	50	30
Zn(T) µg/l	210	160	60	30	60	Error
Zn(D) µg/l	150	120	50	<20	40	20
Sulfate mg/l			12.5	15.8	10.4	24.8
A&Ww						
WQS (D)						
As	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3
Cu	14	16	5	5	9	8
Mn	10000	10000	10000	10000	10000	10000
Pb	4.4	5.3	1.3	1.2	2.6	2.2
Zn	182	211	71	67	120	107
Date	29-Nov-00	03-Jan-01	30-Jan-01	27-Feb-01	27-Mar-01	22-May-01
Time	1800	1315	1145	1315	1300	1315
pH	7.82	7.81		7.75	7.17	7.83
Tw(ºC)		8.01		8.17	16.7	24.9
Tw(ºF)		46.42		46.71	62.06	76.82
SpecCon	445.2	530.4		90.2	275.6	567.9
DO mg/l				10.03	7.58	7.49
DO%				95	86.4	100.9
ORP	219	647		390	336	245

Site ID: JJ	Topo Quad:	Bozarth Mesa	Lat:	34 38 17.7	Long:	113 12 40.6
Sample Date	25 April 2001	22 May 2001	15 August 2001	31 December 2001		
TDS mg/l	237	319	2600	410		
TSS mg/l	<1	<1	11	7		
Hardness mg/l	95	103	1064	231		
As(T) µg/l	14	22	**58**	15		
As(D) µg/l	9	22	<25	11		
Be(T) µg/l	<2	<2	12	<2		
Be(D) µg/l	<2	<2	13	<2		
Cu(T) µg/l	<15	19	15200	140		
Cu(D) µg/l	<15	<15	**14400**	**80**		
Pb(T) µg/l	<5	<5	<5	<5		
Pb(D) µg/l	<5	<5	<5	<5		
Mn(T) µg/l	30	30	**23400**	**310**		
Mn(D) µg/l	20	<20	21600	290		
Zn(T) µg/l	100	Error	**129000**	1170		
Zn(D) µg/l	70	60	**115000**	**900**		
Sulfate mg/l	11.7	39	1780	46		
A&Ww						
WQS (D)						
As	50	50	50	50		
Be	5.3	5.3	5.3	5.3		
Cu	9	9	29	18		
Mn	10000	10000	10000	10000		
Pb	2.4	2.6	11	6.2		
Zn	112	120	379	238		
Date	25-Apr-01	22-May-01	15-Aug-01	31-Dec-01		
Time	1200	1430	1519	1050		
pH	7.9	8.02	3.71	8.07		
Tw(ºC)	21.55	29.4	28.98	8.58		
Tw(ºF)	70.79	84.92	84.16	47.44		
SpecCon	488	609	3046	710.8		
DO mg/l	8.59	7.19	5.48			
DO%	115.7	105.3	72			
ORP	219	241				

Site ID: L	Topo Quad:	Bozarth Mesa	Lat:	34 38 18.030	Long:	113 12 20.258
Sample Date	26 October 2000	29 November 2000	3 January 2001	30 January 2001		
TDS mg/l		273	302	100		
TSS mg/l		ND	<1	<1		
Hardness mg/l	230	174	191	55		
As(T) µg/l	11	9	10	<5		
As(D) µg/l	ND	9	9	<5		
Be(T) µg/l	ND	<2	<2	<2		
Be(D) µg/l	ND	<2	<2	<2		
Cu(T) µg/l	ND	<15	<15	<15		
Cu(D) µg/l	ND	<15	<15	**<15**		
Pb(T) µg/l	ND	<5	<5	<5		
Pb(D) µg/l	ND	<5	<5	<5		
Mn(T) µg/l	ND	40	30	<20		
Mn(D) µg/l	ND	30	20	<20		
Zn(T) µg/l	ND	<20	<60	<20		
Zn(D) µg/l	ND	<20	<20	<20		
Sulfate mg/l				10.8		
A&Ww						
WQS (D)						
As	50	50	50	50		
Be	5.3	5.3	5.3	5.3		
Cu	18	14	16	5		
Mn	10000	10000	10000	10000		
Pb	6.2	4.6	5.1	1.3		
Zn	237	187	203	71		
Date	26-Oct-00	29-Nov-00	03-Jan-01	30-Jan-01		
Time	1630	1230	1400	1315		
Q (cfs)		0.754				
pH		7.59		7.16		
Tw(ºC)		9.24		6.14		
Tw(ºF)		48.63		43.05		
Ta						
SpecCon		451		156.9		
DO mg/l		8.68		10.6		
DO%		84		88.5		
ORP		349		322		

Site ID: M	Topo Quad:	Bozarth Mesa	Lat:	34 38 25.976	Long:	113 12 18.245	
Sample Date	29 November 2000	3 January 2001	30 January 2001	27 March 2001	25 April 2001	22 May 2001	31 December 2001
TDS mg/l	325	323	207	225	272	285	356
TSS mg/l	<1	<1	<1	1	<1	<1	<1
Hardness mg/l	199	205	114	169	95	83	246
As(T) µg/l	8	11	12	10	9	10	9
As(D) µg/l	9	10	14	13	7	9	11
Be(T) µg/l	<2	<2	<2	<2	<2	<2	<2
Be(D) µg/l	<2	<2	<2	<2	<2	<2	<2
Cu(T) µg/l	<15	<15	<15	<15	<15	<15	<20
Cu(D) µg/l	<15	<15	<15	<15	<15	<15	<10
Pb(T) µg/l	<5	<5	<5	<5	<5	<5	<5
Pb(D) µg/l	<5	<5	<5	<5	<5	<5	<5
Mn(T) µg/l	<20	<20	<20	<20	<20	<20	<20
Mn(D) µg/l	<20	<20	<20	<20	<20	<20	<20
Zn(T) µg/l	<20	<60	<20	60	<20	Error	<20
Zn(D) µg/l	<20	<20	<20	<2	<20	<20	<20
Sulfate mg/l			**6.9**	**8**	**6.9**	**<5**	**12.3**
A&Ww							
WQS (D)							
As	50	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Cu	16	17	10	14	9	8	19
Mn	10000	10000	10000	10000	10000	10000	10000
Pb	5.3	5.5	2.9	4.4	2.4	2.1	6.6
Zn	210	215	131	183	112	100	251
Date	29-Nov-00	03-Jan-01	30-Jan-01	27-Mar-01	25-Apr-01	22-May-01	31-Dec-01
Time	1130	1515	1430	1430	1330	1545	911
Q (cfs)	0.862	1.33	2.3	0.873	0.279	0.094	0.371
Q (gpm)	387	597	1032	392	125	42	166.67
MGD	0.557	0.860	1.487	0.564	0.180	0.061	0.240
pH	7.87		7.8	8.02	8.6	8.21	7.79
Tw(ºC)	10.38	7.72	6.76	16.88	20.67	28.4	8.52
Tw(ºF)	50.68	45.90	44.17	62.38	69.21	83.12	47.34
SpecCon	530.4	544.3	363.6	441.2	533	568.7	606.5
DO mg/l	10.23		11.03	9.11	10.67	8.5	
DO%	101		93.1	104.3	140.8	122.2	
ORP	331	543	291	293	189	248	

Site ID: N	Topo Quad:	Bozarth Mesa	Lat:	34 35 26.704	Long:	113 12 06.502		
Sample Date	29 November 2000	3 January 2001	30 January 2001	27 February 2001	27 March 2001	25 April 2001	22 May 2001	31 December 2001
TDS mg/l	147	207	88	66	92	155	288	394
TSS mg/l	ND	<1	<1	17	2	<1	<1	3
Hardness mg/l	75	123	37	47	67	75	128	172
As(T) µg/l	<5	<5	<5	<5	<5	<5	<5	<5
As(D) µg/l	<5	<5	<5	<5	<5	<5	<5	<5
Be(T) µg/l	<2	<2	<2	<2	<2	<2	<2	<2
Be(D) µg/l	<2	<2	<2	<2	<2	<2	<2	<2
Cu(T) µg/l	<15	<15	<15	<15	<15	<15	<15	<20
Cu(D) µg/l	<15	<15	<15	<15	<15	<15	<15	<10
Pb(T) µg/l	<5	<5	<5	<5	<5	<5	<5	<5
Pb(D) µg/l	<5	<5	<5	<5	<5	<5	<5	<5
Mn(T) µg/l	30	<20	<20	50	30	<20	70	<20
Mn(D) µg/l	30	<20	<20	<20	30	<20	60	<20
Zn(T) µg/l	<20	<60	<20	30	20	<20	Error	Possible error 140
Zn(D) µg/l	<20	<20	<20	<20	<20	<20	<20	<20
Sulfate mg/l			13.4	10.6	9.3	6.9	<5	47.4
A&Ww								
WQS (D)								
As	50	50	50	50	50	50	50	50
Be	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Cu	7	11	4	5	6	7	11	14
Mn	10000	10000	10000	100000	10000	10000	10000	10000
Pb	1.8	3.2	0.84	1.1	1.6	1.8	3.3	4.5
Zn	92	140	57	62	84	93	144	182
Date	29-Nov-00	03-Jan-01	30-Jan-01	27-Feb-01	27-Mar-01	25-Apr-01	22-May-01	31-Dec-01
Time	1015	1430	1345	1515	1515	1415	1600	935
Q (cfs)	0.32	0.217	9.317		1.869	1	0.01	0.129
Q (gpm)	144	97	4182		839	449	4	58
MGD	0.207	0.140	6.022		1.208	0.646	0.006	0.083
pH	6.75	6.67	7.15	7.57	7.56	7.56	7.4	7.89
Tw(ºC)	8.75	8.92	5.26	7.71	17.6	25.42	32.37	8.13
Tw(ºF)	47.75	48.06	41.47	45.88	63.68	77.76	90.27	46.63
SpecCon	217.2	342.6	108.8	62.2	185.3	338.1	545.7	684.8
DO mg/l	9.16		10.7	10.12	7.54	8.39	6.93	
DO%	87.4		87	94.7	87.8	121.6	105.4	
ORP	308	685	333	470	311	248	272	

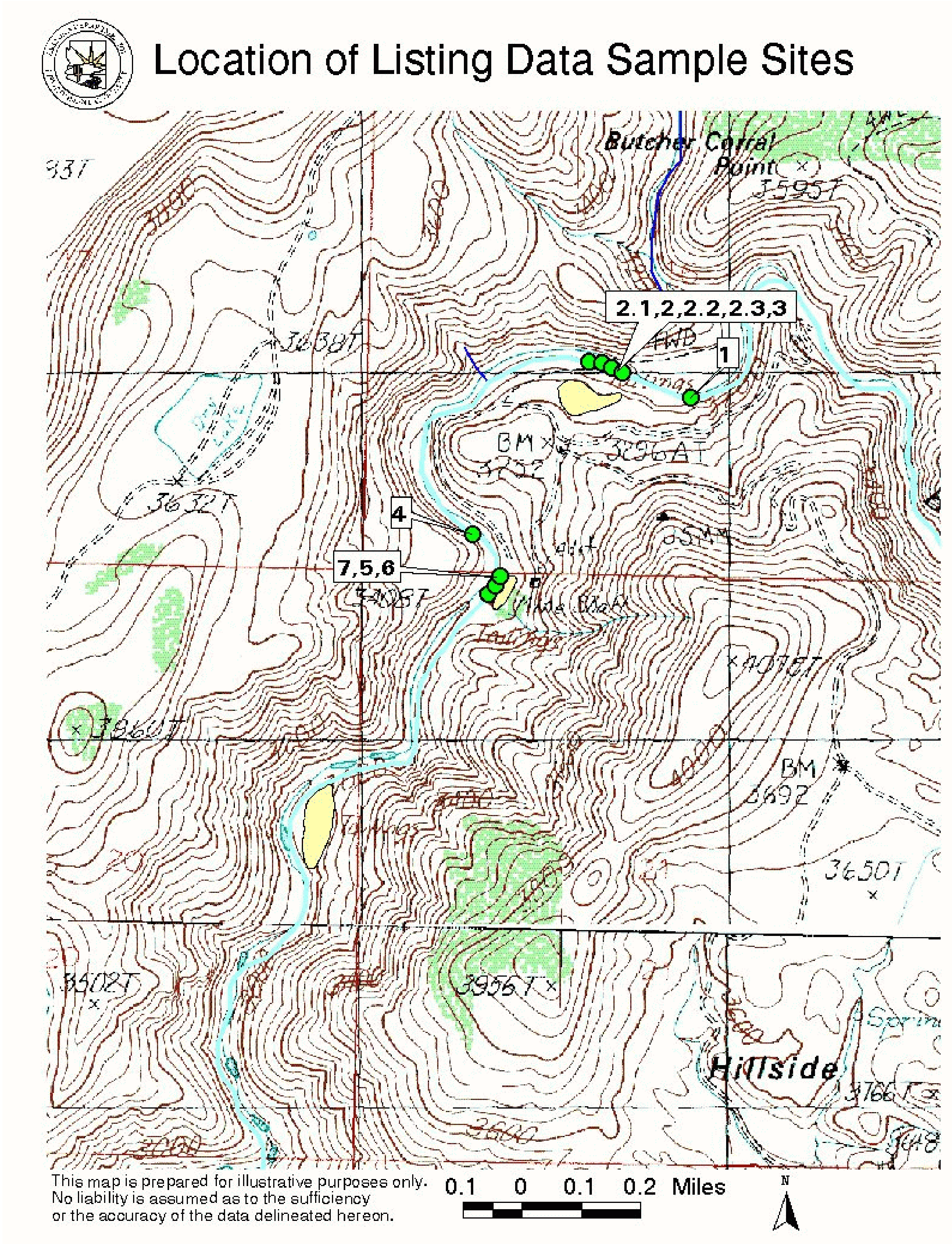
APPENDIX B
SUMMARY OF LISTING DATA

SUMMARY OF LISTING DATA-October 22, 1992[1]

SITE ID	Be, T Fg/L		Zn, T Fg/L		Zn, D[2] Fg/L		As, T Fg/L		As, D Fg/L		Pb, T Fg/L		Mn, T Fg/L		Cu, D[2] Fg/L	
	value	std	value	std	value	std	value	std	value	std	value	std	value	std	value	std
#2.1	0.8	0.21 FC	17300	10000 AgI	1700	(591)[3] 527									155	(591)[3] 95
#2.2			14300	10000 AgI	13100	(591)[3] 527										
#2	0.9	0.21 FC			7570	(591)[3] 527	19	3.1 FC								
#2.3					1530	(591)[3] 527	10	3.1 FC								
#3					1290	(482)[3] 444	12	3.1 FC								
#4							13	3.1 FC								
#5[4]	11	0.21 FC			1600	(1300)[3] 1030	15000	3.1 FC	5450	360 AWw	130	100 AgL	22000	10000 AgI		
#6	1.9	0.21 FC					500	3.1 FC					13100	10000 AgI		
#7	1.1	0.21 FC					150	3.1 FC								

1 The standards listed on this table are the standards that were used in 1998, when the listing decision was made.
2 Standard based on hardness
3 Hardness expressed in mg/L $CaCO_3$. Standards for Zn,D and Cu,D for sites #2.1, #2.2, and #2.3 are calculated using the hardness value for site #2
4 Site #5 corresponds to ADEQ TMDL sampling site I. This is the adit discharge, not waters of Boulder Creek

Figure B-1


Location of Listing Data Sample Sites
Butcher Corral Point
2.1,2,2.2,2.3,3
1
4
7,5,6
Hillside
This map is prepared for illustrative purposes only.
No liability is assumed as to the sufficiency
or the accuracy of the data delineated hereon.
0.1 0 0.1 0.2 Miles
N

APPENDIX C
COPPER CREEK DRAINAGE

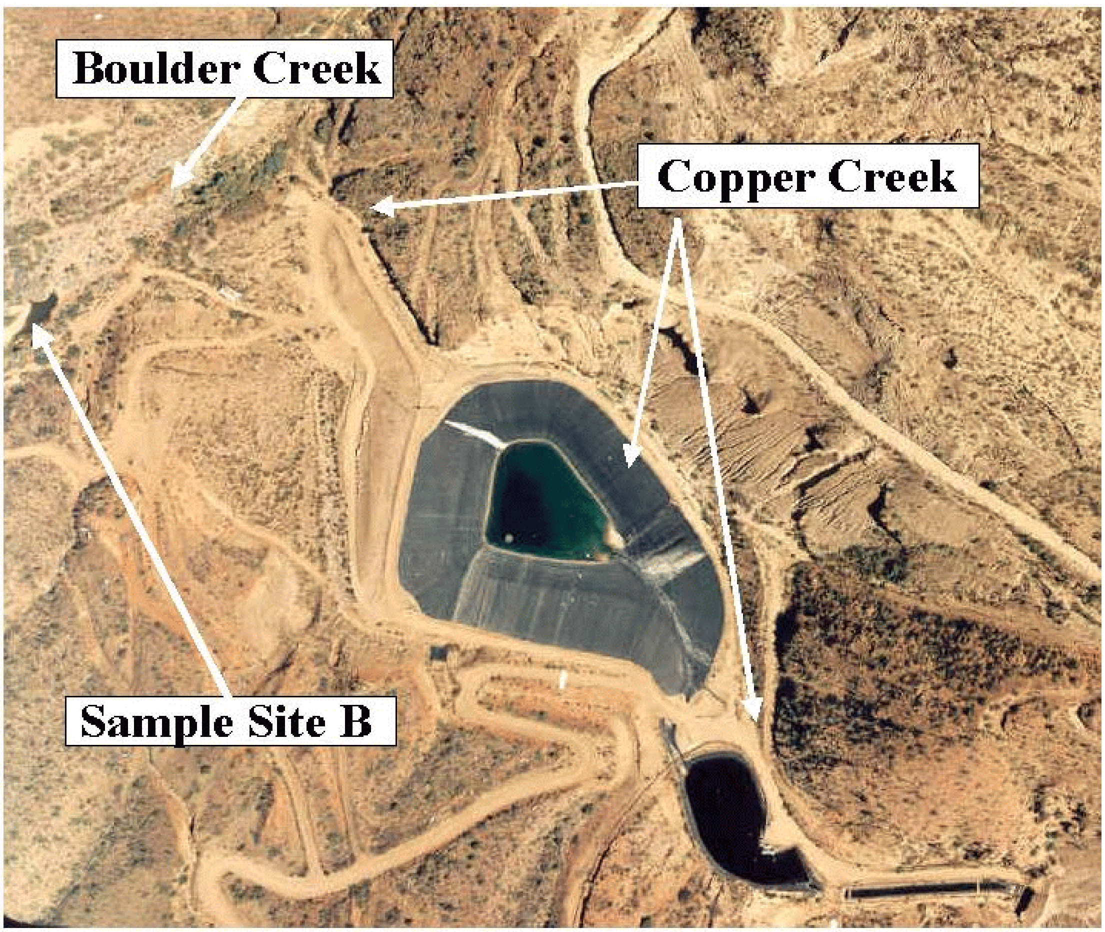


Figure C-1 An aerial view of the Copper Creek retention basin constructed by PDBI for stormwater retention. (photo courtesy of BLM, July 1999.)