The Boulder Creek TMDL Implementation Plan

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Scope of this Document

The scope of work for this document is established by Arizona Revised Statue § 49-234, paragraphs G, H, & J requiring Total Maximum Daily Load (TMDL) implementation plans to be written for those navigable waters listed as impaired and for which a TMDL is required pursuant to Section 303(d) of the Clean Water Act. The Boulder Creek TMDL Implementation Plan will provide a strategy that explains "how the allocations in the TMDL and any reductions in existing pollutant loadings will be achieved and the time frame in which compliance with applicable surface quality standards is expected to be achieved." The voluntary implementation of this plan, due to the nonpoint source of pollutants within Boulder Creek, lies on the responsibilities of stakeholders to achieve necessary load reductions to maintain water quality standards within the described reach of Boulder Creek.

Congress amended the Clean Water Act in 1987 to establish the Section 319 Nonpoint Source Management Program. As a result of this federal guidance, states have an improved partnership in their efforts to reduce nonpoint source pollution. The Arizona Department of Environmental Quality (ADEQ) Water Quality Improvement Grant Program allocates 319 grant funds from the United States Environmental Protection Agency (EPA) to interested parties for implementation of nonpoint source management and watershed protection. Under Section 319, state, private/public entities, and Indian tribes receive grant money which support restoration projects to implement on-the-ground water quality improvement projects to control nonpoint source pollution

When a given grantee applies for 319 funding, a watershed based plan or implementation plan submitted with the proposal demonstrates that the project has been carefully planned, reveals technical-economic feasibility, and illustrates the milestones that need to be implemented within a clear timeline. Watershed-based plans, such as TMDL implementation plans, help 319 proposals gain the highest priority for funding.

The following plan will define nine essential elements to help provide reasonable assurance to EPA, stakeholders, and the state of Arizona that load allocations identified in the Boulder Creek TMDL will be achieved, Boulder Creek receives high priority for 319 grant funds, and a well designed implementation plans has been calculated for Boulder Creek. These nine essential elements clearly define: causes and sources of pollutant(s), an estimate of load reductions, management measures that will need to be implemented, an estimate of technical and financial assistance needed, an information and education component, reasonable schedule of implementation, measurable milestones and events to determine if whether the management measures are being implemented, a set of criteria to evaluate pollutant reduction, as well as, a set of methods to monitor project effectiveness.

Stakeholder input is requested to promote collaboration and acceptance of the strategies proposed in this TMDL implementation plan. After the plan is adopted through a public participation process, then ADEQ is required to revisit and review the TMDL every five years to determine if the TMDL implementation plan was successful and Boulder Creek meets state surface water quality standards.

Our nation's historical approach to regulating water quality can be defined as a continually changing and evolving process. Accordingly, the development and progression of the TMDL implementation process is in itself a dynamic relationship and should employ an adaptive management strategy. Adaptive management is a systematic process for continually changing and improving management policies and practices by applying lessons-learned from previous actions. Moreover, adaptive management is, by its nature, an ongoing process open to new information and new evidence to inform future actions. With respect to the Boulder Creek TMDL Implementation Plan, this water quality management project is never "final" and adopts an adaptive management system to future development.

Background

The Boulder Creek TMDL Implementation Plan was prepared to meet the State of Arizona's TMDL implementation plan requirements based on Arizona Revised Statutes (A.R.S.) 231-4 and is designed to meet the nine elements specified in EPA's watershed based plan guidelines. This plan was also prepared to assist stakeholder efforts in restoring Boulder Creek and to help gain necessary funding under Clean Water Act Section 319(h) or any other available funding. Moreover, this report defines an action plan to implement cleanup of the four main sources of pollution defined by ADEQ's TMDL report for Boulder Creek. It provides very specific milestones to achieve a successful cleanup.

Boulder Creek resides within the Bill Williams Watershed in western Yavapai County, Arizona. Boulder Creek is a 37 mile intermittent waterway that drains seasonal precipitation from its headwaters near Camp Wood Mountain, 7,000 feet above mean sea level, to its confluence with Burro Creek at 2,460 feet.

The Boulder Creek watershed drains approximately 138 square miles and contains a variety of vegetation ranging 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. (ADEQ, 2003)

Boulder Creek, from Copper Creek to Wilder Creek, has been identified as an impaired surface water due to excessive amounts of arsenic, copper, and zinc in the water column. Historic metal mining from the "inactive" Hillside Mine left behind abundance of metal contaminates that negatively affect the downstream health of Boulder Creek and accompanying ecosystem.

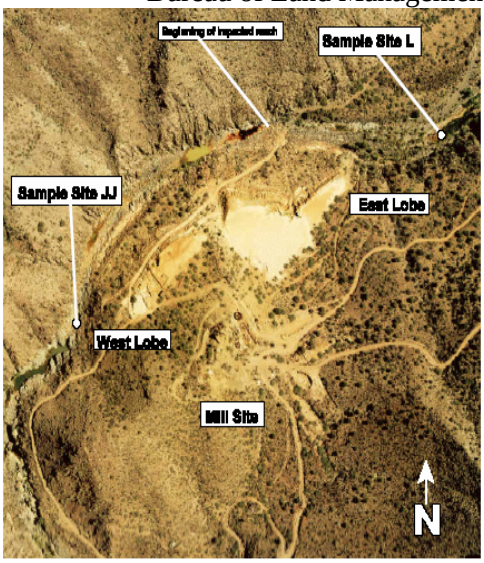
The Hillside Mine burrowed through the Boulder Creek landscape from its inaugural operations in the late 1800's to its closure in 1951. The mine is considered "inactive" due to its inoperative status. The mine is not considered "abandoned" as a result of the presence and communication with land owners. Mineral production primarily consisted of silver and gold, with subordinate lead and zinc.

Hillside Mine
January 1940

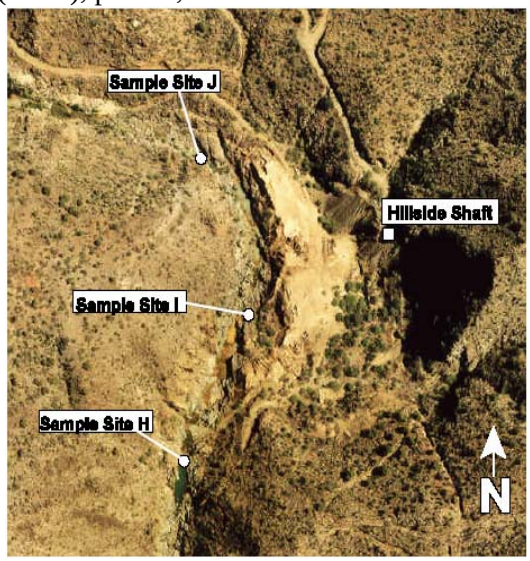
Seasonal variation of
Boulder Creek's flow
← On left is February
On right is November →

Summary of TMDL Process

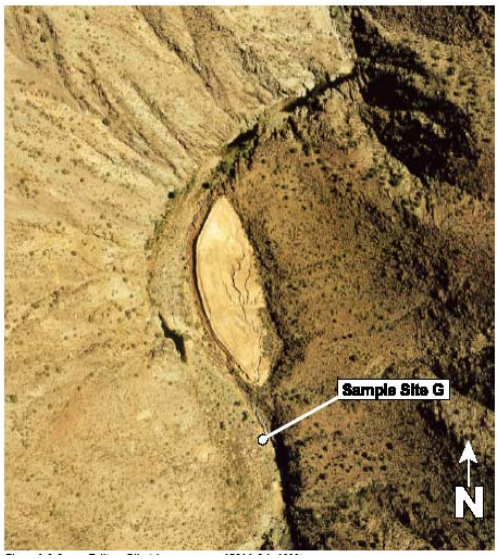
Based on the Total Maximum Daily Load analysis conducted in 2002, the sources of pollutants are three tailings piles, the Upper Tailings Pile, the Middle Tailings Pile, and the Lower Tailings Pile, and an adit discharge from the Hillside Mine. An adit, in mining terminology, is described as a horizontal mineshaft usually used for dewatering. The tailings piles are located on land owned by three different entities: Bureau of Land Management (BLM), private, and State of Arizona.



Upper Tailings Pile



Middle Tailings Pile



Lower Tailings Pile

This land ownership within the Boulder Creek watershed made for a collaboration of stakeholders during the TMDL process. Through public meetings with these stakeholders, the draft TMDL report was made available for a 30-day public comment period on July 12, 2002. The draft Boulder Creek TMDL was presented in a public meeting in Bagdad, Arizona, on July 23, 2002. Comments received during the public notice period were addressed in the Arizona Administrative Register (A.A.R.) on October 25, 2002. After the 45-day public comment period following this A.A.R. notice, 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. The revised draft was submitted to the A.A.R. and a 45-day public comment period followed the notice. After completion of the 45-day public comment period, the TMDL report will be submitted to the EPA for final approval (ADEQ, 2003).

The Boulder Creek TMDL implementation plan makes recommendations for the cleanup of source areas identified in the TMDL. ADEQ has encouraged stakeholder input during development of the Plan so that cleanup strategies are economically feasible and can be accomplished in a timely fashion. This Plan meets state and federal requirements for completion of TMDL implementation plans so that impaired waters will once again meet all “applicable surface water quality standards” (A.R.S. 49-234). Applicable standards for Boulder Creek are based on the “designated uses” assigned in rule (Arizona Administrative Code A.A.L18-11, Appendix B).

Section 303(d) of the Clean Water Act requires each state to develop TMDL studies 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 nonpoint sources with the inclusion of a margin of safety and natural background considerations. (ADEQ, 2003)

$$TMDL = \Sigma LA + \Sigma WLA + MOS$$

To summarize the following TMDL equation, wasteload allocations (**WLA**) are the point sources in a watershed, furthermore, load allocations (**LA**) are the nonpoint sources. Also included in the equation are natural background sources, and a margin of safety (**MOS**), a built-in correction to account for the differences between modeled data and monitored data. The built-in Margin of Safety percentage varies for each TMDL investigation.

Through studies, ADEQ has concluded that the historic mining within Boulder Creek's watershed has impaired this intermittent waterway. The specific reach of concentration for the Boulder Creek TMDL Implementation Plan is from Wilder to Burro Creek. Boulder Creek appeared on the 1998 List of Water Quality Limited Waters (303d List) 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 A.A.C.

Through sampling and testing of creek waters, monitoring 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 TMDL's for copper and zinc from Wilder Creek to Butte Creek and for arsenic from Wilder Creek to Copper Creek are described in table 1 below.

Table 1: Boulder Creek TMDL's

	Wilder Creek to Butte Creek		**Wilder Creek to Copper Creek**
	Copper: grams/day	**Zinc: grams/day**	**Arsenic: grams/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***

To refer back to the conceptual definition, a TMDL is comprised of the sum of individual **wasteload allocations** (WLA) for point sources, **load allocations** (LA) for nonpoint sources, and **natural background levels**. This TMDL contains a 5% explicit **margin of safety** (MOS) to account for differences between modeled and monitored data.

This maximum amount (load) of a water quality parameter which can be carried by a surface waterbody, on a daily basis, without causing an exceedance of surface water quality standards also accounts for critical conditions, seasonal variation, a margin of safety, and TMDL endpoints. A summary of these parameters along with the allocations, of load and wasteload for Boulder Creek, will conclude this summary of the TMDL process.

Critical Conditions
The TMDL study reports the critical condition of Boulder Creek occur during low flow (0.75 cubic feet/second). 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. (ADEQ, 2003) Consequently, the most adverse effects of metal contamination occur during low flows.

Seasonal Variation
Stream flow in Boulder Creek responds dramatically to seasonal conditions. As an intermittent creek, Boulder's dynamic flows respond to climate changes. Thus during high flows the concentration of metals in the water column rises. Low flows can produce independent scattered pools which can act as sinks for metals along banks and riverbeds. 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. (ADEQ, 2003)

Margin of Safety
The margin of safety included in a TMDL usually includes "implicit" and "explicit" components. The implicit margin of safety includes conservative approaches to sampling and conservative assumptions made during load calculation. The explicit margin of safety takes into account uncertain flow limitations and water quality. For the Boulder Creek TMDL, an implicit margin of safety and a 5% explicit margin of safety were included in the TMDL to account for the difference between modeled and monitored data.

TMDL Endpoints
The TMDL endpoint is a precise value calculated as a reasonable goal for the surface water. TMDL endpoints represent the in-stream water quality targets. Different TMDL endpoints are necessary for each parameter. 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).

The TMDL endpoint for total arsenic was selected as 47.5 (µg/L). (Based on a 50 micrograms per liter criteria for "full body contact" (FBC) minus a 5% MOS). (Tetra Tech, 2002)

Table 2: Arsenic Endpoints

Parameter	Most Stringent Standard	TMDL Endpoint = Water Quality Standard – 5% MOS
Arsenic	50 µg/L for FBC	50-2.5=47.5 µg/L

The endpoints for dissolved copper and zinc were selected as the hardness-based chronic criteria for the aquatic and wildlife warm water (A&Ww) use designation minus a 5% MOS (Tetra Tech, 2002).

Table 3: Copper and Zinc Endpoints

Parameter	Most Stringent Standard (based on hardness = 225 mg/l)	TMDL Endpoint = Chronic Water Quality Standard – 5% MOS
Copper	A&Ww chronic = 17.91µg/l	17.91 – 0.90 = 17.01 µg/l
Zinc	A&Ww chronic = 232.9 µg/l	232.9 – 11.64 = 221.26

Using the TMDL endpoints identified in the sections above and the critical flow of 0.75 cfs, the loading capacity, per pollutant, at critical flow, for Boulder Creek comprises table 4.

Table 4: Loading Capacity

Parameter	TMDL Endpoint	Loading Capacity
Arsenic	47.5 µg/l	87.3 grams/day
Copper	17.01 µg/l	31.19 grams/day
Zinc	221.26 µg/l	405.75 grams/day

Average stream hardness was used for copper and zinc calculations

Allocations

The TMDL equals the sum of allocations and cannot exceed the loading capacity. Below are the load and wasteload allocations for Boulder Creek.

Wasteload Allocations

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. (ADEQ, 2003) The flow from the adit was represented conceptually as a constant 5 grams per minute. The wasteload allocations are presented as daily loads, in terms of grams per day (Tetra Tech, 2003).

Table 5: Wasteload Allocations (grams/day)

Arsenic	Copper	Zinc	Reduction (%) from Existing Loadings
24.6	0.1	8.6	85%

Load Allocations

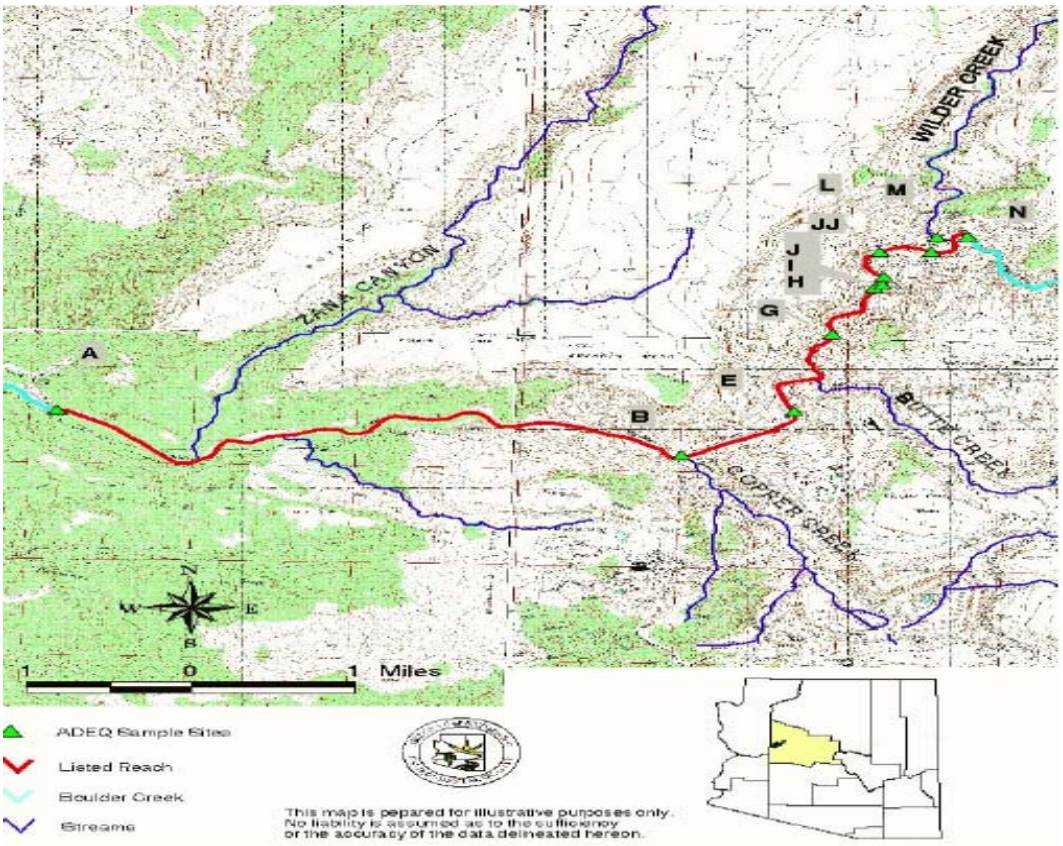
The daily load allocations (LA) for each metal are presented in terms of grams per day (Tetra Tech, 2003). Load allocations apply to flows at, or below, the critical condition of 0.75 cfs. At higher flows, un-impacted waters provide dilution and there is little to no negative water quality impacts. ADEQ 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. (ADEQ, 2003)

Table 6: Load Allocations (grams/day) Tailings Piles

	Arsenic	Copper	Zinc	Average Reduction (%) from Existing Loadings
Upper Tailings Pile	9.5	13.5	133.3	78%
Middle Tailings Pile	n/a	n/a	1.7	40%
Lower Tailings Pile	n/a	n/a	97.7	55%

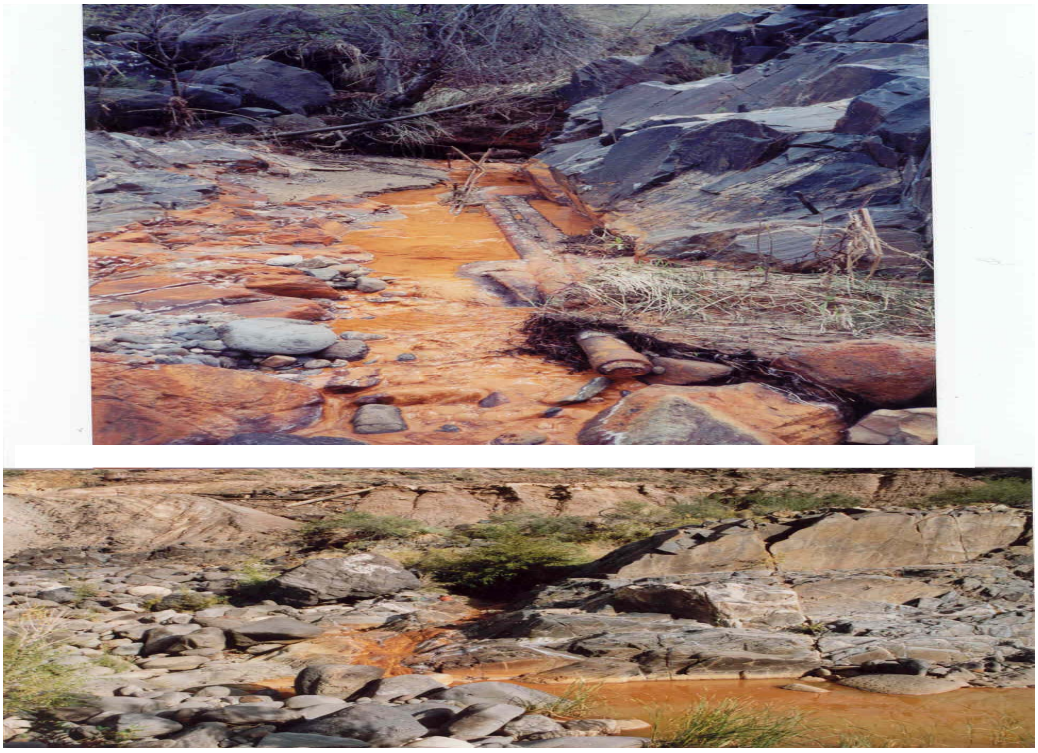
View Boulder Creek TMDL Report at: azdeq.gov/environ/water/assessment/download/bldr2040407.pdf

TMDL Sample Sites



A. Causes & Sources of Impairments

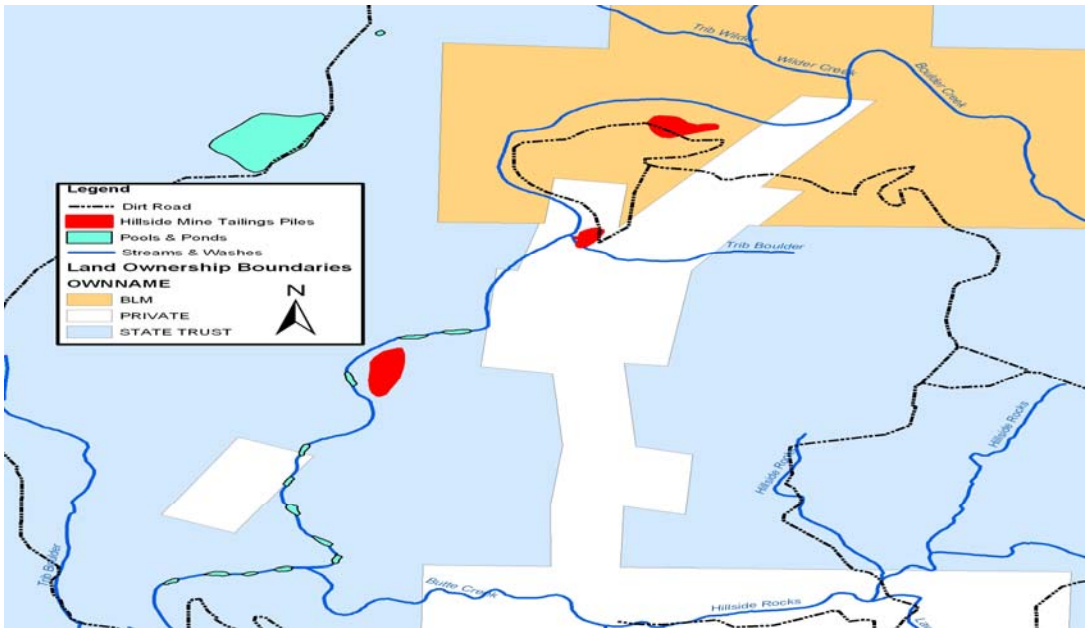
Three tailings piles from the former Hillside Mine were identified as the primary nonpoint sources of arsenic, copper and zinc that contribute to surface water quality exceedances. An additional seep/spring from a collapsed adit was also identified as a main contributing point source for arsenic and zinc.



Adit Discharge → Point Source

Top of Lower Tailings Pile → Nonpoint Source

The Upper Tailings Pile, consisting of two distinct lobes, lies on Bureau of Land Management (BLM) owned land just south of the Wilder Creek confluence on the southeast sides of Boulder Creek's canyon walls. An eroded dam structure also lies on the edge of the tailings, preventing some of the material from eroding into the creek. Further south on Boulder Creek, the Middle Tailings Pile and eroded dam structure lie on privately owned land held by KFX, a construction company. The collapsed adit seep is located at the foot of the Middle Tailings Pile on KFX property continuously discharging contaminated water to the creek. The third or Lower Tailings Pile is located further downstream in a very steep ravine area with poorly maintained foot path trails providing access. This third pile has an eroded dam structure and lies on state owned land managed by the Arizona State Land Department.



Land Ownership – At the Hillside Mine

To determine concentrations of <u>existing</u> pollutant loads, including that from natural background, ADEQ calculated loads from each source in grams per day as shown in the table 7 below.

Table 7: Existing Pollutant Loadings (grams/day)

Existing Load Allocation Areas	**Arsenic (g/day)**	**Copper (g/day)**	**Zinc (g/day)**
1. Upstream Boundary Conditions (Natural Background)	**7.9**	**23.7**	**31.6**
2. Upper Tailings Pile	**43.2**	**61.4**	**605.8**
3. Middle Tailings Pile	**<1**	**<1**	**2.8**
4. Adit discharge from Middle Tailings Pile (WLA)	**164.17**	**0.40**	**57.59**
5. Lower Tailings Pile	**<1**	**<1**	**217.1**
6. Butte Creek Watershed	**1.7**	**2.5**	**6.6**
7. Copper Creek Watershed (Below Critical Area)	22.1	7.5	20.1

The four main pollution sources highlighted in **bold** were identified as problem areas that need reduction of loading in Boulder Creek. The two areas in *italics* represent the natural background loads to the critical area that were included for the final TMDL load allocations.

B. Load Reductions

Table 8 below illustrates the load reduction goals, (g/day), for each pollutant at the four problem sites identified in the TMDL report. The **targeted load allocation** is the amount of pollutant each source can contribute and still achieve water quality standards in Boulder Creek.

Table 8: Targeted Load Allocations

Critical Area	Existing Load (g/day)	Load Reduction (g/day)	Targeted Reduction (Percentage %)	Targeted Load Allocation (g/day)
Upper Tailings Pile	As = 43.2	As = 33.7	78% reduction	As = 9.5
	Cu = 61.4	Cu = 47.9		Cu = 13.5
	Zn = 605.8	Zn = 472.5		Zn = 133.3
Middle Tailings Pile	As = <1	As = *	40% reduction	As = *
	Cu = <1	Cu = *		Cu = *
	Zn = 2.8	Zn = 1.1		Zn = 1.7
Adit Discharge At toe of MTP	As = 164.17	As = 139.5	85% reduction	As = 24.6
	Cu = 0.40	Cu = 0.34		Cu = 0.1 (rounded up)
	Zn = 57.59	Zn = 48.9		Zn = 8.6
Lower Tailings Pile	As = <1	As = *	55% reduction	As = *
	Cu = <1	Cu = *		Cu = *
	Zn = 217.1	Zn = 119.4		Zn = 97.7

Existing Load - Load Reduction = Targeted Load Allocation. *** Insignificant data allocation**

For Example, the Upper Tailings Pile must reduce arsenic contribution by 33.7 g/day to meet the targeted load allocation.

C. Management Measures

The process of selecting management measures for Boulder Creek was a collaborative effort among stakeholders. The interested parties include state agencies, local land owners and the active mining company near the Bagdad area, Phelps Dodge. These stakeholders promote this collaboration in Boulder Creek clean up efforts. Concurrent with an engineering cost and feasibility study paid for by BLM, conducted by AMEC Earth and Environment Inc., ADEQ hosted several meetings, conference calls, and a field trip with stakeholders in 2003. Goals of these efforts were to identify concerns, promote collaboration between parties, and discuss ideas for cleanup. ADEQ also conducted its own research to investigate more about what other states have done and whether these states were successful in their cleanup of contaminated mine sites. ADEQ discovered numerous examples of successful cleanups in Colorado and New Mexico. Also pleasing was discovery of many creative uses with federal funding mechanisms, including 319(h) funds, helping these western states find the dollars for successful mine cleanups. Additionally, ADEQ considered existing engineering controls in place in the Copper Creek sub-watershed where Phelps Dodge has active mining operations.

BLM conducted their own research and hired an engineering consultant, AMEC, to identify and design solutions towards restoring surface water quality located on BLM owned land at the Upper Tailings Pile. Additionally, BLM and AMEC explored other options for cleaning up the Middle Tailings Pile on privately-owned land, the adit located at the toe of the Middle Tailings Pile, and the state owned Lower Tailings Pile.

During Boulder Creek field trips, stakeholder discussions, and meetings with agency representatives, Boulder Creek's cleanup had physical and economically challenged limitations. The following is a list summarizing these limitations.

- Middle and Lower Tailings Piles are not readily accessible and would require, at minimum, constructing an improved roadway to get equipment to these piles.
- The area is typically very dry and would require continuous water supply for dust and sediment suppression.
- Materials needed for certain management measures are not readily available in this rural area.
- Geographic limitations, including steep canyon walls.
- Operation and maintenance in such a remote location would require solar power and frequent monitoring.

Even with these limitations, several treatment alternatives, and a combination of management measures were identified by stakeholders that could potentially accomplish the load reduction goals set forth by the TMDL report.

General Strategy

The general consensus or strategy chosen by stakeholders was "in-situ" encapsulation, re-grading and capping of the tailings piles. Preferred was this alternative rather than moving the materials to another location. The AMEC consultant report made some other suggestions for cleanup, including the use of local materials for capping, and moving the Middle Tailings Pile tailings to the Upper Tailings Pile during the re-grading process. It was determined that moving tailings from the Middle Tailings Pile to the Upper Tailings Pile would be cost-prohibitive and provide increased liability issues. Stakeholders agree that the Middle Tailings Pile should remain in-place and not be moved to the Upper Tailings Pile. However, where middle tailings are determined to be in the 100-year flood plane of Boulder Creek, they should be moved to the top of the Middle Tailings Pile and re-graded.

Placement of the tailings in ten-foot lifts with the use of benching was also recommended at the Upper Tailings Pile. This is a useful structural method of contouring the slope so that erosion is "trapped and slowed" with the aid of bench layers. Benching can be used on the surface of each of the three piles where it is determined by site engineers to be advantageous for grading and drainage. This type of benching is similar to the sedimentation management measure "contour farming."

Contouring is a method of farming
Sloped land on the contour
In order to reduce erosion,
Control water flow,
And increase infiltration.

Some of the management measures identified for Boulder Creek are similar thus can be used in combination with each other as the cleanup project progresses through time. Combination efforts that could be implemented this way are "runoff controls" and "stormwater diversion installations." A phased approach could be used by installing fencing and/or barricades at the start of the project to keep people and animals away from the tailings (exclusion zone), before and throughout cleanup. Exclusion zones are

recommended during cleanups of this type to protect the general public and wildlife, as well as, eliminate erosion due to foot traffic.
The stakeholders have not achieved a final strategy on how to control and treat the adit discharge point source. Preliminary designs and alternatives have been discussed by stakeholders and documented in this plan. Finding appropriate funding for this point source will also be further explored.

Project Accessibility at Boulder Creek

An invitation to Arizona Department of Transportation (ADOT) was made to gain their input, expertise, and potential contributions toward the road improvement efforts at Hillside Mine. During one conference call, ADOT offered a contribution of road materials of used asphalt stockpiles they have available in the Kingman, Arizona District. These materials can be used as rough surface material for road improvements/reinforcement. BLM, KFX, Phelps Dodge, and the Arizona State Land Department are landowners where the roadway is located. Potentially they could share and divide the cost of repairing the road. Money from Department of Interior Central HazMat may also be available for funding the road improvement efforts (See Section D Technical and Financial Assistance). Additional funding and collaboration with federal and state agencies, Yavapai County, and other various stakeholders will be necessary to implement these management measures.

The following are the management measures explained in more detail by individual sections of the Boulder Creek site. The management measures considered during the collaboration process with stakeholders have been organized (see table 9), in descending order of importance, explaining the reasons these alternatives were chosen or eliminated. The process of selecting appropriate management measures for the cleanup was deemed successful in 2003, and will continue as stakeholders learn more through research.

Upper Tailings Pile Management Measures

ADEQ, BLM, and AMEC conducted research into management measures that would be appropriate for the Upper Tailings Pile cleanup. AMEC was hired by BLM to conduct an engineering cost and feasibility analysis for the Upper Tailings Pile. The Engineering and Cost Analysis studies have gone through several stages of refinement based on further research, characterization, on-site field trips, and stakeholder input. The Upper Tailings Pile consists of two different piles, east and west lobes. In the latest report, AMEC recommended re-grading the Upper Tailings Pile in specific areas where erosion is a problem, then encapsulating the lobes with an eighteen inch thick geotextile liner material on top of the

east and west sections. Sediment run-on and runoff controls are recommended around the pile lobes to control stormwater runoff and sediment transport.

After re-grading accomplishes the task of lowering the gradient slope, stakeholder consensus and AMEC's recommendations conclude that geotextile materials are positioned to cap the tailings pile lobes. In combination with the chosen "in-situ" cleanup strategy, the use of run-on sediment controls uphill of the Upper Tailings Pile site was further recommended. This is method used to control the stormwater pathways leading to the tailings pile area. In a report, BLM also proposed to repair portions of the dam structure at the Upper Tailings Pile (BLM, 2002, pp. 20).

Middle Tailings Pile Management Measures

Similar prescriptions designed to mitigate the Upper Tailings Pile were also chosen for the Middle Tailings Pile. AMEC, with stakeholder input, recommended the re-grading option, with encapsulation using geotextile liner along with run-on and runoff controls at the Middle Tailings Pile site. Additional work was described where tailings need to be removed and placed away from the 100-year flood zone of Boulder Creek, creating additional cost compared to the Upper Tailings Pile cleanup estimates.

A preliminary design, funded by BLM, was submitted by AMEC for the Middle Tailings Pile in 2003. The preliminary design for the Middle Tailings Pile encapsulation was conducted by AMEC and BLM. The feasibility and cost assessment work was completed in November 2003, and AMEC took into consideration stakeholder input from representatives of KFX.

The construction of a retaining wall at the Middle Tailings Pile coincides with the re-grading and capping management measure. A retaining wall would reinforce sediment control run off for the Middle Tailings Pile. Preliminary remedial design at the Middle Tailings Pile concludes moving part of tailings away from the mine adit and flood plane and building the retaining wall to help keep tailings from slumping. The slumping tailings further the nonpoint source threat to Boulder Creek. Additionally, the shifting of tailings and construction of retaining wall will help clear more room for an evaporation pond, which provides an alternative for the adit discharge (further explanation in Middle Tailings Pile Adit discharge section). No investigation has been made into material type for the retention wall.

Through research analysis at the Middle Tailings Pile, the geotextile liner may require a thicker membrane than eighteen inches. A thicker liner, one with two feet thick membrane and designed to meet more strict standards, may be required if the Middle Tailings Pile is determined to have the potential for uranium radiation. The thicker liner may increase the cost compared to the Upper Tailings Pile liner unit cost. The liner's unit cost can be revisited if AMEC or KFX completes a more thorough design submittal.

The option to remove and haul the Middle Tailings Pile to the Upper Tailings Pile was researched as a remedial option and management measure for the Middle Tailings Pile. This management measure will necessitate the need for road and accessibility improvements in order to transport materials with heavy duty construction equipment, thus not a viable measure due to accessibility constraints.

Worker safety issues may be the biggest issue concerning closure of the Middle Tailings Pile. The Arizona Radon & Radiation Agency enforces regulation due to health and safety reasons concerning workers during closure of tailings sites similar to the Middle Tailings Pile (Tony Frieman, AMEC correspondence, 2003).

Middle Tailings Pile Adit Discharge Management Measures

Preliminary design discussions for the adit discharge management measures were discussed with major stakeholders, including input from Phelps Dodge and Tony Williams with Jett Electrical Services, a local solar-power subcontractor. Based on our stakeholder field trip in September 2003, three management measures were selected for the adit discharge:

- Control/collection basin
- Solar-powered pump system to convey the captured water uphill to a pond
- Evaporation/storage pond near the top of the Middle Tailings Pile tailings

This three-part system is intended to remove and convey the contaminated water away from the stream enabling evaporation in a separate pond area. Given the adit discharge is a point source of pollution, sources other than 319(h) funds will be essential for cleanup. Point sources of pollution, stationary location or fixed facility from which pollutants are discharged, cannot be funded with Section 319 federal grant funds, thus will require the need for creative funding alternatives.

Installation of a weir structure proximate to the adit discharge area to control the discharge into Boulder Creek was a management measure discussed, but not chosen, for the Middle Tailings Pile adit discharge. A weir is a wall or plate placed in an open channel to measure the flow of water or a wall/obstruction used to control flow. The weir structure could also be utilized for future monitoring of hydrologic conditions, flow rates and future monitoring efforts in Boulder Creek.

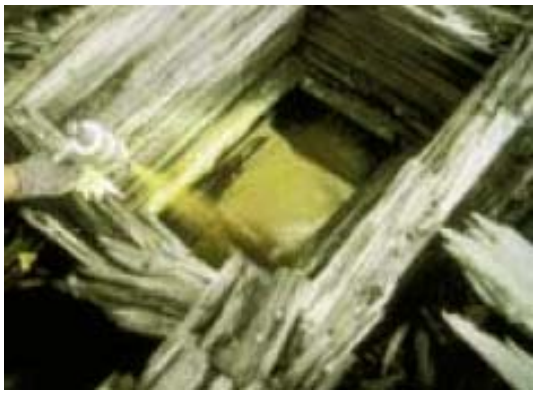
Example of a weir structure

ADEQ conducted research on several other remediation efforts for the Middle Tailings Pile adit in late 2003 and early 2004. ADEQ evaluated three general types of approaches used for safeguarding and controlling nonpoint source pollution from mine adits. Barriers designed to keep visitors away from the hazard, along with seals and plugs intended to close the adit portal were discussed among stakeholders. Each of these three could be individual management measures, or they can be used in combination for an enhanced effect. In addition to these approaches, construction of a wetland or permitting the discharge from the adit was analyzed as possible activities to achieve implementation goals.

A fence barrier to enclose the area surrounding the mine adit is the least effective management measure. Enclosing the mine adit perimeter with 10 foot barbed wire fencing will restrict casual visitors to a safe distance from access to the adit. This management measure is low in cost, easy to construct, and safe to install, especially at this remote location. A disadvantage of this management measure is the fence is temporary and does not eliminate or decrease discharge into Boulder Creek, just discourages access.

A structural seal can be constructed in the horizontal opening of the adit by pouring concrete, or inserting concrete blocks or native rock. Whether using a 4-6 foot concrete slab or a bulkhead seal to hold back high pressure, these management measures are superior to the fence barriers, but have drawbacks. A discharge pipe made of high density polyethylene would be needed for discharge into Boulder Creek. A substantial amount of water pressure could build within the adit and encompassing shaft as a result of concrete capping of the portal. This pressure could eventually cause environmental hazards if released into bedrock, land surface, and especially the rocks that surround the mine adit. Another downside of the concrete seal would be the high cost and risk of construction.

Concrete seal



Polyurethane Plug

Plugging the mine adit at the Middle Tailings Pile with polyurethane foam will provide a similar seal as concrete but would be cheaper, pose less physical threat during construction, and provide a low impact closure alternative. Polyurethane foam is a mixed compound similar to insulating foam used in houses, ice chests, thermos jugs, refrigerators, and buildings. Homeowners may be most familiar with polyurethane foam available in aerosol cans at the hardware store used to seal around window casements and door jambs to prevent air and thermal leaks. The polyurethane foam needs a structural support which typically can be a concrete base/frame or rock material. Once a structural support is attained, pouring or spraying polyurethane foam into the opening and capping it with a vegetative cover will achieve this speedy management alternative.

An additional management measure commonly used for adit flow and seeps is the construction of an aerobic wetland. An anaerobic constructed wetland would be installed to treat contaminated discharge. This system relies on the use of sulfate reducing bacteria to reduce the metals to sulfides and render them insoluble in the wetland substrate. The wetland would be placed and designed to prevent infiltration into rock dumps. Run-on controls would be constructed above the adit to minimize infiltration.

An advantage of this alternative is that it does not require active operation and maintenance while effectively reducing releases of metals into Boulder Creek from the adit flow. The concerns of this alternative are the terrain and climate of the Middle Tailings Pile adit area. The adit entrance is surrounded by large boulders with adjacent rocky terrain. The climate of the Boulder Creek watershed consists of dry, hot summers. A consistent flow from the adit is necessary. If discharge stopped or was stagnant over time, the wetlands could dry up and the adit would remain collapsed and open to hazards.

The final management measure for the adit at the Middle Tailings Pile researched by ADEQ for Boulder Creek implementation would be applying for appropriate discharge permitting. As discussed, the adit discharge is a point source of pollution. Point sources of pollution require appropriate permits to discharge into surface waters.

Under the Arizona Pollutant Discharge Elimination System Permit Program, all facilities that discharge pollutants from any point source into waters of the United States (navigable waters) are required to obtain or seek coverage under an Arizona Pollutant Discharge Elimination System Permit. The permit intends to limit or contain the discharge into a waterbody to meet applicable surface water quality standards. There is a monitoring component required by the Arizona Pollutant Discharge Elimination System Permit process which requires sampling to assure permit conditions related to flow amounts and water quality standards are met. This management measure would not completely remediate exceedances in Boulder Creek due to the nonpoint source pollutant loadings. In addition, an Aquifer Protection Permit is needed if you own or operate a facility that discharges a pollutant either directly to an aquifer or to the land surface or the vadose zone (the area between an aquifer and the land surface) in such a manner that there is a reasonable probability that the pollutant will reach an aquifer. If an Aquifer Protection Permit is needed, the cost can be as high as $100,000. The Aquifer Protection Permitting process is longer and more demanding than the Arizona Pollutant Discharge Elimination System Permit process.

Lower Tailings Pile Management Measures

Additional brainstorming took place during the September 2003 field trip regarding the state-owned Lower Tailings Pile. Several physical factors limit the mitigation efforts needed at the Lower Tailings Pile area. No roadway currently exists to the pile, and very steep upland slopes consisting of mica schist, hard bedrock, along with numerous boulders that obstruct the surrounding Lower Tailings Pile area. The Lower Tailings Pile was originally formed by a long wooden slurry line from the Hillside Mine head-frame area at the Middle Tailings Pile site. Slurry is a watery mixture of insoluble matter resulting from some pollution control techniques. The slurry line no longer exists. Stakeholders currently believe that building a roadway would not be an economically feasible alternative for the Lower Tailings Pile cleanup. Therefore, preliminary designs for the Lower Tailings Pile area do not currently include a road-building effort to access the pile due to the assumed high cost and feasibility of a roadway in such a remote and steep area.

AMEC joined the major stakeholders in the field to try to identify the most feasible solutions while visiting the Lower Tailings Pile site in September 2003. During the field trip, AMEC suggested re-grading the pile and installing sediment run-on and runoff controls. This temporary control option was considered to be the most economically feasible solution to achieve erosion controls at the Lower Tailings Pile. With the aid of a large helicopter transport, a bulldozer, fuel tank, and other necessary hardware can be hauled in. With necessary equipment in place, re-grading and installing run-on controls uphill of the pile will be manageable. Afterwards, this alternative was agreed upon by stakeholders during a conference call in October 2003. ADEQ learned in January 2004 that the appropriate helicopter, a Super Huey, would cost approximately $2500 per hour to rent from a private helicopter firm out of Long Beach, California. This firm already has experience working at the Phelps Dodge Bagdad Mine hauling large concrete pipes. Additional considerations have explored renting or unrecompensed helicopter usage from either private, state, or federal agencies.

Gabions

Through collaborative research and exploration, the stakeholders have developed several other possible remediation strategies for the Lower Tailings Pile. The following are some of the alternatives.

- Installing brow ditches and stormwater control channels above the Lower Tailings Pile to funnel rain water away and around the pile as a run-on control option.
- Gabions could be installed in the rill area to control and slow down runoff that flows from the top of the tailings pile. Gabions are welded wire mesh baskets which, when filled with stone, provide resistance to earth movement and controls movement of retained soil.
- Erosion rills from runoff drainage have developed over time on the Lower Tailings Pile. A rill is a small channel eroded into the soil by surface runoff. Minimal liner materials installed inside the rill areas could help separate the tailings materials in the rills from stormwater runoff. Nonetheless, plugging the existing erosion rills entirely may cause other erosion and structural stability problems. Rather, the existing erosion rills could be used to help funnel the erosion off on the pile without excessive scouring of the surface, and limiting the potential for large collapses of the tailings materials.
- Re-grading of the surface should help accomplish the task of controlling rainwater that directly flows across the rills**.**

Erosion Rills

Further structural characterizations were also considered by stakeholders. Ascertaining the structural integrity of the Lower Tailings Pile would help to more thoroughly tailor the potential treatment options. As stated previously, the Lower Tailings Pile was originally formed in three distinct sections from a slurry line with the use of wooden dam structures. These wooden dam structures can still be seen protruding from the surface of the pile.

Soil samples using hand auger core holes could help test the subsurface structural integrity of each distinct section of the Lower Tailings Pile prior to any preliminary re-grading work. This characterization work should allow for better re-grading designs and improved safety for the workers who will implement the mitigation effort on the tailings pile surface. Collection of core samples for both structural integrity and metal content could help limit not only the cost of characterization, but speed up the mitigation efforts. Understanding potential health and safety risks associated with the regarding the tailings piles should be a key consideration during cleanup. BLM's document, "BLM Health Management Criteria for Metals at BLM Mining Sites," should be used as guidance by all cleanup personnel prior to the cleanup activities.

Soil Sampling

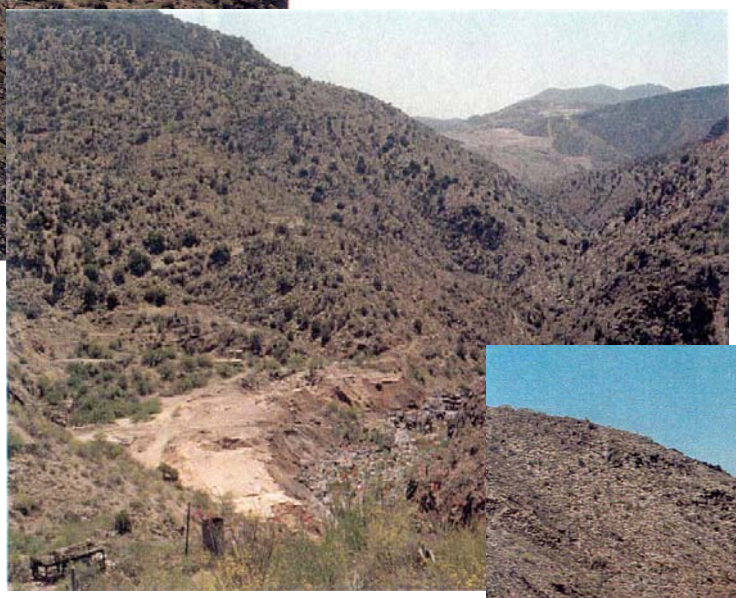
Slurry

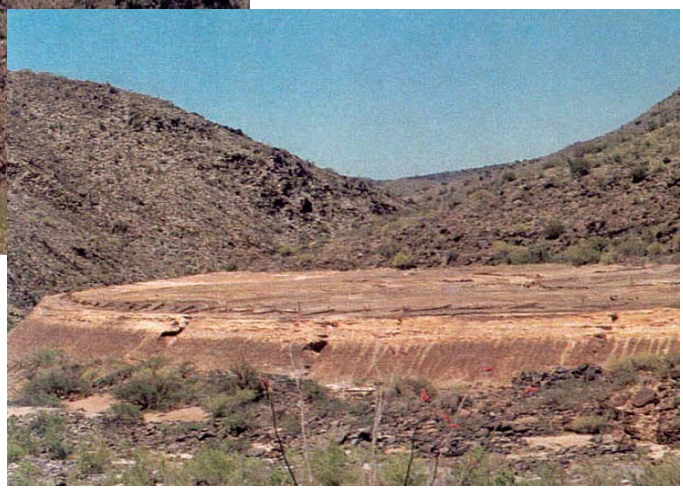
Management Measures or Best Management Practices	Applicable: Yes, No, or Maybe
1. Re-grading surface of tailings piles	**Yes**: Chosen for all three tailings pile areas.
2. Geotextile encapsulation of tailings piles	**Yes & No**: This was chosen for Upper Tailings Pile & Middle Tailings Pile areas, not the Lower Tailings Pile area due to lack of feasible access (no roadways & very steep canyon walls).
3. Placing locally available rock materials on top of geotextile materials (encapsulation)	**Yes**: Chosen for the Upper Tailings Pile & Middle Tailings Pile areas to protect the geotextile membrane from surface wear.
4a. Placing soils and grass seeding on top of encapsulation materials	**Yes**: Chosen for the Upper Tailings Pile & Middle Tailings Pile areas to protect the encapsulation materials.
4b. Vegetative practices – seeding, mulching, sodding, buffer strips, critical area planting	**Yes**: Chosen for Upper Tailings Pile and Middle Tailings Pile areas. Reseeding may require placement of lime in top soil. BLM advocates hydroseeding the capped tailings pile after placing 2-inches of topsoil and fertilizer over the capping materials.
5. Moving tailings material away from flood plane	**Yes & No**: Chosen for Middle Tailings Pile due to some tailings in 100-year flood plane to the top of re-graded portion of the pile. Not chosen for the Upper Tailings Pile and Lower Tailings Pile due to lack of suitable location for material to be placed.
6. Reinforcing existing dam face towards the creek	**Yes**: Chosen for all three tailings pile areas.
7. Sediment "run-on" controls upslope of tailings piles	**Yes**: Chosen for all three tailings pile areas.
8a. Stormwater diversions	**Yes**: Chosen for all three tailings pile areas. Stormwater diversions could help improve surface water pathway uphill of tailings.
8b. Runoff controls on tailings piles	**Yes**: Chosen for all three tailings pile areas, could improve surface water pathway uphill of tailings.
9. Gabions	**Yes**: Chosen for the Lower Tailings Pile erosion rill for installed runoff controls.
10. Contouring	**Yes**: Works best with re-vegetation practices. However, AMEC recommends 10-foot lifts with benching.
11. Fencing or barricading	**Yes**: Chosen for all three tailings piles, fencing could limit trampling of surface causing further erosion of tailings piles & establishes an exclusion zone for safety reasons.
12. Sediment/Treatment pond	**Yes**: Chosen for the Middle Tailings Pile area to collect adit discharge above and behind the pile.
13. Collection basin or trough for the adit discharge	**Yes**: Chosen for the adit at the toe of Middle Tailings Pile area. Would be required to control contaminated discharge from adit to pump uphill to a sediment pond away from 100-year flood plain.
14. Seepage collection return ponds	**Yes**: Similar to No 12, 13 & 15. However, a pond is larger than a collection trough envisioned for the tight space below the adit discharge (See 13.) Also, this is similar to the sediment pond in No. 12 placed on top and behind the Middle Tailings Pile.
15. Reclamation pond with crushed limestone	**Maybe**: Beyond the adit discharge low pH is not a major issue but limestone placed in drainage areas could help improve the pH of acid mine drainage in general. This is similar to the sediment pond No. 12. Limestone materials themselves could be used in general wherever water touches rock material to buffer pH levels.
16. Oxidation pond	**Maybe**: A sediment pond was chosen over this alternative for the adit discharge at the Middle Tailings Pile. However, oxidation in the sediment pond may still be a form of treatment that could mitigate heavy metals in the stored surface water.
17. Stormwater control weir	**Maybe**: Potentially chosen for the Middle Tailings Pile area near the adit discharge point in Boulder Creek. Advantage would be to control stormwater flows behind weir to limit scouring of tailings down gradient from this point and could assist in further studies, hydrologic modeling and water quality sampling. Disadvantages include the permitting process *and* potential surface water rights would have to be considered.
18. Level Spreaders	**Maybe**: More research needed to see if this could be used to diffuse a concentrated point source runoff from the adit then pumped into a sediment basin.

Table 9: Management Measures for Boulder Creek

19. Passive treatment – wetland treatment cells	**No**: Requires too much operation & maintenance as well as continuous water supply for vegetation.
20. Move the tailings piles to another location	**No**: Suitable level space is not available nearby.
21. Excavate, reprocess, redeposit & cap	**No**: Lack of valuable ore in tailings to make reprocessing profitable.
22. Dikes, berms, and curbs	**No**: These are not big enough to handle the size and gradient of tailings piles.
23. Rock outlet protection	**No**: Too costly to implement, gradient too steep and tailings are too tall.
24. Structural practices: straw bale dikes, silt fences or brush barriers	**No**: These fixes are temporary measures & require too much operation & maintenance.
25. Fence barrier	**Yes:** would prevent intrusion, but no effect on water quality.
26. Structural seal	**Maybe**: Would control flow but questions of water pressure and accessibility.
27. Polyurethane plug	**Yes**: Plug could help in adit closure and flow. Low maintenance construction.
28. Wetland	**Maybe**: Enough flow to keep moisture but terrain is a question.
29. Arizona Pollutant Discharge Elimination System Permit/Aquifer Protection Permit	**Yes**: Would not lower pollutant loads in Boulder Creek but would control adit discharge. This would be a costly implementation strategy.

TAILINGS PILES: UPPER
MIDDLE
LOWER





D. Technical Assistance

Technical Assistance

For the successful execution of Boulder Creek's TMDL Implementation Plan, the following agencies and organizations will need to continue their valuable technical assistance: ADEQ's Watershed Management Unit, ADEQ's TMDL Unit, Arizona State Land Department, BLM, AMEC, and Phelps Dodge.

Regulatory guidance and environmental science information can be obtained from various Web sites, including ADEQ and EPA Web sites.

www.azdeq.gov/environ/water/index.html
www.epa.gov

OSHA regulations will need to be followed to adequately design a health & safety plan for the workers who will conduct on-the-ground work at all three tailings pile sites. Links to these Web sites, and more, are provided in the reference section.

Grant Writing Assistance

Many stakeholders and public/environmental interest groups would like to apply for grant money but neglect the proper resources to do so. There are resources available to those who seek technical assistance with organizing grant materials and drafting grant proposals.

ADEQ's Water Quality Improvement Grant Unit allocates money from the EPA to interested parties for implementation of nonpoint source management and watershed protection. The Water Quality Improvement Grant Unit is the administrator of federal 319 grant money allocated to on the ground water improvement project in Arizona. The Water Quality Improvement Grant Unit provides annual grant workshops that act as "fact finding" and "information gathering" sessions for grantees. Attendance at these grant workshops will provide the most up-to-date information pertinent to the year's grant cycle. The Water Quality Improvement Grant Unit provides customer service and assistance if further explanation of grant policies and procedures is necessary.

The EPA has published a handbook and tutorial with many helpful tools and guidelines for grant writing, Grants Application Handbook:

www.yosemite.epa.gov/r10/omp.nsf/7ec302bdd9d6d43488256b56007bb4c7/86d9f96e96b1beb488256e8400621d03/$FILE/EPA%20R10%20Grants%20App.%20Handbook.pdf

EPA Grant Writing Tutorial:

www.epa.gov/seahome/grants/src/grant.htm.

The following are Web sites organizations designed to consult and provide tools that will help interested parties complete grants successfully, as well as, find additional funding for environmental restoration projects.

www.earthwrites.com/index.html
www.ericfacility.net/ericdigests/ed359067.html
www.fundsnetservices.com/environ.htm

E. Financial Assistance

The cost estimates of implementation measures proposed for Boulder Creek have been outlined in the subsequent sections. Many factors have been considered for Boulder Creek's remedial action including, but not limited to, cost estimates of management measures, planning and characterizing, design and engineering, labor, available resources, and maintenance.

Cost of Management Measures

BLM and AMEC researched the cost of re-grading and capping the Upper Tailings Pile and conducted preliminary cost analysis research. The estimated cost of cleaning up the Upper Tailings Pile would be approximately $420,000. This cost does not include the road improvements leading to the Upper Tailings Pile area. Based on the first stakeholder meeting in 2003, BLM estimated that the cost of road improvements could be approximately an additional $5,000-$10,000. BLM worked proactively to authorize and pay for further engineering and cost analysis work by AMEC at the Middle Tailings Pile and Lower Tailings Pile sites. In late October 2003, BLM computed the cost and drafted preliminary designs for the other two tailings pile sites not on BLM-owned land. Estimated costs for cleanup at each of the three tailings pile sites are detailed below. As of summer 2004, BLM still agrees to fund engineering through AMEC for the Middle and Lower Tailings Pile remediation.

- *Upper Tailings Pile* – BLM provided the following information in tables 10 and 11, which details the associated costs of re-grading and capping the tailings piles, as well as, the costs of engineering and runoff controls uphill of the Upper Tailings Pile site (BLM, 2000, See table 10).

- *Middle Tailings Pile* – Cost estimates include similar management measures prescribed for the Upper Tailings Pile, including encapsulation of the pile materials with geotextile materials. Additional work is needed at the Middle Tailings Pile site not prescribed for the Upper Tailings Pile site. Movement of tailings currently located in the 100-year flood zone to the top of the pile for placement and re-grading and constructing a retention wall to seize slumping tailings. Much of the cost estimates accounted for the difference of volume between Middle and Upper Tailings Piles. The Middle Tailings Pile is approximately 77% the size of the Upper Tailings Pile in volume. (This conversion was not necessary for some items because these are being done only at the Middle Tailings Pile.) Line items identified in the Upper Tailings Pile cost estimates were multiplied by 0.77 to gain a general estimate of costs for each similar line item for the Middle Tailings Pile. See Table 12 for detailed cost estimates. The column labeled "Scaling Factor" denotes where the conversion formula was applied.

- *Middle Tailings Pile Adit* – Remediation measures for the adit discharge can range from cheap fixes, like a fence barrier, to an expensive alternative, like a concrete seal or permit requirements. See Table 13. Due to the point source pollution, the cost of management measures for the adit at Middle Tailings Pile would be 100% funded by the landowners unless KFX found funding outside of 319 Grants.

- *Lower Tailings Pile* – Based on the stakeholder meetings in 2003, it was mutually agreed that establishing sediment run-on and runoff controls at the Lower Tailings Pile site would be the most feasible and economic approach.

  According to Arizona State Land Department, further characterization of the Lower Tailings Pile may be necessary. All parties agreed that building a roadway to the Lower Tailings Pile site would not be cost effective. Rather, the use of a large helicopter transport to lift-in the necessary equipment and fuel to the site would be the most efficient and feasible solution. AMEC's engineer stated verbally that the estimated cost for cleanup of the Lower Tailings Pile would be approximately $150,000 (Tony Frieman, AMEC, 2003).

Table 10: Costs for Upper Tailings Pile Re-Grading and Capping

Task	Safety Level	Amount Required	Unit Cost	Unit	Subtotal
Project oversight	D	1,000	$26.06	Hour	$26,060
Clear & grub heavy brush	D	4	$323.68	Acre	$1,295
Excavate and stockpile topsoil	D	4,450	$2.50	CY	$11,125
Rough grading 2 passes for pad area	D	14,000	$0.21	SY	$2,940
Dig 1,000' run-on trench, including boulders	D	2,000	$1.91	CY	$3,820
Excavate tailings, haul, place & compact	C	85,000	$2.50	CY	$212,500
Haul & place waste rock capillary barrier	D	4,444	$2.50	CY	$11,110
Place geotextile filter fabric	D	14,000	$2.60	SY	$36,400
Place 2' soil cap	D	8,888	$2.50	CY	$22,220
Construct 20x20x8 foot oxidation pond	D	119	$8,000	Item	$8,000
Hydroseed former pond area	D	3	$1,000	Acre	$3,000
Hydroseed fertilizer former pond area	D	2	$144.73	Acre	$289
Hydroseed cap	D	4	$1,000	Acre	$4,000
Hydroseed fertilizer over cap	D	4	$144.73	Acre	$579
Subtotal					$343,338
Miscellaneous Task	Safety Level	Amount Required	Percent Cost		**Subtotal**
Mobilization/Demobilization	D	7	7%		$24,034
Contingency	NA	NA	15%		$55,106
Total					$422,478

Table 11: Costs for Upper Tailings Pile Institutional and Run-On Controls

Task	Safety Level	Amount Required	Unit Cost	Unit	Subtotal
Project oversight	D	50	$26.06	Hours	$1,303
Clear & grub heavy brush	D	4	$323.68	Acres	$1,295
Surveying drainage ditches	D	1	$600	Day	$600
Dig 800' run-on trench including boulders	D	1600	$1.91	CY	$3,056
Compact trench - 2 pass with equipment	D	1000	$1.91	CY	$1,910
Riprap steeper portions	D	800	$15	SY	$12,000
Construct 20x20x8 oxidation pond	D	1	$8,000	Item	$8,000
Repair, fill & compact breaches in dam	C	5000	$2.50	CY	$12,500
Grade, compact & berm tailings ponds	C	21,000	$1	SY	$21,000
Place warning signs, barricades on roads	D	4	$1,000	Item	$4,000
Subtotal					$61,664
Miscellaneous Task	Safety Level	Amount Required	Percent Cost		**Subtotal**
Mobilization	D		5%		$3,083
Contingency	NA		15%		$9,172
Total					**$74,459**

Table 12: Middle Tailings Pile Preliminary Cost Estimates

Management Measures/Activities	Unit Cost	Unit	Scaling Factor	Amount Required	Preliminary Estimated Costs
Engineering Design	$20,000	Lump Sum	1	1	$20,000
Mobilization	$20,000	Lump Sum	0.77	1	$15,400
Improve Access Road	$1,000	Lump Sum	0.77	1	$770
Water Supply	$15,000		0.77	1	$11,560
Retaining Wall					$100,000
Impoundment					
Clear and Grub	$0.50	Square Yd	0.77	21,000	$5,000
Excavate Tailings	$4.00	Cubic Yd	1	20,000	$66,000
Final Cleaning in Bedrock	$15,000	Lump Sum	1	1	$10,000
Place Embankment Rock	$8.50	Square Yd	1	5,000	$30,000
Surface Treatment	$0.15	Square Yd	0.77	21,000	$2,000
Liner					
60 mil smooth liner	$0.65	Square Yd	0.77	145,500	$30,000
60 mil texture liner	$0.75	Square Yd	0.77	56,500	$15,000
10 ounce geotextile	$0.25	Square Yd	0.77	56,500	$4,000
Anchor Trench	$3.50	Foot	0.77	3,775	$5,000
Cover Materials					
Process Cover	$2.50	Cubic Yd	0.77	12,400	$10,000
Place 18” Coarse Soil	$2.75	Square Yd	0.77	17,000	$14,000
Place 12” Coarse Rock	$2.25	Square Yd	0.77	11,400	$10,000
Diversion Channel	$5,000	Lump Sum	0.77	1	$3,850
QA/QC	$25,000	Lump Sum	0.77	1	$20,000
Borrow Reclamation					
Plant Salvage	$1,750	Lump Sum	0.77	1	$2,000
Topsoil Recovery	$0.75	Square Yd	0.77	5,000	$3,000
Regrade Borrow/Topsoil	$1.50	Square Yd	0.77	5,000	$6,000
Seeding	$5,000	Lump Sum	0.77	1	$4,000
Estimated Total					**$420,000**

Table 13: Adit Discharge Preliminary Cost Estimates

Management Measure/Activity		Resources Required/Details	Preliminary Cost Estimates
Fence Barrier		Chain-link with barbed wire used to surround perimeter of adit approximately 10 feet high.	$1,250
Structural Seal		Concrete used to seal adit portal with discharge pipe. (Concrete slab or bulkhead seal are roughly same cost.)	$100,000
Polyurethane Plug		Polyurethane foam will plug adit portal.	$7,650 - 10,000
Wetland		Wetland construction and vegetation.	$100,000 - 150,000
Arizona Pollutant Discharge Elimination System Permit		Application process involves drafting facts and details.	$0
Aquifer Protection Permit		Application process involves drafting facts, details, and pre-application meeting.	$1,000 - 100,000
3 Part System	Control/collection Basin	Adit discharge collection pool.	$76,800
	Solar-powered Pump System	Pump, solar panels, and drainage pipes.	
	Evaporation/storage Pond	30x40x100 yards, fenced and lined.	

Table 14: Lower Tailings Pile Preliminary Cost Estimates

Management Measure/Activity	Resources Required/Details	Preliminary Cost Estimates
In-Situ Closure without Cap	AMEC engineering work, bulldozer rental and driver, borrowed material for run-off controls, airlift and travel time, and volunteer labor	$150,000

Table 15: Summary of Cost Analysis

Remedial Cost Analysis of management measures at Boulder Creek	
Upper Tailings Pile	**$496,937**
Middle Tailings Pile	**$438,810**
Middle Tailings Pile Adit	**$10,000-150,000**
Lower Tailings Pile	**$100,000**

Available Funding for Project

Clean Water Act Section 319(h) Grants

ADEQ administrates these federally provided funds from the EPA. ADEQ encouraged owners of the three tailings piles to apply for these funds during the 2003 funding cycle. The Arizona State Land Department and the private landowner were further encouraged to apply to help leverage the BLM money already dedicated to the project through the Central HazMat Fund. These 319 funds can only be used to cleanup nonpoint sources of pollution. Therefore the adit point source discharge would not be eligible for the 319 source funds. ADEQ's Water Quality Improvement Grant Unit funds 319 projects designed for the restoration of impaired surface waters. Section 319 grants require a 40% non-federal match on total project costs. Sources of matching funds that can be used for the Boulder Creek restoration project can be in-kind or monetary. Examples of non-federal match sources include: donated labor from non-federal employees, volunteers, or from stakeholders such as Phelps Dodge, KFX, the Arizona Department of Transportation (ADOT) and/or Yavapai County; donated technical assistance or equipment, cash and services.

The ADOT Kingman Office demonstrated interest in donating road surfacing materials to the road improvement portion of the overall project. ADOT apparently maintains stockpiles of used and crushed asphalt material that can be re-used to reinforce the surface of unpaved roadways. This commitment of supplies would be eligible as a matching source to grant funding. The donated materials would be beneficial towards the startup of this implementation project. Phelps Dodge has offered some assistance and may be willing to donate grading equipment.

Donated materials, tools, and administrative costs will help meet this non-federal match as well. ADEQ has made several attempts to contact other potential stakeholders who may want to collaborate and donate labor, equipment and/or technical expertise. ADEQ welcomes and recommends that grant applications be submitted from Boulder Creek stakeholders as a high priority surface water restoration project in the state of Arizona.

Central Hazardous Materials Fund- HazMat

The Department of the Interior (DOI) and BLM intend to use these federal funds to help their restoration efforts on their property at the Upper Tailings Pile. Approximately $500,000 dollars are being held in an account for the Kingman District Office of BLM for this cleanup project (BLM, 2003). The BLM is waiting for approval and release of the funds from DOI. Also, DOI in November 2003 gave permission to BLM to fund further engineering research and scoping of the proposed cleanup on all three tailings pile sites, including the two sites that are not on BLM land. More information about these funds will be added to this Plan as it becomes available.

Arizona's Water Protection Fund (AWPF)

In 1994 the Arizona legislature created a Water Protection Fund administered by a 15-member Commission, the director of Arizona Department of Water Resources and the State Land Commissioner. One of the primary reasons for this fund is to preserve surface water resources, including riparian areas. The authorizing legislation calls for "a coordinated effort for the restoration and conservation of the water resources of this state. This policy is designed to allow the people of this state to prosper while protecting and restoring the state's rivers and streams and associated riparian habitats, including fish and wildlife resources that are dependent on these important habitats."

Brownfield Funds

Brownfield Funding is administered by EPA. EPA initiated these funds in 1995 designated to aid in the restoration of properties that were once used for industrial, manufacturing, or commercial lands abandoned or underused due to the suspicion of hazardous substance contamination. The Arizona State Land Department applied for Brownfield Funds to cleanup the Lower Tailings Pile area. However, their application was not awarded funding in 2003. One of the unique requirements of this fund is that former *Brownfields* be re-used for economic purposes. Furthermore, Brownfield Funds tend to be awarded to urban areas, which put the remote Boulder Creek area at a disadvantage.

The Surface Mining Control and Reclamation Act

SMRCA established in 1977 is a federal program that directs funding towards abandoned mines, usually former coal-extraction mine sites. However, some non-coal sites can be reclaimed under Clean Water Act Section 404 paragraph 5(a) (b). After review of this public law, it appears that only the Navajo Nation in Arizona has "an approved mine reclamation program" and the State of Arizona is not listed as having eligible allocated funds to draw from. It would be useful in the future for Arizona to try to gain these funds because it appears that Colorado and New Mexico are both on the list with funds already allocated for mine reclamation. If Arizona gained eligibility for these funds in the future, they could potentially be used if it's proven that these sites represent "an extreme danger" under the Clean Water Act.

F. Information, Education & Outreach

The information, education, and outreach component of this implementation plan is an integral part of public relations and community involvement for the future of Boulder Creek. The goal is to enhance public understanding of the project and encourage participation in selecting, designing, and implementing management measures. As many historical grassroots organizations and public awareness campaigns can attest, public involvement and education can blaze positive trails for an environmental cause and show that there really is "strength in numbers." Several categories and methods will be discussed to support the development of education, outreach, and public involvement strategies.

Community Involvement/Public Awareness

Establishing public knowledge of an issue to the community is a crucial step in establishing public awareness. The community must first understand what, how, and why an issue exists. This can be done through public meetings, seminars, fliers, signs, conversation, and newsletters. Notifying the local press to have information relayed in newspapers, television, and/or radio is a great method to get to the masses the quickest.

An important factor in this process is to keep the facts/information objective and unbiased. A consideration with Boulder Creek is that it is located in a very rural area and the creek's nearest community is Bagdad with an estimated population of 1,600 citizens. Prescott, Arizona is within a short distance and might provide for more successful community involvement given its size and Prescott College.

Bureaucracy/Government

Direct involvement within the Bagdad, Prescott, and Yavapai County local governments would be a key goal for public awareness and outreach of the polluted state of Boulder Creek. Submitting an ecological summary of Boulder Creek, including the TMDL report and implementation plan, to the city council and county offices may provide municipal support towards the cleanup efforts on Boulder Creek. This government involvement might pave the way for public awareness and increased governmental support for environmental quality.

Committees and Commissions

The Yavapai County Water Advisory Committee is a noteworthy organization for county government awareness at the county seat located in Prescott, Arizona. The Yavapai County Water Advisory Committee is a coalition of communities and selected stakeholders that are dedicated to developing a management plan for the sustainable use of our regional water supply. Though water *quantity* and resources issues are always important to Arizona, speaking on behalf of Boulder Creek's impaired status could help expand the committee's aim and gain interest by local community groups on water *quality* issues in their community.

Information on the impaired status of Boulder Creek should be forwarded to the Prescott Area Wildland/Urban Interface Commission. This commission is an informative outreach source for the community of Yavapai County. The commission states "When there is vital, urgent or emergency public information in the Prescott, Arizona, Metro Area, and the rest of Yavapai County, the commission will relay this information via the internet and other sources" (Prescott Area Wildland/Urban Interface Commission, www.regionalinfo-alert.org/PAWUIC.php).

Volunteers

Volunteers are needed to help in Boulder Creek restoration efforts and can aid in the efficiency and productivity of cleanup projects. Whether this volunteering is aiding in physical labor or administration, it will help keep budgets lower and can provide valuable non-federal match opportunities.

Establishing relationships with local community service groups, churches, and organizations may prove successful in establishing volunteers. The Grand Canyon Council of Boy Scouts of America (www.grandcanyonbsa.org) and the Arizona 4-H Club (www.ag.arizona.edu/4-h) have shown their loyalty to stewardship and may want to provide volunteers for restoration and cleanup.

There is a national resource for finding and posting volunteer opportunities. VolunteerMatch is a nonprofit, online service that helps interested volunteers get involved with community service organizations throughout the United States. Prospective volunteers enter a zip code on the VolunteerMatch Web site (www.volunteermatch.org) to quickly find local volunteer opportunities. This simple, effective service has already generated hundreds of thousands of volunteer referrals nationwide. Volunteer recruitment for the restoration of Boulder Creek could be resourced with the aid of this service.

The Master Watershed Steward program is an ADEQ and University of Arizona Cooperative Extension program intended to educate and train citizens across the state of Arizona to serve as volunteers for monitoring, restoration, conservation and protection of water and watersheds. The mission of the Master Watershed Steward Program (MWS) is to educate and train citizens across the state of Arizona to serve as volunteers in the monitoring, restoration, conservation and

protection of their water and watersheds (ADEQ, 2003). The power of volunteering is an exceptional assistance in productivity for implementation goals. Volunteers will aid in monitoring various conditions of Boulder Creek. Volunteers can make visual observations of habitat, land uses, and the impacts of storms at Boulder Creek. In addition to these observations, volunteers can measure the physical and chemical characteristics of waters while assessing the abundance and diversity of living creatures like aquatic insects, plants, fish, birds, and other wildlife in the Boulder Creek ecosystem. During the next year, ADEQ will be collaborating with Gateway Community College in Phoenix to train volunteers to conduct water quality sampling around the state. An advantage of volunteer sampling is that the associated costs can be used as a non-federal match if a federal grant is awarded.

*It should be noted that as valuable as the volunteer aid is, the Boulder Creek landscape poses threats and dangers to physical injury. Any volunteer effort should be organized through appropriate landowners and agencies to assure the safety of individuals.

Colleges and Universities

A powerful resource that can be utilized on behalf of Boulder Creek's restoration project is outreaching to colleges and universities. Prescott College has a very active environmental program which could help facilitate awareness of Boulder Creek's impairment.

Prescott's Arizona Wilderness Coalition has a mission to protect and restore wilderness and other wilderness and waters in Arizona. The coalition will coordinate and conduct inventories, educate citizens about these lands, enlist continuing support and advocate for lasting protection. The Education for Preservation Program is another possible partner as they strive to develop a sense of awareness in the public through intimate contact with the land. This program could help promote environmental stewardship.

At Northern Arizona University, in Flagstaff, the Center for Sustainable Environments brings together the talents and expertise of scientists, educators, independent scholars, business leaders, government agencies, non-profits, students, and community members to seek creative solutions to environmental problems. These challenges are addressed through initiatives that safeguard natural and cultural values and resources. The Center is looking to generate long-term environmental solutions that enhance the lives of those they impact and could help provide awareness of the impacts deserted mining projects have in Arizona.

Mining Community

Outreach and awareness directed towards Arizona's mining community of the environmental impact of mining activities to surface water efforts may benefit this project. The aggressive concern and drive towards implementation efforts to cleanup mine affected lands is a beneficial opportunity for the mining sector to show their stewardship and offer positive community relations.

Arizona Mining Association and Arizona Department of Mines and Mineral Resources recognize the cleanup role involved in the mining process and reclamation of inactive/abandoned mines. An opportunity to speak at a meeting or an informative article in an Arizona Mining Association and/or Arizona Department of Mines and Mineral Resources publication will assist in the education and outreach for this project. For contact with these organizations use the following Web site addresses: www.azcu.org and www.admmr.state.az.us.

Multimedia

Exploiting the use of technology and multimedia, meanwhile tapping the power of their communicative resources and "attention grabbing" capabilities, should be explored when a TMDL cleanup project is being implemented. The use of television, radio, and internet resources can have an informative, newsworthy, graphical impact on public outreach within the community. Utilizing television and radio resources for the Boulder Creek cleanup project may take a creative funding approach due to the expense of airtime. Conversely, internet resources are a cheaper alternative although they do not have the communicative qualities of television/radio.

For starters, a Boulder Creek Web site can be constructed. The Boulder Creek Web site can provide this implementation plan, education and outreach components, status/tracking of cleanup projects, contact and volunteer information, and photos/graphics. The low maintenance and cost (free web hosting is available), of a Web site will allow for minimal project upkeep effort. In turn, stakeholders will benefit from such a graphical, informative, and educational tool.

Group Networking

Networking is a powerful education and outreach component. Historically, grassroots organizations have made huge strides in environmental protection, law, and awareness. Many environmental organizations are non-profit, so they may provide ways to use resources more efficiently and cost effective. Environmental groups are a great source for ideas and outlets for outreach and education. If something has worked in the past, the chances that it will continue to be successful are good. So, in turn, mimicking the actions and tools that have flourished in the past, can provide success in the future. The following is a short list of groups that can provide assistance with the execution of the Boulder Creek implementation and cleanup efforts.

www.nature.org/wherewework/northamerica/states/arizona The Nature Conservancy in Arizona has been working locally with communities, businesses and people, providing hope for the preservation of our land, our water, our way of life.

www.prescottcreeks.org The Prescott Creeks Preservation Association strives to protect the ecological integrity of Central Arizona's riparian systems and their associated wetlands through preservation, conservation, and education.

www.foe.org Friends of Earth is the US voice of the world's largest network of environmental groups.

www.treeswaterpeople.org Trees, Water, and People are dedicated to improving people's lives by helping to protect, conserve, and manage the natural resources upon which their long-time-well-being depends.

www.arizonacleanandbeautiful.org Arizona Clean and Beautiful, founded in 1985, is a non-profit, volunteer-driven organization dedicated to preserving, maintaining, and enhancing the beauty and environmental quality of Arizona through research, education and the Arizona Affiliate Network.

www.blm.gov/education
www.blm.gov/education/LearningLandscapes/menu/states/arizona.html
Outreaching to children and young adults might be one of the most vital links into environmental protection and, more importantly, shifting towards a more environmentally conscience paradigm

within our communities. The BLM's Environmental Education Program in the state of Arizona currently runs programs throughout the year. The BLM owns lands across Arizona in which mines reside, including Boulder Creek. Working with the local BLM officials, mining programs could be drafted and the Boulder Creek would be a great example of "cause/effect" and, in the future, a success story.

www.earthjustice.org
www.environmentaldefense.org/home.cfm
Defenders of environmental causes are a great tool in today's environmental litigation. Earthjustice is a non-profit law firm for the environment, representing—without charge—hundreds of public interest clients, large and small. Earthjustice works through the courts to safeguard public lands, national forests, parks, and wilderness areas; to reduce air and water pollution; to prevent toxic contamination; and to preserve endangered species and wildlife habitat.

G. Schedule for Implementation

ADEQ cannot assign concrete timelines to a voluntary cleanup without seeing the work plan proposals from BLM, the private stakeholder KFX, and/or Arizona State Land Department. The timelines should remain flexible, be economically feasible, and adjust to changing weather conditions. For instance, re-grading the top portions of the piles should probably not be conducted during monsoon season or during the wetter rain periods for obvious reasons. The schedule will be dynamic, due to the multiple groups involved, seasonal weather patterns, funding timelines, and further refinement of project details.

Following is the proposed schedule for the restoration of Boulder Creek. Ideally, ADEQ anticipates that Phase I could be achieved in 2005, Phase 2 in 2006, and Phase 3 in 2007.

Phase I – Preparation 2004-2005

1) Secure Central HazMat, 319(h), and other possible funding for all three tailings areas.
2) Repair and improve existing unpaved roadway leading to the Upper Tailings Pile and Middle Tailings Pile areas.
3) Transport via helicopter re-grading and fuel equipment to the remote Lower Tailings Pile area.

Phase 2 – Cleanup 2006

4) Move tailings materials from the flood plain to the top of the Middle Tailings Pile.
5) Re-grade, contour, bench, and shape Upper Tailings Pile and Middle Tailings Pile surfaces.
6) Install run-on controls above Upper Tailings Pile and Middle Tailings Pile where appropriate.
7) Cap Upper Tailings Pile and Middle Tailings Pile with geo-textile liners (varied mil thickness where appropriate), add rock layers, apply topsoil, and plant vegetation on piles.
8) Install a discharge collection area and solar pumps for the adit and a treatment settling pond above the adit area and Middle Tailings Pile.
9) Begin re-grading work at and above the Lower Tailings Pile to install run-on and run-off controls. (This can occur as soon as step 3 is accomplished).

Phase 3 – Monitoring & Evaluation 2007-2009

10) Conduct effectiveness monitoring to determine if the TMDL allocations and Boulder Creek's water quality standards are being met.

After the road improvements are done at Upper Tailings Pile and Middle Tailings Pile areas, then the initial stages of on-the-ground implementation can begin. The Upper Tailings Pile should be ready for re-grading and encapsulation soon after the road is refinished. The Middle Tailings Pile area will require some additional tailings materials to be moved on top of the pile from the 100-year flood plain of Boulder Creek prior to re-grading.

The first step in cleanup at the Lower Tailings Pile is not contingent upon the road improvements; rather, finding an organization willing to donate or fund a helicopter to transport equipment to the project. Clearly, the entire schedule is contingent upon step 1, obtaining funding.

H. Measurable Milestones

In order to evaluate the effectiveness of TMDL implementation at Boulder Creek, measurable events must be tracked. As selected management measures take effect in the Boulder Creek watershed, a routine assessment of the project status and achievements is needed to determine reasonable assurance of successful implementation.

Milestones are interim and contingent on certain measures like funding, coordination/organization, schedules of stakeholders, communication, staffing, and temporal patterns. Measurable milestones will track the progress of the management measures, schedules, and evaluation of this project. The stakeholders and land owners at Boulder Creek will be responsible for tracking milestones. Continued water quality monitoring is encouraged at Boulder Creek. If the water quality calculations found in the Boulder Creek TMDL are used as a baseline, the future progress of pollutant reduction in Boulder Creek can be measured. Table 16 below charts the milestones for certain goals of the Boulder Creek TMDL Implementation Plan.

Table 16: Measurable Milestones

Milestone	Deliverable
1. Secure funding all three tailings piles.	Complete and submit 319, and other applicable grant applications.
2. Improve Roadway to Upper Tailings Pile & Middle Tailings Pile.	Communication with ADOT on gravel contribution.
3. Helicopter transport equipment to Lower Tailings Pile.	Target date of helicopter reservation.
4. Move tailings from flood plain at Middle Tailings Pile to top of pile.	Construction project begins at Middle Tailings Pile.
5. Re-grade, contour, bench and shape top of Upper Tailings Pile and Middle Tailings Pile.	Construction begins at Upper Tailings Pile and Middle Tailings Pile.
6. Install run-on controls above Upper Tailings Pile and Middle Tailings Pile.	Construction of run-on controls begins above Upper Tailings Pile and Middle Tailings Pile.
7. Cap, rock, seed and sod Upper Tailings Pile and Middle Tailings Pile.	Geotextile liners, associated hardware, and vegetation in place for construction.
8. Adit discharge treatment and collection pond system at Middle Tailings Pile.	Design completed for adit discharge treatment and collection pond system at Middle Tailings Pile.
9. Re-grade and install run-on and runoff controls at remote Lower Tailings Pile site.	Accessibility to Lower Tailings Pile is improved.
10. Evaluation monitoring and assessments over next 2 years.	Upper Tailings Pile = 50% load reduction Middle Tailings Pile = 20% load reduction Adit Discharge = 50% load reduction Lower Tailings Pile = 20% load reduction
11. Delist Boulder Creek from Arizona 303(d) List of Impaired Waters.	Upper Tailings Pile = 78% load reduction Middle Tailings Pile = 40% load reduction Adit Discharge = 85% load reduction Lower Tailings Pile = 55% load reduction

I. Criteria to Evaluate Load Reductions

Water quality samples will be the most effective way to verify that pollutant loadings are being reduced. It is important that water sampling be conducted during different seasons, considering the temporal flows of this intermittent waterway. Additional monitoring upstream of the critical area may also be necessary to keep track of "natural background" contributions of the TMDL listed parameters. Three types of monitoring should ideally be performed.

- metals sampling based on numeric standards
- physical parameters such as suspended sediment concentrations and pH levels
- biocriteria sampling for biological health of in-stream macroinvertebrates

(Note that biological sampling would currently be a supplemental indicator, since Arizona has not yet established biological standards.)

Table 17 lists Arizona's current surface water quality standards for the parameters addressed in the TMDL investigation. These standards are established in rule and can be found in the Arizona Administrative Code, Title 18, Chapter 11.

Table 17: Applicable Water Quality Standards in the Boulder Creek TMDL

Designated Use	A&Ww µg/L	FBC µg/L	FC µg/L	AgI µg/L	AgL µg/L
Arsenic (As)	360 D (acute)	50 T	1,450 T	2,000 T	200 T
Copper (Cu)	Hardness Dependent	1,300 T	NNS	5,000	500 T
Zinc (Zn)	Hardness Dependent	420,000 T	69,000 T	10,000 T	25,000 T

T = Total & D = Dissolved

Along with water quality sampling for parameters considered in the TMDL (arsenic, copper and zinc), other metals should be periodically monitored. Boulder Creek was formerly listed on Arizona's 303(d) List of impaired waters for beryllium, lead, and manganese. It should be noted, however, that some of these parameters were delisted due to changes in water quality standards, and may no longer represent a valid water quality concern.

Another form of tracking that could be used is to run soil loss equation analyses to determine the estimated volume of sediment loads that are prevented from entering Boulder Creek. Measurements of the relationship between sediment erosion and the transport of metal contaminants in Boulder Creek can provide additional monitoring benefits.

A process for evaluating load reductions and effectiveness of management measures can be establishing a baseline of standards in which all progress can be measured. These standards can be numeric water quality measurements or existing project and management measures that need to be addressed for a successful cleanup of Boulder Creek.

J. Water Quality Monitoring

Monitoring is an essential tool to evaluate the restoration of impaired waters. To measure the milestones that have been established previously in this implementation plan, an effective monitoring process must be able judge the criteria set forth in this project. Reasonable assurance must be given to ADEQ and the stakeholders of Boulder Creek. With appropriate water quality monitoring, the ultimate goal to de-list Boulder Creek from Arizona's 303(d) List of Impaired Waters will be attainable.

Effectiveness monitoring will the best way to evaluate the success of the project. Effectiveness monitoring involves in-stream monitoring to evaluate water quality changes that occur due to implementation of management measures. In addition to planned follow-up monitoring by ADEQ, stakeholders may choose to collect their own samples during and after the project.

Water quality samples collected from Boulder Creek will be used in the state's 305(b) Water Quality Assessment Report and 303(d) List of Impaired Waters. Assessing water quality data for Boulder Creek will determine whether Boulder Creek is attaining its designated uses and meeting applicable water quality standards. This assessment, required under the Clean Water Act, is completed every two years and considers available surface water data collected within the last five years. Surface waters are assessed according to state water quality standards based on the designated uses assigned to each waterbody.

It is important for any parties interested in collecting samples to understand Arizona's "credible data requirements" as established the Arizona Administrative Code, Title 18, Chapter 11, Article 6. Data submitted to ADEQ for assessment must meet these requirements in order to be used for the 305(b)/303(d) report. These requirements include proper training of samplers, development of a sample plan, and use of a state certified laboratory for sample analysis. For more information, visit the ADEQ Web site at www.azdeq.gov/environ/water/assessment/submissions.html

Implementation monitoring is another necessary component to measure the success of Boulder Creek's cleanup. Implementation monitoring is used to determine whether activities are carried out as planned and how effective the activities have been. If the Boulder Creek stakeholders receive a federal 319 grant, management of the project will be organized and administered by ADEQ's Water Quality Improvement Grant Unit. ADEQ will assign a project manager to conduct tracking and effectiveness of the project. Corresponding feedback via telephone and written documentation is required. Photos of project status and site visitation will accompany the aforementioned correspondence. 319 funded grant projects generally will have a timeframe of 2 years for implementation and tracking.

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Glossary of Frequently Used Terms and Acronyms

ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AGFD	Arizona Game & Fish Department
ALRIS	Arizona State Land Information System Web site
AMA	Arizona Mining Association
ASLD	Arizona State Land Department
A.R.S.	Arizona Revised Statutes
AZPDES	Arizona Pollution Discharge Elimination System
BLM	Bureau of Land Management
DOI	Department of the Interior
EPA	Environmental Protection Agency
FBC	full body contact
FSN	Fixed Station Network – Sampling Program
GIS	Geographic Information Systems – Mapping Software
HUC	Hydrologic Unit Code – Numeric Watershed Code
LTP	lower tailings pile
MLRU	Major Land Resource Unit – Land Use Cover
MTP	middle tailings pile
NMA	National Mining Association
NPDES	National Pollution Discharge Elimination System
NRCS	National Resource Conservation Service
PS	point source pollution
TMDL	Total Maximum Daily Load
USFS	United States Forest Service
USGS	United States Geological Survey
UTP	upper tailings pile
µg/L	micrograms per liter
g/L	grams per liter