WATER QUALITY RESTORATION PLAN FOR THE COOKE CITY TMDL PLANNING AREA

McLaren Pit, 1970's

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Montana Department of Environmental Quality

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Purpose and Water Quality Restoration Plan Elements and Strategies

This document is a water quality restoration plan (WQRP) and Total Maximum Daily Load (TMDL) submittal for several water bodies (streams) located in the Cooke City TMDL Planning Area. Figure E-1 (reference Figure Section) shows the locations of the Cooke City Planning area and some of the primary water bodies of concern. The water bodies in need of TMDL development have been identified on the State of Montana 303(d) list as impaired water bodies that are not fully supporting their beneficial uses, with aquatic life support being the most significant use impairment and metals, pH, and sediment being the pollutants of concern. The overall goal is to identify an approach to improve water quality to a level where beneficial uses are restored and protected. By addressing this goal, the document fulfills the requirements of Section 303 (d) of the Federal Clean Water Act and Title 75, Chapter 5, Part 7 of the Montana Water Quality Act. Table E-1 is a summary of TMDL and restoration plan components and strategies found within this WQRP.

Table E-1: Restoration Plan Components and Strategies Summary

Water Bodies & Pollutants of Concern		- Daisy Creek (pollutants: metals, pH, sediment) - Stillwater River (pollutants: metals, sediment) - Fisher Creek (pollutants: metals, pH, sediment) - Clarks Fork of the Yellowstone River (pollutants: metals, pH) - Miller Creek (pollutants: metals) - Soda Butte Creek (pollutants: metals)
Impaired Beneficial Uses for Each Water Body		- Daisy Creek (impaired uses: aquatic life; cold water fish; drinking water; recreation/aesthetics; agriculture; industry) - Stillwater River (impaired uses: aquatic life; cold water fish; drinking water; recreation/aesthetics) - Fisher Creek (impaired uses: aquatic life; cold water fish; drinking water; recreation/aesthetics; agriculture; industry) - Clarks Fork of the Yellowstone River (impaired uses: aquatic life; cold water fish; drinking water) - Miller Creek (impaired uses: aquatic life; cold water fish; drinking water) - Soda Butte Creek (impaired uses: aquatic life; cold water fish; drinking water; recreation/aesthetics)
Pollutant Sources		- Metals: Mine disturbances, natural background - pH: Mine disturbances, natural background - Sediment: Mine disturbances, roads and trails, natural background
Target Development Strategies		- Numeric values for aquatic life support (metals, pH) - Numeric values for drinking water/domestic use support (metals) - Elimination of objectionable deposits and turbidity from metal precipitates (metals/pH) - Non-toxic levels in stream sediments (metals) - Biota at greater than or equal to 75% of reference conditions (all pollutants) - Stream habitat conditions within 25% of reference stream (sediment)

Numeric TMDL Value Development Strategies		- Based on numeric concentration targets multiplied by stream flow (all metals) - Metals TMDLs used as surrogates for pH - Based on yearly loads and percent reductions in loading (sediment)
Pollutant Load Allocations Strategies		- Performance-based for mine disturbances (applies to metals and pH in all drainages except Soda Butte) - Allocated to loading sources by category with focus on mining and natural background sources (applies to metals in Soda Butte Creek) - Allocated to loading sources by category with focus on mine disturbances, roads and trails, and natural background sources (applies to sediment TMDLs)
Restoration Strategies		- New World Mining District restoration efforts currently underway for mine disturbances and related erosion control practices (benefits all major water bodies with initial focus on sources within the Daisy, Fisher, and Miller Creek drainages) - Additional National Forest Service erosion control practices and mine restoration efforts where needed (all water bodies) - Further characterization and possible restoration of mine disturbances on private lands (for some water bodies; key strategy component for Soda Butte Creek drainage) - Significant water quality and related monitoring including additional source characterization (all water bodies) - Adaptive management approach to identify any necessary changes to targets, TMDLs or load allocations (all water bodies)
Margin of Safety		- Addition of biota targets in addition to metals concentration targets - Application of chronic aquatic life numeric standards - Built in margins of safety within existing numeric water quality standards - Significant monitoring efforts associated with metals related watershed characterization and restoration efforts - Metals and pH targets apply during high and low flow conditions with considerations for changing hardness conditions - Phased approach for sediment TMDLs and allocations - Use of relatively undisturbed stream(s) for sediment target reference condition
Seasonal Considerations		- Metals and pH targets apply during high and low flow conditions with considerations for changing hardness conditions - Metals and pH impairment and loading conditions evaluated at high and low flow conditions - Existing and future monitoring addresses high and low flow conditions for metals and pH - Sediment targets, source assessment and controls are based on modeling and monitoring efforts intended to capture impacts from seasonal and event-driven loading conditions

Problem Description

The six impaired water bodies (also referred to as streams) in the Cooke City TMDL Planning Area, as shown by Figures E-1 and E-2, are Daisy Creek, the upper 22 miles of the Stillwater River, Fisher Creek, the Clarks Fork of the Yellowstone River (Clarks Fork River) upstream of the Montana - Wyoming border, Miller Creek, and segments of Soda Butte Creek. No other water bodies in the Cooke City Planning Area have yet been identified as being impaired and in need of Total Maximum Load development, although the data presented within this report suggests that some of the additional tributaries to Soda Butte Creek are possibly impaired. The restoration strategy for Soda Butte Creek addresses these potential impairment conditions.

Several different metals impact each impaired stream. Many of the metals create toxic conditions in the water column or in sediments at levels that negatively impact aquatic life and/or exceed human health criteria for drinking water. Some metals also impact aesthetic qualities creating turbid water conditions, and/or creating objectionable sludge deposits or staining in the streambed. The specific metals of concern include copper, iron, zinc, manganese, lead, cadmium, silver, and aluminum. Copper and iron typically represent the greatest negative impacts to water quality in most of the six streams. Low pH conditions are also associated with the elevated metals, further impacting aquatic life and other beneficial uses in Daisy Creek, Fisher Creek, and the Clarks Fork River.

Excessive sediment accumulation in the streambed because of human caused conditions is also a problem in Daisy Creek, the Stillwater River, and Fisher Creek. The sediment can smother aquatic life and cause overall negative impacts to habitat conditions.

Mining disturbances primarily associated with historical adits, waste rock and tailings represent the primary sources of increased metals loading from human activities. Problems associated with low pH (acidic conditions) are also related to many of these same metals sources. Many of these same mining disturbances along with significant road and trail networks represent the primary sources of increased sediment loads from human activities. In addition, natural background conditions also contribute to both metals and sediment loads to the streams, perhaps at elevated levels that alone could negatively impact beneficial uses in some of the six water bodies.

Mine disturbances and roads in the Daisy Creek drainage are the cause of essentially all of the controllable problems in both Daisy Creek and the upper portion of the Stillwater River. In a similar manner, mine disturbances and roads in the Fisher Creek drainage are the cause of essentially all of the controllable problems in both Fisher Creek and the Clarks Fork River upstream from the Wyoming border. Although mine disturbances in Miller Creek are a significant source of metals in Soda Butte Creek, there are additional significant sources of metals to Soda Butte Creek, such as the McLaren Tailings, not located in the Miller Creek Drainage.

Restoration Targets and TMDLs

Restoration targets and TMDLs are developed for each stream. The targets reflect conditions necessary to meet Montana Water Quality Standards and, most importantly, support applicable beneficial uses. For aquatic life and cold water fish uses, the target goals are to provide stream conditions that can support a healthy aquatic life community based on stream capabilities. This includes the ability to support a self-sustaining fishery along with healthy macroinvertebrate and periphyton communities. For the human health/domestic water related use as well as industrial and agriculture uses, the goal is to maintain state waters in a condition that supports the use of this valuable resource for a broad range of human activities associated with a use either directly from the stream of concern or from downstream water bodies which rely on these and other upstream tributaries as a source of clean water.

Once a target is identified, then conditions necessary to meet that target can be defined in a way that meets the definition of a TMDL or surrogate TMDL, and an overall allocation approach can be developed to address restoration goals. In other words, the targets describe the desired conditions, and the TMDL and allocation help describe how these conditions can be met. Table E-2 is a summary of the metals and pH targets applicable to each impaired water body. The metals targets are based on the numeric water quality standards set at concentrations that support aquatic life, human health, and all other beneficial uses. Additional metals targets are based on elimination of objectionable streambed deposits and turbidity. To address potentially synergistic affects and to add a margin of safety to the overall restoration process, additional targets apply to all water bodies based on biota being greater than or equal to 75% of a reference stream that represents desirable conditions.

Metals targets, TMDLs, and estimated load reductions are all analyzed at high and low flow conditions to address the complete range of seasonal impacts. Addressing these flow ranges and the varying water quality conditions associated with them helps to ensure that restoration planning is geared toward meeting the metals and pH standards all year long.

For the metals targets associated with numeric standards, the TMDLs are calculated by multiplying the applicable target concentration by the stream flow to promote a problem solving approach that can be based on consideration of load contributions from various sources or source areas. An assumption within this plan is that meeting the TMDLs based on numeric standards is expected to satisfy all other metals related targets associated with objectionable sludge deposits, stream sediment chemistry, turbid conditions, pH, and biota indicators.

Water quality standards for sediment are narrative, and the sediment targets are developed to reflect desired conditions that would satisfy Montana Department of Environmental Quality (MDEQ) interpretations of relevant water quality standards. These sediment targets are only developed for the three streams identified as being impaired from sediment: Daisy Creek, Stillwater River, and Fisher Creek.

The sediment TMDLs are based on sediment modeling conducted by Forest Service personnel and professional judgement as to what conditions will satisfy the target. Because of the nature of sediment transport, yearly loads, along with yearly load reductions for some water bodies, are used as surrogate TMDLs. The uncertainty associated with this approach requires an adaptive management (phased) strategy whereby monitoring will be used to verify that anticipated load

Table E-2. Metals and pH Water Quality Restoration Targets for Impaired Water Bodies in the Cooke City TMDL Planning Area

Pollutant	Daisy Creek and Stillwater River Targets	Fisher Creek and the Clarks Fork River Targets	Miller Creek and Soda Butte Creek Targets	Limiting (most sensitive) Beneficial Use
Copper[1]	5.2 ug/l (high flow) 7.3 ug/l (low flow) sediment concentrations at non-toxic levels	2.8 ug/l (high flow) 4.2 ug/l (low flow) sediment concentrations at non-toxic levels	4.7 ug/l (high flow) 7.3 ug/l (low flow) sediment concentrations at non-toxic levels	Aquatic Life
Cadmium[1]	0.16 ug/l (high flow) 0.22 ug/l (low flow)	0.10 ug/l (high flow) 0.14 ug/l (low flow)	0.15 ug/l (high flow) 0.22 ug/l (low flow)	Aquatic Life
Lead[1]	1.3 ug/l (high flow) 2.2 ug/l (low flow) sediment concentrations at non-toxic levels	0.54 ug/l (high flow) 0.99 ug/l (low flow) sediment concentrations at non-toxic levels	1.2 ug/l (high flow) 2.2 ug/l (low flow) sediment concentrations at non-toxic levels (Miller Creek)	Aquatic Life
Zinc[1]	67 ug/l (high flow) 94 ug/l (low flow)	37 ug/l (high flow) 55 ug/l (low flow)	61 ug/l (high flow) 94 ug/l (low flow)	Aquatic Life
Iron	300 ug/l (all flows) - no visible streambed deposits associated with controllable human causes	300 ug/l - no visible streambed deposits associated with controllable human causes	1000 ug/l (both streams) 300 ug/l (both streams) no visible streambed deposits associated with controllable human causes below McLaren Tailings in Soda Butte Creek	Aquatic Life & Drinking Water (domestic use); Aesthetics
Manganese	50 ug/l	50 ug/l	50 ug/l	Drinking Water (domestic use)
Aluminum	no precipitants causing visible turbidity at low flow conditions	- 87 ug/l (dissolved aluminum in pH range of 6.5 to 9.0; outside of this range there is no applicable dissolved aluminum target) - no precipitants causing visible turbidity at low flow conditions	87 ug/l (dissolved)	Aquatic Life/Aesthetics
Silver	NA	0.37 ug/l (high flow) 0.84 ug/l (low flow)	NA	Aquatic Life
PH	6.0 to 9.0	6.0 to 9.0	NA	Aquatic Life
Metals & pH	Macroinvertebrate and periphyton communities at 75% or greater of reference stream conditions	Macroinvertebrate and periphyton communities at 75% or greater of reference stream conditions	Macroinvertebrate and periphyton communities at 75% or greater of reference stream conditions	Aquatic Life

Notes:
1. All targets for this pollutant are estimated based on predicted hardness values after completion of restoration activities, actual values will be determined by hardness as defined in Appendix A

reductions from restoration activities (primarily erosion control) result in meeting the target. If the target is not met, then a new TMDL and associated load allocations will be identified to reflect the need for a lower yearly load and increased load reductions via additional erosion controls.

Load Allocations and Implementation Strategy

An approach based on the performance of specific source control actions is the primary allocation approach and implementation strategy to address metals problems for all water bodies except Soda Butte Creek. These control actions are associated with New World Mining District Response and Restoration Project activities that are underway in the Daisy, Fisher and Miller Creek drainages. This effort will presumably satisfy applicable metals and pH restoration targets for Daisy Creek, Fisher Creek, the Stillwater River, and some or all of the remaining streams in the Cooke City area depending on funding conditions and the results from further characterization of potentially significant metals sources.

Although Miller Creek restoration discussed above can significantly improve water quality in Soda Butte Creek, there is still a lack of firm commitments to address all other significant metals loading sources to Soda Butte Creek, such as the McLaren Tailings. These other sources, which are mainly associated with mine disturbances and natural background conditions, are instead given load allocations either by source category or by individual source areas. The load allocations represent loading conditions that would support the overall TMDL and targets within all of Soda Butte Creek, and can help direct future characterization and restoration work.

The allocation approach and implementation strategy for sediment sources is similar to the above metals approach. It is anticipated that New World Mining District efforts will address most of the necessary load reductions. Any additional load reduction needs will likely be addressed via additional Forest Service erosion control practices for roads and trails.

This document also includes a monitoring plan that identifies some data gaps that should be addressed and provides recommendations for further study to help direct future restoration activities, particularly in the Soda Butte Creek drainage. The monitoring plan also addresses the need to determine overall progress toward meeting targets at least once every five years as directed by Montana State Law.

SECTION 1.0
INTRODUCTION

1.1 Water Quality Restoration Planning

This document is a water quality restoration plan (WQRP) and Total Maximum Daily Load (TMDL) submittal for the Cooke City TMDL Planning Area (Figure E-1). The overall goal is to identify an approach to improve water quality to a level where beneficial uses are restored for all impaired water bodies in the Cooke City TMDL Planning Area and ensure that Montana water quality standards are not violated.

Under Montana State Law, an "impaired water body" is defined as a water body or stream segment for which sufficient credible data shows that the water body or stream segment is failing to achieve compliance with applicable water quality standards (Montana Water Quality Act; Section 75-5-103). Furthermore, State Law directs the Montana Department of Environmental Quality (MDEQ) to develop TMDLs for impaired water bodies (Montana Water Quality Act; Section 75-5-703). A TMDL is a pollutant budget developed at a level where water quality standards will not be exceeded. The TMDL accounts for loads from point and nonpoint sources in addition to natural background loads. Appendix A provides additional details on the definition of a TMDL and how it fits into water quality planning.

To satisfy Montana State Law, and the Federal Clean Water Act, TMDLs are developed for each water body-pollutant combination and are presented within the context of a water quality restoration plan. The WQRP not only includes the TMDL but also includes information that can be, or in some cases, is being used to effectively restore water quality using a coordinated and scientifically based approach.

The Cooke City Planning Area is one of 91 planning areas in the State of Montana where one or more water bodies have been, and/or currently are listed as having one or more pollutants or other causes leading to impaired conditions. A planning area typically encompasses a complete watershed or significant portion of a watershed. The Cooke City Planning Area is unique because it encompasses the upper drainages of three different watersheds due to the close proximity of the stream segments addressed, the similar nature of impairment conditions, and the ongoing coordination of restoration efforts for many of the water bodies in the planning area. The three watersheds that the work is associated with are the Stillwater River, the Clarks Fork of the Yellowstone, and the Yellowstone Headwaters (specifically the Soda Butte Creek drainage), all of which are part of the Yellowstone River basin. By addressing impairment conditions in these three watersheds, potentially significant impairment contributions and associated needed pollutant reductions for downstream water bodies in other TMDL planning areas are also addressed. The extent that these upstream pollutant reductions help address any downstream beneficial use support concerns will be evaluated further as restoration plans are developed for the downstream TMDL planning areas.

As discussed in Appendix A, the water quality restoration plan and the TMDL can be used to help focus ongoing programmatic efforts in a direction that helps ensure proper consideration of water quality impairments and applicable Montana water quality standards. Much of the Cooke City area is covered by existing state and federal programs that address many of the specific TMDL development requirements, often at a level of detail not typically available for the majority of water bodies in Montana. Because of this significant ongoing effort, this plan generally references much of this ongoing work and the information found in associated planning documents.

1.1.1 Water Bodies and Pollutants of Concern

Section 303 of the Clean Water Act requires states to submit a list that includes impaired water bodies (streams, lakes, wetlands) to the U.S. Environmental Protection Agency (EPA) every two years. An impaired water body is a water body that does not satisfy state water quality standards and does not fully support all designated beneficial uses for that water body. The 303(d) List identifies which beneficial uses are impaired and indicates the probable causes (i.e., the pollutant such as metals) and the probable sources of the impairment (i. e., activities, land uses, or conditions such as mining or roads). Table 1-1 provides 303(d) listing information for the water bodies of concern in the Cooke City TMDL Planning Area. Table 1-1 includes the water body names and probable causes for the 1996, 1998, and 2000 EPA-approved 303(d) lists. Figure E-2 shows the locations of these water bodies as well as key tributaries in the area.

The Montana 2000 303(d) List is the most current EPA-approved list and is based on more rigorous scientific analyses in comparison to past 303(d) Lists. A ruling by the U.S. District Court (CV97-35-M-DWM) on September 21, 2000 stipulates that the state of Montana must complete "all necessary TMDLs for all waters listed as impaired or threatened on the 1996 303(d) List". This would mean that a TMDL needs to be developed for each pollutant (probable cause) and water body combination identified in Table 1-1 for the 1996 list or any new pollutant-water body combinations added in later lists. The exception is where subsequent data and assessment work reveals that there is no impairment associated with the pollutant of concern, meaning that a TMDL is not necessary for the purpose of restoring water quality and associated beneficial uses.

Review of Table 1-1 shows that metals are the most commonly listed cause of impairment. Metals can include anywhere from one to several different specific metal compounds, each representing a unique pollutant in need of TMDL development for the water body of concern. For each water body in the Cooke City area, the metals of concern can include any one or all of the following: copper, cadmium, aluminum, zinc, lead, iron, and manganese. All metals have numeric standards set at levels necessary to support specific beneficial uses.

Sediment is another listed cause of impairment in Table 1-1. Sediment is a broad pollutant term that can lead to beneficial use support problems from such things as deposition of the sediment in the water body or loss of water clarity. Terms such as suspended solids (meant to represent suspended sediment in this document) and siltation can be considered under the broad category of sediment from a pollutant control and TMDL development perspective (EPA, 1999). There are no numeric standards for sediment. DEQ has developed guidance (Water Quality Assessment Process and Methods; Appendix A to the 2000 303(d) List) that can be used to define a water body as being impaired from sediment. For example, aquatic life/fisheries use can be considered impaired if the levels of sediment create conditions where at least one biological assemblage (macroinvertebrate, periphyton, or fishery) is 75% or less of a reference condition.

Also listed as a cause of impairment is pH. The parameter pH is defined as the negative logarithm of the hydrogen-ion activity, with lower pH values reflecting acidic water conditions.

Table 1-2 provides a general summary of each water body including the beneficial uses not fully supported and the specific pollutants requiring TMDL development within this document. Note that a few water bodies are identified as not fully supporting the beneficial uses of agriculture and industry. State water quality standards are protective of multiple uses that always include agriculture and industry for A-1 or B-1 classified streams. The goal is to not only protect these uses within given water bodies, but to also protect these uses in downstream waters. This then ensures a healthy aquatic ecosystem while at the same time keeping pollutant levels low enough to support other existing or potential human related uses such as agriculture or industry. Fortunately, by developing this plan around targets and restoration efforts needed to protect aquatic life and drinking water beneficial uses, both agriculture and industry beneficial uses are also protected since the aquatic life and drinking water uses are more sensitive to the pollutants of concern. This approach also provides protection for the recreation/aesthetics related beneficial use by providing targets that address aesthetic problems that result from metals precipitates and associated turbid waters and stream deposits.

The specific details associated with each water body and the metals and other pollutants that are causing impairment problems are further discussed within Sections 2.0 through 4.0 of this document.

Table 1-1. 303(d) Impaired Water Bodies Listing History (1996, 1998, and 2000) for the Cooke City Area

Water Body Name	Stream Segment Number	Probable Cause (pollutant or pollutant category)	Year(s) Listed
Daisy Creek	MT43C002_140	Metals	1996, 1998, 2000
Daisy Creek	MT43C002_140	pH	1996, 1998
Daisy Creek	MT43C002_140	Sediment (Siltation)	2000
Stillwater River	MT43C001_010	Metals	1996, 1998, 2000
Fisher Creek	MT43D002_110	Metals	1996, 1998, 2000
Fisher Creek	MT43D002_110	pH	1996, 1998, 2000
Clarks Fork of the Yellowstone	MT43D001_020	Metals	1996, 1998, 2000
Clarks Fork of the Yellowstone	MT43D001_020	pH	1996, 1998
Soda Butte Creek*	NA	Metals	1996, 1998
Soda Butte Creek*	NA	Sediment (Suspended Solids)	1996, 1998
Soda Butte Creek (upper)*	MT43B002_032	No impairments	2000
Soda Butte Creek (lower)*	MT43B002_031	Metals	2000
Miller Creek	MT43B002	Metals	Not previously listed

*Soda Butte Creek was divided into two segments for the 2000 list, the upper section from the headwaters to the McLaren Tailings, and the lower section from the McLaren Tailings to the Montana-Wyoming border.

Table 1-2. Water Bodies Needing a Restoration Plan (Cooke City Planning Area)

Water Body	Beneficial Uses not Fully Supported	Watershed	Pollutants
Daisy Creek (headwaters to the mouth at Stillwater River)	Aquatic Life; Cold Water Fish; Drinking Water; Recreation/Aesthetics; Agriculture; Industry	Stillwater River (upper portion)	Metals (Copper, Cadmium, Lead, Zinc, Iron, Manganese, Aluminum); pH; Sediment
Stillwater River (headwaters to Flood Creek)	Aquatic Life; Cold Water Fish; Recreation/Aesthetics	Stillwater River (upper portion)	Metals (Copper, Iron, Manganese); Sediment
Fisher Creek (headwaters to the mouth at the Clarks Fork of the Yellowstone)	Aquatic Life; Cold Water Fish; Drinking Water; Recreation/Aesthetics; Agriculture; Industry	Clarks Fork of the Yellowstone (upper portion)	Metals (Copper, Iron, Manganese, Aluminum, Zinc, Cadmium, Lead, Silver); pH; Sediment
Clarks Fork of the Yellowstone (Fisher Creek to the Montana border)	Aquatic Life; Cold Water Fish; Drinking Water	Clarks Fork of the Yellowstone (upper portion)	Metals (Copper, Zinc, Cadmium, Silver, Iron); pH
Miller Creek (Headwaters to the mouth at Soda Butte Creek)	Aquatic Life; Cold Water Fish, Drinking Water	Yellowstone Headwaters (upper portion)	Metals (Copper, Iron, Cadmium, Lead, Manganese, Zinc)
Soda Butte Creek (McLaren Tailings to the Montana border)	Aquatic Life; Cold Water Fish; Drinking Water; Recreation/Aesthetics	Yellowstone Headwaters (upper portion)	Metals (Copper, Iron, Manganese, Lead, Aluminum)

1.1.2 Water Quality Restoration Plan Organization and Terminology

This plan starts out with this introductory section (Section 1.0) which includes general planning information, a description of the area, and a description of applicable water quality standards. This is then followed by Sections 2.0, which specifically addresses restoration goals and load allocations for Daisy Creek and the portion of the Stillwater River within the Cooke City TMDL Planning Area. Section 3.0 addresses the same information for the Fisher Creek and the portion of the Clarks Fork of the Yellowstone River upstream of the Montana-Wyoming border. Section 4.0 addresses the same information for Miller Creek and the portions of Soda Butte Creek within Montana. Section 5.0 provides information on the overall implementation strategy for planned restoration work, including a water quality monitoring plan. Section 6.0 addresses stakeholder and public participation. The plan is written in a manner that someone only interested in Daisy Creek and/or the Stillwater River could just read Sections 1, 2, 5 and 6. In the same manner, someone only interested in Fisher Creek and/or the Clarks Fork River need only read Sections 1,3, 5 and 6, and someone only interested in Miller Creek and/or Soda Butte Creek need only read Sections 1, 4, 5 and 6.

Throughout this document, the term restoration is used in a broad sense that includes water quality improvements realized through activities referred to as restoration or otherwise referred to as cleanup, remediation, treatment, or source control. These water quality improvements include a broad consideration of improvements to the chemical, physical, and/or biological components of the system. Note that water quality improvements address more than just a consideration of water column chemistry.

The term pollutant is associated with the "cause" of a water quality impairment as used for 303(d) listing purposes.

Natural background is a commonly used term in this document. Natural background conditions can often be a significant source for some pollutants and should be taken into account for determining baseline conditions. Natural background loading does not include the accelerated transport of pollutants to a receiving water body from processes such as increased erosion, increased ground water flow, or increased surface or ground water exposure to metal-bearing materials, if the accelerated transport or exposure is caused by human activities. This is true even if the pollutant occurs naturally in soils or rock materials

1.2 Area and Water Body Characterization

This section describes many of the physical and environmental characteristics associated with the water bodies of concern and subsequent water quality restoration planning.

1.2.1 Location and Land Use

The Cooke City Planning Area is located in the southern portion of Montana just north of the Montana-Wyoming border and northeast of Yellowstone National Park, including a small portion of the park. As previously discussed, it includes the headwaters of river systems that all eventually flow into the Yellowstone River. The three river systems are the Clark's Fork of the Yellowstone, the Stillwater, and the Lamar. Soda Butte Creek flows into the Lamar River, both of which flow through Yellowstone National Park. Other significant tributary streams in the area include Daisy, Miller, Fisher, Goose, Sheep, Lady of the Lake, Republic, and Woody Creeks (Figure E-2).

Figure 1-1 is a map showing land ownership information for the area. Much of the area falls within the boundaries of the Gallatin and the Custer National Forests, some of which includes portions of the Absaroka-Beartooth Wilderness Area. To the south is the Montana-Wyoming state line and public lands administered by the Shoshone National Forest.

Figure 1-2 is a map showing land use/cover in the area of interest. Forest, shrubland, and transitional areas (from fairly recent fires) cover most of the drainage area. The area includes portions of Park, Sweet Grass, and Stillwater Counties in Montana. All impaired water bodies are located within Park County except for a lower section of the Stillwater River located within the southern portion of Stillwater County, although all significant sources and associated restoration planning activities are within Park County.

The communities of Cooke City and Silver Gate, Montana are the only population centers in the area. The neighboring communities of Mammoth, Wyoming and Gardiner, Montana are located about 50 miles to the west. Red Lodge, Montana is about 65 miles to the northeast, via the Beartooth Highway, and Cody, Wyoming is located 60 miles to the southeast.

The drainage areas of concern are located at elevations that range from over 10,000 feet above sea level in the upper reaches to approximately 7400 to 8000 feet in the lower reaches. Much of the area is therefore snow-covered for a significant portion of the year. The topography of the area is mountainous, with the dominant topographic features created by glaciation. The stream valleys are U-shaped and broad while the ridges are steep, rock covered, and narrow. Much of the area is located at or near tree line, especially in the Fisher Mountain area where many of the major mining disturbances are located.

1.2.2 Climate

The Cooke City Planning Area has a continental climate modified by the mountain setting. The area is characterized by large daily and annual temperature ranges and marked differences in precipitation, temperature, and wind patterns over distances of only a few miles.

Precipitation and temperature data have been collected periodically at Cooke City from 1967 through 1995. The Cooke City station is located at an elevation of 7,460 feet. The average annual precipitation for the period of record is 25.38 inches. Temperatures are coldest in January with an average minimum of 2.4ºF and an average maximum temperature of 23.3ºF. Temperatures are warmest in July with an average minimum temperature of 37.9ºF and an average maximum temperature of 73.1ºF. Precipitation and temperature vary with elevation, and freezing conditions can occur any day of the year.

Precipitation records from a Soil Conservation Service SNOTEL station (SCS Station TX06) at an elevation of 9,100 feet in the Fisher Creek drainage indicate that the average annual precipitation at this location is 60 inches, most of which occurs as snowfall. Fifty percent of the annual precipitation occurs between October and February, with January being the highest average precipitation month (14.4 percent) and August having the lowest average monthly precipitation (3.9 percent) (URS, 1998). Average annual snowfall at higher elevations is about 500 inches.

1.2.3 Hydrology

Surface water discharge in the area is quite variable and seasonally dependent. The watersheds tend to show rapid flow response to snowmelt and summer precipitation events. Significant diurnal variations occur particularly during the peak snowmelt periods. The upper drainage basins are geomorphically similar and relatively small in aerial extent. The following sections provide specific hydrology information, much of it based on information at sampling locations referenced throughout this document and shown in Figure 1-3.

1.2.3.1 Hydrology of Daisy Creek and the Upper Portion of the Stillwater River

The Daisy Creek drainage basin collects water from the north side of Daisy Pass, the north flank of Crown Butte, the west flank of Fisher Mountain, and from the historic McLaren open pit mining operation. Daisy Creek flows northward from its origin below Daisy Pass approximately two miles to its confluence with the Stillwater River, which continues generally northward through the Absaroka-Beartooth Wilderness Area. Elevation of the headwaters is about 9,400 feet, dropping to 8,500 feet at the confluence of Daisy Creek and the Stillwater River. Near the headwaters of Daisy Creek, streamflow measurements at DC2 have ranged from less than 0.2 to 15 cfs based on database information available on a Maxim Technologies, Inc website (Maxim, 2001a). Farther downstream, flows in Daisy Creek have ranged from less than 0.3 to 57 cfs.

Several large springs and tributaries, including Daisy Creek, form the headwaters of the Stillwater River. Streamflow measurements upstream of the wilderness boundary at SW7 have ranged from 1.5 to 223 cfs.

1.2.3.2 Hydrology of Fisher Creek and the Upper Portion of the Clarks Fork of the Yellowstone

Fisher Creek drains the south side of Lulu Pass, the east flanks of Fisher and Henderson Mountains, and the west flanks of Scotch Bonnet and Sheep Mountains. Fisher Creek flows generally to the southeast for approximately 3.5 miles to its confluence with the Clarks Forks River. Flows in the upper portion of Fisher Creek at site SW3 have ranged from 0.2 to 18 cfs. Farther downstream, flows in Fisher Creek at site SW4 have ranged from 0.4 to 112 cfs (Maxim, 2001a).

Fisher Creek and the Lady of the Lake Creek combine to form the Clarks Fork River. Flows downstream of this location at site SW6 have ranged from 1 to 273 cfs (Maxim, 2001a). Farther downstream, the Broadwater River joins the Clarks Fork upstream of the Montana - Wyoming border and significantly increases streamflow.

1.2.3.3 Hydrology of Miller Creek and Soda Butte Creek

Miller Creek drains the south side of Daisy Pass, the west flank of Henderson Mountain, and the east flank of Miller Mountain. The headwaters are about 9,400 feet in elevation, dropping to 7,600 feet at the Soda Butte Creek confluence. Miller Creek flows southeastward for approximately two miles to its confluence with Soda Butte Creek just upstream of where Soda Butte Creek flows through Cooke City. Flows in Miller Creek at site SW2 have ranged from less than 0.5 to 49 cfs (Maxim, 2001a). During very dry conditions, Miller Creek will no longer flow above its confluence with Soda Butte Creek.

Soda Butte Creek has its headwaters near Colter Pass about 1 mile east of Cook City. Just below Miller Creek and the McLaren Tailings, flows in Soda Butte Creek have ranged from 14 to 101 cfs (Maxim, 2001a). Farther downstream, Woody Creek flows into Soda Butte Creek and provides about 70 percent of the total flow prior to Soda Butte Creek entering Wyoming and Yellowstone National Park, where flows are significantly greater.

1.2.4 Fish Habitat and Aquatic Life

The *New World Project 3rd Preliminary Review Draft Environmental Impact Statement* (Draft EIS, 1996) contains considerable detail concerning aquatic life habitat conditions within Chapter 8 of the document. Below is some summary information concerning fish habitat, and aquatic macroinvertebrates from the above referenced document.

Both Daisy Creek and the Upper Stillwater River are naturally void of fish due to barrier falls in the Stillwater River just upstream of the Goose Creek confluence. The upper portion of the Stillwater River above the Daisy Creek confluence does, however, support a relatively abundant and diverse macroinvertebrate community containing numerous sensitive taxa. Downstream from Daisy Creek, the macroinvertebrate community declines substantially until near Goose Creek where it begins to improve. The macroinvertebrate community is under severe stress in Daisy Creek.

The upper reaches of Fisher Creek have limited fish habitat, with increasing pool frequency, habitat complexity and other indicators of suitable conditions for fry, juvenile and adult fish in the middle to lower reaches. The upper reaches of the Clarks Fork have high quality pools formed by either large boulders or woody debris and other indicators of suitable habitat for fish. Aquatic macroinvertebrates in the upper reaches of Fisher Creek reflect stressed conditions, with partial recovery farther downstream. The Clarks Fork data suggests a trend of improved conditions as you move downstream and where there is less influence from Fisher Creek.

Miller Creek may be naturally void of fish due to high gradients and a waterfall in the lower reaches preventing upstream migration of fish into the stream. Nonetheless, habitat conditions in the watershed are sufficient for a small resident salmonid fishery to exist. Aquatic macroinvertebrate communities include sensitive species indicating better health than some of the other streams impacted by metals in the area.

The lower portion of Soda Butte Creek within Yellowstone National Park supports a popular stream fishery. Within Montana, the Soda Butte fishery is limited. The very upper reach of Soda Butte Creek has limited fish habitat, with improved conditions downstream of the McLaren Tailings and below the Woody Creek confluence. Extremely high levels of fine sediment, primarily associated with natural conditions, enter and deposit in Soda Butte Creek via Woody Creek. Although this sediment deposition has the ability to limit fish reproduction, the overall lack of suitable habitat may be more of a limiting factor for trout. Aquatic macroinvertebrate communities include sensitive species indicating better health than some of the other streams impacted by metals in the area, although diversity and abundance are reduced in an area downstream of the McLaren Tailings. Macroinvertebrates collected in Soda Butte Creek downstream of the McLaren Tailings have been shown to have elevated whole-body concentrations of metals. Additional studies have also shown elevated levels of metals, including copper, in fish in Soda Butte Creek below the McLaren Tailings (Peterson and Boughton, 2000)

1.3 Background Information

This section describes some of the historical context associated with mining activities in the area and efforts to address water quality restoration.

1.3.1 New World Mining District

All water bodies addressed by this document are streams or stream segments that either fall within or are in close proximity to the boundaries of the New World Mining District (District) as shown by Figure 1-4. The District, which includes a mixture of National

Forest and private lands, is a historic metals mining area generally located near Cooke City, Montana in the Beartooth Mountains. This historic mining district contains hard rock mining wastes and acid discharges that impact the environment. Human health and environmental issues are related to elevated levels of metals present in mine wastes, open pits, acidic water discharging from mine openings, and stream sediments.

On August 12, 1996, the United States signed a Settlement Agreement (Agreement) with Crown Butte Mining, Inc. (CBMI) to purchase CBMI's interest in their District holdings. This transfer of property to the U.S. government effectively ended CBMI's proposed mine development plans and provided $22.5 million to clean up historic mining impacts on certain properties in the District. In June 1998, a Consent Decree (Decree) was signed by all interested parties and CBMI and approved by the United States District Court. The Decree finalized the terms of the Agreement and made available the funds that will be used for mine cleanup. Monies available for cleanup are to be first spent on District Property, which, as defined in the Decree, includes all property or interests in property that CBMI relinquished to the United States. As funds are available after District Property is cleaned up to the satisfaction of the United States, other mining disturbances, such as the McLaren Tailings, in the area will be addressed. **It is important to note that the District encompasses a large area of about 40 square miles, but District Property is limited to certain holdings within the overall District (Figure 1-4).**

Historic mining disturbances on District Property are about 50 acres in size according to recent measurements made by the USDA-FS Interagency Spatial Analysis Center. The McLaren Tailings Area, including the McLaren Mill Site, covers an additional 12 acres on non-District Property.

The New World Mining District Response and Restoration Project: Project Summary, 2001(Maxim, 2001b) provides a relatively short and informative overall description of the area and associated mining impacts. It also describes the restoration planning and implementation process for the District. In addition, Maxim Technologies, under contract through the USFS, maintains a website at http://www.maximtechnologies.com/newworld/ (Maxim, 2001a) that includes a comprehensive database of water quality sampling results for all water bodies of interest in the Cooke City TMDL Planning Area. This database includes information from numerous historical and recent sampling events. The website also includes many of the reports referenced within this restoration plan. The USFS also provides a link to this website via http://www.fs.fed.us/r1/gallatin/main/index.shtml.

Impairment conditions associated with Daisy Creek, the Stillwater River, Fisher Creek, the Clarks Fork of the Yellowstone, and Miller Creek are mainly addressed via District activities. Therefore, planning information for these water bodies, as found within this document, closely parallel District efforts.

1.3.2 Soda Butte Creek

Soda Butte Creek impairment conditions are only partly addressed, at least at this time, via District cleanup commitments. This includes potential reductions in metal loads via cleanup efforts in the Miller Creek drainage. It also includes the possibility that District efforts could address the McLaren Tailings and other mining disturbances impacting Soda

Butte Creek if funding exists once all other District responsibilities are addressed (Maxim, 2001b). Otherwise, the McLaren Tailings will need to be addressed via some other yet-to-be-addressed approach. Some of the additional metal sources to Soda Butte Creek are within the Republic/Woody Creek and other tributary drainage areas. Some of the needed restoration efforts are currently being pursued as further discussed in Chapters 4 and 5. For example, the MDEQ is currently working with other stakeholders on efforts to characterize and mitigate environmental impacts associated with some of the historical mining in the Republic/Woody Creek drainage and is also working on a solution for the McLaren Tailings. These and other restoration efforts for the Soda Butte Creek drainage are further discussed in Chapters 4 and 5.

1.4 Water Quality Standards

This section describes the applicable water quality standards for the water bodies within the Cooke City TMDL Planning Area. These standards provide the basis for 303(d) listing decisions as well as the basis for setting restoration goals.

1.4.1 Water Body Classifications and Beneficial Uses

The Montana Surface Water Quality Standards and Procedures (Water Quality Standards: Title 17, Chapter 30, Sub-Chapter 6) are a part of the Administrative Rules of Montana. Per the Water Quality Standards, all water bodies in the Cooke City Planning Area are classified as B-1 (17.30.611) except for the section of the Stillwater River, which falls within the boundaries of the Absaroka-Beartooth Wilderness, and the Montana portions of Soda Butte Creek located within Yellowstone National Park (Figure E-2). These sections are classified as A-1 (17.30.614). The Montana portions of Soda Butte Creek located within Yellowstone National Park are also identified as an “outstanding waters”, and a section of the Clarks Fork within Wyoming is included within the National Wild and Scenic Rivers System.

1.4.2 Numeric and Narrative Standards

There are several sections within the Water Quality Standards that are applicable to water bodies classified as either A-1 or B-1 and also applicable to water quality restoration and TMDL development in the Cooke City TMDL Planning Area. Several of these sections are identified below, with the relevant wording from each section quoted. In addition, the pollutants of concern associated with the specific section and the water bodies of concern are also listed. Where A-1 and B-1 standards are the same, it is noted.

17.30.623(1):

"*Waters classified B-1 are suitable for drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply*."

Pollutants: All

17.30.622:

(1) "*Waters classified A-1 are suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities."*

(2) *"Water quality must be suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.*"

Pollutants: All

17.30.623(2) and 17.30.622(3): [Applies to B-1 and A-1 classifications]

"*No person may violate the following specific water quality standards for waters classified B-1 (A-1 for 17.30.622(3)):"* Relevant specific standards are discussed below:

17.30.623(2)(c) and 17.30.622(3)(c): [Applies to B-1 and A-1 classifications]

"*Induced variations of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.*"

Pollutants: pH

17.30.623(2)(d): [Applies to B-1 classification only]

"The maximum allowable increase above naturally occurring turbidity is 5 nephelometric turbidity units except as permitted in ARM 17.30.637."

Pollutants: Sediment (suspended solids); Metals (suspended precipitants)

17.30.622(3)(c): [Applies to A-1 classification only]

"No increase above naturally occurring turbidity is allowed except as permitted in ARM 17.30.637."

Pollutants: Sediment (suspended solids); Metals (suspended precipitants)

17.30.623(2)(f) and 17.30.622(3)(f): [Applies to B-1 and A-1 classifications]

"*No increases are allowed above naturally occurring concentrations of sediment, settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.*"

Pollutants: Sediment (suspended solids)

17.30.623(2)(h)(i) and 17.30.622(3)(i): [Applies to B-1 and A-1 classifications]

"*Concentrations of carcinogenic, bioconcentrating, toxic or harmful parameters which would remain in the water after conventional water treatment may not exceed the applicable standards set forth in department Circular WQB-7*"

Pollutants: Metals, specifically numeric standards for Cadmium, Copper, Iron, Lead, Manganese, and Zinc. No distinctions between an A-1 or B-1 classification exist for these parameters.

17.30.637(1): [This is from a section of the water quality standards applicable to all water bodies including those classified as either B-1 or A-1]

"*State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:*

17.30.637(1)(a): [Applies to B-1 and A-1 classifications]
"*settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;*"
Pollutants: Sediment and Metals (Precipitates)

17.30.637(1)(d): [Applies to B-1 and A-1 classifications]
"*create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life;*"
Pollutants: All

17.30.602 Definitions:

17.30.602 (17): [Applies to B-1 and A-1 classifications]
"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971 are natural.
Pollutants: All

17.30.602(21): [Applies to B-1 and A-1 classifications]
"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.
Pollutants: All

Note that the standards of interest are nearly identical for B-1 and A-1 classified streams. An A-1 classification has stricter protection requirements associated with allowable levels of impurities for drinking, culinary and food processing purposes (Section 17.30.622) and stricter protection requirements associated with allowable levels of turbidity (Section 17.30.622(3)(c)). In reference to the A-1 sections of each stream, strict upstream targets have been incorporated into this plan to address the sediment in the Stillwater River and metals loading and potentially associated turbid conditions in both the Stillwater River and Soda Butte Creek. It is believed that these targets will be protective of both the A-1 and B-1 classified sections of these water bodies.

Also note that the term “naturally occurring” is not the same as “natural background” as used in the plan per Section 1.1.2. “Naturally occurring” can incorporate some limited level of human influence under conditions where reasonable land, soil, and water conservation practices are applied whereas “natural background” is not intended to incorporate any human influences.

An important consideration within WQB-7 is the fact that the numerical standards associated with aquatic life protection for several metals (copper, cadmium, zinc, silver, and lead) are a function of water hardness. As hardness decreases, the applicable numeric standard for these metals decreases resulting in more stringent water quality protection requirements to protect aquatic life. For all water bodies in this WQRP, water hardness decreases with increasing flow, resulting in lower applicable standards. Because of this, water quality standards and associated restoration targets are identified for both low and high flow conditions in order to estimate the total range for restoration planning purposes. In general, the low flow values are based on hardness during flows typically experienced before and after spring runoff (late July through May), and the higher flow values are based on hardness during flows typically experienced during spring runoff (June through mid July). Estimates toward the low end of the hardness range are used to provide a conservative approach toward the application of standards.

Throughout this plan, several targets (reference Table E-2) are based on biota indicators being at or greater than 75% of a desired or reference condition. The 75% is directly from *Appendix A of Water Quality Assessment Process and Methods* (MDEQ, 2000). This number represents an interpretation of narrative standards, particularly those standards based on harmful conditions to aquatic life. Where any biota indicator is below 75% of reference, the stream is considered moderately impaired, and if the indicator is below 25%, the stream is considered non-supporting. Minor impairment is a situation where all biota indicators are greater that 75% of reference but still showing some negative impact(s). A stream is considered fully supporting of its beneficial uses where there is no impairment or only minor impairment. This approach recognizes that a stream where all biota indicators are at or above 75% can support a fully functioning aquatic community while also recognizing the variations in measurement methods and variations between streams that would make it difficult to justify the use of higher percentages. The approach takes into account the fact that limited minor impacts to a water body do not necessarily represent a violation of Montana's water quality standards, although they still may represent opportunities for water quality improvements. Where direct measures of biota are not available, the 75% approach is sometimes applied to habitat indicators, as is the case for the sediment targets associated with pebble counts in this plan.

Montana State law for outstanding waters (Montana Water Quality Act; Section 75-5-316) focuses on the need to prevent any new point or nonpoint sources from causing significant degradation, with focus on limiting impacts from toxic and other health related pollutants. The contaminant sources of concern, as identified within this document, are associated with existing nonpoint sources and cleanup of such sources. The outstanding resource designation appears to have no bearing on existing or proposed future activities within the Cooke City Planning Area, and restoration activities discussed within this plan are consistent with the outstanding waters designation that applies to portions of Soda Butte Creek.

1.4.3 Temporary Standards

Title 75, Chapter 5, Section 312 (ARM 75-5-312) of the Montana Water Quality Act allows for the temporary modification of water quality standards via the Board of Environmental Review (Board). This applies to a specific water body or segment on a parameter-by-parameter basis in those instances in which substantive information indicates that the water body or segment is not supporting its designated uses. When the Board adopts temporary standards, the goal is to improve water quality to the point at which an additional beneficial use or uses are supported. As a condition of establishing temporary water quality standards, an implementation plan is required for use by the Board in determining whether to adopt a proposed temporary water quality standard. This petition must specifically describe the affected state water, the existing ambient water quality for the parameter or parameters at issue, the water quality standard or standards affected, and the temporary modification sought. Additional information includes an implementation plan to eliminate the water quality limiting factors to the extent considered achievable as well as a schedule for implementing the plan.

Section 312 goes on to require that the DEQ report to the Board at least once every three years regarding whether adequate efforts have been made to implement the plans submitted as the basis for the temporary standard. The Board then reviews the temporary standards and has the option of terminating the temporary standard or modifying the existing plan associated with the temporary standards. Termination can be based on improvements in water quality to where beneficial uses are supported, reclassification, or failure to implement the plan according to the plan's schedule.

Temporary standards are currently in place for three water bodies (Daisy Creek, Stillwater River, and Fisher Creek) within the New World Mining District (Section 17.30.630.1). The standards became effective on June 4, 1999 and are in effect until June 4, 2014. These standards were adopted in response to a "petition report" (Stanley, 1999) submitted by Crown Butte Mines, Inc. (CBMI). This petition report is entitled *Support Document and Implementation Plan Submitted by Crown Butte Mines, Inc. in Support of its Petition for Temporary Modification of Water Quality Standards for Selected Parameters for Fisher and Daisy Creeks and a Headwater Segment of the Stillwater River, Park County, Montana*. This reference document will be referred to as the *Petition Report* throughout this document. Temporary standards do not apply to the Clark Fork of the Yellowstone, Miller Creek, Soda Butte Creek, or the A-1 classified section of the Stillwater River.

The goal for the water bodies with temporary standards is stated under 17.30.630.(1)(a) as: "(t)he goal of the state of Montana is to have these water bodies support the uses listed for waters classified B-1 at ARM 17.30.623(1)." The temporary numeric standards apply to water quality extremes (mean plus two standard deviations) associated with existing water quality conditions prior to any cleanup efforts. The purpose of these temporary standards is to effectively insulate the responsible party from legal enforcement actions during a cleanup phase as defined by the time period during which the standards apply. The responsible party is still responsible for performing cleanup activities in a manner consistent with the overall work plan and commitments within the *Petition Report* as discussed above. The numeric values associated with the temporary standards in no way represent any existing or future water quality restoration goals. They instead help define a process to proceed with water quality restoration efforts in situations such as those found in the New World Mining District. The goal of having the water bodies support the uses listed for waters classified B-1, as stated at the beginning of this paragraph, is the primary goal for the streams with temporary standards as well as other water bodies addressed in this water quality restoration plan (unless otherwise classified as A-1).

SECTION 2.0 DAISY CREEK AND STILLWATER RIVER WATER QUALITY RESTORATION

2.1 Impairment Conditions

Daisy Creek and the Stillwater River are both severely impacted from elevated metals concentrations. Daisy Creek also has low pH values, and both streams are impacted from sediment deposits. Many reports and data sources identify impacts to beneficial uses. Section 2.1.1 below provides impairment details associated with metals and pH, and Section 2.1.2 provides impairment details associated with sediment.

2.1.1 Metals and pH

The *Petition Report* (Stanley, 1999) for temporary standards includes water quality data tables for Daisy Creek and the Stillwater River. Included in the data tables are statistical summaries of the analytical data from 1989 through 1998. Another report, entitled *Quantification of Metal Loads by Tracer Injection and Synoptic Sampling in Daisy Creek and the Stillwater River*, *Park County*, *Montana*, *August 1999* (Nimick and Cleasby, 2001), provides sample results at numerous locations along Daisy Creek and the Stillwater River during a relatively low flow period. In addition, the Maxim website (Maxim, 2001a) provides significant water quality and sediment metals concentration data. Additional sediment metals concentration data are also available based on work done to support restoration efforts (Camp, Dresser and McKee, 1997).

The above referenced information and other reports show that conditions in Daisy Creek do not fully support the beneficial uses associated with a B-1 classification and do not comply with applicable B-1 standards for copper, cadmium, lead, zinc, iron, manganese, and pH. Also, metals and pH values are such that the water body would not be able to support any agriculture or industry uses associated with a B-1 classification.

The above referenced information and other reports show that conditions in the Stillwater River below Daisy Creek do not fully support the beneficial uses associated with a B-1 or A-1 classification and do not comply with applicable B-1 or A-1 standards for copper, iron, and manganese.

In addition to elevated metal concentrations in water, metals precipitate and settle to form objectionable sludge deposits in both water bodies, and colloidal particles associated with metal precipitates result in high turbidity conditions that may not be supportive of narrative standards in the Stillwater River below Daisy Creek. The objectionable sludge layer is apparently composed of colloidal particles, metallic precipitates (primarily aluminum and iron), algae, bacteria, and organic matter from dead algae and bacteria. Periphyton and bacteria colonize most of this layer and produce gas bubbles from respiration. Many or most of these bubbles become entrapped in this layer, resulting in a soft and porous sludge that is present late summer and perhaps other low flow periods. These deposits and associated turbidity from metal precipitates also negatively impact the aesthetics of both water bodies.

Tables 2-1 and 2-2 provide summaries of the impairment concerns associated with metals and pH. All metal concentrations are total recoverable unless otherwise noted. The metals concentrations and pH values are from Daisy Creek sampling location DC5, and Stillwater River sampling location SW7. The Daisy Creek sample location DC5 is downstream of mining impacts and provides representation of the significant mining impacts to water quality not only to Daisy Creek but also to the Stillwater River. The Stillwater River sample location SW7 represents water quality just upstream of the wilderness boundary. Both sampling locations, which are shown in Figure 1-3, are routinely used to track water quality in this stream and to measure progress of ongoing restoration efforts. As expected, metal concentrations in the Stillwater River are significantly lower than in Daisy Creek since Daisy Creek flows into the Stillwater River and essentially all significant contaminant sources are in the Daisy Creek drainage. In fact, values are low enough for some metals such that the concentrations are below water quality standards, meaning that a TMDL is not necessary for that particular metal in the Stillwater River.

For the section of the Stillwater River above Daisy Creek, sampling results (Maxim 2001a) and efforts to identify potential sources of metals show that there are probably not any impairment conditions associated with metals, pH or other pollutants in this stream segment. TMDL development is, therefore, not pursued for this stream segment.

Appendix B provides a descriptive water quality summary for each of the metals of concern and pH as they relate to impairment determinations.

2.1.2 Impairment Conditions Associated with Sediment

Eroded soils and metal precipitates create impairment conditions due to their resulting deposition in the streambed. This discussion focuses on impairment conditions associated with eroded soils, although it is recognized that these eroded soils may also transport metal contaminants. It is also further recognized that precipitation of metals on the streambed can confound efforts to measure sediment impacts and that these precipitates can negatively impact aquatic life in a manner similar to sediment impacts.

A final technical memorandum entitled *New World Response and Restoration Project Final 2000 Aquatic Monitoring Results* (Maxim, 2000) provides a summary of historical aquatic assessment results as well as more recent data for Daisy Creek and the Stillwater River below Daisy Creek. The previously referenced Draft EIS also provides information concerning sediment and habitat conditions, including modeled sediment yield information. Both reports indicate habitat concerns associated with sediment indicators such as embeddedness and percent fines.

The USFS has calculated and recently updated the modeled sediment yield information for Daisy Creek (discussions with Mark Story, USFS). The modeled results show that on an annual basis, there is a greater than 50% yield above natural background for Daisy Creek. This additional yield in sediment also impacts the Stillwater River below Daisy Creek where much of the sediment is deposited.

Table 2-1. Daisy Creek Metals and pH Impairment Summary

Pollutant	Sampling Results	Water Quality Standard Concern	Water Quality Standards Reference(s)
Copper	346 – 2850 ug/l	- consistently > 5.2 ug/l chronic aquatic life (high flow)[1] - consistently > 7.3 ug/l chronic aquatic life (low flow)[1] - consistently > 7.3 ug/l acute aquatic life (high flow)[1] - consistently > 10.7 ug/l acute aquatic life (low flow)[1] - often > 1300 ug/l human health - results in elevated copper levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Iron	2380 – 6880 ug/l	- consistently > 1000 ug/l chronic aquatic life - consistently > 300 ug/l domestic use - consistently forms objectionable sludge deposits	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(a) 17.30.637(1)(d) 17.30.623(2)(d)
Manganese	14 – 1230 ug/l	- consistently > 50 ug/l domestic use	17.30.623(2)(h)(i) - WQB-7
Aluminum	40 – 300 ug/l (dissolved) 1400 - 8100 ug/l (total recoverable)	- consistently > 87 ug/l aquatic life for dissolved aluminum (chronic at pH 6.5 to 9.0; but high values only occur at pH values less than 6.5) - consistently forms objectionable streambed deposits - consistently produces high turbidity from metal precipitates	17.30.637(1)(a) 17.30.623(2)(d)
Zinc	60 – 420 ug/l	- consistently > 67 ug/l chronic & acute aquatic life (high flow)[1] - consistently > 94 ug/l chronic & acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Cadmium	< 1 – 2.85 ug/l	- often > 0.16 chronic aquatic life (high flow)[1] - often > 0.22 ug/l chronic aquatic life (low flow)[1] - sometime > 1.0 ug/l acute aquatic life (high flow)[1] - sometimes > 1.6 ug/l acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Lead	< 1 – 3 ug/l	- sometimes > 1.3 ug/l chronic aquatic life (high flow)[1] - sometimes > 2.2 ug/l chronic aquatic life (low flow)[1] - results in elevated lead levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
pH	5.3 – 7.7	- below naturally occurring levels during much of the year - contributes to metals solubility and resulting precipitation problems	17.30.623(2)(c) 17.30.637(1)(d)

Notes:
1. Standards reflect adjustments for water hardness, which varies during lower flow periods (generally before and after runoff) and higher flow periods (generally during late spring and early summer runoff) in Daisy Creek; the low flow hardness value used for Daisy Creek is 75 mg/l as calcium carbonate; and the higher flow hardness value is 50 mg/l as calcium carbonate.

Table 2-2. Stillwater River (Below Daisy Creek) Metals Impairment Summary

Pollutant	Sampling Results	Water Quality Standard Concern	Water Quality Standards Reference(s)
Copper	Below Detection - 210 ug/l	- consistently > 5.2 ug/l chronic aquatic life (high flow) [1] - consistently > 7.3 ug/l chronic aquatic life (low flow) [1] - consistently > 7.3 ug/l acute aquatic life (high flow) [1] - consistently > 10.7 ug/l acute aquatic life (low flow) [1] - results in elevated copper levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Iron	70 – 1200 ug/l	- sometimes > 1000 ug/l aquatic life (chronic) - consistently > 300 ug/l domestic use - consistently forms objectionable sludge deposits (near Daisy Creek confluence)	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(a) 17.30.637(1)(d)
Manganese	Below Detection - 80 ug/l	- often > 50 ug/l domestic use	17.30.623(2)(h)(i) - WQB-7
Aluminum	Below Detection (dissolved) 20 – 600 (total recoverable)	- consistently produces high turbidity from metal precipitates (near Daisy Creek confluence)	17.30.623(2)(d)

Notes:
1. Standards reflect adjustments for water hardness, which varies during lower flow periods (generally before and after runoff) and higher flow periods (generally during late spring and early summer runoff) in the Stillwater River; the low flow hardness value used for the Stillwater River is 75 mg/l as calcium carbonate; and the higher flow hardness values is 50 mg/l as calcium carbonate.

Subsequent field visits by MDEQ water quality specialists during September 2001 further verify impairment conditions. Figure 2-1 shows percent fines curves in Daisy Creek just upstream from the confluence with the Stillwater River and the Stillwater River above and below Daisy Creek (reference Figure 1-3 for the general location of these sediment sample sites). These curves represent the results from Wolman Pebble Counts. For the section of the Stillwater River just below Daisy Creek, the measurements were made by reaching through the floc/bio layer of metal precipitates. Note that current percent fines conditions for Daisy Creek and the Stillwater River below Daisy Creek indicate a relatively large percentage of fine material in comparison to the upper portion of the Stillwater River. This fine material is considered harmful to aquatic life.

Although sediment has not been a listed pollutant (probable cause) for impairment in the Stillwater River, it is addressed as a cause of impairment within this document for the section of the Stillwater River below Daisy Creek only. This is convenient since a significant portion of sediment loading comes from the Daisy Creek drainage where much of the sediment load is being addressed as part of the New World Mining District cleanup effort.

In 2001, MDEQ water quality specialists performed a field investigation of the section of the Stillwater River above Daisy Creek and concluded that any potential sources of sediment would be almost exclusively due to natural background conditions and that there were not any habitat parameters indicating impairment conditions for this portion of the river, making it a reasonable reference stream candidate.

2.2 Source Characterization

2.2.1 Source Inventory

Mining disturbances primarily associated with historical adits and waste rock represent the sources of increased metals and pH conditions due to human activities in the Daisy Creek and Stillwater River drainage areas. Figure 2-2 shows the locations of identified mining disturbances, with the McLaren Pit and associated disturbances from this mine site representing the most significant mining related sources of metals and pH lowering constituents. These same mining disturbances, along with the existing and historic road network and trails shown by Figure 2-3, represent the primary sources of increased sediment loads from human activities. This increased loading of sediment from erosion also represents a potential pathway for metal contaminants located in the soils or along eroding streambanks, although not all eroded soils will necessarily be associated with increased metal transport.

Forest, high elevation shrubland, and rock cover most of the remaining drainage area (Figure 1-2). Therefore, there appears to be a low probability of any other human related sources that could represent significant loading for any of the pollutants of concern. In addition, neither of the impaired water bodies or their tributaries receive point source discharges regulated by a Montana Pollutant Discharge Elimination System permit, meaning that waste load allocations are not necessary for these water bodies.

2.2.2 Metals and pH Source Assessment

As previously discussed, higher metal concentrations in Daisy Creek generally occur during low flow periods when metals loading is predominately transported via acidic ground water discharging directly to Daisy Creek or discharging to springs which run into Daisy Creek and subsequently flow to the Stillwater River. In the upper headwaters pH values are initially greater than 7, then greatly decrease where most of the metal loading occurs, and then consistently increase in the downstream direction along Daisy Creek to the point where pH is no longer of concern within the Stillwater River. This increase in pH promotes the precipitation of metals, which subsequently settle to the bed of Daisy Creek or the Stillwater River and ultimately result in reduced water column concentrations (and perhaps increased concentrations of metals in sediments) in a downstream direction during low flow conditions. Metals concentrations within the Stillwater River decrease even further in a downstream direction due to additional dilution from tributaries and probable additions of clean sources of ground water. In fact, the dilution of metal concentrations is such that higher values are often seen during higher flow events in the lower portions of the Stillwater River (such as sample location SW7) presumably due to the re-suspension of metal precipitates with possible contributions from eroded sediments with attached metal contaminants.

The Nimick and Cleasby (2001) metals loading report provides source information, during a relatively low flow time of year, on a subreach by subreach scale, looking at both surface inflows and subsurface inflows. Appendix B is an excerpt from Nimick and Cleasby that includes a discussion on metal sources and the overall study summary and conclusions. This information provides a good discussion of loading uncertainties as they relate to the study results. Table 2-3 presents loading results information for copper from this report. Similar patterns of loading would be expected for all metals of concern and constituents contributing to pH impairments, as evident by comparisons of the "cumulative load" versus "distance downstream" plots within the referenced report. Though Table 2-3 provides a good summary of relative inputs by location and by pollutant pathway, there is still significant uncertainty and debate as to what portions of these metal loads are from historical mining or natural background. The data does not clearly distinguish between natural background loads and mining related loads. Some of the loading sources such as the moraine or landslide hill, the manganese bog, and the area north and west of the McLaren Mine may eventually prove to be indicators of natural background loads. The extent of mining caused loads of metals versus natural background loads will depend on which inflows are impacted by mining activities and, where inflows are impacted by mining, the difference between any natural background loading levels versus the elevated levels caused by mining impacts.

The *Draft McLaren Pit Response Action Engineering Evaluation/Cost Analysis (EE/CA), New World Mining District Response and Restoration Project Report* (Maxim, 2001c) also discusses potential contributions from natural background conditions and relative loading inputs from a significant portion of the McLaren Pit area. The report provides reference to investigations associated with natural background conditions (Runnells, 1992; Furniss and Hinman 1998; Lovering, 1929). The studies generally suggest the existence of probable sources of elevated metals (and subsequent pH lowering conditions) associated with naturally occurring acid rock drainage due to ground water contact with naturally elevated metal-bearing bedrock materials. The transport of metals from elevated metal-bearing soils, via direct dissolution or erosion to Daisy Creek and subsequent dissolution, is also identified as a possible source. As identified in the EE/CA, absolute quantification of the amount of loading attributable to pre-mining (natural background) sources is a difficult task.

There has not been a study focused on metal quantification at higher flow events like the one discussed above. Lower levels of many metals in Daisy Creek and the Stillwater River indicate possible similar sources during high flow with some dilution from the higher flows. Additional high flow pathways include metal loading from accelerated erosion associated with roads and land disturbances, or loading from contaminated streambed sediments transported to downstream locations. Some sample locations such as SW7 show an increase in metal concentrations with increased flow, further indicating the importance of some of the above referenced high flow pathways.

There are some limited mine diggings and other limited indicators of prospecting efforts in the Stillwater drainage above the Daisy Creek confluence. Based on the 2001 MDEQ staff inspection of the area, the diggings did not appear to represent any significant threat to water quality based on the type of and area of disturbance. Sampling of the Stillwater River upstream of Daisy Creek results in metal loads that are well below those coming from Daisy Creek based on concentration and flow data (reference Maxim website and Nimick and Cleasby (2001)). Most concentrations either fall below detection limits for all metals of concern or are detected at levels well below numeric standards found within WQB-7. Based on these results, metals sources in this headwaters portion of the Stillwater River do not represent significant sources of concern at this time.

2.2.3 Sediment Source Assessment

Sediment sources include land disturbances from past mining activities (Figure 2-2), a road network (Figure 2-3) and natural background generally from undisturbed soil surfaces. Sediment transport was modeled by the USFS for the Daisy Creek drainage using the R1R4 Sediment Model (unpublished information from Mark Story, USFS). It should be noted that the R1R4 model is a fairly simplistic analysis of very complex geomorphic processes and is based on annual average precipitation. The model attempts to predict sediment levels, but actual levels in any one year can vary by a magnitude or more depending on precipitation. The model results, summarized in Table 2-4, show an annual modeled baseline, or natural background, loading rate of 22.7 tons per year. The modeled loading rate for roads in the area was 5.6 tons per year, and the loading rate for disturbed lands from previous mining activities was 5.7 tons per year. An additional sediment source includes a badly eroded section of a trail (identified in Figure 2-3).

The total modeled load from human activities of 11.3 tons per year is calculated by adding the load from roads to the load from mine disturbances. This represents 33% of the total load, or 50% above natural background.

The R1R4 modeling was not extended to the Stillwater River, although the sediment loading levels from roads and mining disturbances within the Daisy Creek drainage still

Table 2-3. Sources of Dissolved Copper to Subreaches of Daisy Creek, August 26, 1999 (from Nimick & Cleasby 2001, with addition of % total load numbers)

[Values listed for loads have been rounded. Abbreviations: µg/s, micrograms per second. Symbol: <, less than]

	Subreach extent (ft)		Dissolved copper load (µg/s)				
Subreach description[1]	Upstream site	Downstream site	Right-bank inflows	Left-bank inflows	Subsurface inflow[2]	Combined surface plus subsurface	% of total load
Moraine or landslide hill	0	270	461	<1	151	612	1.2%
Manganese bog	270	460	9,830	4	251	10,100	20.4%
Southern part of McLaren Mine Area	460	611	16,400	4	8,900	25,300	51.1%
Northern part of McLaren Mine Area	611	1,700	245	<1	7,040	7,290	14.7%
Area north and west of McLaren Mine	1,700	5,475	2	<1	6,210	6,210	12.5%
TOTAL			26,900	8	22,600	49,500	100%

[1] Describes area from which metal-rich surface drainage to subreach is derived.

[2] Calculated as the difference between the gain in instream load between upstream and downstream sites and the sum of the loads in the right-bank and left bank inflows within the subreach.

represent significant sediment sources of concern for the section of the Stillwater River addressed within this plan. This is especially true since the Stillwater River represents a depositional area for transported sediments from Daisy Creek due to a reduction in valley slope near the mouth of Daisy Creek and along the Stillwater River in the vicinity of the Daisy Creek confluence. Additional sediment loading to the Stillwater River appears to be limited to additional natural background loads outside the Daisy Creek drainage and loads associated with one access road, which happens to be in poor condition and crosses the bed of the main Stillwater River channel below the Daisy Creek confluence.

Table 2-4. Sediment Model Loading Rate Summaries for Daisy Creek

Source	Load (tons/yr)	% Total Load	Annual % > Natural
Natural Background	22.7	67	NA
Roads	5.6	16	25
Mine Disturbances	5.7	17	25

2.3 Restoration Targets, TMDLs and Load Allocations

Restoration goals and the allocation approach for Daisy Creek and the Stillwater River are first developed for metals and pH under Section 2.3.1, followed by sediment under Section 2.3.2.

2.3.1 Metals and pH Restoration Targets, TMDLs, and Allocations

2.3.1.1 Metals and pH Targets

Table 2-5 provides target values for metals and pH based on the applicable standards identified in Tables 2-1 and 2-2. Most metals targets are based on the applicable numeric water quality standard with hardness modifications for copper, cadmium, zinc, and lead. Because it is unknown what the actual hardness value will be under restoration conditions, the Table 2-5 values for copper, cadmium, zinc, and lead represent estimated values at high and low flow conditions as identified in Tables 2-1 and 2-2. The actual targets for these four metals are the water quality standard with applicable hardness adjustments based on actual in-stream hardness values at the time of measurement. Appendix A of this document provides an example of the hardness adjustment equation for chronic aquatic life support standards (reference Montana Water Quality Standards WQB-7 for more information and for the similar equation used for acute aquatic life computations).

All metal targets are based on total recoverable concentrations unless otherwise noted. For aluminum, iron, and manganese, the standard and any applicable targets are not a function of hardness. Where there are multiple numeric standards for protecting different beneficial uses, the lowest value is used to ensure protection of all beneficial uses. If the chronic and acute aquatic life targets are different than each other, then the primary target for TMDL development and restoration planning becomes the chronic aquatic life support standard to provide some margin of safety since the chronic standard is normally based on a 96-hour average.

The numeric targets cannot be exceeded at any time. At a minimum, monitoring locations DC5 and DC2 in Daisy Creek and SW7 and STW2 in the Stillwater River will be used for determining compliance with targets. The exception is for iron and aluminum concerns associated with streambed deposits and turbidity in the Stillwater River where the targets should be evaluated just below the Daisy Creek confluence. To meet the numeric targets, there must be at least three consecutive years where target values are met during late winter/early spring low flow, late summer/early fall low flow, and peak or near peak late spring/early summer runoff. All other targets further discussed below need only be measured and confirmed once in conjunction with meeting numeric levels.

Iron has an additional target of no visible streambed deposits of fine material resulting from human caused conditions. There is an additional target associated with aluminum whereby there can be no visible turbidity in the stream due to aluminum precipitates. Both of these targets apply at low flow conditions when the problems have been noted, and apply in both Daisy Creek and in the Stillwater River below the confluence of Daisy Creek.

Copper has an additional target based on stream sediment toxicity in Daisy Creek and the Stillwater River, and lead has an additional target based on stream sediment toxicity in Daisy Creek. Sediment toxicity must be measured during low flow late autumn or early spring conditions to capture impacts from runoff and associated metals depositions.

As an additional measure of overall beneficial use attainment, a target is set for macroinvertebrate and periphyton communities being at 75% or greater in comparison to reference stream conditions based on established protocols for evaluating metals and pH impairment conditions.

For pH, a range of 6.0 to 9.0 is used. This is based on the assumption that being able to meet numeric standards for metals would include a reduction in acid drainage to the point where pH would fall within this range of typical water quality conditions. Satisfying metal and pH targets is expected to help correct conditions associated with objectionable streambed deposits and turbidity associated with precipitation of metals and is also expected to help correct turbidity concerns.

2.3.1.2 Metals and pH TMDLs

Table 2-6 and 2-7 provide example TMDLs for metals and pH based on mean values from low and high flow periods which best represent water quality extremes for Daisy Creek (sample location DC5) and the Stillwater River (sample location SW7). These TMDLs are calculated as examples of typical lower and higher flow conditions, since the actual TMDL will always be dependent on specific flow conditions as defined by the following equation (also reference Appendix A of this document):

Total Maximum Load in lb/day
(X ug/l) (Y ft^3/sec) (0.00534) = (X)(Y)(0.00534) lb/day

where:
X = the applicable water quality numeric standard (target) in ug/l with hardness adjustments
where applicable (see above discussion on targets);
Y = streamflow in cubic feet per second;
(0.00534) = conversion factor

The above equation addresses all seasonal flow variations, and the examples in Tables 2-6 and 2-7 further evaluate seasonality by addressing differences associated with low and high flow conditions of hardness and pollutant levels

Some additional notes concerning the TMDLs in Tables 2.6 and 2.7 are discussed below:

The TMDL for aluminum is based on a total recoverable concentration that is thought to represent a condition where there is no longer excess aluminum available for precipitation and resulting turbidity problems. It is only applied during low flow conditions when the turbidity concerns due to aluminum precipitation have been noted. Satisfying this concentration and TMDL in Daisy Creek at DC5 is expected to result in meeting reduced turbidity goals from aluminum precipitants within both Daisy Creek and the Stillwater River. If turbidity can be avoided at total recoverable aluminum concentrations higher than the 200 ug/l, then that is acceptable since meeting the target is the ultimate goal. This TMDL will, therefore, follow a phased (adaptive management) approach since it is possible to meet the target at higher levels of aluminum.

For iron, the TMDL based on the 300 ug/l drinking water/domestic use support condition is expected to satisfy the additional target of no visible streambed deposits associated with fine materials from human causes.

Iron values are also used as a surrogate for the pH TMDL for Daisy Creek. Acid drainage, which leads to low pH values and elevated metal concentrations in ground and surface waters, results from oxidation and leaching of metals from sulfide-bearing rocks when exposed to air and water. Because of the linkage between metals loading and acidic drainage, it is assumed that restoration activities undertaken to address high metal loads from mining impacts will also address conditions leading to low pH values from these same mining impacts. Since pyrite (FeS_2) is the most commonly occurring mineral that can produce acidic drainage, then the TMDL for iron is also used as a surrogate TMDL for pH in Daisy Creek. Therefore, a mean low flow iron TMDL of 0.80 lb/day, and mean high flow iron TMDL of 45 lb/day represent loading conditions whereby pH values are expected to comply with Montana Water Quality Standards, and therefore represents the surrogate TMDL to be used for pH. This approach is further supported by results from Nimick and Cleasby (2001) where the pH reductions closely parallel increases in iron in Daisy Creek. For example, pH drops from 7.03 to 5.36 in a stretch where total recoverable iron concentrations increase from 114 ug/l to 7,070 ug/l.

Meeting the copper TMDLs associated with the numeric water quality targets is expected to satisfy the sediment toxicity targets for copper in Daisy Creek and the Stillwater River. Likewise, meeting the similar lead TMDLs in Daisy Creek is expected to satisfy the sediment toxicity target for lead in this water body as well as addressing any possible problems in the Stillwater River. As metal loading is reduced to TMDL levels, the existing fine sediments with metals contamination will likely flush through the system at high flows as they have probably been doing over the years, the difference being that they will start being replaced by fewer and cleaner fine sediment deposits.

Meeting all of the metals and pH TMDLs is expected to result in meeting the target associated with macroinvertebrate and periphyton communities being at 75% or greater in comparison to a reference stream.

Tables 2-6 and 2-7 also provide estimates of the percent total load reduction needed to meet the daily load associated with the Table 2-5 targets. These calculations are based on existing concentrations and target concentrations. The data used for these calculations were obtained from the database on the Maxim website using sampling events where metals concentrations and corresponding stream flow data were available. Typically only one representative high flow and one representative low flow set of data per year, where available, were used. Tables D-1 and D-2 in Appendix D provide a summary of the data used for Tables 2-6 and 2-7.

For Daisy Creek, note that copper requires the greatest percent reduction in total load at greater than 99% for the low flow condition and approximately 99% for the higher flow condition. Iron, manganese, cadmium aluminum and zinc also require very high percent load reductions of greater than 50% under low and/or high flow conditions. Even higher load reductions will be necessary for many metals upstream at monitoring location DC2.

For the Stillwater River, copper still requires the greatest percent reduction in total load at 74% for the low flow condition and 94% for the high flow condition. Iron is the only other metal with load reductions at greater than 50% applicable only at high flow conditions. As previously discussed, some of the high flow problems may be due to loading at low flow conditions and the subsequent re-suspension of precipitates from the streambed during these higher flows. Even higher load reductions will be needed at upstream monitoring location STW2, although meeting the load reductions at DC5 in Daisy Creek will satisfy all metal load reduction needs at locations STW2 and SW7 in the Stillwater River.

It is important to note that a given decrease in metal loading at an upstream location does not always directly result in the same loading decrease downstream, particularly during lower flows since chemical reactions associated with changing pH and related metal solubility can determine downstream concentrations. Nevertheless, any load reductions at low flow can significantly contribute to overall yearly loading reductions since there would be a significant reduction in the total amount of precipitated metals that could be re-suspended and transported downstream at higher flows.

Table 2-5. Metals and pH Water Quality Restoration Targets for Daisy Creek and the Stillwater River

Stream(s)	Pollutant	Target(s)	Limiting Beneficial Use
Daisy Creek & Stillwater River	Copper[1]	5.2 ug/l (high flow) 7.3 ug/l (low flow) sediment concentrations at non-toxic levels	Aquatic Life (chronic) Aquatic Life (chronic) Aquatic Life
Daisy Creek	Cadmium[1]	0.16 ug/l (high flow) 0.22 ug/l (low flow)	Aquatic Life (chronic) Aquatic Life (chronic)
Daisy Creek	Lead[1]	1.3 ug/l (high flow) 2.2 ug/l (low flow) sediment concentrations at non-toxic levels	Aquatic Life (chronic) Aquatic Life (chronic) Aquatic Life
Daisy Creek	Zinc[1]	67 ug/l (high flow) 94 ug/l (low flow)	Aquatic Life (acute & chronic) Aquatic Life (acute & chronic)
Daisy Creek & Stillwater River	Iron	300 ug/l (all flows) no visible streambed deposits (both streams) associated with controllable human causes	Drinking Water (domestic use) Aquatic Life/Aesthetics
Daisy Creek & Stillwater River	Manganese	50 ug/l	Drinking Water (domestic use)
Daisy Creek & Stillwater River	Aluminum	no precipitants causing visible turbidity at low flow conditions	Aquatic Life/Aesthetics
Daisy Creek	pH	6.0 to 9.0	Aquatic Life
Daisy Creek & Stillwater River	Metals & pH	Macroinvertebrate and periphyton communities at 75% or greater of reference stream conditions	Aquatic Life

Notes:
1. All targets for this pollutant are estimated based on predicted hardness values after completion of restoration activities, actual values will be determined by hardness as defined in Appendix A

Table 2-6. Daisy Creek TMDL and Load Reduction Examples for Metals and pH at Typical High and Low Flow Conditions

Pollutant	Target (ug/l)	Mean Low Flow (0.5 cfs) TMDL (lb/day)	Mean High Flow (28 cfs) TMDL (lb/day)	% Total Load Reduction Needed to Meet TMDLs and Targets
Copper	7.3 (low flow) 5.2 (high flow)	0.02	0.78	>99% (low flow); 99% (high flow)
Cadmium	0.22 (low flow) 0.16 (high flow)	0.0006	0.024	91% (low flow); 63% (high flow)
Lead	2.2 (low flow) 1.3 (high flow)	0.006	0.19	-- % (low flow)[1]; 43% (high flow)
Zinc	94 (low flow) 67 (high flow)	0.25	10.0	74% (low flow); 0% (high flow)[2]
Iron	Prevent objectionable streambed deposits (low flow) 300 ug/l (all flows)	0.80	45	94% (low flow); 89% (high flow)
Manganese	50	0.13	7.5	95% (low flow); 67% (high flow)
Aluminum	no precipitants causing visible turbidity (low flow conditions)	0.53 (based on 200 ug/l concentration goal)	NA	97% (low flow);
pH	6.0 to 9.0	0.80 lb/day iron load (surrogate TMDL)	45 lb/day iron load (surrogate TMDL)	94% (iron, low flow); 89% (iron, high flow)

Notes:
1. Lead values occasionally exceeded the target during low flow, but the mean low flow value is below the target
2. Zinc problems are primarily associated with low flow conditions

Table 2-7. Stillwater River TMDL and Load Reduction Examples for Metals at Typical High and Low Flow Conditions

Metal/Pollutant	Target (ug/l)	Mean Low Flow (3.5 cfs) TMDL (lb/day)	Mean High Flow (154 cfs) TMDL (lb/day)	% Total Load Reduction Needed to Meet TMDLs and Targets
Copper	7.3 (low flow) 5.2 (high flow)	0.14	4.3	74% (low flow); 94% (high flow)
Iron	300	5.6	247	0% (low flow)[1]; 66% (high flow)
Manganese	50	0.93	41	-- % (low and high flow)[2]

Notes:
1. Iron is generally not a concern at low flow conditions at SW7
2. Manganese occasionally exceeds or equals the target at low and high flow conditions, but the mean low flow values are below the target

2.3.1.3 Performance Based Load Allocation Approach for Metals and pH

A performance based allocation approach is used for metals and pH load allocations. This approach relies on detailed plans and practices that will be developed and applied to all significant mining sources impacting Daisy Creek and the Stillwater River. The *Petition Report* (Stanley, 1999) and the *Final Overall Project Work Plan for the New World Mining District Response and Restoration Project* (Maxim, 1999) provide details concerning the overall restoration strategy for District and some non-District property within the Cooke City Planning Area. The *Petition Report* specifically includes schedules and detailed site descriptions and anticipated restoration activities. The *Final Work Plan* further describes the process whereby potential pollutant sources (e.g. mine dumps, adits, etc.) are evaluated and restoration approaches are analyzed in detail and undergo stakeholder review and comment prior to selection of a final restoration approach for each location of concern. The information is then documented in an annual work plan, which may address one or more locations where restoration is planned over the coming year. This process continues every year with the goal of achieving cleanup by 2014 as required by the Temporary Water Quality Standards. *The New World Mining District Response and Restoration Project: Project Summary, 2001*(Maxim, 2001b) also describes the restoration planning and implementation process for the District.

Overall, a total of 18 source areas have been identified in the District. The source areas that involve Daisy Creek and the Stillwater River, including a summary of the general activities that are planned as well as some potential restoration actions, are discussed below (reference Figures 2-2 and 2-3).

- District Property — Includes all property or interest relinquished by CBMI. Activities will include: surveying the District for additional sources; characterize chemistry, thickness, and quantity of sources (waste rock dumps or tailings) through borehole drilling; identify and investigate potential waste rock disposal sites; identify potential borrow sources; survey cultural resources; and monitor surface and ground water resources. Restoration activities can include activities such as removal to the repository site and/or drainage control.

- McLaren Pit — Complete the hydrologic evaluation and determine necessary controls for reducing pit inflows; determine pit holding capacity; characterize waste rock dumps; evaluate source control and water treatment options; install and maintain stormwater sediment control; monitor and maintain revegetated areas; establish whether all underground mine workings are identified; insure that all capped boreholes are secure; and monitor water diversion system, erosion control practices, and water quality. The *Draft McLaren Pit EE/CA* (Maxim, 2001c) should be referenced for a discussion of restoration options which consider capping, lime additions, and revegetation. The 2002 Annual Work Plan (yet to be developed) will then provide details on selected restoration efforts for the coming field season.

- Road Systems — Roads within or accessing District Property will be evaluated to determine which roads should be closed and which roads will be used during removal actions. In addition, best management practices typically associated with drainage improvements and other erosion controls will likely be pursued on roads and trails where closure is not consistent with overall forest recreational goals.

- Wetland, Stream Bank — Includes contaminated material deposited along stream thalwegs and transported sources and bog material with elevated metal concentrations. Disturbances in this source area will be characterized to determine necessary removal actions.

Figure 2-2 shows the locations of most or all of the mine disturbances in the Daisy Creek and Stillwater River drainages. These mine disturbances can all be addressed under one or more of the above categories. For example, the Daisy Pass Dumps are not specifically identified above, but do fall under the overall category of District Property, and will therefore be addresses as discussed above. Figure 2-3 shows the road network that is discussed above under the Road Systems category. Erosion control efforts focused on the mine disturbances identified in Figure 2-2, as well as some of the roads and trails in the vicinity of the mine disturbances, will further reduce metal loading to both streams.

Some of the potential sources of metals to Daisy Creek and the Stillwater River include erosion from roads and other disturbed areas and sources located on non-District Property. The *Consent Decree and Settlement Agreement* (United States District Court for the District of Montana Billings Division, 1998) provides further restoration guidance for all sources in the Daisy, Fisher, and Miller Creek drainages as well as sources within the whole New World Mining District. Per the Natural Resources Working Group for the New World Mining District Response and Restoration Project, there are two categories of work that can be done (Natural Resources Working Group Meeting Summary, June 19, 2002). These are:

- Category A - hazardous substances (i.e. mine waste) that are on District Property and non-hazardous substances (e.g. principally sediment from roads) on District Property. Work can be done prior to the receipt of the Notice of Completion from the United States Government.

- Category B – after receipt of the Notice of Completion, work can address other hazardous and non-hazardous sources on non-District Property.

It is assumed that all significant metals and pH related sources, other than natural background sources, to Daisy Creek and the Stillwater River are “Category A” type sources and will be addressed as part of the consent decree requirements for a notice of completion. These sources are identified on Figure 2-2 or are yet to be identified as part of the New World Mining District restoration efforts. It is also assumed that for all these sources, restoration activities will be implemented in a manner that represents all reasonable land, soil, and water conservation practices and therefore will satisfy the intent of Montana's Water Quality Standards. This includes appropriate implementation monitoring and maintenance of restoration efforts to ensure success.

If a source of metals located on non-District Property does happen to be identified as significant then it will be addressed under “Category B” within the budget constraints after issuance of the notice of completion. If there is not adequate budget within the New World restoration project, then a load will be allocated to this source to reflect loading conditions needed to ensure that water quality targets would be met once the new allocation is satisfied. This is not expected to happen given the previous discussions on significant source locations and their relations to District Property and non-District Property within the Daisy Creek and Stillwater River drainages.

As previously discussed, once metals loading approaches TMDL levels the existing fine sediments with metals contamination will likely flush through the system at high flows as they have probably been doing over the years, the difference being that they will start being replaced by fewer and cleaner fine sediment deposits. Note that the restoration work for the “Wetland, Stream Bank” source area is intended to verify this assumption and address significantly high levels of metals contaminants in stream sediments and floodplain material if they did not flush through the system as anticipated.

Section 5.0 in this document summarizes some additional components of the overall restoration strategy for Daisy Creek and the Stillwater River.

2.3.2 Sediment Restoration Targets, TMDL Goals and Allocations

2.3.2.1 Sediment Targets

For sediment, target development is based on criteria currently found within *Appendix A of Water Quality Assessment Process and Methods* (MDEQ, 2000). The Appendix A document provides guidelines for making beneficial use support determinations, and essentially provides a process for interpreting narrative water quality standards, such as those that exist for sediment, under certain conditions of data availability.

There are two water quality restoration targets for sediment in Daisy Creek and the Stillwater River, both of which are presented below:

- Periphyton and macroinvertebrate biota at 75% of reference condition based on established protocols for evaluating sediment impairment conditions

AND

- The habitat conditions must represent 75% of the reference condition by allowing no greater than a 25% average increase above reference condition percent fines data for all sizes less than D_{50}.

The first target is based on biological data since ideally this would best represent aquatic life beneficial use support. The second target is developed as a method to directly measure sediment impacts on habitat conditions relative to a reference stream. Meeting this habitat condition is assumed to support biota at a 75% level of reference conditions from a sediment impact perspective. The sizes less than D_{50} are chosen to ensure that particle sizes generally associated with aquatic life impacts, such as 6.35 mm and smaller, are the primary focus.

The Stillwater River just upstream of Daisy Creek serves as the reference stream for both Daisy Creek and the Stillwater River below Daisy Creek. Figure 2-4 is the same as the Figure 2-1 percent fines curves with an additional target line curve added to represent the 25% increase in percent fines. Meeting the habitat target would involve measurements, on the average, falling below the target curve for each impaired water body. Note that current percent fines conditions for Daisy Creek and the Stillwater River below Daisy Creek are currently well above the 25% target line at the low end of the scale (i.e. values less than the D_{50}).

Because percent fines curves can vary from time to time at the same locations, future comparisons to reference conditions curves must be made using measurements from the same day for each water body, including the reference stream. Measurements to evaluate status toward meeting the sediment target should be taken during the lower flow summer or fall season after spring runoff conditions. A similar approach in comparing biota between Daisy Creek and the Stillwater River to reference stream conditions also applies.

It is recognized that the uppermost portion of the Stillwater River represents a fairly pristine reference stream condition. In addition, possible confounding effects of potentially long term elevated metal concentrations in the water column and in sediments of Daisy Creek and the Stillwater River below Daisy Creek may make it difficult to meet the biota target as currently defined. For this reason, the sediment targets will be evaluated at least every five years for suitability and may be modified based on identification of a more suitable reference stream and/or identification of a better indicator of habitat conditions needed to support aquatic life. The sediment targets could also be modified to represent anticipated conditions associated with the implementation of sediment control and mine restoration activities in both the Daisy Creek and Stillwater drainage areas in a manner that represents the application of all reasonable land, soil and water conservation measures.

2.3.2.2 Sediment TMDLs and Load Allocations

As previously discussed under Source Characterization (Section 2.2.3), the current modeled annual percent sediment yield above natural background for Daisy Creek has been calculated at 50%, which amounts to 11.3 tons of sediment above and beyond the natural background of load of 22.7 tons. Based on expected erosion control efforts associated with the McLaren Pit and other mine disturbances, in addition to road improvements, it is envisioned that the modeled annual percent greater than natural background loading to Daisy Creek will be reduced from 50% to 38% or less (discussions with Mark Story, USFS). This would mean that the modeled 11.3 tons of sediment from roads and mining activities would be reduced to 8.6 (38/50 x 11.3) tons or less. This 8.6 tons per year load represents a yearly load allocation to Daisy Creek and the Stillwater

River for the major controllable sources. This sediment load of 8.6 tons per year above natural background plus the natural background load of 22.7 tons equals 31.3 tons per year. This modeled 31.3 tons per year represents a total maximum yearly load for the major sediment sources of concern and represents the surrogate TMDL for both Daisy Creek and the Stillwater River below Daisy Creek, since the Daisy Creek drainage is by far the primary source of problem causing sediments to the Stillwater River.

Table 2-8 provides a summary of the sediment load allocations and percent reductions by source category for both water bodies. It is assumed that the sediment loads and all identified load reductions in Table 2.8 will result in conditions that meet the sediment targets for both water bodies. Note that the actual yearly load for the Stillwater River will include additional natural background loads and insignificant human related loads from outside the Daisy Creek drainage. The possible exception to insignificant human related loads is the road to Lake Abundance. An additional 50% reduction in load from the sections of the road to Lake Abundance that are located outside of the Daisy Creek drainage but still within the Stillwater River drainage is also part of the load allocation and modification to the TMDL for the Stillwater River. The load reduction can be based on modeling or can be achieved via successful implementation and maintenance of erosion control best management practices as verified by MDEQ and Forest Service water quality personnel. This same load reduction approach is also applied to a badly eroding trail within the Daisy Creek drainage and therefore represents a modification to the TMDL and load allocations to Daisy Creek and the Stillwater River.

It is important to note that the actual annual sediment variation can be an order of magnitude greater due to climatic variability, whereas the primary load allocation and TMDL are based on modeled sediment yields assuming average annual precipitation.

Because there is uncertainty associated with the assumption that the Table 2-8 load allocations will result in meeting sediment targets for both water bodies, an adaptive management or phased approach will be pursued. As restoration efforts continue and reductions in sediment yield are achieved, measurements will be taken to evaluate progress toward meeting targets. If it looks like greater reductions in sediment loading are needed, then a new TMDL and new load allocations will be developed in recognition of the need to further reduce sediment yield in the Daisy Creek and Stillwater River drainages. Any modifications to the sediment targets, as discussed above under Section 2.3.2.1, will also be incorporated into this adaptive management approach

Table 2-8. Modeled Sediment Load Allocations for Daisy Creek and the Stillwater River

Source Category	Existing Load (tons/yr)	Load Allocation (tons/yr)	% Reduction in Load by Source Category
Natural Background in Daisy Creek Drainage	22.7	22.7	0%
Natural Background in Stillwater River drainage (not including Daisy Creek drainage)	Not modeled (does not need to be for this allocation)	Set to existing levels	0%
Roads in Daisy Creek Drainage	5.6	4.0	28%
Mine Disturbances in Daisy Creek Drainage	5.7	4.6	20%
Trail Erosion in Daisy Creek Drainage	Not modeled (does not need to be if trail meets applicable erosion control practices)	50% of existing load accomplished by meeting erosion control best management practices	50%
Lake Abundance Road Section not in Daisy Creek Drainage	Not modeled (does not need to be if road meets all erosion control practices)	50% of existing load accomplished by meeting erosion control best management practices	50%
Other trails, mines, and human disturbances in the Stillwater River drainage only	Not modeled (does not need to be since no load reductions will be pursued)	Set to existing minimal levels representing probable naturally occurring conditions	0%

SECTION 3.0 FISHER CREEK AND THE CLARKS FORK OF THE YELLOWSTONE RIVER WATER QUALITY RESTORATION

3.1 Impairment Conditions

Fisher Creek and the Clarks Fork of the Yellowstone River (Clarks Fork) are both impacted from elevated metals concentrations and low pH values. Sediment deposits also impact Fisher Creek. Many reports and data sources identify impacts to beneficial uses. Section 3.1.1 below provides impairment details associated with metals and pH, and Section 3.1.2 provides impairment details associated with sediment.

3.1.1 Metals and pH

The *Petition Report* for temporary standards includes water quality data tables for Fisher Creek and the Clarks Fork. Included in the data tables are statistical summaries of the analytical data from 1989 through 1998. Another report, entitled *Quantification of Metal Loading in Fisher Creek by Tracer Injection and Synoptic Sampling, Park County, Montana, August 1997* (Kimball et al., 1999) provides sample results at numerous locations along Fisher Creek during a relatively low flow time of the year. In addition, the Maxim website (Maxim, 2001a) provides significant water quality and sediment metals concentration data. Additional sediment metals concentration data are also available based on work done to support restoration efforts (Camp, Dresser and McKee, 1997).

The above referenced information and other reports show that conditions in Fisher Creek do not fully support the beneficial uses associated with a B-1 classification and do not comply with applicable B-1 standards for copper, iron, manganese, aluminum, zinc, cadmium, lead, silver, and pH. This causes significant negative impacts to aquatic life from the elevated metals concentrations and low pH values (reference Section 1.2.4). In addition to metal concentration and pH concerns, metal precipitates associated with iron and aluminum settle to form objectionable sludge deposits in Fisher Creek and can also cause increased turbidity. These deposits and the associated turbidity from metal precipitates negatively impact the aesthetics of Fisher Creek and add further to the negative impacts to aquatic life.

The above referenced information and other reports show that conditions in the Clarks Fork below Fisher Creek do not fully support the beneficial uses associated with a B-1 classification and do not comply with applicable B-1 standards for copper, zinc, cadmium, lead, silver and pH. Section 1.2.4 provides discussion associated with these negative impacts to aquatic life from pollutants in Fisher Creek.

Tables 3-1, 3-2, and 3-3 provide summaries of the impairment concerns associated with metals and pH. All metal concentrations are total recoverable unless otherwise noted. The metals concentrations and pH values are from Fisher Creek sampling locations SW3 and SW4, and Clarks Fork sampling location SW6. The Fisher Creek sample locations SW3 and SW4 capture most or all mining impacts and provide representation of the significant mining impacts to water quality. Location SW3 represents the more severe upstream mining impacts and SW4 represents most or all impacts at a further downstream location where these impacts are less severe. The Clarks Fork sample location SW6 represents water quality impacts from Fisher Creek to the Clarks Fork upstream of any major tributaries to the Clarks Fork. All three sampling locations, which are shown in Figure 1-3, are routinely used to track water quality in this stream and to measure progress of ongoing restoration efforts. As expected, metal concentrations in the Clarks Fork are significantly lower than in Fisher Creek since Fisher Creek flows into the Clarks Fork and essentially all significant contaminant sources are in the Fisher Creek drainage. In fact, values are low enough for some metals such that the concentrations are below water quality standards, meaning that a TMDL is not necessary for that particular metal in the Clarks Fork.

Appendix B provides a descriptive water quality summary for each of the metals of concern and pH as they relate to impairment determinations.

3.1.2 Impairment Conditions Associated with Sediment

Eroded soils and metal precipitates create impairment conditions due to deposition in the streambed. This discussion focuses on potential impairment conditions associated with eroded soils, although it is recognized that these eroded soils also transport metal contaminants. It is also further recognized that precipitation of metals to the streambed can confound efforts to measure sediment impacts and that these precipitates can negatively impact aquatic life in a manner similar to sediment impacts.

The New World Project Draft EIS provides percent fines sample results from monitoring locations at or near SW4. These results show that the mean percent of particles 6.3 mm or smaller in diameter was 19.6 percent and the range was 11.7 to 39.4 percent. The mean percent particle size 2.38 mm diameter and smaller was 18%, indicating that most particles smaller than 6.3 mm are also smaller than 2.38 mm. Embeddedness measurements in Fisher Creek were also relatively high based on measurements from 1990 through 1993, generally in the 25 to 50% range.

In addition to the above measured data, the USFS has modeled the sediment yield above natural sediment levels for Fisher Creek (Draft EIS, 1996) using the R1R4 model. The modeled results show that on an annual basis, the modeled sediment yield is 36% above natural sediment levels for Fisher Creek, which can lead to conditions that do not fully support aquatic life in a stream with a B-1 classification. A subsequent field visit by MDEQ water quality specialists during August 2001 further verified the probability of impairment based on observation of high apparent embeddedness and percent fines conditions in a lower gradient meandering section of Fisher Creek where some of the more suitable fish habitat exists.

Table 3-1. Fisher Creek Metals and pH Impairment Summary (Sample Site SW3)

Pollutant	Sampling Results	Water Quality Standard Concern	Water Quality Standards Reference(s)
Copper	30 - 1530 ug/l	- consistently > 2.8 ug/l chronic aquatic life (high flow)[1] - consistently > 4.2 ug/l chronic aquatic life (low flow)[1] - consistently > 3.8 ug/l acute aquatic life (high flow)[1] - consistently > 5.9 ug/l acute aquatic life (low flow)[1] - elevated copper levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Iron	40 - 11,600 ug/l	- consistently > 1000 ug/l chronic aquatic life - consistently > 300 ug/l domestic use - consistently forms objectionable streambed deposits	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(a) 17.30.637(1)(d)
Manganese	160 - 1670 ug/l	- consistently > 50 ug/l domestic use	17.30.623(2)(h)(i) - WQB-7
Aluminum	1360 - 5000 ug/l (dissolved) 1100 - 4800 ug/l (total recoverable)	- consistently > 87 ug/l aquatic life for dissolved aluminum (chronic at pH 6.5 to 9.0; but no detections of concern are within this pH range) - consistently forms objectionable streambed deposits - consistently produces high turbidity from colloidal precipitants	17.30.637(1)(d) 17.30.623(2)(d)
Zinc	30 - 290 ug/l	- consistently > 37 ug/l chronic & acute aquatic life (high flow)[1] - consistently > 55 ug/l chronic & acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Cadmium	< 0.1 - 2.2 ug/l	- sometimes > 0.10 chronic aquatic life (high flow)[1] - often > 0.14 ug/l chronic aquatic life (low flow)[1] - possibly never > 0.52 ug/l acute aquatic life (high flow)[1] - sometimes > 0.84 ug/l acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Lead	< 3 - 9 ug/l	- often > 0.54 ug/l chronic aquatic life (high flow)[1] - consistently > 0.99 ug/l chronic aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Silver[2]	< 0.5 - 1.1 (2 to 4 detections)	> 0.37 acute aquatic life (high flow)[1] > 0.84 acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7
pH	2.9 - 6.6 (field)	- below expected naturally occurring levels - contributes to metals solubility and resulting precipitation problems	17.30.623(2)(c) 17.30.637(1)(d)

1 Standards reflect adjustments for water hardness, which varies during lower flow periods (generally before and after runoff) and higher flow periods (generally during late spring and early summer runoff) in Fisher Creek; the low flow hardness value used for Fisher Creek is 40 mg/l calcium carbonate; and the higher flow hardness value is 25 mg/l as calcium carbonate.
2 Silver does not have a chronic aquatic life standard

Table 3-2. Fisher Creek Metals and pH Impairment Summary (Sample Site SW4)

Pollutant	Sampling Results	Water Quality Standard Concern	Water Quality Standards Reference(s)
Copper	< 1 - 180 ug/l	- consistently > 2.8 ug/l chronic aquatic life (high flow)[1] - consistently > 4.2 ug/l chronic aquatic life (low flow)[1] - consistently > 3.8 ug/l acute aquatic life (high flow)[1] - consistently > 5.9 ug/l acute aquatic life (low flow)[1] - elevated copper levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Iron	< 30 - 3,170 ug/l	- sometimes > 1000 ug/l chronic aquatic life - consistently > 300 ug/l domestic use - consistently forms objectionable streambed deposits	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(a) 17.30.637(1)(d)
Manganese	< 10 - 160 ug/l	- often > 50 ug/l domestic use	17.30.623(2)(h)(i) - WQB-7
Aluminum	< 100 - 1300 ug/l (dissolved) <100 - 1100 ug/l (total recoverable)	- consistently > 87 ug/l aquatic life for dissolved aluminum (chronic at pH 6.5 to 9.0; many detections of concern are within this pH range) - consistently forms objectionable streambed deposits - consistently produces high turbidity from colloidal precipitants	17.30.637(1)(d) 17.30.623(2)(d)
Zinc	< 10 - 80 ug/l	- sometimes > 37 ug/l chronic & acute aquatic life (high flow)[1] - often > 55 ug/l chronic & acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Cadmium	< 0.1 - 2 ug/l	- sometimes > 0.10 chronic aquatic life (high flow)[1] - sometimes > 0.14 ug/l chronic aquatic life (low flow)[1] - sometime > 0.52 ug/l acute aquatic life (high flow)[1] - sometimes > 0.84 ug/l acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Lead	< 1 - 10 ug/l (3 detections)	- sometimes > 0.54 ug/l chronic aquatic life (high flow)[1] - elevated lead levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Silver[2]	< 0.2 - 9 (2 detections)	> 0.37 acute aquatic life (high flow)[1] > 0.84 acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7
pH	5 - 9.1 (field)	- below naturally occurring levels during much of the year, particularly upstream of SW4 - contributes to metals solubility and resulting precipitation problems	17.30.623(2)(c) 17.30.637(1)(d)

1 Standards reflect adjustments for water hardness, which varies during lower flow periods (generally before and after runoff) and higher flow periods (generally during late spring and early summer runoff) in Fisher Creek; the low flow hardness value used for Fisher Creek is 40 mg/l calcium carbonate; and the higher flow hardness value is 25 mg/l as calcium carbonate.
2 Silver does not have a chronic aquatic life standard

Table 3-3. Clarks Fork River Below Fisher Creek Metals Impairment Summary (Sample Site SW6)

Pollutant	Sampling Results	Water Quality Standard Concern	Water Quality Standards Reference(s)
Copper	< 1 – 70 ug/l	- consistently > 2.8 ug/l chronic aquatic life (high flow)[1] - consistently > 4.2 ug/l chronic aquatic life (low flow)[1] - consistently > 3.8 ug/l acute aquatic life (high flow)[1] - consistently > 5.9 ug/l acute aquatic life (low flow)[1] - elevated copper levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Zinc	< 10 – 40 ug/l (high flow) < 10 – 50 ug/l (low flow)	- sometimes > 37 ug/l chronic & acute aquatic life (high flow)[1] - < 55 ug/l chronic & acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Cadmium	3 high flow detections at 1, 2, and 80 (sample or reporting error?)	- sometimes > 0.10 chronic aquatic life (high flow)[1] - < 0.14 ug/l chronic aquatic life (low flow)[1] - sometime > 0.52 ug/l acute aquatic life (high flow)[1] - < 0.84 ug/l acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Lead	Consistently below detection	- elevated lead levels in sediment	
Silver[2]	< 0.2 – 30 (2 detections)	> 0.37 acute aquatic life (high flow)[1] > 0.84 acute aquatic life (low flow)[1]	17.30.623(2)(h)(i) - WQB-7
pH	4.8 – 9.4 (field)	- possibly below naturally occurring levels during parts of the year presumably due to Fisher Creek pollutant impacts	17.30.623(2)(c)

1 Standards reflect adjustments for water hardness, which varies during lower flow periods (generally before and after runoff) and higher flow periods (generally during late spring and early summer runoff) in the Clarks Fork River; the low flow hardness value used for the Clarks Fork River is 40 mg/l calcium carbonate; and the higher flow hardness value is 25 mg/l as calcium carbonate.

2 Silver does not have a chronic aquatic life standard

At this time, a suitable reference stream has not been identified and measured as was done for Daisy Creek and the Stillwater River, and a determination on impairment status relating to sediment is difficult to make with the same degree of certainty. None of the three previous 303(d) lists (1996, 1998, and 2000) identify sediment as a pollutant of concern for Fisher Creek. Nevertheless, the high levels of modeled sediment yield, increased levels of embeddedness, and especially the high level of percent fines less than 2.38 mm all provide sufficient credible data for an impairment determination. For this reason, a sediment target, TMDL, and allocations are identified for sediment in Fisher Creek. Efforts to ensure reduced sediment production can then be coordinated with ongoing restoration efforts, which address both metals and sediment loading sources as part of the New World Cleanup. In fact, at least one major source of sediment loading has already been addressed via road improvements that the Forest Service had completed along the main Fisher Creek Road.

As implied above, the additional yield in sediment from Fisher Creek may have some level of negative impact on the Clarks Fork River below Fisher Creek. At this time it is not considered sufficient enough to cause impairment conditions because of naturally occurring high levels of sediment transport including elevated levels from relatively recent fire activities. Therefore, target and TMDL development is not pursued for sediment in the Clarks Fork River, although it should be recognized that efforts to address sediment loading to Fisher Creek will also result in reduced sediment loading from many of the human related activities impacting the Clarks Fork River.

3.2 Source Characterization

3.2.1 Source Inventory

Mining disturbances primarily associated with historical adits and waste rock represent the sources of increased metals and pH conditions due to human activities in the Fisher Creek and Clarks Fork River drainage areas. Figure 3-1 shows the locations of these mining disturbances, with the Glengary Adit representing one of the most significant sources of metals and pH lowering constituents. These same mining disturbances, along with an existing and historic road network shown by Figure 3-2, represent the primary sources of increased sediment loads from human activities. This increased loading of sediment from erosion also represents a potential pathway for metal contaminants located in the soils or along eroding stream banks, although not all eroded soils will necessarily be associated with increased metal transport.

Forest, high elevation shrubland, rock and some transitional areas from recent fires cover most of the remaining drainage area (Figure 1-2). Therefore, there appears to be a low probability of any other human related sources that could represent significant loading for any of the pollutants of concern. In addition, neither of the impaired water bodies or their tributaries receive point source discharges regulated by a Montana Pollutant Discharge Elimination System permit, meaning that waste load allocations are not necessary for these water bodies.

3.2.2 Metals and pH Source Assessment

As previously discussed, higher metal concentrations in Fisher Creek generally occur during low flow periods. This is when metals loading is predominately transported via acidic ground water discharging directly to Fisher Creek or discharging to springs which run into Fisher Creek, all of which have the potential to ultimately impact the Clarks Fork River. In some of the upper headwaters tributaries pH values are relatively low. The pH values then significantly decrease in the area of the Glengary Adit discharge, and then increase in the downstream direction along Fisher Creek to the point where pH is no longer thought to be of concern within the Clarks Fork River during most of the year. This increase in pH promotes the precipitation of metals, which subsequently settle to the bed of Fisher Creek and ultimately result in reduced water column concentrations (and perhaps increased concentrations of metals in sediments) in a downstream direction during low flow conditions. Metals concentrations within the Clarks Fork River decrease even further in a downstream direction due to additional dilution from tributaries and possible additions of clean sources of ground water.

The Kimball et al. (1999) synoptic sampling study provides metals loading information for Fisher Creek. This information was developed during a relatively low flow time of year, on a subreach by subreach scale, looking at both surface inflows and subsurface inflows. In general, it was found that about 60% of the aluminum, copper, manganese, and zinc loads can be attributed to visible inflows, including the Glengary Adit, which contributes about 32% of the total copper load during low flow conditions. The remaining 40% were found to be from diffuse subsurface (ground water) inflows. As was the case for Daisy Creek and the Stillwater River, much of this low flow load settles to the streambed of Fisher Creek and is re-suspended during higher flows, thus contributing to the high flow downstream loads.

Appendix E is an excerpt from the Kimball et al. (1999) report that includes a discussion on metal sources and the overall study summary and conclusions. This information provides good loading curves in a downstream direction for most metals of concern. Note that the copper loading curve from this report shows a significant increase in copper load at the Glengary Adit location as well as from mine waste drainage. Similar loading curve shapes also exist for other metals as shown by the figures in Appendix E.

There has not been a study focused on metal quantification at higher flow events like the one discussed above. Lower concentrations at high versus low flow for many metals in Fisher Creek and the Clarks Fork River indicate possible similar sources during high flow with some dilution from the higher flows. Additional high flow pathways include metal loading from accelerated erosion associated with roads and land disturbances, or loading from contaminated streambed sediments transported to downstream locations. Some sample locations such as SW6 show an increase in some metal concentrations with increased flow, further indicating the importance of some of the above referenced high flow pathways.

Though the Kimball et al. (1999) study provides a good summary of relative inputs by location and by pollutant pathway, there is still significant uncertainty and debate as to the extent of metals and pH-related loads associated with natural background. The extent of mining caused loads of metals versus natural background loads will depend on which inflows are impacted by mining activities and, where inflows are impacted by mining, the difference between any natural background loading levels versus the elevated levels caused by mining impacts.

As discussed under the Daisy Creek and Stillwater River Source Characterization (Section 2.2.2), there have been several investigations associated with natural background conditions in the area of interest (Runnells, 1992; Furniss and Hinman 1998; Lovering, 1929). The studies generally suggest the existence of probable sources of elevated metals (and subsequent pH lowering conditions) associated with naturally occurring acid rock drainage due to ground water contact with naturally elevated metal-bearing bedrock materials. The transport of metals from elevated metal-bearing soils, via direct dissolution or erosion to Fisher Creek and subsequent dissolution, is also a possible natural source. Nevertheless, absolute quantification of the amount of loading attributable to pre-mining (natural background) sources is a difficult task.

Lady of the Lake Creek (Figure E-2) appears to contribute some minor metal loading to the Clarks Fork River at levels normally below water quality standards and therefore this tributary may not be of significant concern. The possible exception is potentially high copper loads during very high flow events based on the results from one sampling event (6/19/96; 400 cfs; 29 ug/l total recoverable copper). There appears to be a lack of significant mining related pollutant sources in the Lady of the Lake Creek drainage. This indicates a need for further investigation to determine whether or not Lady of the Lake Creek is impaired and/or represents a significant copper load to the Clarks Fork River during very high flow events, and whether or not there are controllable sources if high metals loading is verified. Similar such work is needed for the Broadwater River as discussed in Section 3.4 below.

3.2.3 Sediment

Sediment sources include land disturbances from past mining activities (Figure 3-1), an existing and historical road network (Figure 3-2), and natural background generally from undisturbed soil surfaces. Sediment transport was modeled by the USFS for the Fisher Creek drainage using the R1R4 Sediment Model (Draft EIS, 1996). It should be noted that the R1R4 model is a fairly simplistic analysis of very complex geomorphic processes and is based on annual average precipitation. The model attempts to predict sediment levels, but actual levels in any one year can vary by an order of magnitude or more depending on precipitation. The model results, summarized in Table 3-4, show an annual modeled baseline, or natural background, loading rate of 38 tons per year. Roads and disturbed lands from previous mining activities were combined in the model and resulted in 13 tons per year. This represents 25% of the total 51 ton yearly modeled load, or 34% above natural background.

Table 3-4. Sediment Model Loading Rate Summaries for Fisher Creek:

Source	Load (tons/yr)	% Total Load	Annual % > Natural
Natural Background	38	75	NA
Roads & Mine Disturbances	13	25	34

3.3 Restoration Targets, TMDLs, and Load Allocations

Restoration goals and the allocation approach for Fisher Creek and the Clarks Fork River are first developed for metals and pH under Section 3.3.1, followed by sediment under Section 3.3.2.

3.3.1 Metals and pH Restoration Targets, TMDLs and Allocations

3.3.1.1 Metals and pH Targets

Table 3-5 provides target values for metals and pH. Most metals targets are based on the applicable numeric water quality standard identified in Tables 3-1 through 3-3, with hardness modifications for copper, cadmium, zinc, lead, and silver. Because it is unknown what the actual hardness value will be under restoration conditions, the Table 3-5 values for copper, cadmium, zinc, lead, and silver represent estimated values at high and low flow conditions as defined in Tables 3-1 through 3-3. The actual targets for these five metals are the water quality standard with applicable hardness adjustments based on actual in-stream hardness values at the time of measurement. Appendix A of this document provides an example of the hardness adjustment equation for chronic aquatic life support standards (reference Montana Water Quality Standards WQB-7 for more information and for the similar equation used for acute aquatic life computations).

All metal targets are based on total recoverable concentrations unless otherwise noted. For aluminum, iron, and manganese, the standard and any applicable targets are not a function of hardness. Where there are multiple numeric standards for protecting different beneficial uses, the lowest value is used to ensure protection of all beneficial uses. If the chronic and acute aquatic life targets are different than each other, then the primary target for TMDL development and restoration planning becomes the chronic aquatic life support standard to provide some margin of safety since the chronic standard is normally based on a 96-hour average.

The numeric targets cannot be exceeded at any time. Monitoring locations SW3 (Fisher Creek), SW4 (Fisher Creek), and SW6 (Clarks Fork River) should be used for determining compliance with targets based on water quality and sediment metals concentrations, whereas iron and aluminum targets associated with precipitants and turbidity should apply at any locations below SW3. To meet the numeric targets, there must be at least three consecutive years where target values are met during late winter/early spring low flow, late summer/early fall low flow, and peak or near peak late spring/early summer runoff. All other targets further discussed below need only be measured and confirmed once in conjunction with meeting numeric levels.

Iron has an additional target of no visible streambed deposits of fine material resulting from human caused conditions, and there is an additional target associated with aluminum whereby there can be no visible turbidity in the stream due to aluminum precipitates. Both of these targets apply at low flow conditions in Fisher Creek when the problems have been noted.

Copper and lead both have additional targets based on stream sediment toxicity that applies to both streams. Sediment toxicity must be measured during low flow late autumn or early spring conditions to capture impacts from runoff and associated metals depositions.

As an additional measure of overall beneficial use attainment, a target is set for macroinvertebrate and periphyton communities being at 75% or greater in comparison to reference stream conditions based on established protocols for evaluating metals and pH impairment conditions.

For pH, a range of 6.0 to 9.0 is used. This is based on the assumption that being able to meet numeric standards for metals would include a reduction in acid drainage to the point where pH would fall within this range. Satisfying metal and pH targets is expected to help correct conditions associated with objectionable streambed deposits and turbidity associated with precipitation of metals.

3.3.1.2 Metals and pH TMDLs

Tables 3-6, 3-7, and 3-8 provide TMDL values for metals and pH based on mean values from low and high flow periods which best represent water quality extremes for Fisher Creek (sample locations SW3 and SW4) and the Clarks Fork River (sample location SW6). These TMDLs are calculated as examples of typical lower and higher flow conditions, since the actual TMDL will always be dependent on specific flow conditions as defined by the following equation (also reference Appendix A of this document):

<u>Total Maximum Load in lb/day</u>
(X ug/l) (Y ft^3/sec) (0.00534) = (X)(Y)(0.00534) lb/day

where:
X = the applicable water quality numeric standard (target) in ug/l with hardness adjustments
where applicable (see above discussion on targets);
Y = streamflow in cubic feet per second;
(0.00534) = conversion factor

The above equation addresses all seasonal flow variations, and the examples in Tables 3-6 through 3-8 further evaluate seasonality by addressing differences associated with low and high flow conditions of hardness and pollutant levels.

Some additional notes concerning the TMDLs in Tables 3.6 through 3.8 are discussed below:

The TMDL for aluminum is based on a total recoverable concentration of 200 ug/l that is thought to represent a condition where there is no longer excess aluminum available for precipitation and resulting turbidity problems. It is only applied during low flow conditions when the turbidity concerns due to aluminum precipitation have been noted. If turbidity can be avoided at total recoverable aluminum concentrations higher than the 200 ug/l, then that is acceptable since meeting the target is the ultimate goal. This

TMDL will, therefore, follow a phased (adaptive management) approach since it is possible to meet the target at higher levels of aluminum.

For iron, the TMDL in Fisher Creek based on the 300 ug/l drinking water/domestic use support condition is expected to satisfy the additional target of no visible streambed deposits associated with fine materials from human causes.

Iron values are used as a surrogate for the pH TMDL for Fisher Creek. Acid drainage, which leads to low pH values and elevated metal concentrations in ground and surface waters, results from oxidation and leaching of metals from sulfide-bearing rocks when exposed to air and water. Because of the linkage between metals loading and acidic drainage, it is assumed that restoration activities undertaken to address high metal loads from mining impacts will also address conditions leading to low pH values from these same mining impacts. Since pyrite (FeS_2) is the most commonly occurring mineral that can produce acidic drainage, then the TMDL for iron is also used as a surrogate TMDL for pH in Fisher Creek. Unfortunately, this approach is only supported partially by results from Kimball et al. (1999). For example, pH averages about 4 where levels of filtered (dissolved) and total iron are all below 235 ug/l, although these iron values do go up above 45,700 ug/l in association with a subsequent pH drop to 3.1 further downstream below the Glengary Adit. Upstream of the Glengary Adit where iron values are relatively low, filtered and total copper values are elevated at or above 570 ug/l. For this reason, copper values are also used as a surrogate TMDL for pH, meaning that it is assumed that both the copper and iron TMDLs will need to be satisfied to meet the pH targets in Tables 3-6 through 3-8. For example, the mean low flow iron TMDL of 0.51 lb/day at SW3, and the mean low flow copper TMDL of 0.007 lb/day at SW3 represent loading conditions whereby pH values are expected to comply with Montana Water Quality Standards.

Meeting the copper and lead TMDLs associated with the numeric water quality targets is expected to satisfy the sediment toxicity targets for both streams. As metal loading is reduced to TMDL levels, the existing fine sediments with metals contamination will likely flush through the system at high flows as they have probably been doing over the years, the difference being that they will start being replaced by fewer and cleaner fine sediment deposits.

Meeting all of the metals and pH TMDLs is expected to result in meeting the target associated with macroinvertebrate and periphyton communities being at 75% or greater in comparison to a reference stream.

Tables 3-6 through 3-8 also provide the percent total load reduction needed to meet the daily load associated with the Table 3-5 targets. These calculations were made based on existing concentrations and target concentrations. The data used for these calculations were obtained from the database on the Maxim website using sampling events where metals concentrations and corresponding stream flow data were available. Typically only a maximum of one representative high flow and one representative low flow set of data per year, where available, were used. Tables D-3 - through D-5 in Appendix D provide a summary of the data used for these tables.

For Fisher Creek, note that copper requires the greatest percent reduction in total load at greater than 99% for low and high flow conditions at SW3 and 96% at low and high flow conditions at SW4. Iron, manganese, cadmium, aluminum, zinc and lead also require very high percent load reductions of greater than 50% under low and/or high flow conditions, particularly at upstream sample location SW3. Note that many metals have only occasional detections above the target levels during low and/or high flow conditions, particularly at the more downstream sample location SW4, making the calculation of percent reductions based on mean (average) values difficult.

For the Clarks Fork River, copper still requires the greatest percent reduction in total load at 63% for the low flow condition and 88% for the high flow condition. No other metal has consistent detections above target values, making the calculation of percent reductions based on mean (average) values difficult. As previously discussed, there tend to be more detections above target levels at higher versus lower flows for most metals. This tendency toward high flow problems may be partly due to loading at low flow conditions and the subsequent re-suspension of precipitants from the streambed during these higher flows.

It is important to note that a given decrease in metal loading at an upstream location does not always directly result in the same loading decrease downstream, particularly during lower flows since chemical reactions associated with changing pH and related metal solubility can determine downstream concentrations. Nevertheless, any load reductions at low flow can significantly contribute to overall yearly loading reductions since there would be a significant reduction in the total amount of precipitated metals that could be re-suspended and transported downstream at higher flows.

3.3.1.3 Performance Based Load Allocation Approach for Metals and pH

A performance based allocation approach is used for metals and pH load allocations. This approach relies on detailed plans and practices that will be developed and applied to all significant mining sources impacting Fisher Creek and the Clarks Fork River. The *Petition Report* (Stanley, 1999) and the *Final Overall Project Work Plan for the New World Mining District Response and Restoration Project* (Maxim, 1999) provide details concerning the overall restoration strategy for District and some non-District property within the Cooke City Planning Area. The *Petition Report* specifically includes schedules and detailed site descriptions and anticipated restoration activities. The *Final Work Plan* further describes the process whereby potential pollutant sources (e.g. mine dumps, adits, etc.) are evaluated and restoration approaches are analyzed in detail and undergo stakeholder review and comment prior to selection of a final restoration approach for each location of concern. The information is then documented in an annual work plan, which may address one or more locations where restoration is planned over the coming year. This process continues every year with the goal of achieving cleanup by 2014 as required by the Temporary Water Quality Standards. *The New World Mining District Response and Restoration Project: Project Summary, 2001*(Maxim, 2001b) also describes the restoration planning and implementation process for the District.

Table 3-5. Metals and pH Water Quality Restoration Targets for Fisher Creek and the Clarks Fork River

Stream(s)	Pollutant	Target(s)	Limiting Beneficial Use
Fisher Creek and Clarks Fork River	Copper[1]	2.8 ug/l (high flow) 4.2 ug/l (low flow) sediment concentrations at non-toxic levels	Aquatic Life (chronic) Aquatic Life (chronic) Aquatic Life
Fisher Creek and Clarks Fork River	Cadmium[1]	0.10 ug/l (high flow) 0.14 ug/l (low flow)	Aquatic Life (chronic) Aquatic Life (chronic)
Fisher Creek and Clarks Fork River	Lead[1]	0.54 ug/l (high flow) 0.99 ug/l (low flow) sediment concentrations at non-toxic levels	Aquatic Life (chronic) Aquatic Life (chronic) Aquatic Life
Fisher Creek and Clarks Fork River	Zinc[1]	37 ug/l (high flow) 55 ug/l (low flow)	Aquatic Life (acute & chronic) Aquatic Life (acute & chronic)
Fisher Creek	Iron	300 ug/l no visible streambed deposits associated with controllable human causes	Drinking Water (domestic use) Aquatic Life/Aesthetics
Fisher Creek	Manganese	50 ug/l	Drinking Water (domestic use)
Fisher Creek	Aluminum	- 87 ug/l (dissolved aluminum in pH range of 6.5 to 9.0; outside of this range there is no applicable dissolved aluminum target) - no precipitants causing visible turbidity at low flow conditions	Aquatic Life (chronic) Aquatic Life/Aesthetics
Fisher Creek and Clarks Fork River	Silver[1]	0.37 ug/l (high flow) 0.84 ug/l (low flow)	Aquatic Life (acute) Aquatic Life (acute)
Fisher Creek and Clarks Fork River	PH	6.0 to 9.0	Aquatic Life
Fisher Creek & Clarks Fork River	Metals & pH	macroinvertebrate and periphyton communities at 75% or greater of reference stream conditions	Aquatic Life

1 All targets for this pollutant are estimated based on predicted hardness values after completion of restoration activities, actual values will be determined by hardness as defined in Appendix A

Table 3-6. Fisher Creek TMDL and Load Reduction Examples for Metals and pH at Typical High and Low Flow Conditions at SW3

Pollutant	Primary Target (ug/l)	Mean Low Flow (0.32 cfs) TMDL (lb/day)	Mean High Flow (9.4 cfs) TMDL (lb/day)	% Total Load Reduction Needed to Meet TMDLs and Targets
Copper	4.2 (low flow) 2.8 (high flow)	0.007	0.14	>99% (low flow); >99% (high flow)
Cadmium	0.14 (low flow) 0.10 (high flow)	0.0002	0.005	87% (low flow); 50% (high flow)
Lead	0.99 (low flow) 0.54 (high flow)	0.0017	0.027	86% (low flow); 89% (high flow)
Zinc	55 (low flow) 37 (high flow)	0.094	1.86	69% (low flow); 24% (high flow)
Iron	Prevent objectionable streambed deposits (low flow) 300 ug/l (all flows)	0.51	15	96% (low flow); 92% (high flow)
Manganese	50 (all flows)	0.085	2.51	96% (low flow); 79% (high flow)
Aluminum	87 (dissolved, all flows) [1] no precipitants causing visible turbidity at low flow conditions	0.15 (dissolved) 0.34 (total recoverable; based on 200 ug/l concentration goal)	0.40 (dissolved)	98% (dissolved, low flow); 95% (dissolved high flow); 95% (total recoverable, low flow)
Silver	0.84 (low flow) 0.37 (high flow)	0.0014	0.018	--% (low flow) [2]; --% (high flow) [2]
pH	6.0 to 9.0 (all flows)	0.51 lb/day iron load 0.007 lb/day copper load (surrogate TMDLs)	15 lb/day iron load 0.14 lb/day copper load (surrogate TMDLs)	96% (iron, low flow); 92% (iron, high flow); >99% (copper, low flow); >99% (copper, high flow)

Notes:
1 Target and TMDLs only apply if pH is in the range of 6.0 to 9.0
2 The limited number of detections makes it difficult to calculate a % reduction

Table 3-7. Fisher Creek TMDL and Load Reduction Examples for Metals and pH at Typical High and Low Flow Conditions at SW4

Pollutant	Primary Target (ug/l)	Mean Low Flow (1.5 cfs) TMDL (lb/day)	Mean High Flow (73 cfs) TMDL (lb/day)	% Total Load Reduction Needed to Meet TMDLs and Targets
Copper	4.2 (low flow) 2.8 (high flow)	0.034	1.1	96% (low flow); 96% (high flow)
Cadmium	0.14 (low flow) 0.10 (high flow)	0.001	0.039	52% (low flow); --% (high flow) [2]
Lead	0.99 (low flow) 0.54 (high flow)	0.008	0.21	0% (low flow) [3]; 85% (high flow)
Zinc	55 (low flow) 37 (high flow)	0.44	14.4	--% (low flow) [4]; --% (high flow) [5]
Iron	Prevent objectionable streambed deposits (low flow) 300 ug/l (all flows)	2.4	117	96% (low flow); 64% (high flow)
Manganese	50 (all flows)	0.40	19.5	58% (low flow); --% (high flow) [5]
Aluminum	87 (all flows) [1] no precipitants causing visible turbidity at low flow conditions	0.70 (dissolved) (total recoverable; based on 200 ug/l concentration goal)	3.12 (dissolved)	--% (dissolved, low flow)[5]; --% (dissolved, high flow)[5]; 26% (total recoverable, low flow)
Silver	0.84 (low flow) 0.37 (high flow)	0.007	0.14	--% (low flow) [2]; --% (high flow) [2]
pH	6.0 to 9.0 (all flows)	2.4 lb/day iron load 0.034 lb/day copper load (surrogate TMDLs)	117 lb/day iron load 1.1 lb/day copper load (surrogate TMDLs)	96% (iron, low flow); 64% (iron, high flow) 96% (copper, low flow) 96% (copper, high flow)

Notes:
1 Target and TMDL only apply if pH is in the range of 6.0 to 9.0
2 The limited number of detections makes it difficult to calculate a % reduction
3 A lack of detections at low flow imply that lead is only a higher flow concern
4 Although the average reduction in load computes to 0% for zinc at low flow, the fact that some values exceed the target is sufficient to require TMDL development
5 The limited number or lack of values at levels above the example target or surrogate value for TMDL development makes it difficult to calculate a % reduction

Table 3-8. Clarks Fork River TMDL and Load Reduction Examples for Metals at Typical High and Low Flow Conditions at SW6)

Pollutant	Primary Target (ug/l)	Mean Low Flow (3.7 cfs) TMDL (lb/day)	Mean High Flow (173 cfs) TMDL (lb/day)	% Total Load Reduction Needed to Meet TMDL
Copper	4.2 (low flow) 2.8 (high flow)	0.08	2.6	63% (low flow); 88% (high flow)
Cadmium	0.14 (low flow) [1] 0.10 (high flow)	0.003	0.09	--% (low flow)[1]; --% (high flow)[3]
Lead	0.99 (low flow) [2] 0.54 (high flow) [2]	0.019	0.50	--% (low flow) [3]; --% (high flow) [3]
Zinc	55 (low flow) [1] 37 (high flow)	1.1	34	--% (low flow)[1]; --% (high flow)[3]
Silver	0.84 (low flow) 0.37 (high flow)	0.02	0.34	--% (low flow)[1]; --% (high flow)[1]
pH	6.0 to 9.0 (all flows)	6 lb/day iron load 0.08 lb/day copper load (surrogate TMDLs)	277 lb/day iron load 2.6 lb/day copper load (surrogate TMDLs)	--% (iron, low flow) [3]; --% (iron, high flow) [3] 63% (copper, low flow) 88% (copper, high flow)

Notes:

1 Cadmium, and zinc are not considered low flow concerns, although TMDL examples are provided anyway.

2 These targets represent conditions where sediment toxicity problems can be avoided

3 The limited number or lack of detections above the target or TMDL value of concern makes it difficult to calculate a % reduction

Overall, a total of 18 source areas have been identified in the District. The source areas that involve Fisher Creek and the Clarks Fork River, including a summary of the general activities that are planned as well as some potential restoration actions, are discussed below (reference Figures 3-1 and 3-2).

- District Property — Includes all property or interest relinquished by CBMI. Activities will include: surveying the District for additional sources; characterize chemistry, thickness, and quantity of sources (waste rock dumps or tailings) through borehole drilling; identify and investigate potential waste rock disposal sites; identify potential borrow sources; survey cultural resources; and monitor surface and ground water resources. Restoration activities can include activities such as removal to the repository site and/or drainage control.

- Glengary Adit/Shafts — Complete the hydrologic evaluation of the mine workings; determine control options for reducing adit inflows; rehabilitate adit as necessary to evaluate source control measures; characterize waste rock dumps; evaluate source control and water treatment options; install and maintain stormwater sediment control; insure that all capped boreholes are secure; monitor and maintain revegetated areas; and monitor water diversion system and erosion control measures.

- Spalding Tunnels — Includes the underground workings north of the Como Basin (also know as the upper Glengary workings) and associated waste rock material. Activities will include: completion of the hydrologic evaluation of the mine workings; evaluate source control options, water treatment and adit closure options; rehabilitate adits as necessary to evaluate source control measures; characterize waste rock dumps; install and maintain stormwater sediment control; monitor and maintain revegetated areas; and monitor water diversion system and erosion control measures.

- Como Basin — Includes the disturbed areas and waste rock material in and around the topographic depression at the headwaters of Fisher Creek. Likely activities include: insuring that all underground workings are identified; evaluate source control measures and water treatment options including evaluating installation of caps over certain areas and shafts; install and maintain stormwater sediment control; monitor and maintain revegetated areas; insure that all capped boreholes are secure; and monitor water diversion system and erosion control measures.

•Gold Dust Adit	Includes the underground workings and associated waste rock material and surface disturbances comprising the Gold Dust mine. Activities are likely to include the following: complete the hydrologic evaluation of the mine workings; insuring that all underground workings are identified; rehabilitate adits if necessary to evaluate source control options; evaluate source control, water treatment and adit closure options; characterize waste rock dumps; install and maintain stormwater sediment control; install erosion control measures; monitor and maintain revegetated areas; and monitor water diversion system and erosion control measures.
•New Chicago Mill Site	Includes the surface disturbances and mill waste in and around the historic White smelter site near the Fisher Creek road crossing. Disturbances and mine waste at this site will be characterized to determine necessary removal actions.
•Fisher Creek	Encompasses the general area defined by the Fisher Creek drainage basin and includes miscellaneous waste rock piles and prospects. Disturbances and mine waste in this source area will be characterized to determine necessary removal actions.
•East Henderson Mountain	Encompasses the general area of the east and northeast slopes of Henderson Mountain and includes miscellaneous adits, shafts, waste rock piles, and prospects. Disturbances and mine waste in this source area will be characterized to determine necessary removal actions.
•Sheep Mountain - FCT-12	Encompasses the west and south west slopes of Sheep Mountain including the Tredennic adit and waste rock piles and miscellaneous short adits and prospect pits. Disturbances and mine waste in this source area will be characterized to determine necessary removal actions.
•"Other" Reeb Property	Includes other property owned or controlled by Margrete Reeb including the silver claims adit, prospects and waste rock above Goose Creek, miscellaneous short adits and waste rock piles on Henderson Mountain. Disturbances and mine waste in this source area will be characterized to determine necessary removal actions.
•Road Systems	Roads within or accessing District Property will be evaluated to determine which roads should be closed and which roads will be used during removal actions. In addition, best management practices typically associated with drainage

improvements and other erosion controls will likely be pursued on roads and trails where closure is not consistent with overall forest recreational goals.

- Wetland, Stream Bank — Includes contaminated material deposited along stream thalwegs and Transported Sources and bog material with elevated metal concentrations. Disturbances in this source area will be characterized to determine necessary removal actions.

Figure 3-1 shows the locations of most or all of the mine disturbances in the Fisher Creek and Clarks Fork River drainages. These mine disturbances are all addressed under one or more of the above categories. For example, the Homestake Mine Dump and Pit may not be specifically addressed above, but it does fall under either the overall category of District Property or Fisher Creek, and will therefore be addressed as discussed above.

Note that the Chicago Mill Site is specifically addressed as a separate source category in the above list, even though is located predominately on private, non-District property as shown by Figure 3-1. The Scotch Bonnet Dumps represent another similar situation. Characterization work completed thus far indicates that these are probably not significant sources of metals contamination to surface waters (personal discussion with Forest Service Project personnel).

Figure 3-2 shows the road network that is discussed above under the Road Systems category. Erosion control efforts focused on the mine disturbances identified in Figure 3-1, as well as some of the roads and trails in the vicinity of the mine disturbances, will further reduce metal loading to both streams.

Some of the potential sources of metals to Fisher Creek and the Clark Fork River include erosion from roads and other disturbed areas and sources located on non-District Property. The *Consent Decree and Settlement Agreement* (United States District Court for the District of Montana Billings Division, 1998) provides further restoration guidance for all sources in the Daisy, Fisher, and Miller Creek drainages as well as sources within the whole New World Mining District. Per the Natural Resources Working Group for the New World Mining District Response and Restoration Project, there are two categories of work that can be done (Natural Resources Working Group Meeting Summary, June 19, 2002). These are:

- Category A - hazardous substances (i.e. mine waste) that are on District Property and non-hazardous substances (e.g. principally sediment from roads) on District Property. Work can be done prior to the receipt of the Notice of Completion from the United States Government.

- Category B – after receipt of the Notice of Completion, work can address other hazardous and non-hazardous sources on non-District Property.

It is assumed that all significant metals and pH related sources, other than natural background sources, to Fisher Creek and the Stillwater River are “Category A” or

"Category B" type sources that will be addressed as part of the New World Restoration efforts. The "Category A" sources, which are located on District Property (reference Figures 3-1 and 3-2), will be addressed as part of the consent decree requirements for a notice of completion. Any significant "Category B" sources located on either private or Forest Service lands will be addressed within the budget constraints of the New World restoration project after issuance of the notice of completion. If there is not adequate budget, then a load will be allocated to each significant source to reflect loading conditions needed to ensure that water quality targets would be met once each new allocation is satisfied.

It is assumed that all New World restoration activities will be implemented in a manner that represents all reasonable land, soil, and water conservation practices and therefore will satisfy the intent of Montana's Water Quality Standards for metals and pH. This includes appropriate implementation monitoring and maintenance of restoration efforts to ensure success.

As previously discussed, once metals loading approaches TMDL levels the existing fine sediments with metals contamination will likely flush through the system at high flows as they have probably been doing over the years, the difference being that they will start being replaced by fewer and cleaner fine sediment deposits. Note that the restoration work for the "Wetland, Stream Bank" source area is intended to verify this assumption and address significantly high levels of metals contaminants in stream sediments and floodplain material if they did not flush through the system as anticipated.

Section 5.0 in this document summarizes some additional components of the overall restoration strategy for Fisher Creek and the Clarks Fork River.

3.3.2 Sediment Restoration Targets, TMDLs and Allocations

3.3.2.1 Sediment Targets

For sediment, target development is based on criteria currently found *within Appendix A of Water Quality Assessment Process and Methods* (MDEQ, 2000). The Appendix A document provides guidelines for making beneficial use support determinations, and essentially provides a process for interpreting narrative water quality standards, such as those that exist for sediment, under certain conditions of data availability.

The are two water quality restoration targets for sediment in Fisher Creek, both of which are presented below:

- Periphyton and macroinvertebrate biota at 75% of reference condition based on established protocols for evaluating sediment impairment conditions

AND

- The habitat conditions must represent 75% of the reference condition by allowing no greater than a 25% average increase above reference condition percent fines data for all sizes less than D_{50}.

The first target is based on biological data since ideally this would best represent aquatic life beneficial use support. The second target is developed as method to directly measure sediment impacts on habitat conditions relative to a reference stream. Meeting this habitat condition is assumed to support biota at a 75% level of reference conditions from a sediment impact perspective. The sizes less than D_{50} are chosen to ensure that particle sizes generally associated with aquatic life impacts, such as 6.35 mm and smaller, are the primary focus.

At this time, a reference stream condition and recent pebble count data are not available to provide comparisons as was done for Daisy Creek and the Stillwater River. Because percent fines curves can vary from time to time at the same locations, any comparisons to reference conditions curves must be made using measurements from the same day for each water body, including the reference stream. Measurements to evaluate status toward meeting the sediment target should be taken during the lower flow summer or fall season after spring runoff conditions. A similar approach in comparing biota between Fisher Creek to reference stream conditions also applies. At a minimum, the identification of a reference stream will be necessary as restoration efforts progress toward completion (i.e. in about 5 or more years) in order to evaluate overall progress and determine whether or not the target conditions will be satisfied.

Possible confounding effects of potentially long term elevated metal concentrations in the water column and in sediments of Fisher Creek may make it difficult to meet the biota target due to difficulty in finding a similarly impacted reference stream. For this reason, the sediment targets will be evaluated at least every five years for suitability and may be modified based on identification of a more suitable reference stream and/or identification of a better indicator of habitat conditions needed to support aquatic life. The sediment targets could also be modified to represent anticipated conditions associated with the implementation of sediment control and mine restoration activities in the Fisher Creek drainage area in a manner that represents the application of all reasonable land, soil and water conservation measures.

3.3.2.2 Sediment TMDLs and Load Allocations

As previously discussed under Source Characterization (Section 3.2.3), the current modeled annual percent sediment yield above natural background for Fisher Creek has been calculated at 34%, which amounts to 13 tons per year (tons/yr) of sediment above and beyond the natural background of load of 38 tons/yr. Based on expected erosion control efforts associated with mine disturbances, in addition to road improvements, it is envisioned that the modeled annual percent greater than natural background loading to Fisher Creek will be reduced from 34% to 25% or less (discussions with Mark Story, USFS). This would mean that the modeled 13 tons/yr of sediment from roads and mining activities would be reduced to 9.5 tons/yr or less. This 9.5 tons per year load represents a yearly load allocation for the combined categories roads and mine disturbances in the Fisher Creek drainage. The sediment load of 9.5 tons/yr above natural background plus the natural background load of 38 tons/yr equals 47.5 tons/yr. This modeled 47.5 tons/yr represents the total maximum yearly load and represents a surrogate TMDL for Fisher

Creek. It is assumed that this sediment load, and associated reduction to meet the load, will result in conditions that will meet the sediment targets.

Table 3-9 provides a summary of the load allocations and associated percent reductions for the major sediment load categories for Fisher Creek. Note that a performance based approach is not used for sediment load allocations since information on load contributions from specific sources is available. Instead, the Sediment load allocations are based on anticipated load reductions associated with the combined categories of roads and mine disturbances, as shown in Table 3-9, with most reductions anticipated from road restoration efforts (discussion with Mark Story, USFS).

It is important to note that the actual annual sediment variation can be an order of magnitude greater due to climatic variability, whereas the allocation and TMDL are based on modeled sediment yields assuming average annual precipitation.

Table 3-9. Modeled Sediment Load Allocations for Fisher Creek

Source Category	Existing Load (tons/yr)	Load Allocation (tons/yr)	% Reduction in Load by Source Category
Natural Background	**38**	**38**	**0%**
Roads & Mine Disturbances	**13**	**9.5**	**27%**

Because there is uncertainty associated with the assumption that the Table 3-9 load allocations will result in meeting one or more sediment targets, an adaptive management or phased approach will be pursued. As restoration efforts continue and reductions in sediment yield are achieved, sediment measurements will be taken to evaluate progress toward meeting targets. If it looks like greater reductions in sediment loading are needed, then a new TMDL and new load allocations will be developed in recognition of the need to further reduce sediment yield in the Fisher Creek drainage. Any modifications to the sediment targets, as discussed above under Section 3.3.2.1, will also be incorporated into this adaptive management approach.

3.4 Metals Impairment for the Clarks Fork of the Yellowstone in Wyoming

The Clarks Fork River across the border from Montana is also identified as not supporting Wyoming Water Quality Standards for copper, silver, and cadmium. The Wyoming standards for these three metals are based on dissolved versus total recoverable concentrations (Wyoming Water Quality Rules and Regulations, 2001). Table 3-10 shows the applicable Montana water quality standards at the border on the Montana side, and the applicable Wyoming water quality standards at the border on the Wyoming side. These standards are all computed using a hardness of 25 mg/l $CaCO_3$, which is an appropriately conservative value to use for this river. Note that the levels are similar. Where Montana numbers are higher, they are still likely to be more protective since total recoverable levels are often higher than dissolved levels. In other words, if the total recoverable metal concentration in a stream was 2.8 ug/l, then the dissolved portion or concentration would be less than 2.7 ug/l based on the trend from numerous sample results for the Cooke City TMDL Planning Area.

Table 3-10. Comparison of Montana and Wyoming Standards

Metal	Aquatic Life Support Criteria	Montana Total Recoverable Metal Standard (ug/l)	Wyoming Dissolved Metal Standard (ug/l)
Copper	Chronic	2.8	2.7
Copper	Acute	3.8	3.7
Cadmium	Chronic	0.10[2]	0.80
Cadmium	Acute	0.52[2]	0.95
Silver[1]	Acute	0.37	0.32

Notes:
1. Silver does not have a chronic aquatic life support standard
2. Montana cadmium values reflect new EPA determinations for aquatic life support

There is a USGS station (#06205450) located on the Clarks Fork in Wyoming near the Montana Wyoming border. Below is a summary of dissolved copper, cadmium, and silver results for sample information collected between 1990 and 1999.

Dissolved Copper: Out of 36 samples, 11 were below a 1 ug/l detection limit. All detections were between 1 and 8 ug/l, with higher values tending to occur with some of the older data. A total of 10 detections exceeded Wyoming's chronic aquatic life standard, and three exceeded the acute aquatic life standard. There is an apparent trend of higher values during higher flow events for all data collected from 1992 through 1999.

Dissolved Cadmium: Out of 36 samples, 27 were below a 1 ug/l detection limit, and 3 were below an 8 ug/l detection limit. There were six detections ranging from 1 to 3 ug/l, all of which exceed the Wyoming aquatic life support standards associated with both chronic and acute conditions. The highest flow events had detections, but detections also occurred during lower flow periods.

Dissolved Silver: Out of 36 samples, 27 were below a 1 ug/l detection limit, and 3 were below a 4 ug/l detection limit. There were six detections ranging from 1 to 2 ug/l, all of which exceed the Wyoming aquatic life support standard associated with acute conditions. It is difficult to identify flow related trends. The past 17 samples, which include all data between 1996 and 1999, are below detection.

Between Fisher Creek and the Montana-Wyoming border (border), the Broadwater River enters the Clarks Fork and greatly increases the flow (Figure E-2). For example, on 9/22/93 the Broadwater River at sample location was flowing at 23.5 cfs, whereas the Clarks Fork River at SW6, which is upstream of the Broadwater River, was flowing at 4.2 cfs. The dissolved copper concentration in the Clarks Fork was at 13 ug/l (0.29 lb/day), and was less than the detection level of 1 ug/l in the Broadwater River. Two days later, the flow in Wyoming at the USGS station was measured at 26 cfs with a dissolved copper concentration of 2 ug/l. This equates to a load rate of 0.28 ug/l, which is nearly identical to the 0.29 lb/day load at SW6. Unfortunately, this appears to be the only time frame where such loading comparisons can be calculated.

The Maxim database (Maxim, 2001a) does provide limited sample results (7) for the Broadwater River at location BW-1 for the 1990 through 1993 time period. Hardness values are typically below 10 mg/l $CaCO_3$. The data indicates total recoverable copper is at levels (up to 10 ug/l) that may be of concern from a Montana beneficial use support perspective. The 3 available dissolved copper results are all below 1 ug/l. All 7 total recoverable cadmium results are below 0.1 ug/l except for one at 0.7 ug/l, which also indicates an aquatic life concern. The 3 available dissolved cadmium results are all below detection. All 7 total recoverable silver results are below detection, except for one at 1.2 ug/l, which again indicates an aquatic life concern. Of the 2 available dissolved silver values, two are below detection, and one is at 0.9 ug/l, which by itself is of concern from a Wyoming standard perspective given that the Broadwater is most of the flow for the Clarks Fork River just below the border.

Potential sources of these metals from mining or other human caused conditions in the Broadwater River drainage are not apparent at this time, and increased loads could be associated with natural background conditions. It appears as though efforts in Montana to reduce loading to the Clarks Fork River by addressing the mine sources and erosion sources identified by Figure 3-1 and 3-2 will primarily address metals concerns in the Clarks Fork River near the border and into Wyoming. Nevertheless, there remains the possibility of occasional elevated levels of some metals associated with controllable sources in the Broadwater drainage.

It appears as though the targets and TMDLs developed for the Clarks Fork River in Montana can also serve as the metals TMDLs and targets for the section of the Clarks Fork River within Wyoming. This would be protective of Wyoming's beneficial uses, satisfy Wyoming water quality standards, and be protective of the National Wild and Scenic River designation for this stream segment. The performance based allocations for Fisher Creek and the Clarks Fork River will likely be sufficient to protect this stream segment within Wyoming. The lack of apparent metals sources in Wyoming further supports this conclusion. Nevertheless, additional analyses will need to be pursued within the Broadwater River drainage to determine whether or not there is a need for additional load allocations and restoration planning for the lower sections of the Clarks Fork River in Montana, the section of the Clarks Fork River in Wyoming, and for the Broadwater River drainage. This effort should include potential source identification and characterization, as well as additional data to better characterize metal loads to the Clarks Fork River from drainages other than Fisher Creek.

SECTION 4.0
MILLER CREEK AND SODA BUTTE CREEK WATER QUALITY RESTORATION

4.1 Impairment Conditions

Miller Creek and Soda Butte Creek are both impacted from elevated metals concentrations. Several reports and data sources identify impacts to beneficial uses as discussed below.

4.1.1 Metals Impairment Conditions

There are several pertinent sources of water quality and sediment chemistry data. Recent surface water and sediment sample results for both water bodies are reported in *The Effects of Metal Mining and Milling on Boundary Waters of Yellowstone National Park* (Nimmo et al 1999) and in the *Final Site Evaluation Report for the McLaren Tailings Site; Cooke City, Montana* (Pioneer, 2001a)). In addition, the Maxim website (Maxim, 2001a) provides significant data for both water bodies.

A tracer injection and synoptic sampling study was performed for Miller Creek during 2000 low flow conditions (discussion with Tom Cleasby, 2001). The final report is still undergoing reviews, but the sampling results have been used to assist in the development of this WQRP. The study includes water quality and sediment chemistry data for Miller Creek as well as many of the seeps and small tributaries feeding into Miller Creek. The USGS also performed a synoptic sampling study for Soda Butte Creek during low flow conditions in 1999. The results and conclusions from this study are included within a final report (Boughton, 2001) that also includes a retrospective analysis of previous research. In addition, the USGS has been collecting samples since 1999 at Gaging Station 06187915 (USGS, 2001), which is located at or very close to sample location SBC4 just upstream of Yellowstone National Park (reference Figure 1-3).

The above referenced information and other reports show that conditions in Miller Creek do not fully support the beneficial uses associated with a B-1 classification and do not comply with applicable B-1 standards for copper, iron, cadmium, lead, manganese, zinc, and possibly aluminum. Copper is the only metal that consistently exceeds the standards, generally during moderate to high flow conditions. All other metals appear to primarily be a high flow problem, with additional concerns associated with elevated copper and lead levels in sediments.

The above referenced information and other reports show that conditions in Soda Butte Creek do not fully support the beneficial uses associated with a B-1 classification and do not comply with applicable standards for copper, iron, manganese, lead and aluminum. Copper sampling results indicate that in addition to water chemistry there are also elevated levels of copper in stream sediments causing negative impacts to aquatic life just downstream of the McLaren Tailings and McLaren Mill Site and sometimes throughout Soda Butte Creek from the McLaren Tailings to Yellowstone National Park.

Tables 4-1 and 4-2 provide summaries of the impairment concerns associated with Miller Creek and Soda Butte Creek respectively. The Table 4-1 metals data for Miller Creek are from samples taken from or near location SW5 (Figure 1-3) at the mouth of Miller Creek. The SW5 monitoring results are consistent with the monitoring results from sample location SW2, located upstream on Miller Creek. SW2 has recently become the favored monitoring site for evaluating Miller Creek water quality in relation to New World Mine restoration work. Part of the justification for moving the sample location was a lack of flow at SW5 during late fall sampling.

The Table 4-2 metals data for Soda Butte Creek are representative of sample results downstream of the McLaren Tailings Area (which includes the McLaren Mill Site area). The information is from samples taken adjacent to or just below the tailings at or near sample location SBC-2, from samples taken just upstream of Yellowstone National Park at or near sample location SBC-4, and from samples taken at locations between SBC2 and SBC4. The sampling results downstream of the McLaren Tailings capture impacts from these tailings as well as impacts from Miller Creek, which enters Soda Butte Creek across from the tailings (Figure 1-3). Sample results for the upper section of Soda Butte Creek above the McLaren Tailings Area all show metal values that support the MDEQ decision to identify this stretch of stream as fully supporting beneficial uses (MDEQ, 2000 303(d) List).

An additional significant threat to Soda Butte Creek exists due to the McLaren Tailings dam and the potential for failure since the tailings dam is located adjacent to Soda Butte Creek where high flows can erode and saturate the dam causing an unacceptable risk of dam failure. Such a failure could cause significant damage to the physical habitat within Soda Butte Creek and release very large amounts of contaminated material that would likely deposit all along Soda Butte Creek and Lamar River valleys within Montana and within Yellowstone National Park.

There are drinking water wells in the Cooke City area where some residents obtain their domestic water from an alluvial system that is interconnected to Soda Butte Creek flows. The retrospective analysis of previous research (Boughton, 2001) provides a summary of previous ground water work and metals sampling. Based on this previous work, metal concentrations in wells are currently below levels of concern in area ground water supplies, presumably due to high levels of dilution in the ground water system and other hydrogeologic factors .

Appendix B provides a descriptive water quality summary for each of the metals of concern as they relate to impairment determinations.

4.1.2 Sediment (Suspended Solids) Impairment Decision

Based on a 1989 evaluation by MDEQ staff, the Montana 1996 303(d) List includes suspended solids as a cause of impairment in the first 5 miles of Soda Butte Creek downstream from the McLaren Tailings repository. The MDEQ water quality specialist responsible for beneficial use determinations in the Yellowstone region has subsequently determined that Soda Butte Creek is not impaired as a result of suspended solids.

Table 4-1. Miller Creek Metals Impairment Summary (Total Recoverable Metals Data from Sample Location SW5)

Pollutant	Sampling Results	Water Quality Standard Concern	Water Quality Standards Reference(s)
Copper	1 - 200 ug/l	- consistently > 4.7 ug/l chronic aquatic life (during high flow)[1] - sometimes > 7.3 ug/l chronic aquatic life (during low flow)[1] - often > 6.6 ug/l acute aquatic life (during high flow)[1] - results in elevated copper levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Iron	< 30 - 3220 ug/l	- consistently > 1000 ug/l chronic aquatic life (during high flow only) - consistently > 300 ug/l domestic/drinking water use (higher flows)	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Manganese	< 10 - 130 ug/l	- consistently > 50 ug/l domestic use (during high flow only)	17.30.623(2)(h)(i) - WQB-7
Aluminum	< 100 - 1800 ug/l (total recoverable)	- lack of corresponding dissolved aluminum data at high flow conditions when total recoverable values are very high leaves open the possibility of a water quality concern at high flow	17.30.623(2)(h)(i) - WQB-7
Zinc	< 10 - 460 ug/l	1 detection > 61 ug/l chronic & acute aquatic life (during high flow)[1] 2 detections > 94 ug/l chronic & acute aquatic life (during low flow)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Cadmium	< 0.1 – 0.4 ug/l	- > 0.15 chronic aquatic life (during very high flow only)[1]	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Lead	< 2 - 22 ug/l limited detections	- sometimes > 1.2 ug/l chronic aquatic life (during high flow)[1] - sometimes > 2.2 ug/l chronic aquatic life (during low flow)[1] - one value > 15 ug/l human health standard - results in elevated lead levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)

Notes:
1. Standards reflect adjustments for water hardness, which varies during lower flow periods (generally late summer or fall) and higher flow periods (generally spring/early summer runoff) in Miller Creek; the lower flow hardness value used for Miller Creek is 75 mg/l as calcium carbonate; and the higher flow hardness value is 45 mg/l as calcium carbonate.

Table 4-2. Soda Butte Creek Metals Impairment Summary

Pollutant	Sampling Results	Water Quality Standard Concern	Water Quality Standards Reference(s)
Copper	< 1- 22 ug/l	- sometimes > 4.7 ug/l chronic aquatic life (during high flow)[1] - sometimes > 7.3 ug/l chronic aquatic life (during low flow)[1] - sometimes > 6.6 ug/l acute aquatic life (during high flow)[1] - results in elevated copper levels in sediment	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(d)
Iron	150 - 6260 ug/l	> 1000 ug/l chronic aquatic life (during high and low flows) - consistently > 300 ug/l domestic/drinking use - consistently forms objectionable streambed deposits (downstream of McLaren Tailings)	17.30.623(2)(h)(i) - WQB-7 17.30.637(1)(a) 17.30.637(1)(d)
Manganese	< 10 - 210 ug/l	> 50 ug/l domestic use	17.30.623(2)(h)(i) - WQB-7
Aluminum	< 1 - 200 ug/l (dissolved)	two values > 87 ug/l chronic aquatic life, indication is that one stream reach is consistently above this value at low flow	17.30.623(2)(h)(i) - WQB-7
Lead	< 1 - 58 ug/l	- sometimes > 1.2 ug/l chronic aquatic life (during high flow)[1] - one value > 30 ug/l acute aquatic life (during high flow)[1] - two values > 15 ug/l human health standard	17.30.623(2)(h)(i) - WQB-7

Notes:
1 Standards reflect adjustments for water hardness, which varies during lower flow period (generally late summer or fall data) and higher flow periods (generally spring/early summer) in Soda Butte Creek; the low flow hardness value used for Soda Butte Creek is 75 mg/l as calcium carbonate; and the higher flow hardness values is 45 mg/l as calcium carbonate.

The supporting documentation for the 1996 listing includes discussions in Mohrman et al. (1988) and a personal observation by the MDEQ reviewer. Mohrman et al. reported heavy sediment load contributions to Soda Butte Creek from tributaries. Mohrman et al. and the reviewer both noted that the McLaren Tailings were a source of sediment to Soda Butte Creek at that time.

Through onsite surveys and discussions with USFS, MDEQ professional staff determined that the relatively steep, erosive tributary watersheds discussed in Mohrman et al. naturally carry extremely heavy sediment loads. In 1989, the EPA used a Superfund emergency response action to renovate the McLaren Tailings impoundment and the adjacent reach of Soda Butte Creek to prevent erosion and possible discharge of tailings during floods (Nimmo, 1999). In August 2001, the MDEQ professional staff inspected the site and did not find significant erosion from the McLaren Tailings repository. MDEQ staff determined that even directly below the McLaren Tailings repository, the naturally high sediment load appears to be the primary factor determining substrate composition and channel morphology.

For the above reasons, suspended solids/sediment is no longer pursued as a cause of impairment and a TMDL is, therefore, not necessary for this pollutant category. It is recognized that sediment loading will probably need to be addressed in some locations throughout the Soda Butte drainage for the purpose of reducing metals loading from areas disturbed by mining or other activities.

4.2 Metals Source Characterization

4.2.1 Source Inventory

Mining related disturbances are the primary source of increased metals loading above natural background conditions in the Miller Creek and Soda Butte drainage areas. These disturbances are associated with historical adits, waste rock and tailings, most of which are shown in Figure 4-1. Mine disturbances within Miller Creek have the potential to increase metal loads to both Miller and Soda Butte Creeks. Note that there are also several mine disturbances not within the Miller Creek drainage, but still within the Soda Butte drainage. The McLaren Tailings, located adjacent to Soda Butte Creek and at least partly within the Soda Butte Creek floodplain, is the most significant of these. There is a long history of site characterization and efforts to mitigate problems associated with the McLaren Tailings, most of which are summarized within the Site Evaluation Report (Pioneer, 2001a) and also by Boughton (2001). Forest, high elevation shrubland, rock, and transitional areas from recent fires cover most of the remaining drainage area (Figure 1-4).

The town of Cooke City is also located along Soda Butte Creek as well as a major highway (Highway 212). Waste disposal from Cooke City is via septic tanks. There do not appear to be significant metals sources from Cooke City or from the nearby highway such as from a historic spill event. The synoptic sample results (Boughton, 2001) indicate a lack of metals inputs from the Cooke City area, at least during low flow. Neither of the impaired water bodies or their tributaries receive point source discharges regulated by a Montana

Pollutant Discharge Elimination System permit, meaning that waste load allocations are not necessary for these water bodies.

Natural background conditions associated with acid rock drainage have been discussed as a potentially significant source of metals in the Daisy and Fisher Creek drainages (Sections 2.2.2 and 3.2.2). The lack of acid drainage conditions and lower overall metals concentrations in the Miller and Soda Butte Creek drainages, when compared to the Daisy and Fisher Creek drainages, indicate that natural background metal concentrations are probably significantly lower for Miller and Soda Butte Creeks.

4.2.2 Metals Source Analysis for Miller Creek

The majority of higher metal concentrations in Miller Creek occur during higher flow periods. At high flows, copper, iron, lead, manganese and aluminum are all significantly higher than during low flows at both SW-2 and SW-5 sample locations. The exact mechanisms driving this increased load are unknown, but it is presumably related to a combination of: the transport of metal contaminated soils eroded from mine disturbance areas, increased ground water flows or mine adit flows with corresponding increases in contaminant transport, the re-suspension of contaminated sediments associated with metals precipitates deposited during lower flows, and/or potential increases in natural background loading.

During lower flows, copper is elevated, typically at levels just below water quality standards, with an occasional value above the chronic aquatic life standard. There are also occasional high values associated with zinc and lead at the SW2 and/or SW5 monitoring sites. Review of the USGS synoptic sampling data, which will soon be available in a published report, identifies some of the small tributaries and general locations where elevated metals loads, particularly relating to copper, are entering Miller Creek during low flow conditions (12/01 discussion with Tom Cleasby, USGS). The results of the USGS synoptic study indicate that metal loading to Miller Creek during low flow was relatively small and had generally minor effects on metal concentrations in Miller Creek. Substantial differences in metal loading from mine-affected areas and areas influenced by local geology could not be readily determined. During the study, total-recoverable concentrations of copper, lead, and zinc in Miller Creek were less than the chronic aquatic-life criteria in all samples with the exception of one lead value. Further attempts can be made to link the loads to specific mine disturbances identified in Figure 4-1 once the synoptic report is published. This will not only provide an indicator of low flow sources of metals, but also provide potential links to sources of elevated loads during higher flow periods, which tend to be the flow periods of primary interest for restoration planning. Additional loading associated with erosion from mining and other disturbance areas must also be recognized as a potential source contribution during the higher flow events. Stream sediment results from the synoptic study can also provide potential links to some of the same copper sources as well as sources of cadmium, lead, and zinc.

A comparison of in-stream copper loads during various flow conditions indicates that most sources are above sample location SW-2, although some of the high flow data (Maxim, 2001a) indicate possible copper and iron sources below SW-2 when SW-2 metal loads are compared to SW5 metal loads.

4.2.3 Metals Source Analysis for Soda Butte Creek

The metals loading to Soda Butte can be divided into several potential source areas (reference Figure 4-1). These include:

1. The Miller Creek drainage,
2. The McLaren Tailings Area which includes the McLaren Mill Site,
3. Soda Butte Upstream (potential sources upstream of the McLaren Tailings Area but not within the Miller Creek drainage);
4. Woody/Republic Creek Drainage (potential sources associated with the Woody Creek and Republic Creek drainage area, often referred to as one or the other in different reports),
5. An unnamed tributary (Unnamed Creek) that enters Soda Butte Creek from the south just upstream from SBC4, and
6. Other Sources and Tributary Drainages: (Cook City, miscellaneous mine and other potential dumps in the vicinity of Cooke City; drainages associated with Sheep Creek and Wyoming Creek, and floodplain deposits to the Soda Butte Creek floodplain from past tailings dam failure and flood events).

The Unnamed Creek is completely in Wyoming, and sample location SBC4 is also in Wyoming just upstream of Yellowstone National Park (YNP) and downstream from Unnamed Creek. Meeting Montana Water Quality Standards at SBC4 is considered relevant since there are portions of Soda Butte Creek just downstream within the YNP that meander between Montana and Wyoming. The assumption is that this segment of Soda Butte Creek must satisfy both Montana and Wyoming standards. Where Montana Standards apply in Yellowstone National Park, Soda Butte Creek is classified as A-1.

The recent USGS synoptic sampling study that was performed in August 1999 (Boughton, 2001) quantifies low flow metal loading along with water quality data all along Soda Butte Creek. Appendix F is an excerpt from this report that provides a discussion on the results and conclusions from this study as well as some of the plots of metal load versus distance downstream. These plots clearly illustrate major loading sources for several metals of concern (iron, manganese, aluminum), and provide useful loading information for all of the above referenced potential source areas and all metals of concern during typical low flow conditions.

Tables 4-3 and 4-4 provide a summary of estimated total load contributions from each potential source area for each metal of concern. Appendix G is a discussion that provides the basis for these estimated load contributions. The primary data sources used for these estimates are the website database (Maxim, 2001a), the USGS synoptic report (Boughton, 2001), Soda Butte Creek copper data from Nimmo et al. (1999), and the 1999 and 2000 sample results from the USGS at their gaging station at SBC4 (USGS, 2001). Note that there is still a significant need for high flow source assessment work.

Table 4-3. Estimated Total Cumulative Load Contributions by Source Area for Soda Butte Creek in the Vicinity of SBC2 (based on total recoverable metals)

Source Area	Low Flow Estimated Cumulative Load Contributions (Percent of Total Load)	High Flow Percent Cumulative Load Contributions (Percent of Total Load)
Miller Creek	Copper: 10 - 25 % Iron: < 10 % Manganese: < 5 % Lead [1] Not Estimated Aluminum [1] Not Estimated	Copper: 50 - 90 % Iron: 35 - 60 % Manganese 50 - 75 % Lead > 50 % Aluminum Not Estimated
McLaren Tailings Area	Copper: 60 - 90 % Iron: 70 - 95 % Manganese: 80 - 95 % Lead [1] Not Estimated Aluminum [1] Not Estimated	Copper: > 5 % Iron: 20 - 40 % Manganese: 20 - 40 % Lead: ?? % Aluminum: Not Estimated
Soda Butte Upstream of McLaren Tailings Area	Copper: < 5 - 10% Iron: < 10% Manganese: < 5% Lead [1] Not Estimated Aluminum [1] Not Estimated	Copper: < 10 % Iron: 10 - 30 % Manganese: < 5 % Lead: < 5 % Aluminum: Not Estimated

Notes:
1 Lead and aluminum have not been identified as low flow problems in this section of Soda Butte Creek, most loading during low flow comes from the McLaren Tailings

Table 4-4. Estimated Total Cumulative Load Contributions by Source Area for Soda Butte Creek in the Vicinity of SBC4 (based on total recoverable metals unless otherwise noted)

Source Area	Low Flow Estimated Load Contributions (Percent of Total Load)	High Flow Estimated Load Contributions (Percent of Total Load)
Miller Creek	Copper: < 5 - 25 % Iron[1]: < 5% Manganese[1,2]: < 5% Lead[2]: Not Estimated Aluminum[1](dissolved): < 5%	Copper: ?? - 90% Iron: 5 - 15% Manganese: 15 - 30% Lead: 25 - 30% Aluminum[3](dissolved): ?? %
McLaren Tailings Area	Copper: ?? - 90 % Iron[1]: 25 - 30 % Manganese[1,2]: 80 - 85 % Lead[2]: Not Estimated Aluminum[1] (dissolved): 5% - 10%	Copper: ?? % Iron: 5 - 10 % Manganese: < 5 % Lead: ?? % Aluminum[3](dissolved): < 5%
Soda Butte Upstream of McLaren Tailings Area	Copper: < 5 - 10 % Iron[1]: < 5% Manganese[1,2]: < 5% Lead[2]: Not Estimated Aluminum[1](dissolved): < 5%	Copper: < 5 % Iron: < 5 - 15 % Manganese: < 5 % Lead: < 5 % Aluminum[3](dissolved): < 5 %
Woody/Republic Creek	Copper: ?? % Iron[1]: 35 - 40 % Manganese[1,2]: 9 % Lead[2]: Not Estimated Aluminum[1](dissolved): 60 - 70%	Copper: ?? % Iron: ?? % Manganese: ?? % Lead: ?? % Aluminum[3](dissolved): ?? %
Unnamed Creek	Copper: ?? % Iron[1]: 30 - 35 % Manganese[1,2]: 5 % Lead[2]: Not Estimated Aluminum[1](dissolved): 20 - 30 %	Copper: ?? % Iron: ?? % Manganese: ?? % Lead: ?? % Aluminum[3](dissolved): ?? %
Other Sources (Cook City, hillside sources, in-stream and floodplain, other tributaries)	Copper: ?? % Iron[1]: < 5% Manganese[1,2]: < 5% Lead[2]: Not Estimated Aluminum[1](dissolved): 5 - 10%	Copper: ?? % Iron: ?? % Manganese: ?? % Lead: ?? % Aluminum[3](dissolved): ?? %

Notes

1 Low flow values for iron, manganese, and aluminum are based primarily on cumulative inflow results from the Appendix H reference (Boughton, 2001), with adjustments to incorporate potential ground water loading associated with the major sources

2 Lead and manganese are generally not considered a low flow beneficial use concern in this section of Soda Butte Creek; manganese load estimates are shown due to good data availability

??% - lacking data to make estimates

4.3 Restoration Targets, TMDLs, and Load Allocations

4.3.1 Metals Restoration Targets

Table 4-5 provides target values for metals based on the applicable standards identified in Tables 4-1 and 4-2. Most metals targets are based on the applicable numeric water quality standard with hardness modifications for copper, cadmium, zinc, and lead. Because it is unknown what the actual hardness value will be under restoration conditions, the Table 4-5 values for copper, cadmium, zinc, and lead represent estimated values at high and low flow conditions as identified in Tables 4-1 and 4-2. The actual targets for these four metals are the water quality standard with applicable hardness adjustments based on actual in-stream hardness values at the time of measurement. Appendix A of this document provides an example of the hardness adjustment equation for chronic aquatic life support standards (reference Montana Water Quality Standards WQB-7 for more information and for the similar equation used for acute aquatic life computations).

All metal targets are based on total recoverable concentrations unless otherwise noted. For aluminum, iron, and manganese, the standard and any applicable targets are not a function of hardness. Where there are multiple numeric standards for protecting different beneficial uses, the lowest value is used to ensure protection of all beneficial uses. If the chronic and acute aquatic life targets are different than each other, then the primary target for TMDL development and restoration planning becomes the chronic aquatic life support standard to provide some margin of safety since the chronic standard is normally based on a 96-hour average

The numeric targets cannot be exceeded at any time. Monitoring locations SW2 or SW5 in Miller Creek and monitoring locations SBC-2, SBSW-102, and SBC-4 in Soda Butte Creek should be used for determining compliance with targets. To meet the numeric targets, there must be at least three consecutive years where target values are met during late winter/early spring low flow, late summer/early fall low flow, and peak or near peak late spring/early summer runoff. All other targets further discussed below need only be measured and confirmed once in conjunction with meeting numeric levels, using the above referenced monitoring locations unless otherwise noted.

Iron has an additional target for Soda Butte Creek of no visible streambed deposits resulting from human caused conditions. This target is applied at low flow conditions just below the McLaren Tailings Area where the problem has been noted. The purpose of this target is to protect the beneficial uses of aquatic life as well as aesthetic values of the stream.

Copper has an additional target based on stream sediment toxicity in both Miller Creek and Soda Butte Creek, and lead has a similar such target for stream sediments in Miller Creek. Sediment toxicity must be measured during low flow autumn or early spring conditions to capture impacts from runoff and associated metals depositions.

As an additional measure of overall beneficial use attainment, a target is set for macroinvertebrate and periphyton communities being at 75% or greater in comparison to reference stream conditions using established protocols for evaluating metals impairment conditions.

4.3.2 Metals TMDLs

Table 4-6 through 4-8 provide example TMDLs for metals based on values from different flow periods which represent water quality variations for Miller Creek (SW5) and Soda Butte Creek **(**SBC2 and at or in the vicinity of SBC4). These TMDLs are calculated as examples of typical lower and higher flow conditions, since the actual TMDL will always be dependent on specific flow conditions as defined by the following equation (also reference Appendix A of this document):

Total Maximum Load in lb/day
(X ug/l) (Y ft^3/sec) (0.00534) = (X)(Y)(0.00534) lb/day

where:
X = the applicable water quality numeric standard (target) in ug/l with hardness adjustments
where applicable (see above discussion on targets);
Y = streamflow in cubic feet per second;
(0.00534) = conversion factor

The above equation addresses all seasonal flow variations, and the examples in Tables 4-6 through 4-8 further evaluate seasonality by addressing differences associated with lower and higher flow conditions of hardness and pollutant levels.

Some additional notes concerning the TMDLs in Tables 4.6 through 4.8 are discussed below:

For iron, the TMDL based on the 300 ug/l drinking water/domestic use support condition will satisfy the additional target of no visible streambed deposits associated with fine materials from human causes.

Meeting the copper TMDLs in Miller Creek and Soda Butte Creek is expected to satisfy the targets associated with sediment toxicity for both water bodies. Likewise, meeting the lead TMDLs in Miller Creek is expected to satisfy the sediment toxicity target for lead in this water body. It is assumed that as metal loading is reduced to TMDL levels, the existing fine sediments with metals contamination will likely flush through the system at high flows as they have probably been doing over the years, the difference being that they will start being replaced by fewer and cleaner fine sediment deposits.

Meeting all of the metals targets is expected to satisfy the target associated with macroinvertebrate and periphyton communities being at 75% or greater in comparison to a reference stream

Tables 4-6 through 4-8 also provide estimates of the percent total load reduction needed to meet the daily load associated with the Table 4-5 targets. These calculations can be made based on existing concentrations and target concentrations. Since low flow conditions in

Miller Creek tend to indicate fairly good support for aquatic life, low flow percent reductions were not calculated for Table 4-6. Also, a lack of high flow data at SBC2 made it difficult to calculate average high flow percent reduction requirements for this location.

The data used for Tables 4-6 through 4-8 were obtained from the Maxim database and several of the references discussed in Section 4.1.1. Typically only one representative high flow and one representative low flow set of data per year, per location, where available, were used. Additional data were used for 1999 and 2000 high flow events in Soda Butte Creek at SBC4 because of the variability in the data and the importance of the information in regards to meeting Montana's water quality standards. Tables D-6 and D-7 in Appendix D provide a summary of the data used for Tables 4-6 through 4-8.

For Miller Creek high flow conditions, copper requires the greatest average percent reduction (93%) in total load, followed closely by lead (86%). High flow average load reductions for iron, cadmium, and manganese range from 42% to 56%. Unfortunately, there is a limited amount of high flow data that seems to represent the apparent peak runoff conditions used for these calculations. The copper and lead values are high primarily due to data from two very high flow events. As flows decrease, metals values are lower (Table D-6), indicating percent load reduction requirements would be lower to satisfy targets during much of the year. Nevertheless, the targets apply throughout the year, and impacts to beneficial uses during typical peak flows must be considered.

Metal concentrations upstream at SW-2, particularly copper, are also very high and comparable to those measured at SW-5 on the same very high flow days. Other flow events are also consistent, with copper levels sometimes slightly higher at SW2 than SW5 during low flows. The low flow concentrations at SW2 indicate the need for an approximate 10% to 20% average reduction in copper loading in order to consistently remain below the aquatic life standard associated with chronic conditions.

For Soda Butte Creek at SBC2, the average percent reductions for iron and manganese at low flow conditions are 82% and 38% respectively. A low flow copper percent reduction is difficult to calculate based on a lack of detections above standards from most data sources. There is also a lack of high flow data at this location to determine average concentrations and average percent reductions for most metals. Dissolved copper results from Nimmo et al. (1999) indicate that copper loads may need to be reduced by as much as 25% or more during low flows and 50% or more during high flows to ensure that water quality levels remain below applicable standards every year at this location.

For Soda Butte Creek at SBC4, the average percent reduction for iron at low flow fall conditions is 13%. Most other metals only had limited or no detections above water quality standards during low flows. Data from Nimmo et al. again indicates a need for some reduction in copper loading during some low flow periods, possibly as much as 25% or more. High flow events indicate fairly large average percent reductions needed, at least during some of the highest flow events, to consistently meet water quality standards: 57% for copper, 88% for iron, 36% for manganese, and 92% for lead (based on data from USGS, 2001 and Maxim, 2001a).

Table 4-5. Metals Water Quality Restoration Targets for Miller Creek and Soda Butte Creek

Stream(s)	Pollutant	Target(s)	Limiting Beneficial Use
Miller Creek & Soda Butte Creek	Copper[1]	4.7 ug/l (high flow) 7.3 ug/l (low flow) sediment concentrations at non-toxic levels	Aquatic Life (chronic) Aquatic Life (chronic) Aquatic Life
Miller Creek	Cadmium[1]	0.15 ug/l (high flow) 0.22 ug/l (low flow)	Aquatic Life (chronic) Aquatic Life (chronic)
Miller Creek & Soda Butte Creek	Lead[1]	1.2 ug/l (high flow) 2.2 ug/l (low flow) sediment concentrations at non-toxic levels (Miller Creek)	Aquatic Life (chronic) Aquatic Life (chronic) Aquatic Life
Miller Creek	Zinc[1]	61 ug/l (high flow) 94 ug/l (low flow)	Aquatic Life (acute & chronic) Aquatic Life (acute & chronic)
Miller Creek & Soda Butte Creek	Iron	1000 ug/l (both streams) 300 ug/l (both streams) no visible streambed deposits associated with controllable human causes below McLaren Tailings in Soda Butte Creek	Aquatic Life Drinking Water (domestic use) Aquatic Life/Aesthetics
Miller Creek & Soda Butte Creek	Manganese	50 ug/l	Drinking Water (domestic use)
Miller Creek	Aluminum	87 ug/l (dissolved)	Aquatic Life
Miller Creek & Soda Butte Creek	Metals	Macroinvertebrate and periphyton communities at 75% or greater of reference stream conditions	Aquatic Life

Notes:
1. All targets for this pollutant are estimated based on predicted hardness values after completion of restoration activities, actual values will be determined by hardness as defined in Appendix A

Table 4-6. Miller Creek TMDL and Load Reduction Examples for Metals at Typical High and Low Flow Conditions at Sample Location SW5

Pollutant	Target (ug/l)	Mean Low Flow (0.5 cfs) TMDL (lb/day)	Mean High Flow (60 cfs) TMDL (lb/day)	% Total Load Reduction Needed to Meet TMDLs and Targets
Copper	7.3 (low flow) 4.7 (high flow)	0.02	1.5	-- % (low flow) [1]; 93% (high flow)
Cadmium	0.22 (low flow) 0.15 (high flow)	0.0006	0.048	-- % (low flow) [1]; 46% (high flow)
Lead	2.2 (low flow) 1.2 (high flow)	0.006	0.38	-- % (low flow)[1]; 86% (high flow)
Zinc	94 (low flow) 61 (high flow)	0.25	20	-- % (low flow) [1]; -- % (high flow) [1]
Iron	300 (all flows)	0.80	96	-- % (low flow) [1]; 87% (high flow)
Manganese	50 (all flows)	0.13	16	-- % (low flow) [1]; 42% (high flow)
Aluminum	87 (all flows; dissolved aluminum only)	0.23	28	-- % (low flow) [1]; -- % (high flow) [2]

Notes:

1 There are either no values or a limited number of values at high enough levels to calculate a percent reduction

2 There is a lack of dissolved aluminum data at high flows to determine whether or not there is a need for a reduction in load

Table 4-7. Soda Butte Creek TMDL and Load Reduction Examples for Metals at Typical High and Low Flow Conditions At or Near Sample Location SBC-2

Metal/Pollutant	Target (ug/l)	Mean Low Flow (0.8 cfs) TMDL (lb/day)	Mean High Flow (40 cfs) TMDL (lb/day)	% Total Load Reduction Needed to Meet TMDLs and Targets
Copper	7.3 (low flow) 4.7 (high flow)	0.03	1.0	-- %(low flow) [1] -- %(high flow) [2]
Iron	300 (all flows)	1.3	64	82 % (low flow) -- % (high flow) [2]
Manganese	50 (all flows)	0.21	11	38 % (low flow) -- % (high flow) [2]
Lead	2.2 (low flow) 1.2 (high flow)	0.009	0.26	-- % (low flow) [1] -- % (high flow) [3]

Notes:
1 A limited number of values above levels of concern makes it difficult to calculate an average % reduction
2 The lack of high flow data makes it difficult to determine a percent reduction
3 A lack of detections at low flow implies that lead may be only a higher flow concern

Table 4-8. Soda Butte Creek TMDL and Load Reduction Examples for Metals at Typical High and Low Flow Conditions At or Near Sample Location SBC-4

Metal/Pollutant	Target (ug/l)	Mean Low Flow (12 cfs) TMDL (lb/day)	Mean High Flow (337 cfs) TMDL (lb/day)	% Total Load Reduction Needed to Meet TMDLs and Targets
Copper	7.3 (low flow) 4.7 (high flow)	0.47	8.4	-- %(low flow) [1] 57 %(high flow)
Iron	300 (all flows)	19	540	13 % (low flow) 88 % (high flow)
Manganese	50 (all flows)	3.2	90	-- % (low flow) [2] 36 % (high flow)
Lead	2.2 (low flow) 1.2 (high flow)	0.14	2.2	-- % (low flow) [3] 92 % (high flow)

Notes:
1 A limited number of values above levels of concern makes it difficult to calculate an average % reduction
2 A lack of detections at low flow implies that manganese is only a higher flow concern at this location
3 A lack of detections at low flow implies that lead may be only a higher flow concern

4.3.3 Load Allocations

The strategy for allocating loads varies between Miller Creek and Soda Butte Creek. The allocations are discussed separately below.

4.3.3.1 Performance Based Load Allocation for Miller Creek

A performance based allocation approach is used for metals load allocations for Miller Creek. This approach relies on detailed plans and practices that will be developed and applied to all significant mining sources on District Property that are impacting Miller Creek. The *Petition Report* (Stanley, 1999) and the *Final Overall Project Work Plan for the New World Mining District Response and Restoration Project* (Maxim, 1999) provide details concerning the overall restoration strategy for District and some non-District property within the Cooke City Planning Area. The *Petition Report* includes schedules and detailed site descriptions and anticipated restoration activities. The *Final Work Plan* further describes the process whereby potential pollutant sources (e.g. mine dumps, adits, etc.) are evaluated and restoration approaches are analyzed in detail and undergo stakeholder review and comment prior to selection of a final restoration approach for each location of concern. The information is then documented in an annual work plan, which may address one or more locations where restoration is planned over the coming year. This process continues every year with the goal of achieving cleanup by 2014 as required by the Temporary Water Quality Standards. *The New World Mining District Response and Restoration Project: Project Summary, 2001* (Maxim, 2001b) also describes the restoration planning and implementation process for the District.

Overall, a total of 18 source areas have been identified in the District. The source areas that involve Miller Creek including a summary of the general activities that are planned as well as some potential restoration actions, are discussed below (reference Figure 4-1).

- District Property — Includes all property or interest relinquished by CBMI. Activities will include: surveying the District for additional sources; characterize chemistry, thickness, and quantity of sources (waste rock dumps or tailings) through borehole drilling; identify and investigate potential waste rock disposal sites; identify potential borrow sources; survey cultural resources; and monitor surface and ground water resources. Restoration activities can include activities such as removal to the repository site and/or drainage control.

- Miller Creek — Comprises the Miller Creek drainage basin including the southwest flank of Henderson Mountain, the southeast flank of Crown Butte and the northeast flanks of Miller Mountain. Disturbances and mine waste in this source area will be characterized to determine necessary removal actions. This also includes efforts to reduce adit inflows or rehabilitate adits as necessary, particularly the adit in the area of the Black Warrior mine.

•Alice E Mine and Mill Site	This site is not on District Property. It includes the mine, mill, and waste rock material on the south side of Henderson Mountain. Assessment of sources present at this site will be done along with assessment of District Property wastes. Cleanup work on this source area will be deferred until cleanup of District Property is complete.
•Road Systems	Roads within or accessing District Property will be evaluated to determine which roads should be closed and which roads will be used during removal actions. In addition, best management practices typically associated with drainage improvements and other erosion controls will likely be pursued on roads and trails where closure is not consistent with overall forest recreational goals.
•Wetland, Stream Bank	Includes contaminated material deposited along stream thalwegs and transported sources and bog material with elevated metal concentrations. Disturbances in this source area will be characterized to determine necessary removal actions.

Figure 4-1 shows the locations of most or all of the mine disturbances in the Miller Creek drainage. These mine disturbances are all addressed under one or more of the above categories. Even though sediment is not identified as a separate pollutant for TMDL development, erosion protection activities associated the Road Systems source area discussed above may provide important reductions in metal loading to Miller Creek. Important areas to address erosion protection would be in areas of mine disturbances and where roads intersect mined or heavily mineralized areas. Figure 4-2 shows the fairly significant road system that exists in the Miller Creek drainage.

Some of the potential sources of metals to Miller Creek include erosion from roads and other disturbed areas and sources located on non-District Property. The *Consent Decree and Settlement Agreement* (United States District Court for the District of Montana Billings Division, 1998) provides further restoration guidance for all sources in the Daisy, Fisher, and Miller Creek drainages as well as sources within the whole New World Mining District. Per the Natural Resources Working Group for the New World Mining District Response and Restoration Project, there are two categories of work that can be done (Natural Resources Working Group Meeting Summary, June 19, 2002). These are:

- Category A - hazardous substances (i.e. mine waste) that are on District Property and non-hazardous substances (e.g. principally sediment from roads) on District Property. Work can be done prior to the receipt of the Notice of Completion from the United States Government.

- Category B – after receipt of the Notice of Completion, work can address other hazardous and non-hazardous sources on non-District Property.

It is assumed that all significant metals and pH related sources, other than natural background sources, to Miller Creek are "Category A" or "Category B" type sources that will be addressed as part of the New World Restoration efforts. The "Category A" sources, which are located on District Property (reference Figures 4-1 and 4-2), will be addressed as part of the consent decree requirements for a notice of completion. Any significant "Category B" sources located on either private or Forest Service lands will be addressed within the budget constraints of the New World restoration project after issuance of the notice of completion. If there is not adequate budget, then a load will be allocated to each significant source to reflect loading conditions needed to ensure that water quality targets would be met once each new allocation is satisfied.

It is assumed that all New World restoration activities will be implemented in a manner that represents all reasonable land, soil, and water conservation practices and therefore will satisfy the intent of Montana's Water Quality Standards for metals. This includes appropriate implementation monitoring and maintenance of restoration efforts to ensure success.

As previously discussed, once metals loading approaches TMDL levels the existing fine sediments with metals contamination will likely flush through the system at high flows as they have probably been doing over the years, the difference being that they will start being replaced by fewer and cleaner fine sediment deposits. Note that the restoration work for the "Wetland, Stream Bank" source area is intended to verify this assumption and address significantly high levels of metals contaminants in stream sediments and floodplain material if they did not flush through the system as anticipated.

Section 5.0 in this document summarizes some additional components of the overall restoration strategy for Miller Creek.

4.3.3.2 Load Allocations for Soda Butte Creek

As discussed in Appendix A, the TMDL can be expressed as the sum of the load allocations plus the sum of the waste load allocations plus a margin of safety. There is not a need for waste load allocations and the margin of safety is addressed via the use of chronic standards under all conditions, via significant monitoring to ensure that targets are obtained, and other criteria and assumptions summarized in Table E-1.

To help ensure protection of beneficial uses in Soda Butte Creek and appropriately address the different sources and flow conditions in this water body, load allocations are developed for the three monitoring locations of SBC2, SBSW102, and SBC4. Load allocations are identified for the following source areas:

1. The Miller Creek drainage,
2. The McLaren Tailings Area which includes the McLaren Mill Site,
3. Sheep Creek Drainage,
4. Wyoming Creek Drainage,
5. Woody Creek Drainage (includes Republic Creek Drainage),
6. The Unnamed Creek Drainage that enters Soda Butte Creek from the south just upstream from SBC4, and

7. Remaining Sources (includes Cook City, miscellaneous mine disturbance locations that are not addressed under any of the other above categories, and floodplain deposits from past tailings dam failure and flood events).

Note that the source areas are organized a little differently from the way they were organized for source assessment purposes. Some of the individual drainages, such as Sheep Creek and Wyoming Creek, are addressed separately since load allocations need to also satisfy water quality standards for these streams. Sources of metals in the upper portion of Soda Butte Creek above the McLaren Tailings Area are grouped within Remaining Sources since this section of stream is already satisfying water quality standards. Any load reductions in this upper section of the drainage can then be counted toward accomplishing overall load reduction requirements for downstream portions of Soda Butte Creek.

The TMDL equations for the three locations of concern, using the TMDL loading capacity equation from Page A-1 in Appendix A, are identified below using copper as an example.

Copper TMDL (SBC2) = **Copper Loading Capacity at SBC2** = (Miller Creek Copper Load Allocations) + (McLaren Tailings Area Copper Load Allocations) + (Copper Load Allocations to Remaining Sources Upstream of SBC2).

Copper TMDL (SBSW102) = **Copper Loading Capacity at SBSW102** = (Copper Loading Capacity at SBC2) + (Woody Creek Copper Load Allocations) + (Copper Load Allocations to Remaining Sources Between SBSW102 and SBC2)

Copper TMDL (SBC4) = **Copper Loading Capacity at SBC4** = (Copper Loading Capacity at SBSW102) + (Sheep Creek Copper Load Allocations) + (Wyoming Creek Copper Load Allocations) (Unnamed Creek Copper Load Allocations) + (Copper Load Allocations to Remaining Sources Between SBC4 and SBSW102)

The above equations apply to each of the other metals of concern at each location. For example, there are five equations at SBC2 to address TMDLs for copper, iron, manganese, lead and aluminum. Water quality standards and WQRP targets can be satisfied by ensuring that the load allocations are equal to, or remain below, the maximum daily load at the location of interest for each metal of interest. The load allocations must be satisfied for both high and low flow conditions to address all seasonal variations and all flow conditions between high and low flows.

Below is a discussion of the source area load allocations followed by a discussion on the estimated load reductions needed by source area for each metal of concern.

4.3.3.2.1 Load Allocations by Source Area

4.3.3.2.1.1 Miller Creek

Miller Creek load allocations are defined in Section 4.3.3.1. These allocations rely on load reductions from pursuing a performance-based approach applied to mining disturbances in the drainage to meet Miller Creek targets and satisfy the Miller Creek TMDLs. Since

Miller Creek and Soda Butte Creek have the same metals targets, the Miller Creek load allocation approach will sufficiently protect Soda Butte Creek.

4.3.3.2.1.2 Woody Creek, Wyoming Creek, and Sheep Creek

For Woody Creek (includes Republic Creek), Sheep Creek, and Wyoming Creek, load allocations are based on TMDLs applied at the mouth of each stream. The TMDLs are based on the same targets as those applied to Soda Butte Creek since these streams are also classified as B-1 in Montana Water Quality Standards (Section 17.30.611). This will ensure that water entering Soda Butte Creek from these major tributaries is at or below the concentration associated with water quality standards and targets for Soda Butte Creek. These TMDLs are determined by the equation presented in Section 4.3.2, using the numeric targets identified for Soda Butte Creek in Table 4-5 multiplied by the flow at any given time. Of course, the water quality standards for copper and lead are also hardness dependent as defined by the equations in Appendix A and WQB-7.

The load allocations to satisfy the TMDL for each metal in each of the three tributaries are the combination of natural background sources and metals loading from mine disturbances located within the tributary drainage. Because natural background sources do not represent a controllable load reduction, any load reductions needed to satisfy each metal load allocation must come from mining related sources in the tributary, assuming such sources exist and can be identified and addressed via reasonable land, soil and water conservation practices. It appears as though some of the tributaries are already meeting some of the metal load allocations under certain flow conditions (Boughton, 2001).

4.3.3.2.1.3 McLaren Tailings Area

The McLaren Tailings Area load allocations for metals are based on meeting concentrations that will avoid toxic conditions and ensure compliance with targets. Similar to the tributary load allocation approach, this can be addressed by ensuring that ground water and seep inflows meet stream target concentrations and therefore satisfy the need to avoid toxic conditions associated with copper, lead and iron. This approach is also necessary to avoid iron precipitates and associated streambed deposits and to avoid a situation where localized toxic conditions limit fish passage in the area. In addition, erosion will need to be controlled to significantly reduce metals loading from this pathway.

The manganese target is associated with drinking water/domestic use and is not associated with toxic conditions. The load allocation for manganese can be based on the goal of keeping the manganese load low enough to ensure the target is met at SBC2, meaning that in-stream mixing can be considered

The allowable load to satisfy the above conditions is allocated to the McLaren Tailings and associated mine disturbances in the immediate vicinity across from the tailings. Any natural background levels of metals in ground water in this area are also part of this allocation, although such levels are probably very low in comparison to other highly mineralized areas in the Cooke City TMDL Planning Area.

Given the high iron loading from the McLaren Tailings Area and the significant threat associated with a tailings dam failure, it is assumed that restoration requirements will result in the removal of these threats and will need to achieve at least a 99% reduction in total load for iron. This will then satisfy the iron load allocation. This 99% reduction is therefore used to help estimate average total load allocation and reductions needs for other source areas throughout Soda Butte Creek. Since this restoration approach will likely have similar positive impacts toward reducing loads from the other metals associated with the McLaren Tailings Area, then a 99% load reduction from the McLaren Tailings Area is also assumed for copper, manganese, lead, aluminum and any other metals of concern.

4.3.3.2.1.4 Unnamed Creek

This stream is entirely in Wyoming and Montana Standards would not specifically apply to this stream. Metal loads and related load allocation must be low enough to meet targets at SBC4 to protect the downstream section of Soda Butte Creek that meanders back and forth between Montana and Wyoming.

4.3.3.2.1.5 Remaining Sources

Remaining Sources include inflows and runoff from the Cooke City area and minor tributaries and inflows all along Soda Butte Creek. Some of the specific mine disturbance areas that fall into this overall category include, but are not limited to, the Soda Butte Dumps, the Alice E. Mill Site, and tailings/pollutant deposits in the floodplain from past floods. Allocated metals loading or necessary load reductions associated with this source area are based on conditions needed to ensure that standards and targets are satisfied all along Soda Butte Creek, with focus on monitoring locations SBC2, SBSW102, and SBC4. The individual metals loads are allocated to natural background conditions, potential Cooke City sources, floodplain sources, and mining disturbances not already addressed under one of the other sources discussed above. At this time, there is insufficient data to quantify the existing loads from these Remaining Sources and to identify required load reductions. If there is a need for load reduction(s), then the load reductions would likely apply to mining sources and other source types. This load reduction would be equal to the reduction needed to meet water quality standards in Soda Butte Creek once all other source areas are satisfying their specific TMDL and load allocation requirements discussed above.

Identifying such overall load reductions from this source area can be data intensive and could take a number of monitoring seasons to quantify. To help ensure that Soda Butte Creek targets are met, mine disturbances that are part of this Remaining Sources should be individually analyzed for their potential to contribute significant loads to nearby surface or ground water via seeps or direct runoff or any other pathway. If the significant potential for metals loading is identified for a mine disturbance, then a load allocation will be applied to this source in a manner similar to the above method for the McLaren Tailings, taking into consideration the potential for erosion related transport of metal loads.

4.3.3.2.2 Estimates of Load Reduction Needs by Source Area

It is helpful to estimate the average total load reductions, by source area, needed to meet Soda Butte Creek targets and TMDL conditions during low and high flow conditions. This average total load reduction is the existing average load minus the load allocation. This information can then be used to assist with restoration planning and help identify areas where additional data is needed to further characterize metals sources and source area contributions. The goal is to help ensure that the anticipated load reductions from planned restoration activities for all source areas are consistent with the load reductions needed to satisfy Soda Butte Creek targets and TMDLs. For the section of Soda Butte Creek between the McLaren Tailings Area and Woody/Republic Creek, these load reductions can be estimated to some extent by comparing Table 4-7 metals load reduction requirements to the Table 4-3 estimated percent cumulative loads by source area. For the section of Soda Butte Creek below Woody/Republic Creek, they can be estimated to some extent by comparing the Table 4-8 percent metal load reduction requirements to the Table 4-4 estimated percent cumulative loads by source area.

Tables 4-9 and 4-10 are used to summarize load reduction information and needs for Soda Butte Creek above the confluence with Woody/Republic Creek at SBC2 and just above Yellowstone National Park at SBC4. The first column in each table identifies the metal of concern. The second column lists the source areas, split for low and high flow conditions, for the location of concern. Note there are fewer source areas at SBC2 (Table 4-9) since it is the upstream location. The third column identifies the anticipated load reduction once the load allocation is satisfied. Values are only provided where data is available to make an estimate. Not only is this number provided for each source area/metal combination at high and low flow conditions, the available numbers are also combined to provide an overall estimated average total load reduction for low and high flow conditions. The fourth column is an estimated average reduction in total daily load needed to satisfy the TMDLs and targets conditions for each metal at low and high flow conditions. The flow related number in the fourth column can then be compared to the average flow related number in the third column to help direct restoration planning, including identification of source areas that need additional monitoring to evaluate load reduction potential. Each fourth column load reduction estimate includes a note in parentheses concerning restoration and data needs. For example, if the fourth column load reduction needs are significantly higher than the third column estimated source area reductions, then there is a probable need to identify other source areas where loads can be reduced.

In making these comparisons in Table 4-9, it appears as though efforts to address Miller Creek restoration and an anticipated 99% load reduction for the McLaren Tailings Area will satisfy the load reductions needed for all TMDLs and targets for the upper section of Soda Butte Creek. This conclusion is not surprising since the source analysis (Section 4.2.3) had previously failed to identify any other significant source areas of concern besides Miller Creek and the McLaren Tailings Area.

For Table 4-10, the same total load reductions would still apply for the Miller Creek and the McLaren Tailings source areas, but their overall percent contribution in load reduction at SBC4 would tend to be lower for most metals depending upon the measured concentrations at SBC4. The fourth column summary notes in Table 4-10 indicate that efforts to address restoration needs in Miller Creek and at the McLaren Tailings Area could very well address all of the Soda Butte Creek load reductions needed for both copper and manganese at low flow and maybe even the copper reductions needed at high flow. It appears that many of the other source areas will need to have load reductions pursued in order to meet water quality TMDLs and targets for manganese and lead at high flows, iron at low and high flows, and aluminum during low flows. The extent that many of these other source areas contribute loads is unknown at this time, especially at higher flow conditions. Additional study is needed to characterize these specific source areas and their flow related load contributions. This study needs to also focus on potential individual sources of increased loading including an understanding of natural background loads given the potential for elevated background loads in some of these mineralized drainage areas with high natural erosion and sediment transport as discussed in Section 4.1.2.

Table 4-9. Estimated Total Load Reduction by Source Area and Comparisons to Estimated Load Reductions Needed to Meet Targets for Soda Butte Creek at SBC2

Metal	Source Area and Flow Conditions	Estimated Reduction in Total Daily Load to Soda Butte Creek at SBC2 (Percent of Total Load)[1]	Estimated Average Reduction in Total Daily Load Needed to Satisfy TMDLs and Targets at SBC2 (Percent of Total Load)
Copper	Miller Creek Low Flow: McLaren Tailings Low Flow: Miller Creek High Flow: McLaren Tailings High Flow:	2 - 5% 59 - 89% Average of Total Low Flow Range: 78% 46 - 84% >5% Average of Total High Flow Range:>70%	Low Flow: 50% (Miller Creek and McLaren Tailings Restoration work could satisfy all copper restoration needs for SBC2) High Flow: 75% (Miller Creek and McLaren Tailings Restoration work could satisfy all copper restoration needs for SBC2)
Iron	Miller Creek Low Flow: McLaren Tailings Low Flow: Miller Creek High Flow: McLaren Tailings High Flow:	0% 69 - 94% Average of Total Low Flow Range: 82% 30 - 52% 20 - 40% Average of Total High Flow Range: 71%	Low Flow: 82% (Miller Creek and McLaren Tailings Restoration work could satisfy all iron restoration needs for SBC2) High Flow: Data not available, but the load reductions from Miller Cr. and the McLaren Tailings Area could satisfy the TMDL and targets at SBC2
Manganese	Miller Creek Low Flow: McLaren Tailings Low Flow: Miller Creek High Flow: McLaren Tailings High Flow:	0% 79 - 94% Average of Total Low Flow Range: 86% 21 – 32% 19 – 38% Average of Total High Flow Range: 55%	Low Flow: 38% (Miller Creek and McLaren Tailings Restoration work could satisfy all manganese restoration needs for SBC2) High Flow: Data not available, but the load reductions from Miller Cr. and the McLaren Tailings Area could satisfy the TMDL and targets at SBC2
Lead	Miller Creek Low Flow: McLaren Tailings Low Flow: Miller Creek High Flow: McLaren Tailings High Flow:	0% Probably >50% Average of Total Low Flow Range: >50% 43 % * 48 % * Average of Total High Flow Range: 91% * based on assumption that 50% of the load comes from each source area	Low Flow: 25% to ensure remain below standards (Miller Creek and McLaren Tailings Restoration work could satisfy all lead restoration needs for SBC2) High Flow: 86% using Miller Creek data (Miller Creek and McLaren Tailings Restoration work could satisfy all lead restoration needs for SBC2)
Aluminum	No allocations for aluminum due to lack of data to make impairment determination; load reductions associated with other metals will likely reduce dissolved aluminum below levels of concern if it is found to be a problem	Significant aluminum load reductions will be accomplished per the above reductions	Reductions as Needed to Remain Below Standards (Miller Creek and McLaren Tailings Restoration work could satisfy any aluminum restoration needs for SBC2)

Notes:
1 This is the estimated reduction necessary to meet the load allocation for each metal of concern under low and high flows

??% - lacking data to make estimates

Table 4-10. Estimated Total Load Reduction by Source Area and Comparisons to Estimated Load Reductions Needed to Meet Targets for Soda Butte Creek at SBC4 (page 1 of 2)

Metal	Source Area and Flow Conditions	Estimated Reduction in Total Daily Load to Soda Butte Creek at SBC4 (Percent of Total Load) [1]	Estimated Average Reduction in Total Daily Load Needed to Satisfy TMDLs and Targets at SBC4 (Percent of Total Load)
Copper	Miller Creek Low Flow: McLaren Tailings Low Flow: All Other Source Areas (individual and cumulative source area contributions not yet determined): Miller Creek High Flow: McLaren Tailings High Flow: All Other Source Areas (individual and cumulative source area contributions not yet determined):	<1 - 5% ?? - 89% ??% Average of Total Low Flow Range: >45% ?? - 84% ??% ??% Average of Total High Flow Range: >42%	Low Flow: 25% or more (possibly addressed via McLaren Tailings cleanup) High Flow: 57% (possibly addressed via Miller Creek and McLaren Tailings Area restoration efforts, needs confirmation)
Iron[2]	Miller Creek Low Flow: McLaren Tailings Low Flow: Woody Creek Low Flow: Wyoming Creek Low Flow: Sheep Cr: Unnamed Cr: Remaining Sources: Miller Creek High Flow: McLaren Tailings High Flow: All Other Source Areas (individual and cumulative source area contributions not yet determined):	<5% 25 - 30% 23 - 26% <5% <5% ?? - 28% <5% Average of Total Low Flow Range: >66% <5 - 13% 5 - 10 % ??% Average of Total High Flow Range: ??%	Low Flow: up to 50% (may need additional load reductions in addition to Miller Cr. and McLaren Tailings Area restoration work) High Flow: 88% (significant reductions needed from tributaries below Miller Creek and/or other remaining sources)
Manganese	Miller Creek Low Flow: McLaren Tailings Low Flow: All Other Source Areas (individual and cumulative source area contributions not yet determined): Miller Creek High Flow: McLaren Tailings High Flow: All Other Source Areas (individual and cumulative source area contributions not yet determined):	<5 % 79 - 84% ??% Average of Total Low Flow Range: >82% 6 - 13 % <5 % ??% Average of Total High Flow Range: >10%	Low Flow: Close to 0% (No additional load reductions needed besides McLaren Tailings reductions) High Flow: 36% (significant reductions likely needed from tributaries below Miller Creek and/or other remaining sources)

Table 4-10: Estimated Total Load Reduction by Source Area and Comparisons to Estimated Load Reductions Needed to Meet Targets for Soda Butte Creek at SBC4 (page 2 of 2)

Metal	Source Area and Flow Conditions	Estimated Reduction in Total Daily Load to Soda Butte Creek at SBC4 (Percent of Total Load) [1]	Estimated Average Reduction in Total Daily Load Needed to Satisfy TMDLs and Targets at SBC4 (Percent of Total Load)
Lead	Miller Creek Low Flow: McLaren Tailings Low Flow: All Other Source Areas (individual and cumulative source area contributions not yet determined):	0% possibly > 50 % ??% Average of Total Low Flow Range: >50%(?)	Low Flow: Lead may not be a low flow concern below Woody Creek, McLaren Tailings Area reductions will likely address any potential concerns
	Miller Creek High Flow: McLaren Tailings High Flow: All Other Source Areas (individual and cumulative source area contributions not yet determined):	22 - 26% ?? % ??% Average of Total High Flow Range: >24%	High Flow: up to 92% (significant reductions likely needed from tributaries below Miller Creek and/or other remaining sources)
Aluminum	Woody Creek Low Flow: Other Source Reduction Needs Unknown	> 45 %	At this time, dissolved aluminum has only been identified as a problem in Soda Butte Creek just below Woody/Republic Creek confluence. The identified load reduction may address this situation, but further verification is needed.

Notes:
1 This is the estimated reduction necessary to meet the load allocation for each metal of concern under low and high flows

2 Iron values for many tributaries are calculated based on synoptic study inflow concentrations (Boughton, 2001)

??% - lacking data to make estimate

SECTION 5.0
RESTORATION STRATEGY

5.1 New World Mining District Response and Restoration Project

The restoration strategies for Daisy Creek, the Stillwater River, Fisher Creek, the Clarks Fork of the Yellowstone River and Miller Creek are primarily addressed by activities associated with the New World Mining District Response and Restoration Project. The USDA-FS is currently proceeding with efforts to implement the *New World Mining District Response and Restoration Project Overall Project Workplan* (Maxim, 1999; also referred to as the *Final Workplan*) with the intent of satisfying the requirements of the *Consent Decree* and the *Petition Report*. According to the workplan, the USDA-FS will execute the response and restoration project by following guidance provided by the EPA for Non-time-critical removal actions. Non-Time-Critical Removal Actions are defined by the Comprehensive Environmental Response, Cleanup, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) as actions that are implemented by the lead agency to respond to "the cleanup or removal of released hazardous substances from the environment … as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment…".

The primary goals of the New World response and restoration project, as identified in the workplan, are:

1. to assure the achievement of the highest and best water quality practicably attainable on District Property, considering the natural geology, hydrology and background conditions in the District and,
2. to mitigate environmental impacts that are a result of historic mining, "… taking into consideration the desirability of preserving the existing undeveloped character of the District and the surrounding area."

The workplan also presents additional project goals and objectives, a few of which are listed below:

- Prevent soluble metal contaminants or metals contaminated solid materials in the waste rock and tailings materials/sediments from migrating into adjacent surface waters to the extent practicable.
- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or heavy metals contamination to adjacent surface waters and groundwater to the extent practicable.
- Identify, prioritize, and select response and restoration actions based on a comprehensive source assessment and streamlined risk analysis of District Property.
- Restore a functional balance to the ecosystem that corresponds to the management objectives of the Gallatin National Forest and Custer National Forest Management Plans.

According to the workplan, the USDA-FS envisions that response and restoration work will initially focus on stabilizing the solid mine wastes to prevent or reduce erosion onto adjacent lands or into streams. Other expected response or restoration actions may include:

- Installing appropriate water management systems and, if necessary, operating a water treatment system during the construction phase of various response actions.
- Preparing repository sites to receive consolidated waste materials.
- Engineering appropriate capping systems to reduce potential infiltration through the waste materials to minimize further oxidation and acid production of mineralized materials.
- Closing adits and shafts.
- Revegetating mining-disturbed areas.
- Monitoring water quality.

The philosophy of the USDA-FS, as stated in the workplan, is to achieve the goals stated above to the extent practicable and possible given the constraints of funding and the general desire to blend the response and restoration actions into the surrounding area.

The *Final Work Plan* goes on to identify specific source areas, most of which are identified within Figures 2-2, 2-3, 3-1, 3-2, 4-1, and 4-2 of this report. The *Final Work Plan* also includes monitoring plans and a community relations plan. As part of the overall implementation strategy, annual workplans are prepared to detail the work that will be done to implement the yearly removal action and to plan for the removal action that will be done in the following year. For the work that will be completed each year, an engineering evaluation/cost analysis (EE/CA) will be developed. The EE/CA will identify and screen applicable removal technologies and process options.

The above approach is consistent with the performance based allocation approach for identified metals and pH problems in Daisy Creek, the Stillwater River, Fisher Creek, the Clarks Fork River, and Miller Creek.

Since completion of the workplan in 1999, restoration efforts, monitoring and characterization, and community relations efforts have been ongoing as envisioned within the workplan. Annual workplans and EE/CAs have been completed for 2000, 2001, and 2002, resulting in restoration activities and studies that have been completed or are underway.

Restoration and related efforts either completed or currently in progress include the following:

- Development of a repository site for the relocation of mine wastes,
- Removal of mine wastes in several locations in the Fisher Creek drainage,
- Removal of the Soda Butte Tailings Dump and the Rommel Tailings in the upper portion of Soda Butte Creek drainage,
- EE/CA for the McLaren Pit area,
- Fisher Cr. Road improvement work to reduce erosion and improve access, and

- Significant additional characterization, including further characterization of the Glengary Adit, to assist with future EE/CA and annual work plan development.

5.2 Additional Restoration Strategy Considerations by Drainage Area

5.2.1 Daisy Creek and the Stillwater River

As previously discussed, the two categories of work as defined by the Natural Resources Working Group for the New World Mining District Response and Restoration Project are:

- Category A - hazardous substances (i.e. mine waste) that are on District Property and non-hazardous substances (e.g. principally sediment from roads) on District Property. Work can be done prior to the receipt of the Notice of Completion from the United States Government.

- Category B – after receipt of the Notice of Completion, work can address other hazardous and non-hazardous sources on non-District Property. Since the Forest Service does not have the authority to do work on private land, then another entity such as the State of Montana or the EPA may need to perform the actual cleanup work for Category B sources on private lands.

Based on source assessment results, it is assumed that all significant sources of metals and pH impairment conditions for both Daisy Creek and the Stillwater River will be addressed under Category A as part of the New World Mine restoration project. Note that Category A includes non-hazardous substances and will therefore address sediment reductions in the Daisy Creek drainage in anticipation of satisfying sediment targets for both streams.

Additional sediment load reductions that fall under Category B may end up being addressed by New World Project activities or by Gallatin National Forest road and trail work. The Gallatin National Forest is now beginning a travel plan Environmental Impact Statement (EIS) process to examine all forest roads and trails in the Gallatin National Forest (including the Cooke City area). The travel plan will address the ultimate disposition; modification, maintenance, closure, removal, etc. for forest roads and trails. Preliminary information pubic meetings and scoping has started and the final EIS is scheduled for completion in the fall of 2004. The EIS will include disclosure of effects of roads on natural resources including water quality and sediment.

5.2.2 Fisher Creek and the Clarks Fork River

Similar to the Daisy Creek drainage, there appears to be a high likelihood that all significant sources of metals and pH impairment conditions in the Fisher Creek drainage will be addressed by Category A restoration efforts. It also appears that any needed sediment reductions will be achieved via New World Mine restoration work (Category A) or via additional Category B and/or Forest Service road and trail maintenance to be defined by the forest roads and trails EIS.

Addressing the Fisher Creek metals and pH impairment concerns will address the vast majority of loading to the Clarks Fork River. Nevertheless, there needs to be an assessment and characterization of potentially significant mining sources in the Lady of the Lake Creek and Broadwater River drainages. This assessment will need to identify any additional load allocations requirements to ensure meeting Clarks Fork River targets in addition to protecting beneficial uses for Lady of the Lake Creek and the Broadwater River. If a significant source is located, then it has the potential of being addressed by New World Mine District activities under Category B, or will otherwise need to be addressed by another restoration approach as discussed below in Section 5.3.

5.2.3 Miller Creek

Because of a much higher proportion of private, non-District property within the Miller Creek drainage in comparison to the Daisy or Fisher Creek drainages (reference Figure 4-1), there is a higher likelihood of significant metals sources that would fall within Category B instead of Category A. If New World Mining Project funding is not adequate to address all significant Category B sources of metals, then individual load allocations will need to be developed and restoration will need to be pursued under a different approach as discussed below in Section 5.3.

The higher metals concentrations seen during higher flows is an indicator of potential metals loading associated with erosion. The inclusion of District property roads under Category A and efforts to address forest roads and trails under the EIS discussed above could result in significant reductions of metals loading via erosion.

5.2.4 Soda Butte Creek

As discussed in Chapter 4, there are several significant source areas contributing to metals impairment conditions in Soda Butte Creek. The restoration strategy for Miller Creek is discussed above in Section 5.2.3. Essentially all other significant sources are potential Category B sources, with the McLaren Tailings representing one of the more significant source areas of concern that could be addressed by New World Mine restoration efforts provided that there is sufficient funding after addressing Category A sources. There will likely be several significant metals sources that will need to be addressed via other approaches as discussed under Section 5.3 below.

At this time, there are currently efforts underway to characterize and identify restoration options for the McLaren Tailings. This work is summarized in the *Draft Final Expanded Engineering Evaluation/Cost Analysis; McLaren Tailings Site, Cooke City, Montana* (Pioneer, 2002). The MDEQ is also working on efforts to reduce environmental impacts associated with the Republic Mine and Mill sites along Republic and Woody Creeks under the Abandoned Mine Lands Reclamation Program. There is still a significant need to further characterize impacts from these and other sources located along Soda Butte Creek or within other drainages such as Wyoming Creek, Republic and Woody Creeks, Sheep Creek, and Unnamed Creek. Some monitoring and assessment recommendations for this work are included below in Section 5.4.

Similar to Miller Creek, some high flow loading could be coming from roads and trail and may end up being addressed, at least in part, by the forest roads and trails EIS discussed above.

5.3 Restoration Approaches for Metals Sources

Each significant source of metals loading, particularly those associated with historical mining, may have one or more restoration options associated with it. These options can include a broad range of regulatory and/or voluntary approaches. The four approaches that are probably most applicable in the Cooke City TMDL Planning area include:

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA);
- The Montana Comprehensive Cleanup and Restoration Act (CECRA) which incorporates additional cleanup options under the Controlled Allocation of Liability Act (CALA) and the Voluntary Cleanup and Redevelopment Act (VCRA);
- Abandoned Mine Lands (AML) Reclamation Program;
- Cleanup on federal agency lands outside the context of one of the above regulatory approaches.

The four above approaches as well as some additional options and funding considerations are defined in further detail within Appendix H. As discussed throughout this document, New World Mine restoration efforts are being pursued under CERCLA. Other areas where additional restoration will need to be pursued include the McLaren Tailings, the McLaren Mill Site, and other sources within the Soda Butte Creek drainage area and possibly sources within the Lady of the Lake and Broadwater River drainage areas. In some cases, such as for the Republic Mine and Smelter, the Abandoned Mines Land Reclamation Program is pursuing some or all restoration work needed.

It is assumed that the Forest Service will pursue funding and restoration planning for any significant sources which are located on Forest Service property and cannot be addressed via the New World Mine restoration project. Some of these potentially significant sources can be identified within Figures 3-1 and 4-1.

Any additional restoration work needed on private lands in Montana will probably need to be pursued using one or more approaches identified in Appendix H. If there are restoration needs identified for private lands located in Wyoming, as may be the case where drainage areas originate in Wyoming and then flow into Montana, then the State of Montana will need to work closely with Wyoming and EPA representatives to identify and pursue restoration options needed to support Montana's water quality standards. Since Wyoming water quality standards are primarily based on dissolved metals versus total recoverable metals, some streams that originate in Wyoming may not be identified as being impaired water bodies in Wyoming because elevated metals concentrations may be in a total recoverable form.

All restoration planning will need to be pursued in a comprehensive manner that addresses water quality standards both in the tributary of concern as well as within the downstream water body. For Soda Butte Creek, it will be necessary to further define loading contributions, including any elevated natural background conditions, from all tributaries during low and high flow events. Once contributions are identified, the specific load reduction needs, as partly defined by Tables 4-9 and 4-10, can be further allocated by tributary to ensure protection of Soda Butte Creek's beneficial uses. Once the needed load reductions are identified, then individual metals sources and their relative seasonal contributions can be quantified using existing or yet to be obtained data. A similar approach also needs to be pursued for Lady of the Lake Creek and the Broadwater River drainages, as well as any significant sources that cannot be fully addressed via the New World Mine restoration project. Once this characterization work is completed, it can then provide a means to prioritize restoration efforts, help justify the selection of a given restoration approach, and help with efforts to fund any such approach. Appendix H provides a separate section that discusses some of the funding considerations and options that can apply.

Identification of additional restoration as discussed above will need to be coordinated with ongoing and planned water quality restoration efforts and studies in the area, and also coordinated with state and federal agencies as well as other key stakeholders. Formation of a stakeholder watershed group could help facilitate coordination throughout the Cooke City TMDL Planning Area and could help prioritize studies and restoration efforts not addressed via the New World Mine District Response and Restoration Project. For activities that eventually do not fall under the New World Mine project, the MDEQ will ultimately be responsible for providing direction to other agencies and entities performing water quality work in Montana to ensure characterization efforts and restoration goals are consistent with water quality standards. The MDEQ will also need to ensure internal coordinate between mine reclamation and other MDEQ programs, such as the TMDL and Standards Programs, to evaluate progress toward meeting water quality targets.

5.4 Adaptive Management Approach to Restoration Targets and TMDLs for Metals and pH

The metals and pH targets and associated TMDLs all revolve around values associated with supporting the beneficial uses of a B-1 classified stream (or A-1 for portions of the Stillwater River and Soda Butte Creek). Where there is a need for very high load reductions it is important that every potentially significant source of metals and pH lowering constituents be addressed via all reasonable land, soil, and water conservation practices to achieve the highest and best water quality practicably attainable. Nevertheless, it is recognized that a combination of natural background loading and achievable load reductions may limit the ability to reach one or more of the targets, even after all reasonable land, soil and water conservation practices are defined and applied to pollutant sources. For this reason an adaptive management approach, consistent with the performance-based allocation for most of the water bodies in this WQRP, is undertaken for the metals and pH targets. Under this adaptive management approach, each metal or pH target identified in Tables 2-5, 3-3, or 4-5 will ultimately fall into one of the three categories identified below:

1) The target is achieved or likely will be achieved due to the successful performance of restoration efforts.

2) The target is not achieved and will likely not be achieved even though all applicable restoration efforts have been undertaken in a manner that is considered sufficient application of all reasonable land, soil and water conservation practices. Under this scenario, site-specific water quality standards and/or a reclassification of the water body may be necessary. This would then lead to a new target (and TMDL) for the pollutant of concern, and this new target would either reflect the existing conditions at the time or the anticipated future conditions associated with the restoration work that was performed.
3) The target is not achieved and will not likely be achieved due, at least in part, to a failure to implement all applicable restoration efforts in a manner that is considered sufficient application of all reasonable land, soil and water conservation practices. Under this scenario the water body remains impaired in recognition of the need for further restoration efforts associated with the pollutant of concern. The target may or may not be modified based on additional characterization efforts, but conditions still exist whereby additional pollutant load reductions are needed to support beneficial uses and meet applicable water quality standards via some form of additional restoration work.

Once all targets either fall under categories 1) or 2), then restoration efforts will have been implemented at a sufficient enough level to lead to conditions where applicable beneficial uses are or will be supported in a manner that is consistent with either existing or modified water quality standards. Continuous feedback associated with the performance of restoration work and follow-up monitoring in the area will provide the information to make decisions about the appropriateness of any given target. This feedback will include the MDEQ reports to the Board of Environmental Review as required under the temporary water quality standards process and discussed within Section 1.3.3. The feedback will also involve activities associated with satisfying *Consent Decree* requirements and implementation of the *Final Work Plan*. For all matters relating to District Property, a final decision concerning the adequacy of restoration efforts and a potential final target category will involve MDEQ, the Forest Service, and other stakeholders. The Board of Environmental Review will also be involved with decisions involving targets that relate to satisfying conditions set out by temporary standards. It is anticipated that all target category decisions associated with District Property will be made prior to 2014 when the temporary water quality standards are no longer in effect.

For activities that eventually do not fall under the New World Mine project, the MDEQ will ultimately need to be a lead agency involved with any determinations of final target categories for each pollutant of concern. These determinations will likely include consultation with key stakeholders and also involve public comment. Many of the Soda Butte Creek targets could remain within Category 3 for some time due to a lack of firm restoration commitments and associated funding for source areas such as the McLaren Tailings.

This adaptive management approach for targets, and the overall implementation strategy for the Cooke City area, relies in part on implementation of a comprehensive monitoring program to assist with decision-making efforts. This program is discussed below in Section 5.5.

5.5 Monitoring Strategy

5.5.1 New World Mining District Long-Term Monitoring Plan

The *Final Overall Work Plan for the New World Mining District Response and Restoration Project* (Maxim, 1999) includes *Appendix D: Long-Term Surface Water Quality Monitoring Plan*. This plan commits to monitoring three times per year for metals, field parameters (including pH), flow, and other constituents. The goal is to capture representative low and high flow events. This monitoring effort will be the primary mechanism to track overall progress toward meeting the targets identified in this Water Quality Restoration Plan. Specific monitoring locations, by stream, include:

Daisy Creek:	DC2 and DC5
Stillwater River:	SW-7
Fisher Creek:	SW-3, SW-4, and CFY-2
Clarks Fork River:	SW6
Miller Creek:	SW2
Soda Butte Creek:	SBC-1, SBC-2, SBSW102 (also referred to as RR-SBSW-102), and SBC-4

The plan incorporates a fairly comprehensive list of metals to sample for. These include aluminum, cadmium, copper, iron, lead, manganese, and zinc.

Note that the above sample locations include all of the primary locations used for evaluating the data in the impaired water bodies covered by this plan, with the exception of Miller Creek at SW5 and the Stillwater River at STW2. Fortunately, metals data for Miller Creek is very similar at locations SW2 and SW5, so either may work for the purpose of tracking initial restoration progress. Routine monitoring at STW2 is not critical since monitoring at DC5 and SW7 bracket this location and all pollutant sources of concern are upstream of DC5.

Note that the Soda Butte Creek sampling locations are strategically located to not only help track restoration progress, but also to also help characterize loading conditions, which is needed for this stream. It will be important to try to perform Miller Creek and Soda Butte Creek sampling at the same time to facilitate this characterization effort.

A few additional recommendations for inclusion in the long-term monitoring plan include:
- Samples should be evaluated for both dissolved and total recoverable aluminum, at least for those locations where there is a history of one or the other occurring at high levels. This should include all locations in Miller Creek and Soda Butte Creek.
- Total recoverable silver data, and possibly dissolved silver data, should be collected at Fisher Creek and Clarks Fork River sampling locations.
- The New World Mining District Monitoring Plan extends through the temporary standards period of 2014. Plans need to be put in place to extend the monitoring as needed beyond this date for select parameters starting 2015. This should include monitoring at established stream locations as well as monitoring the success of

individual restoration sites including monitoring for potential leakage from any repository site(s).

5.5.2 Source Characterization

In addition to routine monitoring described above, New World Mining District efforts will also include significant source characterization to further identify and evaluate the relative impacts from specific sources, evaluate restoration options, and also evaluate the success of specific restoration actions. These additional monitoring plans, as well as results and conclusions associated with the data, will tend to be documented in the yearly District workplans and EE/CAs.

Other recommended source characterization activities throughout the Cooke City area include:

- A study to monitor likely source locations during high flows should be undertaken for Miller Creek.
- Soda Butte Creek and the various tributary source areas will require additional characterization, especially during higher flows, to identify contributions from metals sources. Low flow characterization will also be needed at the mouth and further upstream in several of the Soda Butte Creek tributaries to identify loading from specific mining or other source locations including evaluation of potential contributions from floodplain areas along Soda Butte Creek. This floodplain loading could include impacts from a past tailing dam failure as well as casual dumping of old equipment and other junk along the stream bottom.
- Additional data should be collected and a more comprehensive potential source inventory performed for Lady of the Lake Creek and the Broadwater River to help identify natural background conditions, especially during high flows. This would also help determine the need for TMDL development for these water bodies.
- Information is needed to identify probable natural background loads for most water bodies, especially during high flow events, using reference streams where they can be identified.
- Historical photos, maps, and other land use information should be analyzed to help identify potential mining sources, especially in those drainages outside the current focus of the New World Mining project.
- As metals loading sources are removed, sediment and floodplain metals concentrations should be evaluated to determine whether or not there should be removal efforts. Any such plans should take into consideration the extent of yearly flushing associated with stream sediments and the potential for significant damage to the physical structure of the stream from removal efforts.

Any studies undertaken to address these characterization needs must incorporate proper analyses and sample detection limits for all of the appropriate total recoverable and dissolved metals to effectively evaluate conditions relative to Montana and/or Wyoming Water Quality Standards and WQRP targets.

5.5.3 MDEQ Monitoring Efforts to Develop Targets and Analyze Progress

MDEQ staff will continue to review the data from the New World Monitoring program and utilize the information to make updated status determinations on progress as required at least once every five years per State Law (Montana Water Quality Act, Section 75-5-703). One of the activities associated with the long-term surface water monitoring program is evaluation of diurnal affects on water quality. As an added margin of safety, any statistically significant diurnal affects at concentrations near the water quality targets will be factored into monitoring efforts to evaluate overall compliance with targets. For example, if sampling is performed at a time of day when water quality values are 20% less than average conditions for a given metal, then a 20% reduction factor will be used to determine the probable average concentration for comparison against water quality targets.

Some additional monitoring that will be needed to evaluate progress toward setting and meeting targets include the below items. MDEQ will be responsible for ensuring that these monitoring efforts are undertaken and that the data is made available to appropriate stakeholders. Some of the actual monitoring may be done by New World Mine project personnel or other stakeholders working in the drainage.

- At least once every five years, sediment chemistry samples should be taken to determine copper and lead levels at sites SW7, DC5, SW4, SW6, SW2, and SBC2. The purpose is to measure progress toward meeting the targets of sediment concentrations at non-toxic levels and to ensure that there are not toxicity concerns at those locations where sediment data has not been identified as a problem for these two metals.
- Monitoring to evaluate progress toward meeting percent fines goals for Daisy Creek and the Stillwater River will be performed at least once every five years. The locations used for developing the Wolman Pebble count curves, or suitable replacements, are recommended. These sites are identified on Figure 1-5 as SED-1, SED-2, and SED-3. The measurements should be made at the same time during the lower flow summer or fall season after spring runoff conditions. During these measurements, turbidity and streambed deposits associated with metal precipitants will need to be characterized, using pictures and/or field observation notes at a minimum for the SED-2 and SED-3 sites as well as DC5.
- For Fisher Creek, the MDEQ will need to identify one or more reference streams and obtain percent fines data as was done for Daisy Creek and the Stillwater River. It is recommended that location SED-4 or a similar area where some of the best fish habitat exists be used for the percent fines measurements. The information can then be used to evaluate progress toward meeting the sediment target. The development of these reference stream target curves can be done at the same time of, or prior to, the five year monitoring.
- Macroinvertebrate and periphyton samples will need to be collected in each stream at least once every five years or as restoration work reaches a point where collection of such information will be useful to evaluate this particular restoration target.

MDEQ protocols will be followed for all sediment and biological sampling as well as for any water chemistry samples taken.

SECTION 6.0
PUBLIC INVOLVEMENT

Public review and involvement for development of this water quality restoration plan has been ongoing to some extent since the 303(d) lists that MDEQ develops every two years undergo public review, including public meetings. As for this Draft Water Quality Restoration Plan, a one-month public comment period was started in January, 2002, and included public meetings held in Cooke City and Livingston during the public comment period. MDEQ has reviewed and responded to the comments and attempted to incorporate them where possible. Appendix I is a list of the comments with MDEQ responses.

Because a large part of this overall plan revolves around restoration planning efforts for the New World Mining District, the public has had and continues to have the opportunity to review and comment on many of the aspects of this plan, particularly those associated with site characterization and specific restoration strategy development. In addition, the public will continue to have the ability to participate in the implementation of the performance-based approach and overall restoration efforts through comment on yearly workplans and EE/CAs. This additional level of public involvement is facilitated through Forest Service personnel in charge of New World Mining District Restoration efforts and described within the Community Relations Plan portion of the *Final Overall Project Work Plan* (Maxim, 1999).

Restoration work pursued outside the context of the New World Mining project will typically involve numerous stakeholders, including the affected public. A high level of public interest in restoration work, as is evident by the comments in Appendix I, makes it very likely that there will be continued, if not increased, public involvement with overall restoration efforts in the area. This can include comment on eventual target categories as described in Section 5.4. Public comment on target categories could be facilitated via comment on New World Mining district restoration plans, agency decisions associated with temporary standards or water body classifications, and/or comment on restoration plans outside the context of New World Mining project efforts.

Any future significant revisions to this plan or identification of water quality impairment conditions on future 303(d) lists will also undergo public review.

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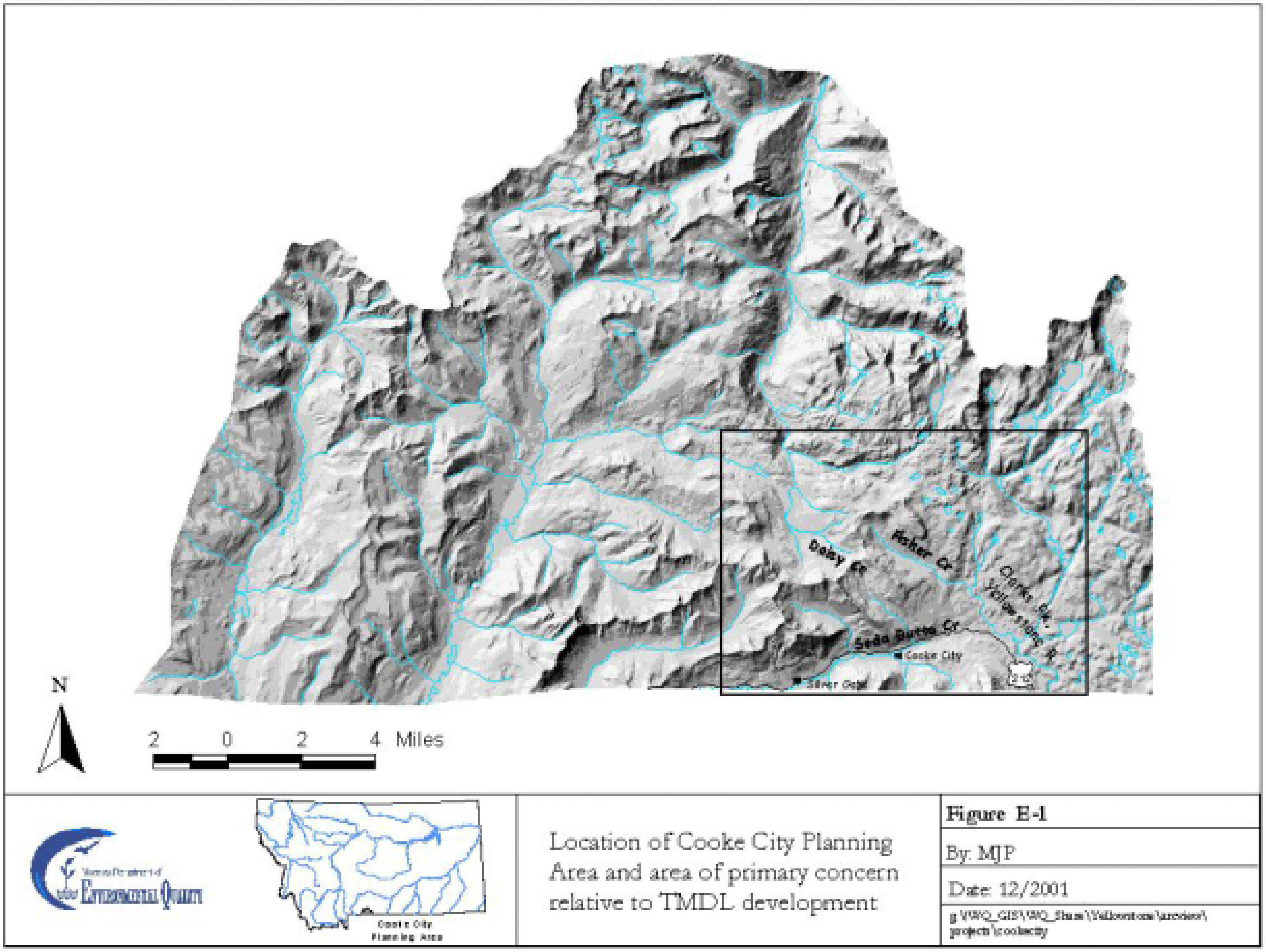
FIGURES



Location of Cooke City Planning Area and area of primary concern relative to TMDL development

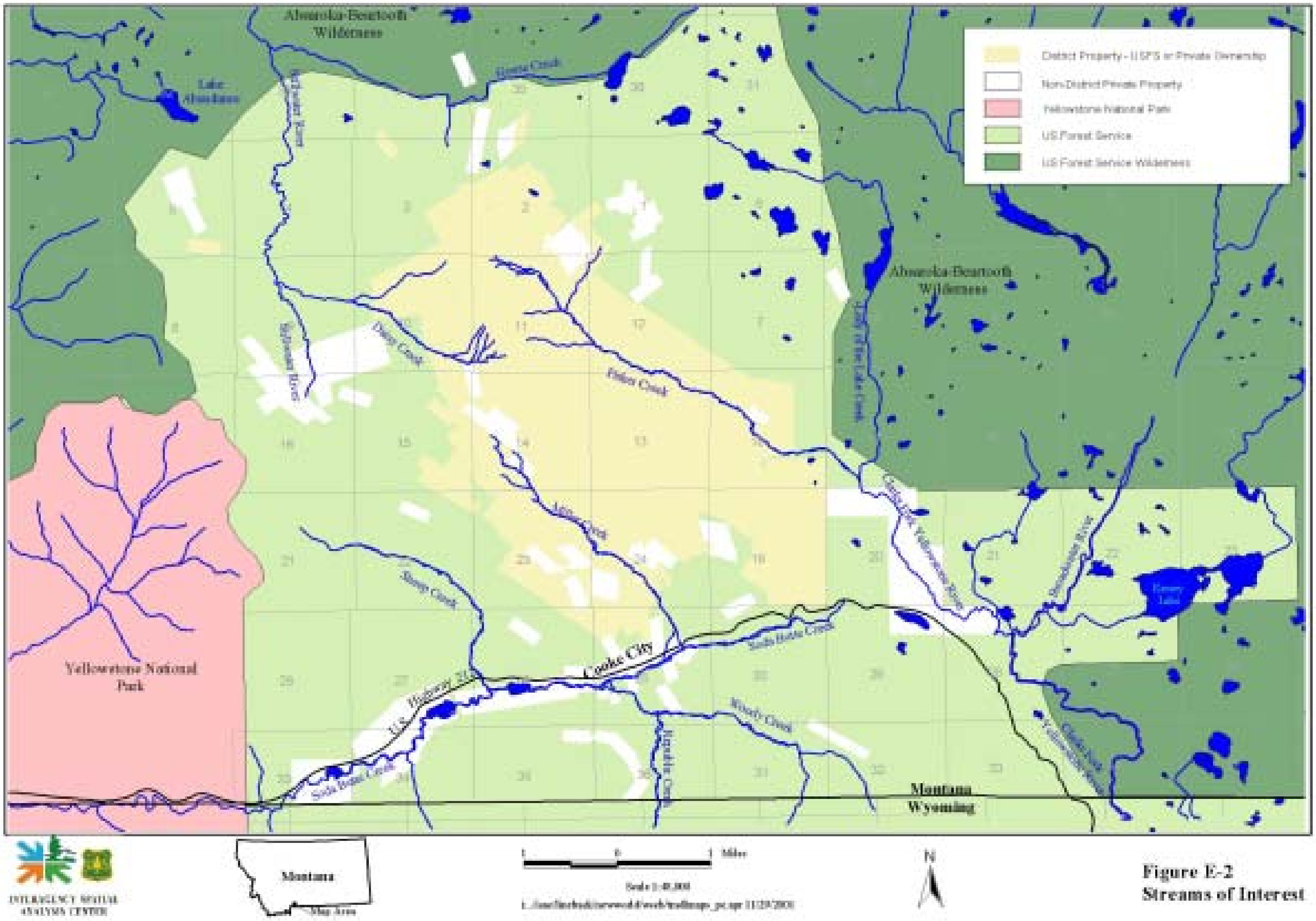


Figure E-2
Streams of Interest

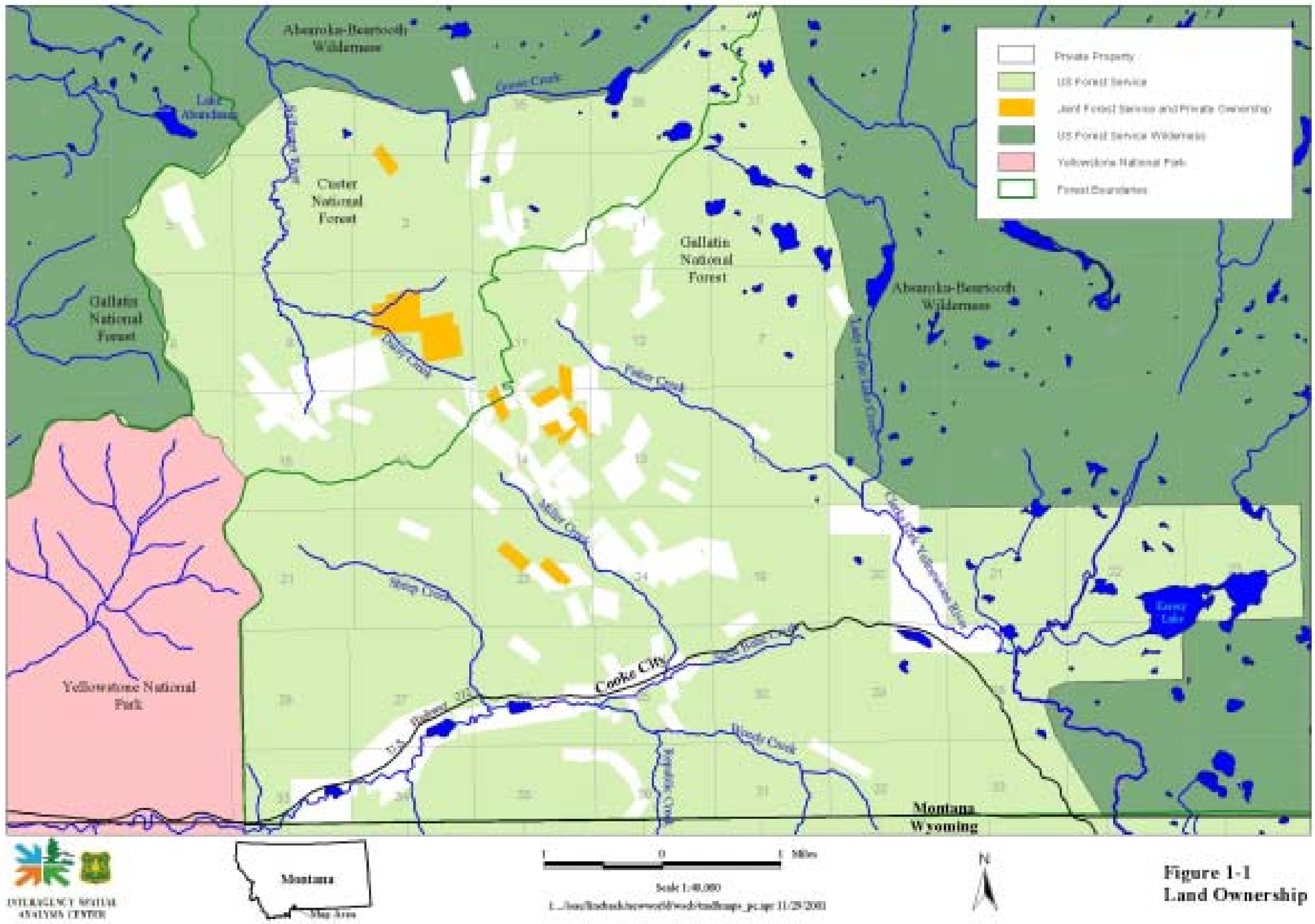
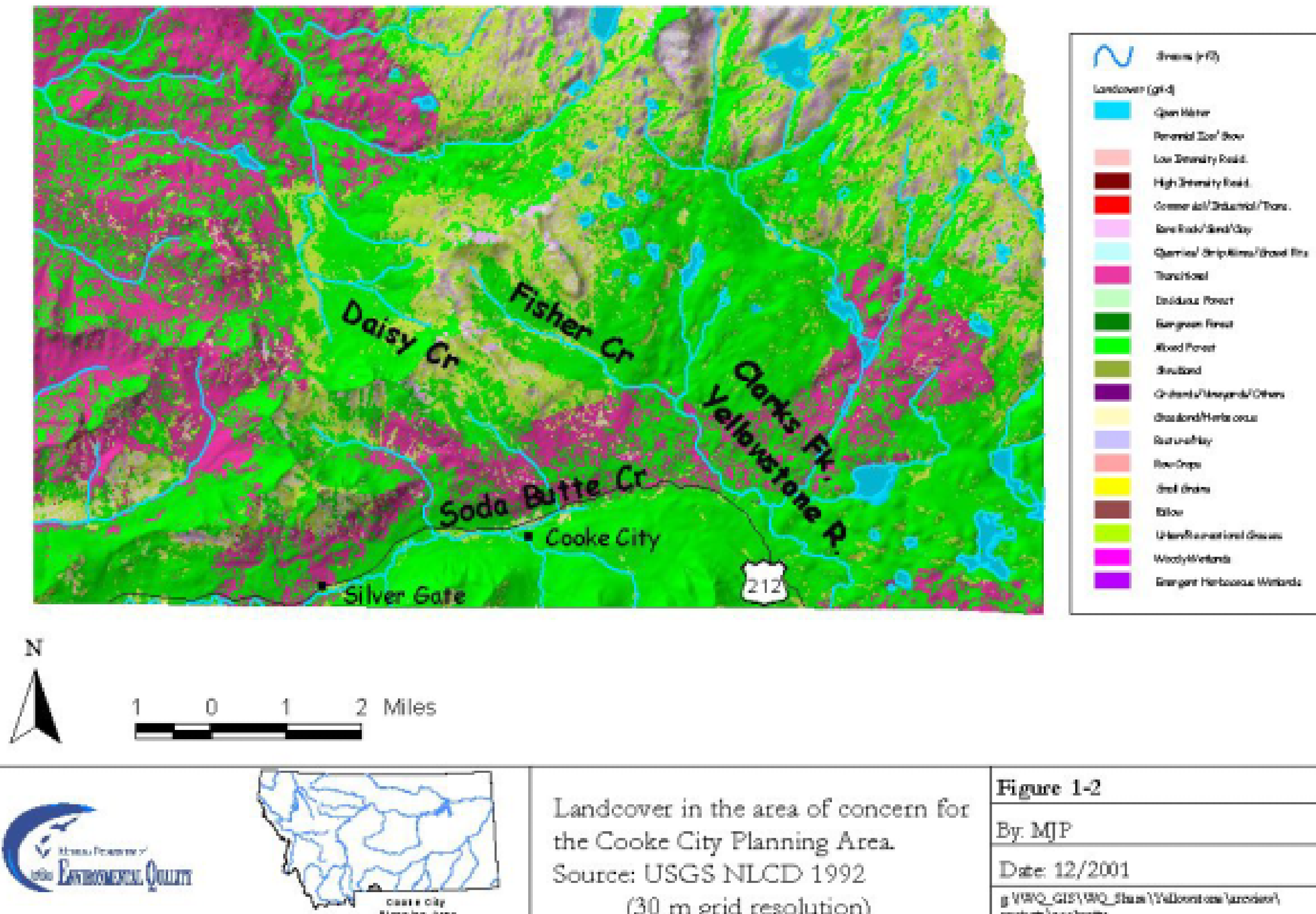


Figure 1-1
Land Ownership



Landcover in the area of concern for the Cooke City Planning Area.
Source: USGS NLCD 1992
(30 m grid resolution)

Figure 1-2

By: MJP

Date: 12/2001

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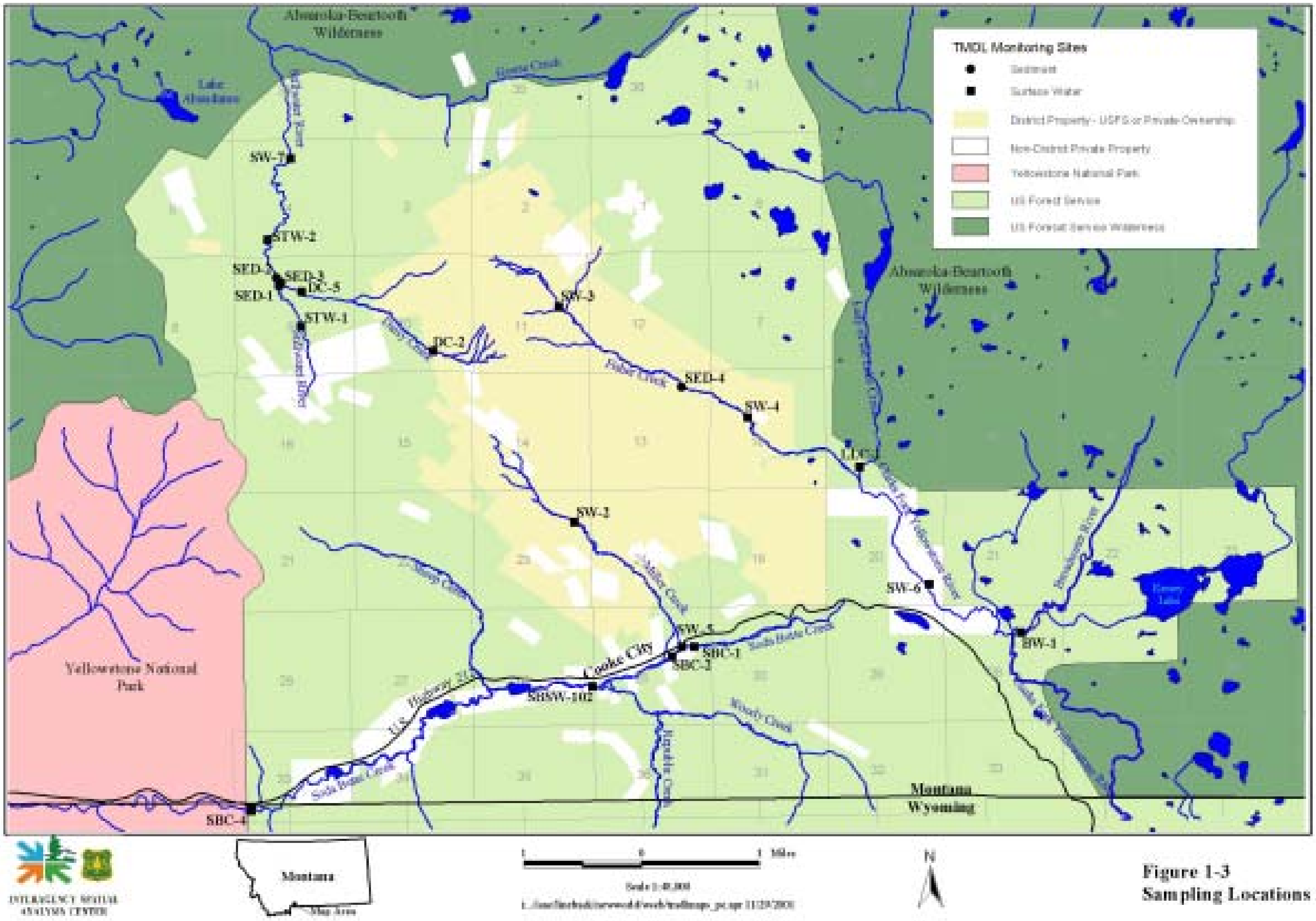


Figure 1-3
Sampling Locations

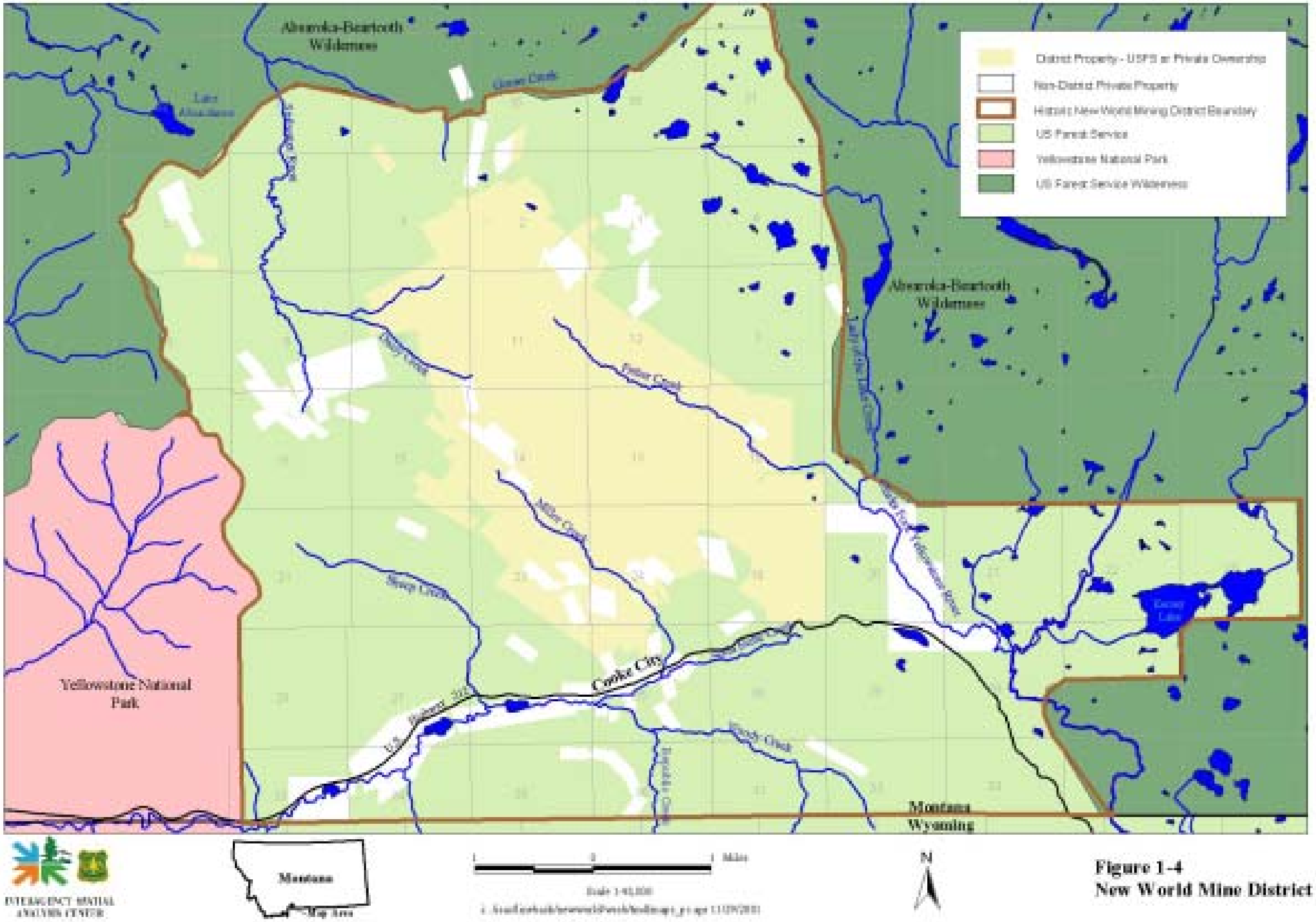
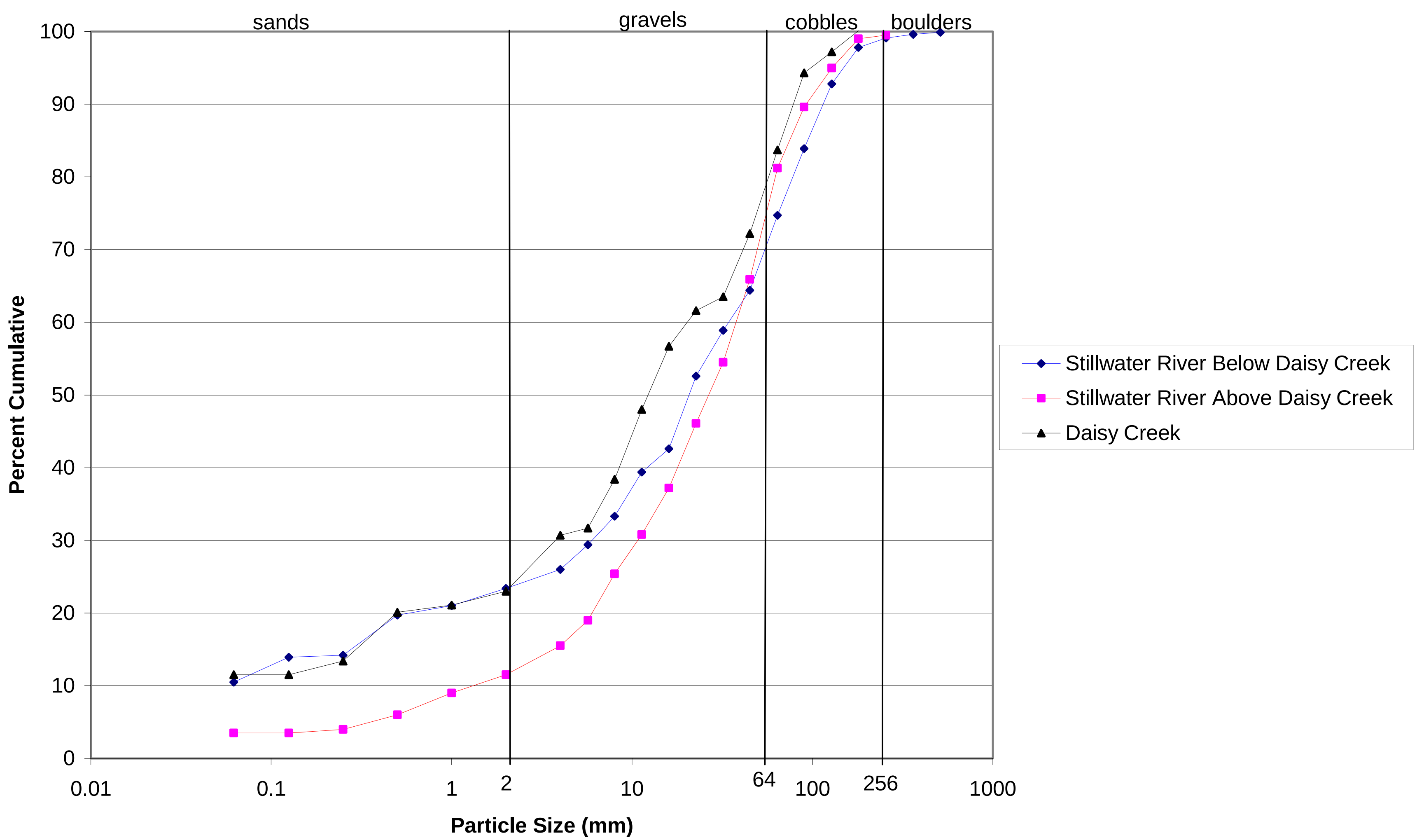


Figure 1-4
New World Mine District

Figure 2-1: Results of Pebble Count Data Collected on August 25, 2001 From Riffle Sections of the Stillwater River and Daisy Creek



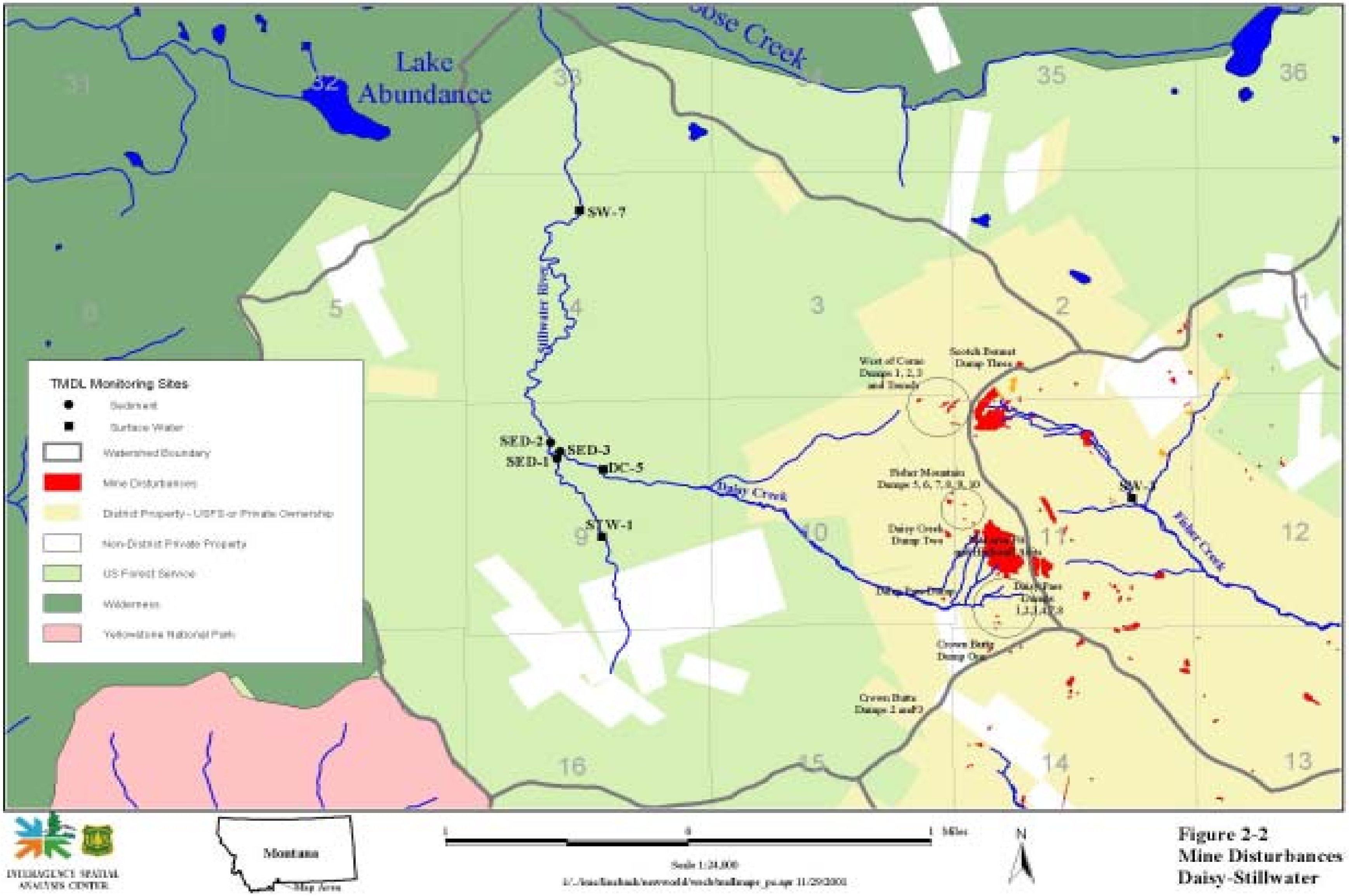
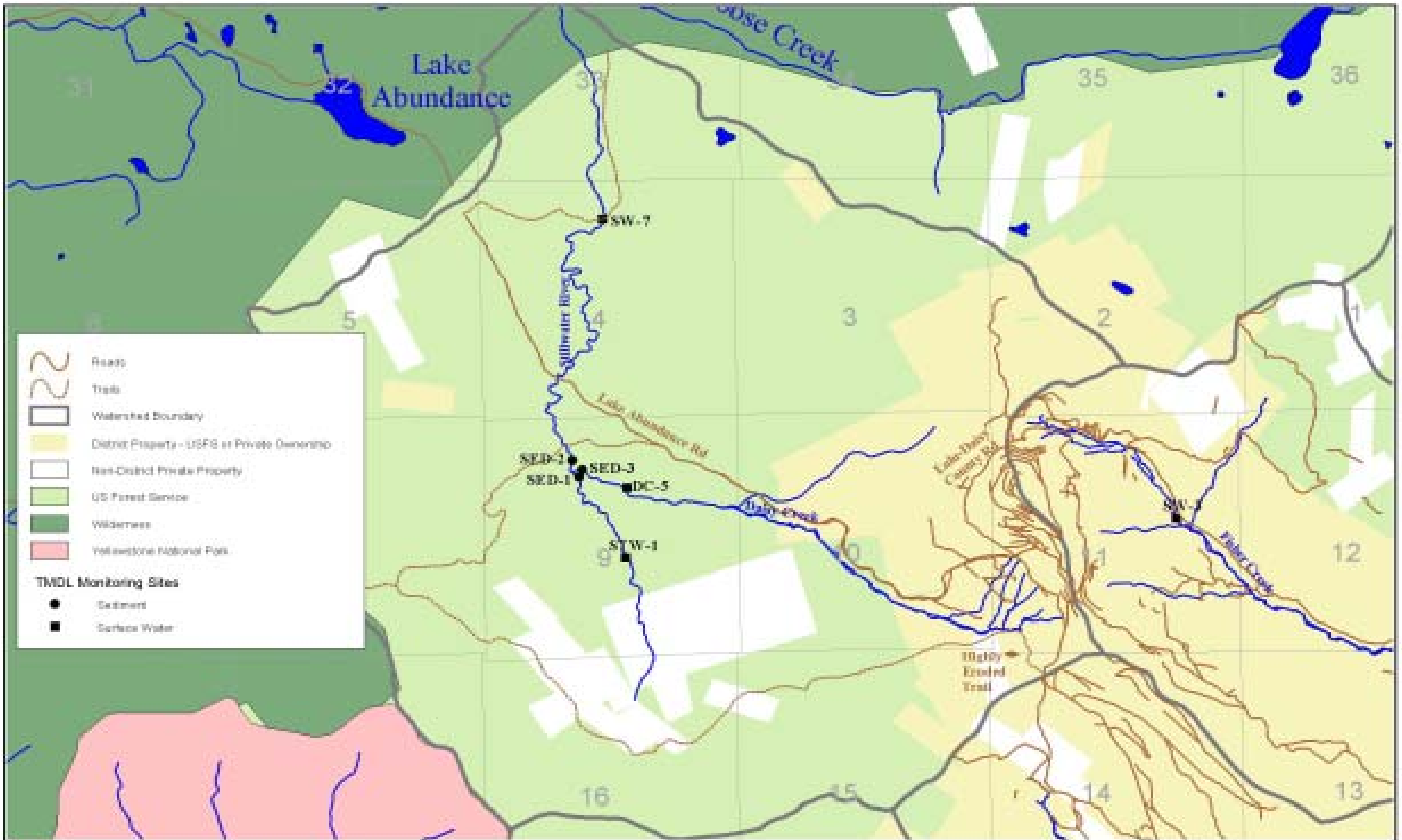


Figure 2-2
Mine Disturbances
Daisy-Stillwater



INTERAGENCY SPATIAL ANALYSIS CENTER

Montana

Map Area

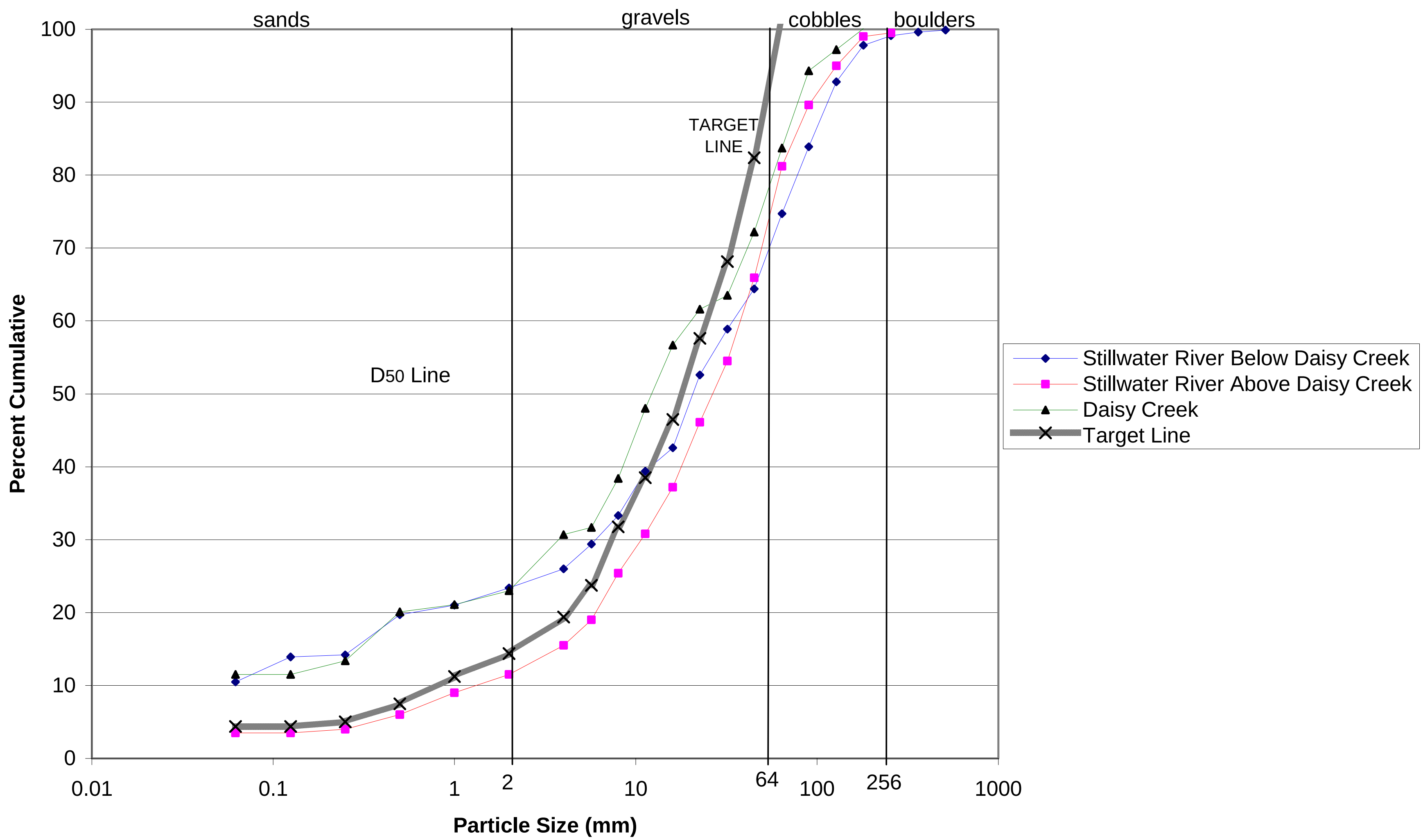
1 0 1 Miles

Scale 1:24,000

N

Figure 2-3
Roads and Trails
Daisy-Stillwater

Figure 2-4: Results of Pebble Count Data Collected on August 25, 2001 From Riffle Sections of the Stillwater River and Daisy Creek; 25% Variation Target Line Added



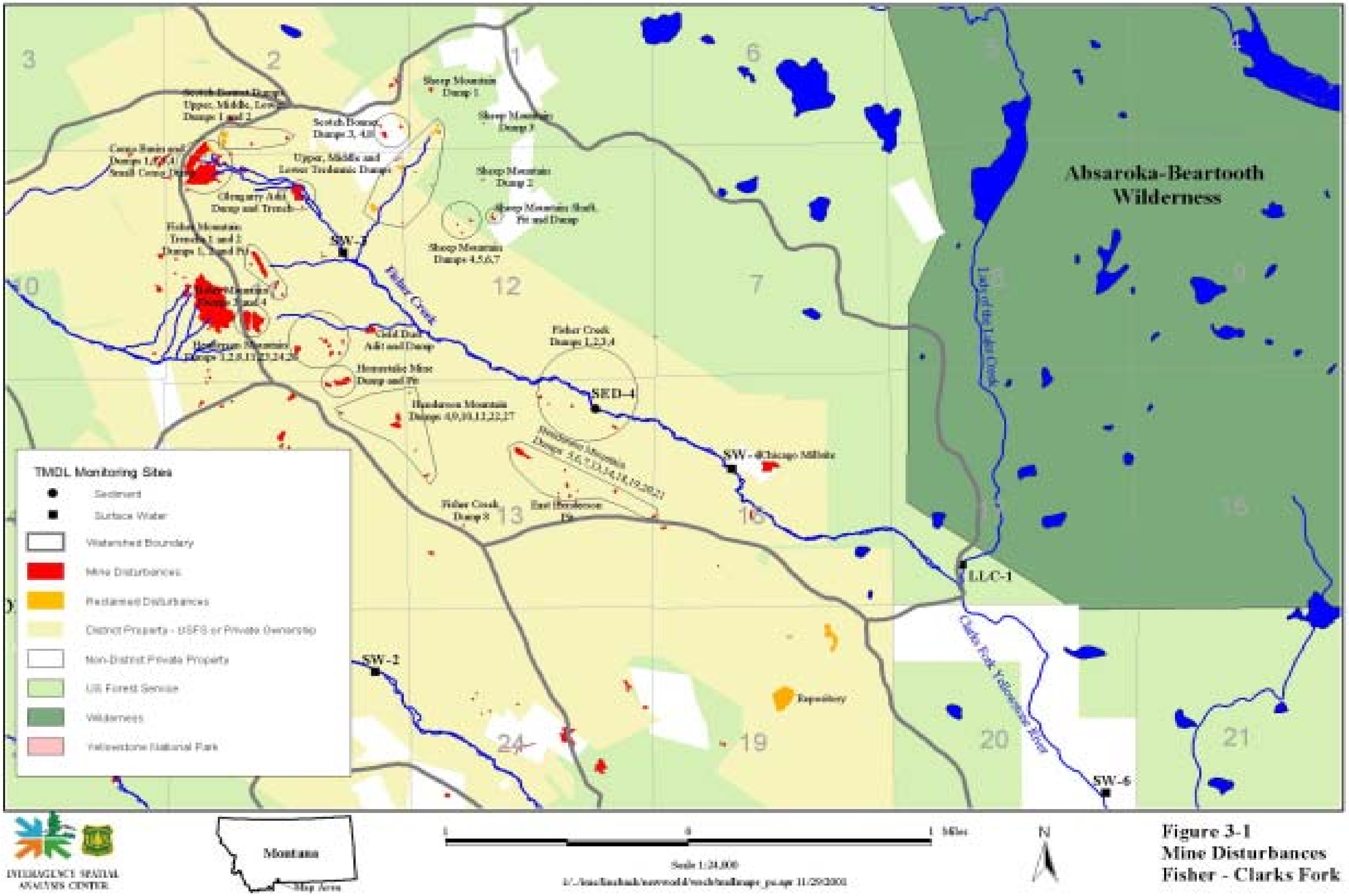


Figure 3-1
Mine Disturbances
Fisher - Clarks Fork

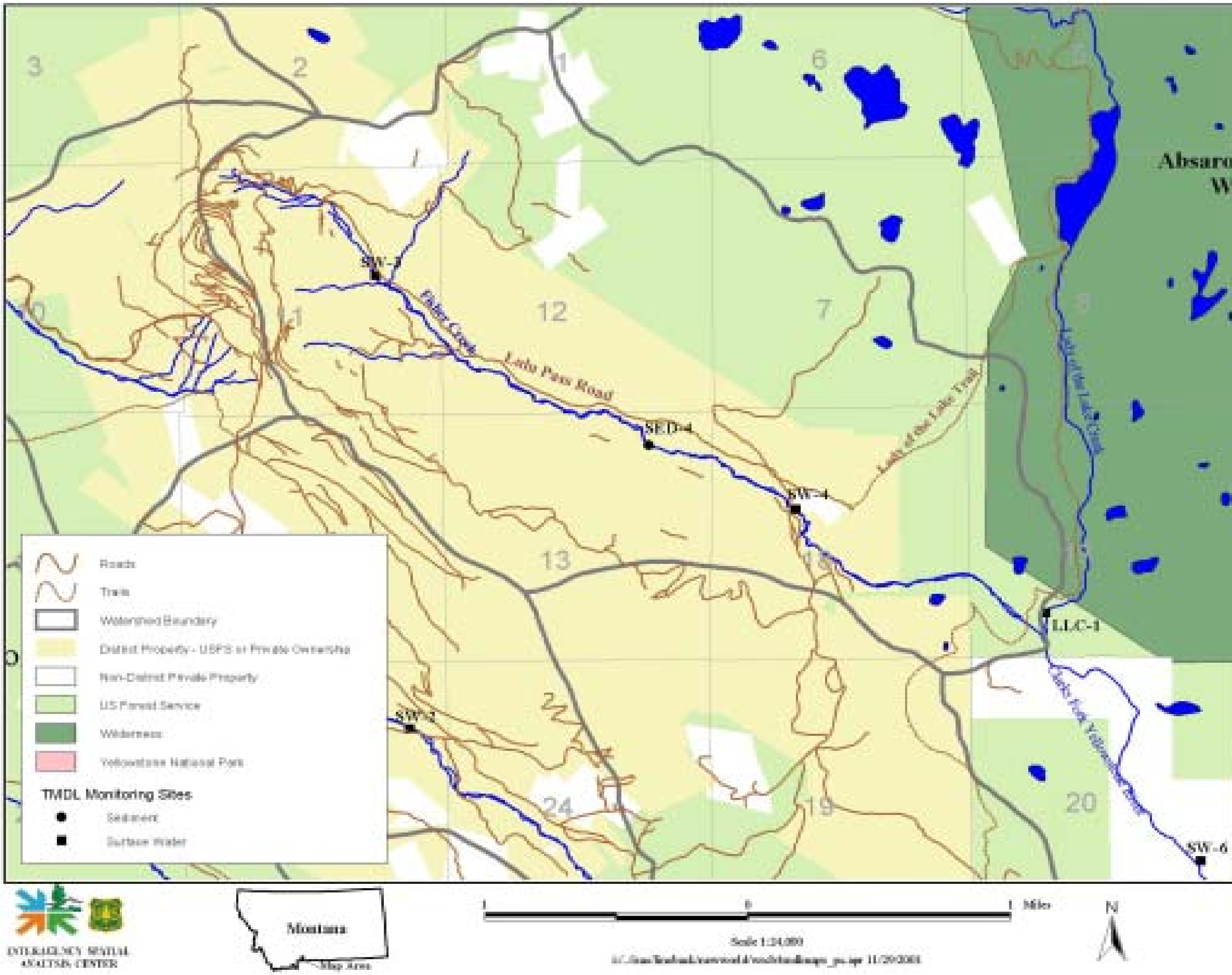


Figure 3-2
Roads and Trails
Fisher - Clarks Fork

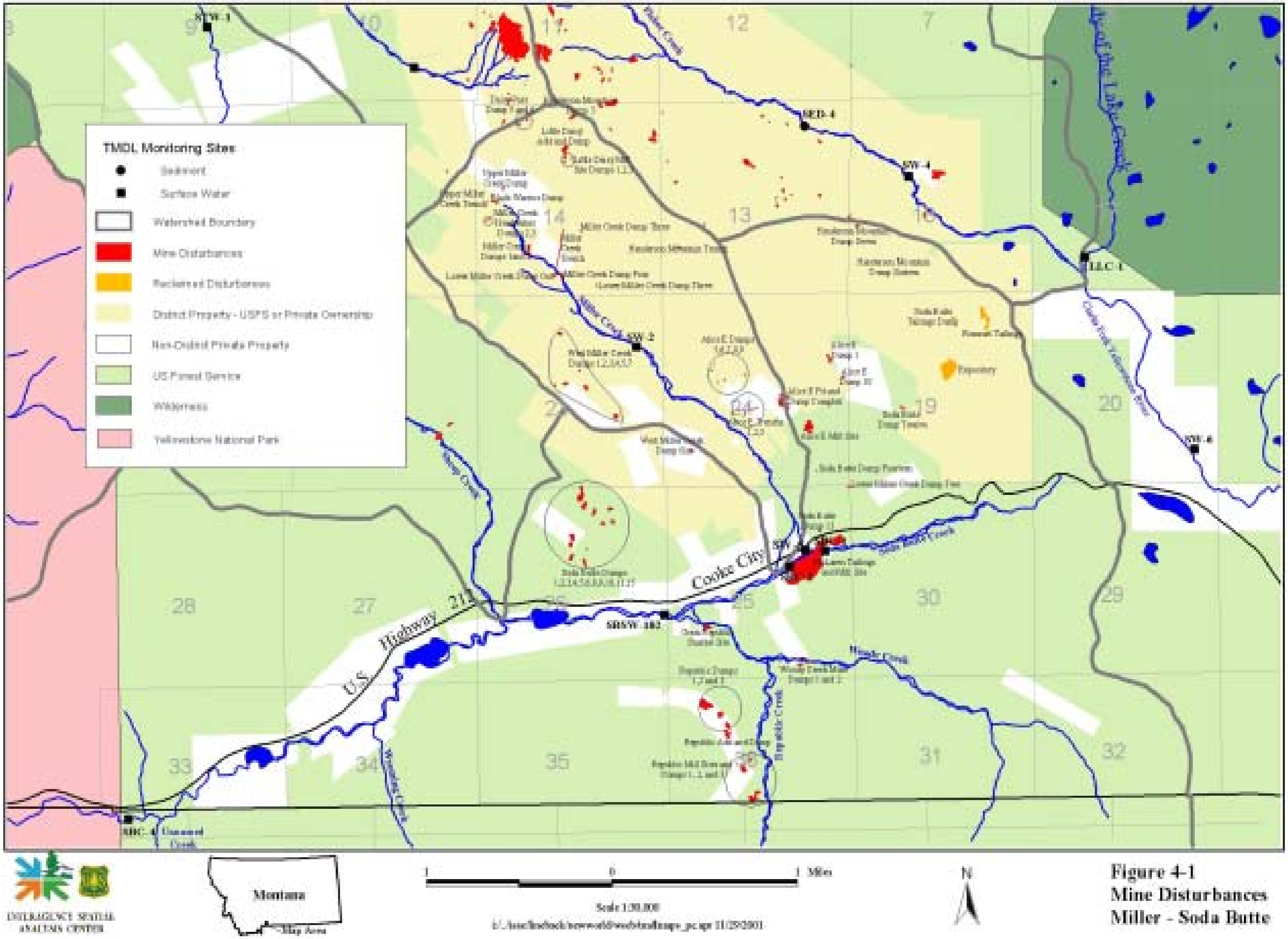


Figure 4-1
Mine Disturbances
Miller - Soda Butte

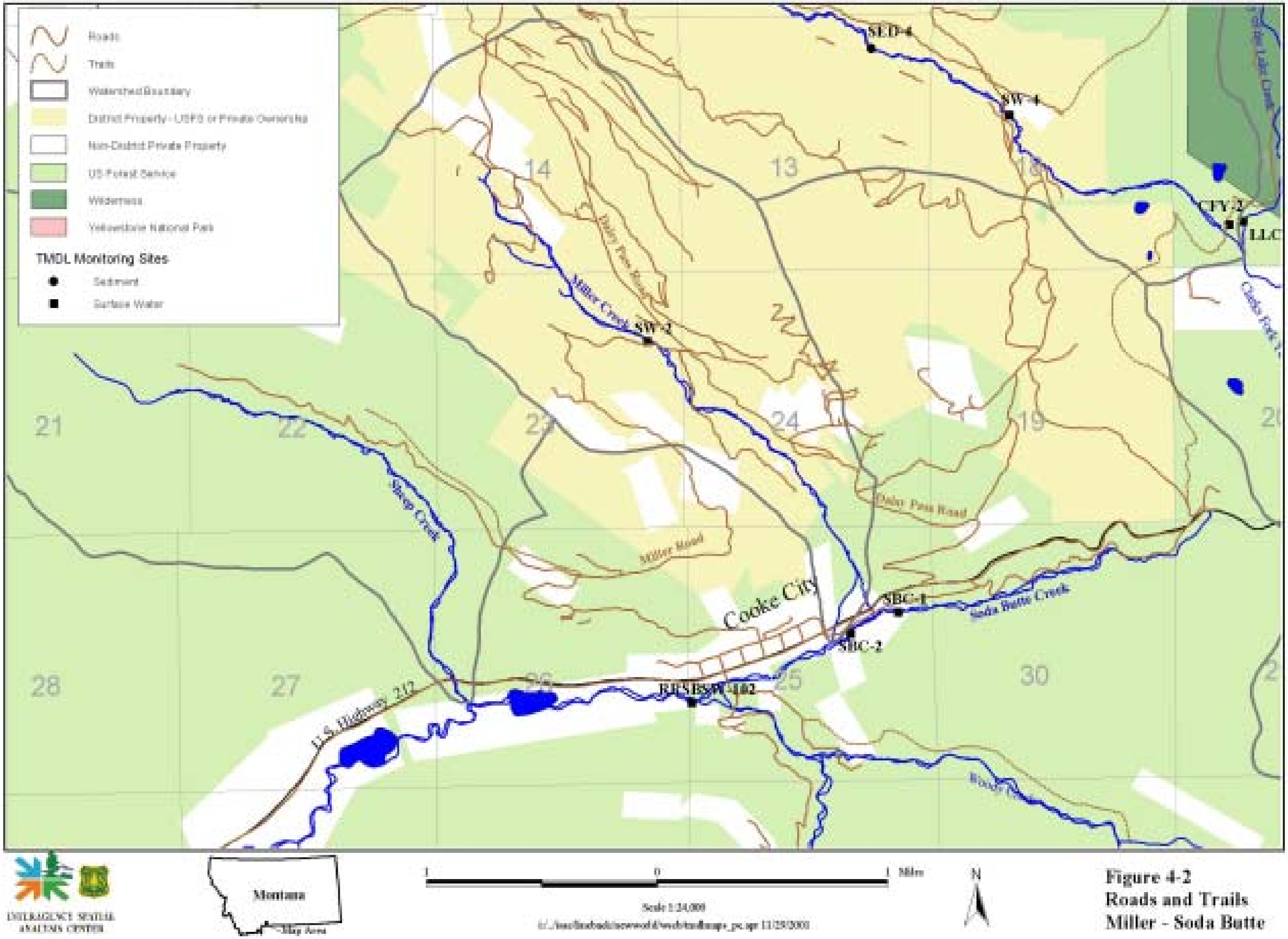


Figure 4-2
Roads and Trails
Miller - Soda Butte

APPENDIX A
TMDL DEFINITION, PURPOSE, AND CALCULATION

TMDL DEFINITION, PURPOSE, AND CALCULATION

TMDL Definition

A TMDL is defined under Section 75-5-103 of the Montana Water Quality Act as follows:

> "Total Maximum Daily Load or TMDL means the sum of the individual waste load allocations for point sources and load allocations for both nonpoint sources and natural background sources established at a level necessary to achieve compliance with applicable surface water quality standards." (75-5-103-32)

> "Waste load allocation means the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources." (75-5-103-34)

> "Load allocation means the portion of a receiving water's loading capacity that is allocated to one of its existing or future nonpoint sources or to natural background sources. (75-5-103-14)

> "Loading capacity means the mass of a pollutant that a water body can assimilate without a violation of water quality standards. For pollutants that cannot be measured in terms of mass, it means the maximum change that can occur from the best practicable condition in a surface water without causing a violation of the surface water quality standards." (75-5-103-15)

The above can be summarized as follows:

> TMDL = Loading Capacity = SUM(Waste Load Allocations) + SUM (Load Allocations) + Margin of Safety

The margin of safety is typically identified in the TMDL equation to account for uncertainty about the relationship between pollutant loads and receiving water quality, and is particularly important for TMDLs based on narrative versus numeric standards. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of the loading capacity (EPA, 1999).

In the process of developing a TMDL, an attempt is made to define the individual components of the TMDL, at least to a necessary level of detail to assist with water quality planning and restoration. The waste load allocations are typically applied to individual point sources, but can be applied to a category of point sources. The load allocation associated with natural background is a separate category that should be set equal to the existing natural background load for TMDL development purposes since it is generally not the intent of this process to pursue modifications to natural conditions. The remaining load allocation applies to nonpoint sources, and is typically applied to nonpoint source categories to address the overall cumulative effects from a given category and to better identify potential pollutant reductions through similar applications of best management practices. For example, "roads" represents a significant sediment source category within this water quality restoration plan. Although individual roads are identified, load allocations are applied to all roads within a specific drainage.

Because the ultimate goal is to reduce a given pollutant load to a level that will result in meeting water quality standards, allocations are often expressed as needed load reductions or in some cases as source control actions instead of allowable loads (reference EPA guidance). Even the TMDL is sometimes determined as a surrogate that represents a load reduction or control actions expected to result in meeting water quality standards.

The TMDL and associated allocations must also be determined such that water quality standards are satisfied during all applicable seasons. For example, the loading may need to be determined to address low flow conditions, high flow conditions, or possibly both. The TMDL and associated allocations should also include a factor of safety or other appropriate measure to address uncertainties in such things as loading determinations.

The Purpose of the TMDL

By including the above details, the TMDL development provides a framework that can and should be used to help prioritize and direct efforts to restore beneficial uses through water quality improvements. Thus the term *water quality restoration plan* is often used to more effectively describe the document, such as this one, which incorporates the TMDL and its components. The development and overall intent of a water quality restoration plan (plan) and associated TMDL can vary significantly between water bodies and even between pollutants for the same water body. Examples include situations where the information in the plan:

- provides some of the only documentation available to develop a scientifically defensible strategy, with public and local interest input, that revolves around efforts to improve water quality;
- more or less references work already completed or underway to meet restoration goals; and/or
- references documents and other studies geared toward water quality improvements and restoration of beneficial uses as driven by another program such as a Superfund cleanup site.

The process of water quality restoration plan and TMDL development, therefore, helps ensure that at least every impaired water body condition has an identified approach on how restoration can be achieved. People living within the watershed and in a position to help improve water quality can then become involved with efforts to directly improve water quality.

The second and third bullets above refer to the fact that TMDL development can be used to document successful restoration efforts, or can be used to help focus ongoing programmatic efforts in a direction that helps ensure proper consideration of water quality impairments and applicable Montana water quality standards. Much of the Cooke City area is covered under existing state and federal programs, such as Superfund, which address many of the specific TMDL development requirements, often at a level of detail not typically available for the majority of water bodies in Montana. Because of this significant ongoing effort, this plan generally references much of this ongoing work and the information found in associated planning documents.

TMDL Calculations

Where numeric standards based on metals concentrations exist, the total maximum daily load can be calculated as a function of flow and the applicable water quality standard or target where the standard is equal to the water quality restoration target. Throughout this document, flow data is given in cubic feet per second (cfs or ft^3/sec) and concentration data for most pollutants is in micrograms per liter (ug/l), which is the equivalent of parts per billion. The total maximum load can be calculated in lb/day or ug/sec as shown below, with the former providing a daily scale of measure and the latter providing useful loading rates per second for comparison to previous studies in the Cooke City area. The equation identifies the overall loading capacity to the stream, which comprised of the load and waste load allocations as discussed at the beginning of this appendix.

Total Maximum Load in lb/day

(X ug/l) (Y ft^3/sec) (0.00534) = (X)(Y)(0.00534) lb/day

Total Maximum Load in ug/sec

(X ug/l) (Y ft^3/sec) (28.1) = (X)(Y)(28.1) ug/sec

where:

X = the applicable water quality numeric standard (target) in ug/l;
Y = streamflow in cubic feet per second;
(0.00534) and (28.1) = conversion factors

The use of the above equations addresses all seasonal flow variations. Generally, calculations during low flow represent the most sensitive time period for most but not necessarily all pollutant-water body combinations.

For copper, cadmium, lead, and zinc, hardness also needs to be considered for aquatic life standards (Reference WQB-7; Note 12). The chronic aquatic life standard equation for these metals is identified below (WQB-7 also provides the applicable equation for acute aquatic life standards):

(X ug/l) = exp{mc[ln(hardness)] + bc}

where:

X = the water quality standard calculated as a function of hardness
mc = constant that varies by metal; values provided in WQB-7;
bc = constant that varies by metal; values provided in WQB-7;
hardness = hardness value in mg/l $CaCO^3$; use 400 if >400

For aluminum, iron, and manganese, the standard and any applicable targets are not a function of hardness.

In many situations, such as for sediment, it is not practical to calculate a total maximum daily load (TMDL). From a water quality management perspective, it is instead more practical to use a surrogate value for the TMDL. This surrogate value is often based on such things as the conditions reflecting beneficial use support, a yearly versus daily load, or the change to existing conditions (e.g. a percent reduction in load) needed to result in beneficial use support.

APPENDIX B
WATER QUALITY SUMMARIES FOR METALS AND pH
(BY WATERSHED)

DAISY CREEK AND STILLWATER RIVER WATER QUALITY SUMMARY FOR METALS OF CONCERN AND pH

Copper (Cu)

Total recoverable copper concentrations in Daisy Creek at sampling location DC5 range from 346 ug/l to 2850 ug/l. These values are routinely above the chronic and acute standards for aquatic life at high and low flow conditions. The values also routinely exceed the human health standard of 1300 ug/l. Higher concentrations occur during low flow conditions.

The total copper concentration in sediments at DC5 averages 4759 mg/kg based on information from the Maxim website, and is 1878 mg/kg based on more recent data (Camp, Dresser and McKee, 1997). These results are well above concentrations which negatively impact aquatic life (Camp, Dresser & McKee, 1994).

Total recoverable copper concentrations in the Stillwater River at sampling location SW7 range from below detection to 210 ug/l. These values are routinely above the chronic and acute standards for aquatic life at high and low flow conditions. Higher concentrations tend to occur during medium to higher flow conditions at this location. The average total copper concentration in sediments at SW7 is 2140 mg/kg based on information from the Maxim website, and is 1166 mg/kg based on more recent data (Camp, Dresser and McKee, 1997). These results are well above concentrations which negatively impact aquatic life (Camp, Dresser & McKee, 1994).

For the portion of the Stillwater River located above the confluence with Daisy Creek, total recoverable copper concentrations from 13 samples show that 12 samples range from below detection to 4 ug/l, and one sample is reported at 7 ug/l. This 7 ug/l occurred during a higher flow condition when the chronic aquatic life standard would be 6.8 mg/l based on actual measured hardness. MDEQ criteria for a (moderately) impaired water body under conditions such as this (MDEQ Appendix A to the 2000 303(d) List) reads as follows:

> "For any pollutant: Acute standards are exceeded by less than 25%; and/or chronic standards are exceeded by 10-50%; and/or water quality standards are exceeded in no more than 10% of the measurements from a large data set."

None of the above criteria for identifying a stream as being impaired for copper appear to be satisfied. The chronic standard is exceeded less than 10% of the time and only by 3%. This implies that the Stillwater River above Daisy Creek is not impaired for copper, although 13 samples may not constitute a large data set. MDEQ criteria further defines an unimpaired or least impaired water body (i.e. fully supports beneficial uses) as follows:

> "For any pollutant: No exceedence of acute or chronic standards, and/or the chronic standards are exceeded by less than 10% no more than once for one parameter in a three year period when measurements were taken at least four times/year (quarterly)."

The only criteria not met above is the three year quarterly sampling, which is difficult to accomplish given the winter conditions in this area. Nevertheless, sampling during the higher flow events of concern has occurred over several years, and indicates that copper may not be a problem for this stream segment.

Iron (Fe)

Total recoverable iron concentrations in Daisy Creek at sampling location DC5 range from 2380 ug/l to 6880 ug/l. At both higher and lower flow conditions, these values are routinely above the 1000 ug/l chronic acute standard for aquatic life (no hardness adjustments for iron). At both higher and lower flow conditions, the iron values in Daisy Creek are also routinely above the 300 ug/l guidance value for determining levels that will interfere with the specified uses, which is applicable due to the drinking water/domestic water beneficial use associated with a B-1 classification. Higher values occur during lower flow conditions. Precipitation of iron also contributes to objectionable streambed deposits.

Total recoverable iron concentrations in the Stillwater River at sampling location SW7 range from 70 ug/l to 1200 ug/l. These values occasionally are above the 1000 ug/l chronic acute standard for aquatic life and are also routinely above the 300 ug/l guidance value discussed above. Higher values of iron tend to occur during higher flow conditions. Precipitation of iron also contributes to objectionable streambed deposits, generally just downstream from the Daisy Creek confluence.

For the portion of the Stillwater River located above the confluence with Daisy Creek, total recoverable iron concentrations from 13 samples show that 12 samples range from very low values to 270 ug/l, and one sample is reported at 390 ug/l measured at a high flow condition. Iron loading during higher flows from this upper section of the Stillwater River may need to be considered when evaluating the ability to reach high flow cleanup goals at SW7.

Manganese (Mn)

Total recoverable manganese concentrations in Daisy Creek at sampling location DC5 range from 14 ug/l to 1230 ug/l. At both higher and lower flow conditions, these values are routinely above the 50 ug/l guidance value for determining levels that will interfere with the specified uses, which is applicable due to the drinking water/domestic water beneficial use associated with a B-1 classification. Higher values occur during lower flow conditions.

Total recoverable manganese concentrations in the Stillwater River at sampling location SW7 range from below detection to 80 ug/l. These values are often above the 50 ug/l guidance value discussed above. There are not any obvious flow related trends at this sampling location.

Total recoverable manganese concentrations are all below 50 ug/l at a sampling location in the Stillwater River above Daisy Creek.

Aluminum (Al)

Dissolved aluminum concentrations in Daisy Creek at sampling location DC5 range from 40 ug/l to 300 ug/l. Although aluminum values typically range well above the 87 ug/l chronic standard for aquatic life, this standard only applies to a pH range of 6.5 to 9.0. None of the data shows aluminum exceeding 87 ug/l at times when the pH was in this range. Precipitation of aluminum does, however, contribute to objectionable streambed deposits and high turbidity. Higher values occur during lower flow conditions. Total recoverable aluminum concentrations at DC5 range from 1,400 to 8,100 ug/l, which is an indicator of available aluminum for precipitation and resulting turbidity problems.

Dissolved aluminum concentrations in the Stillwater River tend to be low, but the precipitation of aluminum in Daisy Creek contributes to high turbidity and may also contribute to objectionable streambed deposits just below the confluence with Daisy Creek. At SW7, which is further downstream (Figure 1-5) turbidity due to aluminum precipitation does not appear to be a problem during low flow conditions. The total recoverable aluminum concentrations are consistently less than 200 ug/l during these low flow conditions at SW7.

Zinc (Zn)

Total recoverable zinc concentrations in Daisy Creek at sampling location DC5 range from 60 ug/l to 420 ug/l. These values are routinely above the chronic and acute standard for aquatic life at high and low flow conditions. Higher concentrations occur during low flow conditions.

Total recoverable zinc concentrations in the upper and lower portions of the Stillwater do not indicate a water quality impairment problem for this pollutant. The sediment data does indicate fairly high zinc levels in sediment at SW7, although this high level is not consistent with lower upstream sediment levels in both the Stillwater River just below Daisy Creek and within Daisy Creek.

Cadmium (Cd)

Total recoverable cadmium concentrations in Daisy Creek at sampling location DC5 range from less than 1 ug/l to 2.85 ug/l. These values are often above the chronic standards for aquatic life at high and low flow conditions, and sometimes above the acute standards for aquatic life at high and low flow conditions. There is a trend of higher concentrations at lower flow conditions.

Total recoverable cadmium concentrations in the upper and lower portions of the Stillwater River do not indicate a water quality impairment problem for this pollutant.

Lead (Pb)

Total recoverable lead concentrations in Daisy Creek at sampling location DC5 range less than 1 ug/l to 3 ug/l. These values are occasionally above the chronic standards for aquatic life at high and low flow conditions (Table 2-1). Flow related trends are not obvious. The average total lead concentration in sediments at DC5 is 76 mg/kg based on information on the Maxim website, and is 138 mg/kg based on more recent data (Camp, Dresser and McKee, 1997). These results are above concentrations which negatively impact aquatic life (Camp, Dresser and McKee, 1994).

Total recoverable lead concentrations in the upper portions of the Stillwater River and at site SW7, in addition to concentrations of lead in sediment samples, do not consistently indicate a water quality impairment problem for this pollutant. There are some indications that the Stillwater River may be impaired due to lead as measured further upstream. Any such conditions would be addressed via efforts to address lead concerns within Daisy Creek since that is where all the sources of lead have been identified.

pH

The pH values in Daisy Creek at sampling location DC5 range from 5.3 to 7.7. At both higher and lower flow conditions, these values are not consistent with applicable standards based on known acid drainage contributions and anticipated pH values in comparison to natural background conditions. Since pH is influenced by several contaminants and associated water chemistry alterations, the natural background conditions are difficult to predict although many waters in Montana fall within the range of 6.0 to 9.0. Acid mine drainage conditions are a prime source of lowered pH in Daisy Creek and are closely tied to the other metal impairments. There is an apparent trend of lower pH values during lower flow conditions.

Water quality results for pH in the upper and lower portions of the Stillwater River do not indicate a water quality impairment problem for this parameter.

FISHER CREEK AND CLARKS FORK RIVER WATER QUALITY SUMMARY FOR METALS OF CONCERN AND pH

Copper (Cu)

Total recoverable copper concentrations in Fisher Creek at sampling location SW3 range from 30 ug/l to 1530 ug/l, and at SW4 range from below detection to 180 ug/l. These values, particularly at SW3, are consistently above the chronic and acute standards for aquatic life at high and low flow conditions. The highest concentrations occur during the late summer and autumn low flow conditions.

Total recoverable copper concentrations in the Clarks Fork River at sampling location SW6 range from below detection to 70 ug/l. These values are routinely above the chronic and acute standards for aquatic life at high and low flow conditions. There may be a trend of higher concentrations during higher flow conditions at this location.

The total copper concentrations in stream sediments is as high as 1176 mg/kg in Fisher Creek at SW4, and 1162 mg/kg in the Clarks Fork River (Camp, Dresser and McKee, 1997). These results are well above concentrations which negatively impact aquatic life (Camp, Dresser & McKee, 1994).

Iron (Fe)

Total recoverable iron concentrations in Fisher Creek at sampling location SW3 range from 40 ug/l to 11,600 ug/l, and at SW4 range from 30 ug/l to 3170 ug/l. These values are consistently above the 1000 ug/l chronic acute standard for aquatic life (no hardness adjustments for iron) at SW3. At both higher and lower flow conditions, the iron values in Fisher Creek are also routinely above the 300 ug/l guidance value for determining levels that will interfere with the drinking water/domestic water beneficial use associated with a B-1 classification. Higher values tend to occur at lower flow conditions at SW3, but during higher flow conditions at SW4 since much of the iron has precipitated out upstream of SW4 during low flow conditions and is possibly re-suspended during the higher flows. Precipitation of iron also contributes to objectionable streambed deposits.

Total recoverable iron concentrations in the Clarks Fork River do not appear to be consistently high enough to cause an impairment to beneficial uses. There is one historical value of 2,880, but this value is not consistent with multiple other sample results during similar flows and time periods when the data shows iron levels consistently below 300 ug/l.

Manganese (Mn)

Total recoverable manganese concentrations in Fisher Creek at sampling location SW3 range from 160 ug/l to 1670 ug/l, and at SW4 range from less than 10 ug/l to 160 ug/l. At SW3, these values are consistently above the 50 ug/l guidance value for determining levels that will interfere with the specified uses, which is applicable due to the drinking water/domestic water beneficial use associated with a B-1 classification. Higher values tend to occur during lower flow conditions.

Total recoverable manganese concentrations in the Clarks Fork River are not high enough to cause an impairment to beneficial uses.

Aluminum (Al)

Dissolved aluminum concentrations in Fisher Creek at sampling location SW3 range from 1360 ug/l to 5000 ug/l, and at SW4 range from less than 100 ug/l to 1300 ug/l. Some of the values at SW4 exceed the 87 ug/l chronic standard for aquatic life within the pH range of 6.5 to 9.0, whereas the pH is consistently below 6.5 at SW3 when elevated dissolved aluminum values have been detected. Precipitation of aluminum contributes to objectionable streambed deposits and high turbidity at upstream locations where total recoverable aluminum concentrations are also high. Total recoverable aluminum concentrations at SW3 range from 1100 ug/l to 4800 ug/l, and at SW4 range from less than 100 ug/l to 1100 ug/l. This total recoverable aluminum is an indicator of available aluminum for precipitation and resulting turbidity problems. Higher upstream values of aluminum occur during low flow conditions.

Dissolved aluminum concentrations in the Clarks Fork River are not high enough to cause an impairment to beneficial uses, nor does there appear to be a problem with streambed deposits and increased turbidity from aluminum.

Zinc (Zn)

Total recoverable zinc concentrations in Fisher Creek at sampling location SW3 range from 30 to 290 ug/l, and at SW4 range from less than 10 ug/l to 80 ug/l. These values, particularly at SW3, are consistently above the chronic and acute standard for aquatic life at high and low flow conditions. Higher concentrations occur during low flow conditions.

Total recoverable zinc concentrations in the Clarks Fork River at sampling location SW6 range from less than 10 ug/l to 50 ug/l. These values are sometimes just above the chronic and acute standard for aquatic life at high flow (softer water) conditions only.

Cadmium (Cd)

Total recoverable cadmium concentrations in Fisher Creek at sampling location SW3 range from less than 0.1 ug/l to 2.2 ug/l, and at SW4 range from less than 0.1 ug/l to 2 ug/l. These values are often above the chronic standard for aquatic life at high and low flow conditions, and sometimes exceed the acute standard for aquatic life. There is a trend of higher concentrations at lower flow conditions.

Total recoverable cadmium concentrations in the Clarks Fork River at sampling location SW6 are typically below detection, although three detections during high flow conditions (1, 2, and 80 ug/l) exceed both the chronic and acute aquatic life standards for cadmium, and the highest concentration exceeds the human health criteria associated with a drinking water use. It is unknown at this time if the 80 ug/l represents an actual stream concentration or is associated with a lab or sampling error.

Lead (Pb)

Total recoverable lead concentrations in Fisher Creek at sampling location SW3 range from less than 3 ug/l to 9 ug/l, and at SW4 range from less than 1 ug/l to 10 ug/l, often above aquatic life standards. Total recoverable lead concentrations in the Clarks Fork River are not high enough to exceed water quality standards. Sediment data shows elevated levels of lead at concentrations that appear to be harmful to aquatic life in both Fisher Creek and the Clarks Fork River (Camp, Dresser and McKee, 1994 & 1997).

Silver (Ag)

Total recoverable silver concentrations in Fisher Creek at sampling location SW3 range from less than 0.5 ug/l to 1.1 ug/l, and at SW4 range from less than 0.2 ug/l to 9 ug/l. These results represent only a few detections at each location which exceed the acute aquatic life standards. The detections and higher concentrations tend to occur at lower flow conditions.

The Kimball et al. study provides silver sample results along several locations along Fisher Creek and for several tributaries. All sampling was done on August 19, 1997. The results indicate a few locations where silver was found to be slightly above the 4 ug/l detection limit, and therefore greater than the aquatic life support standard.

Total recoverable silver concentrations in the Clarks Fork River at sampling location SW6 range from less than 0.2 to 30 ug/l. These results reflect only two detections, both of which exceed the acute aquatic life standard. It is unknown at this time if the 30 ug/l represents an actual concentration in the stream or is associated with a lab or reporting error, especially since it occurs on the same day as the high cadmium concentration whereas other metal concentrations on this same day are relatively low.

pH

The pH values based on field conditions in Fisher Creek at sampling location SW3 range from 2.9 to 6.6, with most values well below 5.0, and at SW4 range from 5.3 to 7. At both higher and lower flow conditions, these values, particularly at SW3, are not consistent with applicable standards based on known acid drainage contributions and anticipated pH values in comparison to natural background conditions. Since pH is influenced by several contaminants and associated water chemistry alterations, the natural background conditions are difficult to predict although most waters in Montana fall within the range of 6.0 to 9.0. Acid mine drainage conditions are a prime source of lowered pH in Fisher Creek and are closely tied to the other metal impairments. There is an apparent trend of lower pH values during lower flow conditions.

Water quality results for pH in the Clarks Fork River also indicate a possible problem, with values ranging from 4.8 to 9.4. Not many pH values are below 6.0, and they tend to occur during higher flow periods.

MILLER CREEK AND SODA BUTTE CREEK WATER QUALITY SUMMARY FOR METALS OF CONCERN

Copper (Cu)

Total recoverable copper concentrations in Miller Creek at sampling location SW5 range from 1 ug/l to 200 ug/l. These values are often above the chronic and acute aquatic life support standards, generally during higher flow conditions. Except for two sample events, all copper values are less than 30 ug/l. These two sample events occurred during two of the four highest sampled flows at SW5. Both high sample results are supported by similar high sample results at upstream location SW2 collected during the same day. Both sampling events were within two weeks of each other during June 1990.

Sediment data for Miller Creek consistently shows high levels of copper up to approximately 540 mg/kg. These results are above concentrations which negatively impact aquatic life (Camp, Dresser, McKee, 1994).

Total recoverable and dissolved copper concentrations in Soda Butte Creek are typically at levels below standards. Some of the dissolved copper data from Nimmo et al (1999) are at higher levels (up to 9 ug/l) than the Montana Water Quality Standards in WQB-7, which are based on total recoverable metals. Values of total recoverable metals should always be as high or higher than dissolved metals values. Therefore, if a dissolved concentration exceeds the standard, then it can be assumed that the total recoverable concentration would also exceed the standard. Higher copper values seem to occur during higher flow periods when the copper is more of a concern due to lower water hardness and a lower applicable standard.

The USGS data near SBC4 (USGS, 2001) for the 1999 through 2000 period show total recoverable copper values ranging from below 10 ug/l to 22.4 ug/l at high flows, and one value at 11 ug/l during winter low flow. The use of relatively high detection levels for total recoverable copper makes it difficult to fully evaluate this data and the USGS synoptic data with respect to Montana's water quality standards.

The Maxim website information shows that total recoverable copper levels all along Soda Butte Creek commonly range from 1 to 8 ug/l, with at least one concentration and hardness combinations leading to conditions where the aquatic life support standard is exceeded. It is worth noting that there is limited high flow data in comparison to the USGS data discussed above.

Sediment data for Soda Butte Creek indicates a copper problem, with sediment levels as high as 1200 mg/kg downstream or adjacent to the McLaren Tailings (Nimmo, et. al, 1999). Other studies with limited numbers of in-stream sediment samples in this vicinity have resulted in values below 300 mg/kg (Pioneer, 2001a), some or all of which may be below levels of concern (Camp, Dresser and McKee, 1994)

Iron (Fe)

Total recoverable iron concentrations in Miller Creek at sampling location SW5 range from 30 to 3220 ug/l. These values are consistently above the 1000 ug/l chronic acute standard for aquatic life (no hardness adjustments for iron) during high flow periods only. These high flow values are also routinely above the 300 ug/l guidance value for determining levels that would interfere with the drinking water/domestic water beneficial use associated with a B-1 classification.

Total recoverable iron concentrations in Soda Butte Creek at sampling location SBC-2 or in the vicinity have ranged from 460 ug/l to 3160 ug/l. These values are routinely above the 1000 ug/l chronic standard for aquatic life during low flow periods and above the 300 ug/l drinking water/domestic use support level. Precipitation of iron also contributes to objectionable streambed deposits downstream from the McLaren Tailings during these same low flow periods. There is a lack of data in this location for high flow periods such as those that cause very high iron values in Miller Creek (discussed above) and further downstream in Soda Butte Creek (discussed below).

At sampling location SBC-4, which is just upstream of Yellowstone National Park, the total recoverable iron values range from 150 ug/l to 6260 ug/l. These values are sometimes above the 1000 ug/l acute aquatic life standard during higher flow periods. The values are also routinely above the 300 ug/l guidance value for determining levels that will interfere with drinking water/domestic use associated with a B-1 or A-1 stream classification.

Manganese (Mn)

Total recoverable manganese concentrations in Miller Creek at sampling location SW5 range from less than 10 ug/l to 130 ug/l. At high flow conditions, the values are routinely above the 50 ug/l guidance value for determining levels that will interfere with the specified uses, which is applicable due to the drinking water/domestic water beneficial use associated with a B-1 classification.

Total recoverable manganese concentrations in Soda Butte Creek at sampling location SBC-2 range from less than 10 ug/l to 160 ug/l. These values are consistently above the 50 ug/l standard discussed above. Manganese values at SBC-4 are below 50 ug/l, except at the highest measured flows when values can be as high as 210 ug/l.

Zinc (Zn)

Total recoverable zinc concentrations in Miller Creek at sampling location SW5 range from less than 10 ug/l to 460 ug/l. There are only three values out of 28 at levels above the applicable standard. Upstream at SW2, only one value out of t 23 is above the applicable standard. This value is 190 ug/l. It is difficult to identify a flow-related trend.

Zinc results indicate that this metal is not a beneficial use problem in Soda Butte Creek, and therefore a zinc TMDL is not developed for this water body.

Cadmium (Cd)

Total recoverable cadmium concentrations in Miller Creek at sampling location SW5 range from less than 0.1 ug/l to 0.4 ug/l. There are only a few values that are greater than the chronic standard for aquatic life, and these only occur at the highest flows.

Cadmium results indicate that this metal is not a beneficial use problem in Soda Butte Creek, and therefore a cadmium TMDL is not developed for this water body, although the McLaren Tailings is contributing cadmium to Soda Butte Creek at elevated levels (Boughton, 2001).

Lead (Pb)

Total recoverable lead concentrations in Miller Creek at sampling location SW5 range from less than 2 ug/l to 22 ug/l. There are only a few values that are greater than the aquatic life standards, and these tend to occur at the higher flows. One value is also greater than the human health standard of 15 ug/l. Sediment data from two different sources show elevated lead levels above 85 mg/kg (Personal communication with Tom Cleasby; Camp, Dresser and McKee, 1997). These results are above concentrations which negatively impact aquatic life (Camp, Dresser, McKee, 1994).

Total recoverable lead concentrations in Soda Butte Creek at sampling location SBC4 range from below detection to 13 ug/l with one value at 58 ug/l. There are only a few values that are greater than the aquatic life or human health standards, and these all occur at high flows. At sampling location SBC2, lead values tend to be below detection except for one value at 2 ug/l, which is less than the aquatic life standards given hardness values on that same day, indicating that lead may not be a significant problem under low flow conditions. Nevertheless, the McLaren Tailings are contributing lead to Soda Butte Creek at elevated levels (Boughton, 2001), which possibly contribute to elevated lead levels in stream sediments.

Aluminum (Al)

Total recoverable aluminum concentrations in Miller Creek at sampling location SW5 range from 200 ug/l to 1800 ug/l. Corresponding dissolved aluminum data is not available during these high flows. Therefore, it is difficult to know if the 87 ug/l chronic standard for aquatic life, which is based on dissolved aluminum within a given pH range, has been exceeded or not.

Dissolved aluminum values are typically low in Soda Butte Creek near sample locations SBC2 and SBC4. During very high flow events, total recoverable aluminum values from the USGS gaging station data located at or near SBC4 are as high as 4640 ug/l, although the corresponding dissolved aluminum values are all low (<18 ug/l). There is one value of high dissolved aluminum (200 ug/l) from 1994 sampling at SBC4. The synoptic sample results (Boughton, 2001) show several stream reaches between Woody Creek and Yellowstone National Park where there are elevated dissolved aluminum levels, with one value as high as 163 ug/l. Both the 163 and 200 ug/l values are above the standard given the corresponding pH levels

APPENDIX C

DISCUSSION, SUMMARY AND CONCLUSIONS FOR DAISY CREEK AND STILLWATER RIVER METALS SOURCES (EXCERPT FROM NIMICK AND CLEASBY, 2001)

METAL SOURCES

Copper is the metal of most concern in Daisy Creek because it occurs at higher concentrations than other metals and can be toxic to aquatic life. Therefore, sources of copper loading are discussed in this section. The sources of the other metals in Daisy Creek, with the occasional exception of lead, are thought to be the same as copper. The magnitude and source of copper loads contributed to subreaches of Daisy Creek from surface and subsurface inflows are presented in table 2.

Copper loading to Daisy Creek was substantial in the reach upstream of mainstem site 5,475 (fig. 15). This reach can be divided into five subreaches on the basis of the different source areas that contribute copper to Daisy Creek (table 2). Dissolved copper loads are discussed here because, in this reach, almost all of the copper load is dissolved. Sources of copper included right-bank surface inflows and subsurface inflow. Left-bank inflows contributed less than 0.02 percent of the entire copper load in this reach.

The upstream subreach (between sites 0 and 270) flows past a small, right-bank hill composed of landslide or glacial-moraine deposits. This subreach had minor copper loading (461 µg/s) from an inflow on the south side of the hill (inflow site 74) and from streamside seeps at its base (inflow sites 114 and 161). Subsurface inflow also contributed a small copper load (151 µg/s) to Daisy Creek (table 2).

The second subreach (between sites 270 and 460) received a substantial copper load (10,100 µg/s). Most of this load came from the four right-bank surface inflows (sites 292, 348, 401, and 411) that originate in the manganese bog adjacent to Daisy Creek. Copper loading from subsurface inflow was small (251 µg/s).

In the third subreach (between sites 460 and 611), one right-bank inflow (site 481), enters Daisy Creek and contributed more copper (16,400 µg/s) to Daisy Creek than all other surface inflows combined (table 7). This inflow drains the southern part of the McLaren Mine (fig. 2), where much of the mine wastes are stockpiled and where substantial unmined mineralized rock remains. Unlike the two upstream subreaches, copper loading from subsurface inflow (8,900 µg/s) in this part of Daisy Creek was substantial.

In the fourth subreach (between mainstem site 611 and inflow site 1,700), subsurface inflow contributed almost all the copper loading (7,040 µg/s). The most prominent right-bank inflows (sites 691 and 1,700, which drain the northern part of the McLaren Mine) contributed only 143 µg/s (table 7). The copper loading from these two sites and the other four right-bank inflows was only 245 µg/s. Although inflow site 1,700 was not a significant source of copper to Daisy Creek, the inflow did contribute a relatively large load of dissolved lead (6.11 µg/s), almost as high as the load contributed by inflow site 481 (7.45 µg/s, table 7).

The fifth, and most downstream, subreach (between sites 1,700 and 5,475) is the longest of the five subreaches. Surface inflows to this subreach do not drain the McLaren Mine. Copper loading from surface inflows was negligible (2 µg/s) while subsurface loading (6,210 µg/s) was relatively large, although smaller than in the two previous upstream subreaches.

Table 2. Sources of dissolved copper to subreaches of Daisy Creek, Montana, August 26, 1999

[Values listed for loads have been rounded. Abbreviations: µg/s, micrograms per second. Symbol: <, less than]

Subreach description[1]	Subreach extent		Dissolved copper load (µg/s)			
	Upstream site	Downstream site	Right-bank inflows	Left-bank inflows	Subsurface inflow[2]	Combined surface plus subsurface
Moraine or landslide hill	0	270	461	<1	151	612
Manganese bog	270	460	9,830	4	251	10,100
Southern part of McLaren Mine area	460	611	16,400	4	8,900	25,300
Northern part of McLaren Mine area	611	1,700	245	<1	7,040	7,290
Area north and west of McLaren Mine	1,700	5,475	2	<1	6,210	6,210
TOTAL			26,900	8	22,600	49,500

[1]Describes area from which metal-rich surface drainage to subreach is derived.

[2]Calculated as the difference between the gain in instream load between upstream and downstream sites and the sum of the loads in the right-bank and left-bank inflows within the subreach.

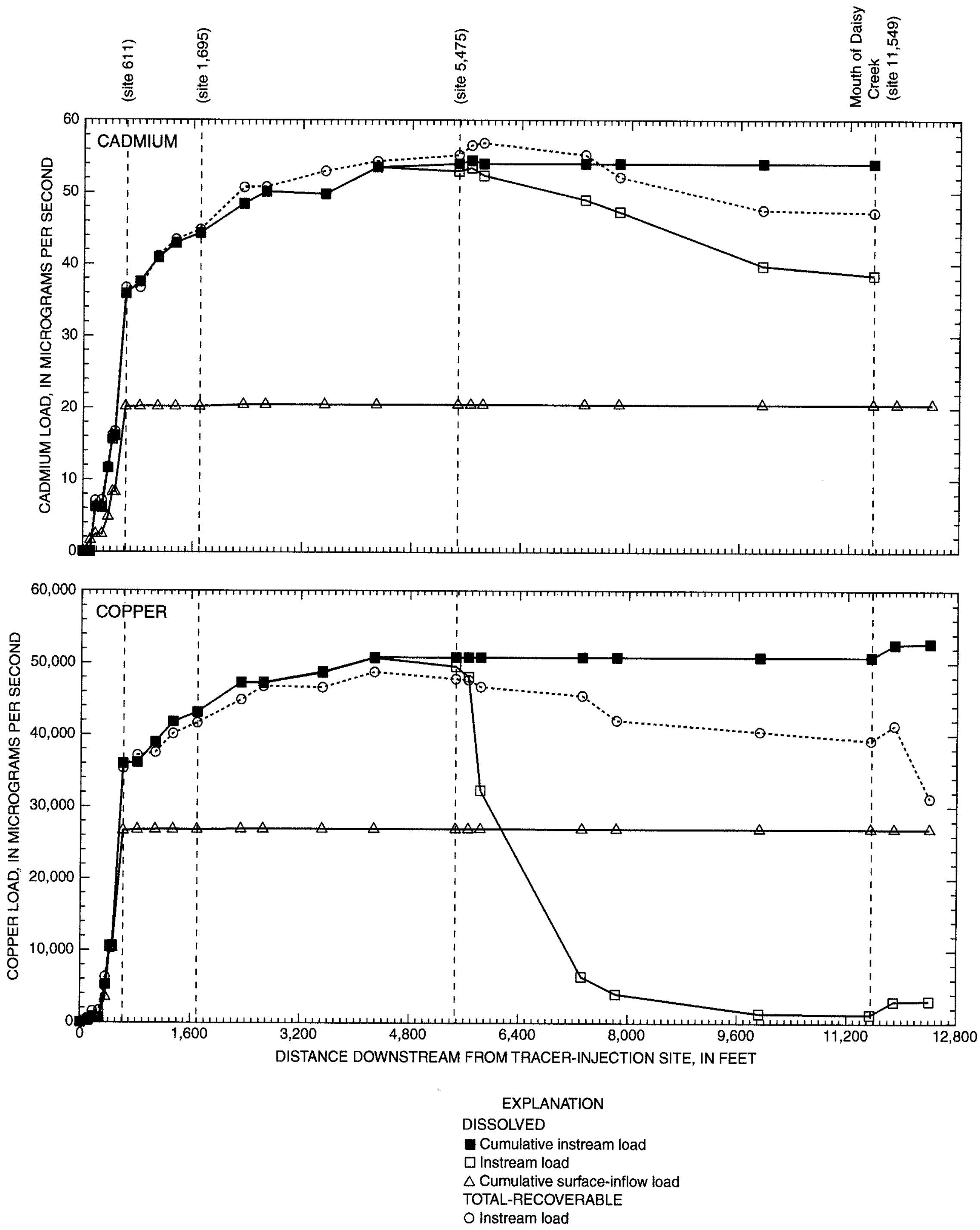


Figure 15. Downstream profiles of cadmium (top) and copper (bottom) loads in Daisy Creek and the Stillwater River, Montana, August 26, 1999.

In summary, the most substantial copper loading to Daisy Creek (71 percent of the total copper load contributed to the entire study reach) occurred between sites 270 and 611, where right-bank inflows originate in the manganese bog and the southern part of the McLaren Mine. About 53 percent of the total load in the study reach was contributed by the five right-bank inflows in this 341-ft reach, with inflow site 481 (33 percent of the total) being the most important. Copper loading to Daisy Creek from all surface inflows downstream from mainstem site 611, including the surface inflows that drain the northern part of the McLaren Mine, was not significant, at least during the low-flow conditions that existed during this study. While surface inflows contributed the most copper to Daisy Creek upstream of site 611, subsurface loading was the only important source of copper for the longer downstream reach between sites 611 and 5,475. Subsurface loading in this reach contributed over half of the total subsurface loading to Daisy Creek and 27 percent of the total load to Daisy Creek.

Although the subsurface inflow to Daisy Creek was not sampled, copper concentrations in the subsurface inflow (table 3) can be calculated from the subsurface inflow rates and copper loads contributed by subsurface inflow. These calculations assumed that one-half of the subsurface inflow came from the right bank and was metal rich; the subsurface inflow from the left bank was assumed to contribute no copper load to Daisy Creek. For the reach between sites 460 and 611, the calculated dissolved copper concentration (26,200 µg/L) in subsurface inflow from the right bank is similar to the concentration in some of the nearby right-bank inflows (for example, sites 292, 348, and 401), indicating that the subsurface pathway feeds both the right-bank surface and subsurface inflows. Calculated copper concentrations for subsurface inflow between sites 611 and 5,475 were lower, but substantially higher than concentrations in surface inflows in that reach. The pH and copper concentrations in the subsurface flow vary spatially, most likely in response to the varying amounts of alteration and buffering capacity in the rocks along different subsurface flow paths, as well as to dilution provided by any deeper ground water flowing from areas of unaltered bedrock.

Much of the metal-rich subsurface inflow to Daisy Creek probably was acidic. Although pH was not measured in subsurface flow, this hypothesis is supported by the presence of dissolved aluminum in the subsurface inflow. Aluminum is only likely to be dissolved where the pH is less than about 4.5 (Stumm and Morgan, 1996, p. 273).

The copper load entering Daisy Creek between sites 270 and 1,700 as surface and subsurface inflow is derived from the McLaren Mine area. Although this copper load has been divided between surface and subsurface inflows (table 2), in reality virtually none of this load comes directly from the McLaren Mine to Daisy Creek as surface flow. Almost all of the right-bank channels (except site 1,700) were dry from the McLaren Mine area to within a short distance of Daisy Creek. Flow in these short reaches near Daisy Creek was maintained by subsurface inflow. Determining the source of the subsurface inflow to Daisy Creek and

Table 3. Calculated concentrations of dissolved copper in subsurface inflow to subreaches of Daisy Creek, Montana, August 26, 1999

[Abbreviations: L/s, liters per second; µg/L, micrograms per liter; µg/s, micrograms per second]

Subreach description[1]	Subreach extent		Subsurface inflow		
	Upstream site	Downstream site	Flow[2] (L/s)	Dissolved copper load[3] (µg/s)	Calculated dissolved-copper concentration[4] (µg/L)
Moraine or landslide hill	0	270	0.40	151	755
Manganese bog	270	460	.21	251	2,390
Southern part of McLaren Mine area	460	611	.68	8,900	26,200
Northern part of McLaren Mine area	611	1,700	1.63	7,040	8,640
Area north and west of McLaren Mine	1,700	5,475	3.12	6,210	3,980

22,552 subsurface

[1]Describes area from which metal-rich surface drainage to subreach is derived.
[2]Calculated from data in table 5.
[3]Data from table 2.
[4]Concentrations are for right-bank surface inflows. Assumes that one-half of subsurface inflow came from right side of Daisy Creek and that subsurface inflow from left side of Daisy Creek contributes no copper load.

inflow channels is difficult because several possible sources exist within the McLaren Mine area. These sources include the mineralized rocks of Fisher Mountain upgradient of the McLaren Mine area, the surficial waste rock at the mine, and the underlying bedrock, which hosts both the McLaren ore deposit and the surrounding altered rock that is pyritic. More detailed hydrogeologic information would be needed to determine the importance of each of these sources.

The occurrence of metal-rich subsurface inflow to Daisy Creek upstream and downstream from the tributaries that drain the McLaren Mine area indicates that bedrock to the south and north of the McLaren Mine area apparently is a source of acid rock drainage not related to mining. The small subsurface metal load that discharges to Daisy Creek upstream of site 104 may be derived from the Chimney Rock area (fig. 1). The larger subsurface metal load that discharges to Daisy Creek downstream from site 1,700 may be derived from Fisher Mountain. The ferricrete deposits mapped by Furniss and others (1999) near site 2,334 and dated as 6,490 radiocarbon years before present support the hypothesis that unmined bedrock is one of the current sources of metals to Daisy Creek. However, this subsurface flow has not been directly measured. Monitoring well MW-3 (fig. 2) presumably should intercept this subsurface flow, but water-quality data for samples collected from the well do not support this hypothesis. This shallow well is completed in unconsolidated surficial material and the Wolsey Shale with a screen that extends from 16 to 46 ft below ground surface (Hydrometrics, Inc., 1990). Five samples collected during 1989-90 had pH values greater than 7 and low dissolved-metal concentrations. Cadmium, copper, and lead concentrations were at or less than minimum reporting levels (Michael Cormier, Maxim Technologies, Inc., written commun., 1999). Manganese (230-380 µg/L) and zinc (10-100 µg/L) concentrations were higher than minimum reporting levels but much lower than would be expected if ground water at this site were affected by acid rock drainage.

Cleanup activities that reduce metal and acid loading from the McLaren Mine area will result in improvements in water quality in Daisy Creek and the Stillwater River. Metal concentrations likely would decrease, and pH values in reaches that are currently acidic likely would increase. However, potential reductions in metal and acid loading and changes in pH and metal concentrations are difficult to predict because the ultimate source of the metals and acid are not well defined. In addition, decreasing copper concentrations during baseflow conditions to values less than the aquatic-life standards may be impossible because of natural sources of copper in unmined mineralized and altered bedrock. If the assumptions are made that all copper loading upstream of site 1,700 comes from sources at the McLaren Mine and that these sources can be removed or isolated, the copper load (6,210 µg/s, table 2) contributed by subsurface inflow derived from bedrock away from the mine between sites 1,700 and 5,475 would result in a copper concentration in Daisy Creek of about 450 µg/L at site 5,475 compared to the 3,570 µg/L measured in this study (table 6). Because the assumed cleanup activities likely would substantially reduce acid loading, thereby resulting in higher pH values, iron and aluminum colloids would be present and some copper likely would be adsorbed to this material. Therefore, this calculated copper concentration represents a total-recoverable concentration; the dissolved copper concentration would be lower. Downstream, at the mouth of Daisy Creek (site 11,549), the estimated total-recoverable copper concentration would be about 190 µg/L under base-flow conditions compared to the 1,200 µg/L measured during this study. Both calculated copper concentrations are higher than the acute aquatic-life standard of 13 µg/L (assuming a hardness of 100 mg/L, U.S. Environmental Protection Agency, 1999). Farther downstream, the maximum total-recoverable copper concentration in the Stillwater River at the end of the study reach (site 12,410) would be about 35 µg/L compared to the 176 µg/L measured in this study. These calculated copper concentrations are based on the copper loading and streamflow conditions that existed during the short period during which this study was conducted. Concentrations would vary to an unknown degree as hydrologic conditions in the drainage basin changed.

The toxicity of copper (and other metals) is dependent on the hardness of the water. If the metals load in Daisy Creek were reduced, hardness values also would be lower because the right-bank and subsurface inflows contributing metals also contribute calcium and magnesium. Therefore, in considering post-cleanup hardness values to use to compute aquatic-life standards, the values in left-bank inflows (generally less than 100 mg/L) or the Stillwater River (58 mg/L) may represent potential post-cleanup values.

SUMMARY AND CONCLUSIONS

A metal-loading study was conducted during August 24-27, 1999, to quantify and identify the principal sources of metal loads to Daisy Creek and to examine the downstream transport of these metals into the Stillwater River. Water-quality and aquatic conditions in Daisy Creek have been affected by acid rock drainage derived from waste rock and adit discharge at the McLaren Mine as well as from natural weathering of pyrite-rich altered and mineralized rock that makes up and surrounds the ore zones in the New World Mining District. Knowledge of the main sources and transport pathways of metals and acid can aid resource managers in planning and conducting effective and cost-efficient remediation activities.

The study reach included virtually all of Daisy Creek and a 850-ft reach of the Stillwater River downstream from the confluence of Daisy Creek. Metal loads in the mainstem were quantified from streamflow data determined by tracer injection and water-quality data determined from synoptic samples. Loads contributed by surface inflows were determined from these data as well as supplemental streamflow measurements made using conventional methods. Downstream changes in metal loads in the stream then were attributed to sources along the stream as well as to instream geochemical reactions. These sources included visible surface inflows and diffuse subsurface inflows.

The metals cadmium, copper, lead, and zinc have concentrations sufficiently elevated to be of concern for aquatic life in Daisy Creek and the Stillwater River. Copper is the most important of these toxic metals, with a maximum dissolved concentration of nearly 5,800 mg/L measured in Daisy Creek during this study. Metal concentrations increased sharply in the short reach between the tracer-injection site and a site 611 ft downstream, where the highest concentrations measured in Daisy Creek occurred. Acidic, right-bank (mined side) inflows in this reach had dissolved concentrations as high as 20.6 µg/L cadmium, 26,900 µg/L copper, 76.4 µg/L lead, and 3,000 µg/L zinc. These inflows resulted in maximum dissolved concentrations in Daisy Creek of 5.8 µg/L cadmium, 5,790 µg/L copper, 3.8 µg/L lead, and 848 µg/L zinc. Left-bank inflows in this upstream reach consistently had low concentrations (<1 µg/L cadmium, <21 µg/L copper, <1 lead, and <4 µg/L zinc), similar to the values in Daisy Creek at the tracer-injection site. Downstream from mainstem site 611, concentrations of metals decreased to the end of the study reach.

Significant copper loading to Daisy Creek only occurred in the reach upstream of mainstem site 5,475. Sources included right-bank surface inflows and subsurface inflow; copper loads in left-bank surface inflows were virtually nonexistent. The most significant metal loading (71 percent of the total copper loading in the study reach) occurred between mainstem sites 270 and 611. About 53 percent of the total load was contributed by the five right-bank inflows in this reach. Four of these inflows drain the manganese bog that is on the right bank between mainstem sites 270 and 460. Just downstream, inflow site 481, which heads in the southern part of the McLaren Mine, contributed the single largest amount of copper, or about 33 percent of the total copper load in the study reach.

Copper loading from subsurface inflow is substantial, contributing 46 percent of the total dissolved copper load to Daisy Creek. Most of this subsurface copper loading occurred in the reach of Daisy Creek downstream from the reach that received surface loading.

Flow through the shallow subsurface is an important copper-transport pathway from the McLaren Mine and surrounding altered and mineralized bedrock to Daisy Creek during base-flow conditions. The pH and metal concentrations in the subsurface flow probably varied in response to the varying amounts of alteration and buffering capacity in the rocks along different subsurface flow paths. Unfortunately, little is known about the source of acid and copper in this subsurface flow. Possible sources include the mineralized rocks of Fisher Mountain upgradient of the McLaren Mine area, the surficial waste rock at the mine, and the underlying bedrock, which hosts both the McLaren ore deposit and the surrounding altered rock.

APPENDIX D

HIGH AND LOW FLOW WATER QUALITY DATA USED FOR ESTIMATING TMDLS AND LOAD REDUCTION REQUIREMENTS FOR EACH WATER BODY

TABLE D-1: DAISY CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION DC5)

<u>DC5 High Flow Data</u> (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
07/13/1995	30	E 485	E 3800	180	2000	< 100	62	0.5	3	6.5
06/18/1996	31	346	3120	143	1400	< 100	60	0.4	E 3	5.8
07/08/1999	24	310	1540	124	1200		70	0.4	1	7.7

<u>DC5 Low Flow Data</u> (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
10/03/1989	0.37	2540	6880	1160			400	3	1	5.2
09/23/1993	0.54	2170	4680	1200	5300		360	2.3	2	5.8
08/25/1994	0.24	E 2850	E 5700	1230	8100	40	420	2.7	2	5.6
09/27/1995	0.42	2450	2380	1180	7700	100	391	2.3	3	5.4
09/10/1996	0.312	2620	4420	1080	7200	300	370	2.3	< 3	5.4
08/26/1999	1.1	1300	3700	564	4330	18	198	1.5	1.4	7.9

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-2: STILLWATER RIVER HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION SW7)

SW7 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese
07/03/1990	123	110	780	50
06/06/1991	158	65	780	35
07/13/1995	113	98	970	50
06/18/1996	223	87	1050	46

SW7 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese
09/25/1990	2.2	20	140	50
08/13/1991	4.1	34	150	70
09/22/1992	8.2	39	150	80
09/23/1993	3.7	60	290	70
08/25/1994	1.7	7	160	27
09/27/1995	2.8	21	170	30
09/10/1996	2.1	19	130	23

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-3: FISHER CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION SW3)

SW3 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
06/27/1990	18	419	5890	160	1700		40	0.1	4	4.8
06/05/1991	7	390	3780	160	1100		30	0.1	2	3.5
06/14/1994	5.42	540	5000	290	2600	1800	58	0.3	7	3.8
07/14/1995	7.29	766	3320	410	2500	2400	76	0.4	8	3.3
07/11/1996	9.18	448	1930	163	1300	1400	40	0.1	<3	4.1

SW3 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
10/20/1989	0.26	850	5590	1230	3700		170	<1	<10	3.4
09/25/1990	0.4	960	6980	1290	3300		160	0.9	7	4.5
09/24/1991	0.2	950	5510	1260	4300	4000	160	2.2	6	3.3
09/21/1993	0.38	1100	11600	1670	3800	3800	170	1	9	3.5
09/27/1995	0.31	1530	11000	1660	4800	5000	231	0.9	8	3.6
09/11/1996	0.38	1040	6910	1320	3500	3800	180	E 0.9	8	3.6

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-4: FISHER CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION SW4)

SW4 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
07/03/1990	83.9	80	650	40	400		20	2	10	9.1
06/05/1991	55.3	E 60	610	30	100		< 10	< 0.1	2	7.1
05/27/1992	77.8	51	310	30	200	200	20	< 0.1	< 2	7.7
05/26/1994	75.2	110	2250	60	800	< 100	18	0.1	3	8.4
06/19/1996	72.2	64	370	36	200	< 100	< 10	< 0.1	< 3	7.8

SW4 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
09/15/1989	1.35	90	90	70	200		70	< 1	< 10	
09/25/1990	1.5	110	210	130	300		50	0.3	< 2	5
09/24/1991	1.1	110	240	80	300	< 100	40	0.6	< 2	6.7
09/23/1992	1.95	117	170	130	300	< 100	50	0.4	< 2	7
09/21/1993	1.98	100	320	160	200	< 100	38	0.2	< 2	7
09/27/1995	1.34	173	90	120	200	< 100	80	0.3	< 2	6.7
09/11/1996	1.46	154	170	150	400	< 100	60	E 0.3	< 3	6.4

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-5: CLARKS FORK OF THE YELLOWSTONE RIVER HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION SW6)

SW6 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
06/26/1990	252	37	400	20	200		20	< 0.1	< 2	8.5
06/05/1991	202	17	180	< 20	200		< 10	< 0.1	< 2	6.7
06/15/1994	88	E16	110	10	100	< 100	E 5	< 0.1	< 2	8.3
07/10/1996	149	24	10	13	E 100	E 100	< 10	0.1	< 3	5.4

SW6 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
10/20/1989	4.5	< 10	< 30	< 20	< 100		10	< 1	< 10	6
09/25/1990	3.3	7	< 30	< 20	< 100		40	< 0.1	< 2	5.5
08/14/1991	3.9	11	60	< 20	< 100		20	< 0.1	< 2	7.3
09/23/1992	3.5	16	200	20	< 100	< 100	50	0.1	< 2	6.4
09/22/1993	4.2	19	30	30	< 100	< 100	E 18	0.1	< 2	7.2
09/11/1996	2.91	11	20	7	< 100	< 100	E 10	E 0.1	< 3	6.6

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-6: MILLER CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS

<u>SW5 High Flow</u> (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
06/26/1990	90	153	3220	130	1400	-	40	0.4	22	8.8
06/05/1991	51	E9	3120	110	1800	-	10	0.4	3	7.6
05/27/1992	38	29	540	20	200	100	20	<0.1	< 2	8.1

<u>SW5 Medium Flow</u> (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
05/29/1990	14.3	19	340	< 20	200	-	20	< 0.1	3	7
07/09/1991	11.1	21	60	< 20	<100	-	20	< 0.1	-	8.4
07/18/1992	5.5	6	70	< 20	<100	< 100	130	< 0.1	< 2	7.6
07/21/1993	7.6	9	<30	< 10	<100	< 100	E6	< 0.1	< 2	7.4
06/16/1994	9.4	6	40	< 10	<100	< 100	7	< 0.1	< 2	7.4

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-7: SODA BUTTE CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS

SBC2 Low Flow (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Cadmium	Lead
07/27/1990	0.02	2	780	30	<100	<100	<0.1	<2
09/24/1991	1.5	E 9	1920	100	100	<100	0.2	2
10/10/2000	0.82	<1	E 2330	110	100		<0.1	<3

SBC4 High Flow (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Cadmium	Lead
06/16/1994	139	E 2	480	10	200	200	<0.1	<2
06/22/1999	504	22.4	6260	210	4640	15	<1	13
07/08/1999	278	3	580	6	400		<0.1	<1
06/07/2000	632	20.7	5200	155	3880	12	<0.11	8
07/07/2000	133	5	E 380	E 10	E 200		<0.1	58

SBC4 Low Flow (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Cadmium	Lead
09/23/1992	14	<1	310	<20	<100	<100	<0.1	<2
09/23/1993	13	3	150	<10	<100	<100	<0.1	<2
09/30/1999	12	<1	150	<5	<100		<0.1	<1
10/10/2000	7	<1	E 410	<20	200		<0.1	<3

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

APPENDIX E

DISCUSSION AND SUMMARY FOR FISHER CREEK METALS SOURCES (EXCERPT FROM KIMBALL, ET AL., 1999)

Loads of Metals

Patterns of metal loads from mine drainage were more comparable to SO_4 than to Ca because of the substantial number of dispersed subsurface inflows and the reactive chemistry that affected their transport. The extent of chemical reaction was greatest for Fe, but also significant for Al, Cu, Mn, and Zn.

Iron

Thermodynamically, Fe should readily precipitate within the pH range of Fisher Creek to form colloidal-sized, hydrous Fe oxide solids (Lindsay, 1979; Pankow, 1991). Through a sequence that includes precipitation to form nanometer-sized particles, aggregation to form micrometer-sized particles, settling of aggregated colloids, and entrapment by biofilm on cobbles, these colloidal Fe solids coat the streambed of Fisher Creek (Grundl and Delwiche, 1993). Many streams affected by mine drainage have a characteristic ochre-colored streambed from this process. This pattern of Fe loss has been documented in St. Kevin Gulch, Colorado, where a rate constant for the first-order removal of Fe was determined (Kimball and others, 1994). Accumulation of Fe precipitate on the streambed can affect the physical habitat of aquatic organisms and also can create a source of chronic toxicity because of the metals that readily sorb to the Fe colloids.

The mass-load profile of filtered Fe was very different from the profiles of Ca, SO_4, and the other filtered metals (fig. 14a). Because of the reactive behavior of Fe, it is very difficult to account for the total inflow of Fe. It is possible that Fe was removed fast enough to cause a net loss in almost every segment of the stream; there were few positive values of ΔM_S (fig. 14b). Thus, the actual amount of Fe lost from streamwater could have been greater than the difference between the cumulative total load and the sampled instream load might indicate (fig. 14).

Steps in the removal of Fe from the stream are illustrated by looking at the load profiles of Fe(II), filtered, and total-recoverable Fe (fig. 14). First, the Glengary adit and FCT-11 were two large point sources of Fe to the stream at about 300 m. As this large input of Fe was transported downstream, Fe(III) precipitated in the water column as Fe colloids, aggregated, and settled from the stream or was entrapped by biofilm. This results in the continuous decrease in filtered and total-recoverable Fe loads. The nearly constant difference between these two loads, continuing for about 1,000 m of the stream, indicates a constant process of precipitation, aggregation, and removal. With the pH change downstream from 1,750 m and an increase of Fe load, the formation of Fe colloids accelerated. More colloidal Fe was in the water column, as indicated by a greater difference between filtered Fe and total-recoverable Fe loads. The rate of settling, however, did not seem to change because there was little change in the decrease of total-recoverable Fe load with distance. As the filtered Fe load reached the level of the Fe(II) load, the Fe(II) decreased along with the filtered Fe, possibly indicating that Fe(II) was converted to Fe(III) and then precipitated as Fe colloids.

Fe-rich colloids that settle to the streambed or are trapped by algae on streambed cobbles, are flushed by snowmelt runoff the following year. This was the likely cause of large increases in colloidal loads of metals in the Animas River, Colorado, during snowmelt runoff (Church and others, 1997).

Aluminum, Copper, Manganese, and Zinc

The most striking difference between the profile of Ca load and the profiles of metal loads is the relative importance of the different sources. Sources of Ca load occur all along the study reach, but a large part of the metal loads comes from the Glengary adit and other mine-related sources in the first 700 m of the study reach (figs. 15, 16, 17, and 18). About 60 percent of the Al, Cu, Mn, and Zn loads can be accounted for by the concentrations in the samples of the visible inflows, and almost all of these loads entered Fisher Creek in the upper 700 m. This means the cumulative inflow load is much closer to the cumulative total load for these metals than for SO_4. The remaining 40 percent was from diffuse subsurface inflows. Considering this diffuse source, the reduction of metal loads in Fisher Creek might be limited unless there were a way to reduce loads from the diffuse sources as well as reducing loads from the Glengary adit and nearby mining wastes. For example, the load of Cu from the Glengary adit was 28 mg/s, which was 32 percent of the total load at the end of the study reach (fig. 15). A decrease of 32 percent of the load may not reduce Cu to concentrations that would be low enough for a healthy fish population. Also, eliminating inflow of the Glengary adit would increase the pH of Fisher Creek, and reduce the load of Fe, changing the dynamics of Cu sorption to Fe colloids. With these chemical complexities, the exact amount of reduction in Cu for eliminating a particular source needs to be estimated by a reactive solute-transport simulation; it is not a simple mass-balance question.

Loads for filtered Al, Cu, Mn, and Zn showed the same general pattern. The major loads from the Glengary adit and nearby mining wastes initially dominate the load profiles. Transport of that load was conservative for each metal to about 800 m. From 802 m to 1,582 m, the sampled instream load and the cumulative total loads diverged because of net losses in some stream segments as a result of chemical reactions. These decreases in load occurred downstream from neutral inflows that raised the instream pH. The decreases could have resulted from sorption of the metals to the Fe colloids or from coprecipitation with the Fe colloids. Amacher and others (1994) have shown a marked increase in the Cu concentration in the streambed Fe precipitates in this same area of Fisher Creek. None of the total-recoverable metal concentrations increased in this reach (table 6), indicating that there must have been sorption directly to bed material. After the instream metal loads decreased, each metal load subsequently increased between 1,582 m and 1,750 m. This area had no visible inflows; the increased load must represent metal-rich, subsurface inflow. The source of this metal-rich inflow was not apparent and should be investigated further.

The loading of Al was different from the other metals downstream from the inflow at 2,116 m (fig. 16a). With the increase in pH, Al precipitated, as indicated by the sharp decline in load. There was visible evidence of precipitation on the streambed cobbles along the right bank downstream from the inflow. The load of Cu also decreased in that reach, most likely as a result of sorption of Cu onto the Fe and Al precipitates rather than by precipitation of a solid phase. If Cu and other metals are stored on the streambed with Fe colloids, they could be flushed by the next snowmelt runoff.

Mass-load profiles of Mn (fig. 17) and Zn (fig. 18) were similar. For both, the Glengary adit was the principal source of the metal load. The largest losses occurred in the area from 1,402 m to 1,462 m and from 2,115 m to 2,235 m, both in response to inflows that had high pH. Between 1,750 m and 1,936 m the load of Zn increased due to subsurface inflows, but the Mn load did not increase. This could indicate a mineralogical difference between the source of metals in that area and the source of the Glengary adit.

Despite the differences in details among the mass-load profiles, the metal loads collectively indicate five areas where most of the metal loads entered the stream. The net gain or loss of metals in each stream segment is summarized in table 7. For each metal, the five largest increases are shaded to point out the principal areas of loading. The first area was between 257 m and 330 m, including the Glengary adit and the FCT-11 tributary. The second area was between 618 m and 725 m, where streams that drain waste-rock piles enter Fisher Creek. The third important area was between

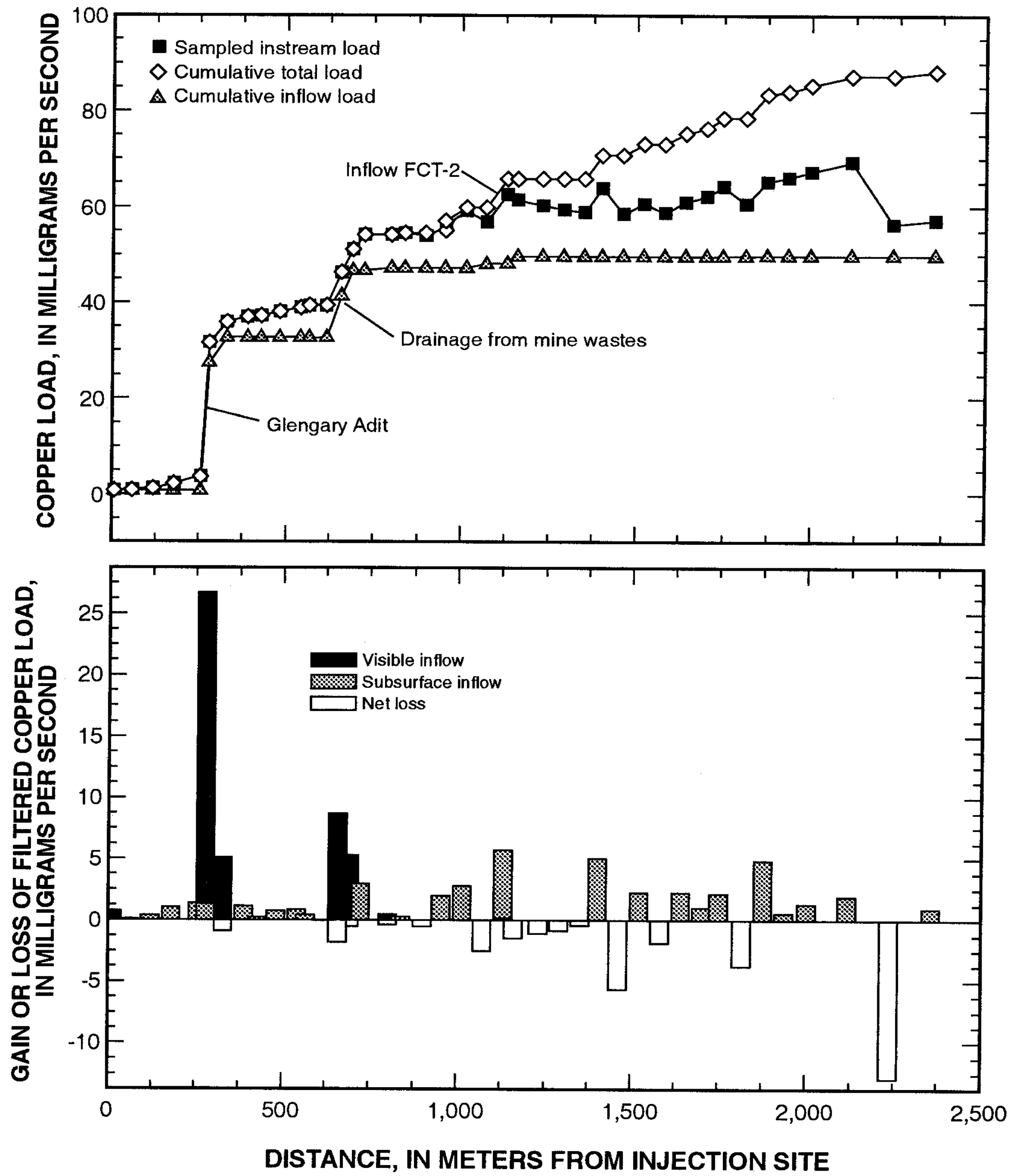


Figure 15. (a) Sampled instream load, cumulative total load, and cumulative inflow load of filtered copper, and (b) net gain or loss of filtered copper load, Fisher Creek, Montana, August 19, 1997.

1,072 m and 1,132 m, which receives the discharge from the largest visible inflow, FCT-2. A fourth area with substantial inflow was between 1,582 m and 1,750 m, where increased load was mostly from subsurface inflow and not visible inflows. Finally, the area from 1,876 m to 1,936 m had a considerable increase of load for Ca, Al, and Cu. This area likely drains carbonate outcrops on the right side of the canyon. The sources of Al and Cu are not clear, however, because drainage from the Gold Dust Mine does not appear to enter the inflow in this area.

SUMMARY

Acid mine drainage from past mining affects the water quality of Fisher Creek, Montana. To effectively plan for remediation requires detailed knowledge of the sources of the mine drainage, how the drainage from the sources enters the stream, and what natural attenuation may remove the metals once they are in the stream. The U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency, conducted a tracer injection and synoptic sampling study to provide the information.

A chloride tracer injection allowed the calculation of discharge for synoptic samples along a 2,355-m reach of Fisher Creek. The study reach began upstream from the Glengary adit and ended in a downstream wetland, just upstream from site FC-5. The load profiles were calculated using discharge, calculated from the dilution of the tracer, and concentration data from detailed synoptic sampling. Loads of aluminum, copper, iron, manganese, and zinc greatly increased from the inflow of the Glengary adit. Downstream from the adit, metal transport was without substantial chemical reaction until the inflow of a tributary with higher pH (FCT-2), which caused instream pH to rise. Chemical reaction also decreased the loads of copper and aluminum in the wetland area, near the end of the study reach. At the higher pH, aluminum changed from the filtered phase to colloidal solids and started settling from the stream. Chemical reactions substantially affected the load profile of iron along the entire study reach. The copper and zinc load profiles indicated the significance of ground-water inflows near the bottom of the study reach.

Calculating the cumulative total load and the cumulative inflow load helps indicate the extent of metal removal and the likely sources of ground-water inflow. Removal of metal loads from the stream has two important consequences. First, the metals are stored in iron colloids each summer and then are flushed by snowmelt runoff, likely causing a large increase of colloidal metal load for many kilometers downstream. Second, accounting for the total load facilitates the illustration of individual sources of metal loads.

The similarity of load profiles for the metals points out the impacts of mine drainage on Fisher Creek. A large part of the metal loads comes from the inflow of the Glengary adit, but substantial loads of each metal also occurred at other locations. Some loads came from diffuse subsurface inflow. Eliminating only a single source, without considering all principal sources, may not reduce instream concentrations to levels that do not adversely affect aquatic life.

APPENDIX F

DISCUSSION AND SUMMARY FOR SODA BUTTE CREEK METALS SOURCES (EXCERPT FROM BOUGHTON, 2001)

Major Ions

The shape of the load profiles of the major ions indicates the locations of the major sources of those ions. Calcium detected in the stream originated mainly from weathering of limestone formations in the upper reaches of the basin. The largest contributions to the cumulative inflow load of dissolved calcium were by inflows between 505 m and 940 m (16 percent), between 1,785 m and 2,422 m (40 percent), and between 3,490 m and 3,720 m (16 percent) (fig. 13). The sampled instream load profile of dissolved calcium is similar to the cumulative instream load profile, indicating that little calcium was removed by chemical or physical processes in the stream. The cumulative inflow load was 51 percent of the cumulative instream load, indicating that the visible sampled inflows likely had lower calcium concentrations than the subsurface inflows.

The load profiles of dissolved silica are dominated by the contributions of Republic Creek (1,859 m). The cumulative inflow load of dissolved silica (fig. 14) was attributable mainly to two areas: inflows between 1,785 m and 2,422 m (53 percent) and between 8,247 m and 8,379 m (34 percent). The cumulative instream load was contributed mainly by inflows between 1,785 m and 2,422 m (67 percent) and between 8,247 m and 8,379 m (24 percent). The sampled instream load profile and cumulative instream load profile are similar, indicating that little silica was removed from the water column by chemical or physical processes.

The load profiles of dissolved sulfate reflect the effects of the ground-water seeps from the McLaren Mine tailings impoundment. Most of the cumulative inflow load of dissolved sulfate was contributed by the inflows between 505 m and 940 m (72 percent) (fig. 15). The cumulative instream load was contributed mainly by inflows between 505 m and 940 m (42 percent) and between 8,247 m and 8,379 m (13 percent). The sampled instream load and cumulative instream load profiles are similar. The difference between the smaller cumulative inflow load and the larger cumulative instream load indicates that the visi-

Metals

Metals bound to colloidal particles make up most of the difference between the total-recoverable and dissolved concentrations. Iron colloids are of particular interest because they have been shown to play a key role in metals transport in other Rocky Mountain streams receiving acid mine drainage (Kimball and others, 1995). Iron colloids can precipitate on the streambed and adversely affect the physical habitat of benthic aquatic organisms. Trace metals tend to sorb to iron colloids. A large percentage of the metal load in Soda Butte Creek was transported in the colloidal phase.

The load profiles of metals were more variable than those of the major ions because of physical and chemical processes in the mainstem. Iron is discussed first because of its importance in regulating the behavior of the other metals.

Accurate load calculations for iron were difficult to derive because of the highly reactive nature of this metal. Dissolved iron loads were small because most of the iron rapidly precipitated out of the neutral-pH waters of Soda Butte Creek as colloidal ferric oxide. Cumulative inflow load was attributable almost entirely to three areas: between 505 m and 760 m (48 percent), between 1,785m and 2,422m (18 percent), and between 8,247 m and 8,379 m (32 percent) (fig. 16). Most of the cumulative instream load (66 percent) was contributed by inflows between 1,785 m and 2,422 m. The large disparity between the total cumulative instream load (326 mg/s) and the sampled instream load (68.9 mg/s) at T4 is indicative of iron removal from the stream by chemical or physical processes.

The cumulative inflow load of total-recoverable iron (fig. 17) was attributable almost entirely to three areas: between 565 m and 760 m (26 percent), between 1,785m and 1,922m (38 percent), and between 8,247 m and 8,379 m (34 percent). Significant contributions to the cumulative instream load came from inflows between 1,785 m and 1,922 m (52 percent) and subsurface inflows between 8,247 m and 8,379 m (31 percent). The sampled instream load and cumulative instream load diverge downstream of 2,172 m, indicating removal of iron by chemical or physical processes.

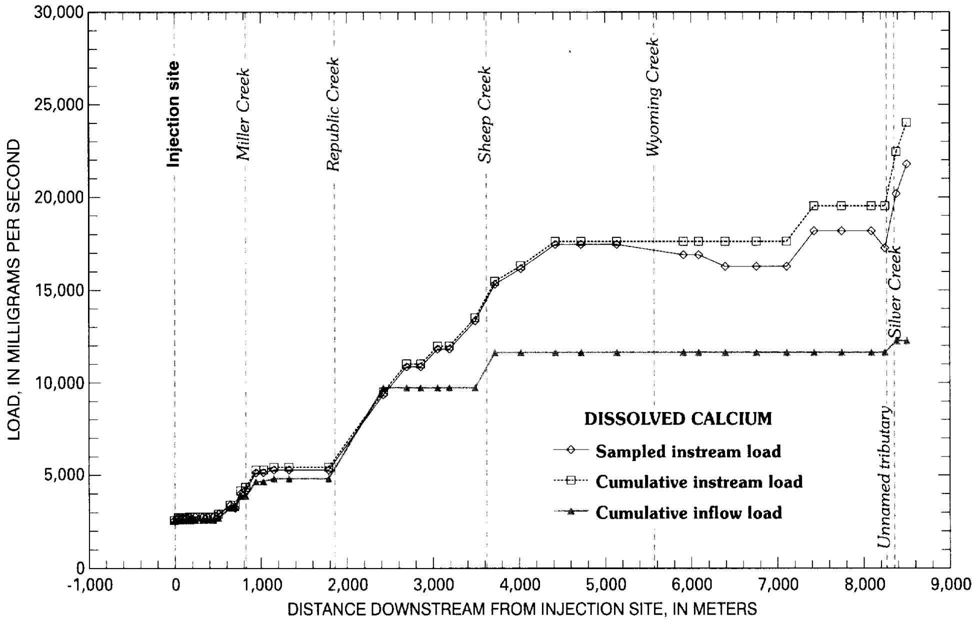


Figure 13. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved calcium, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

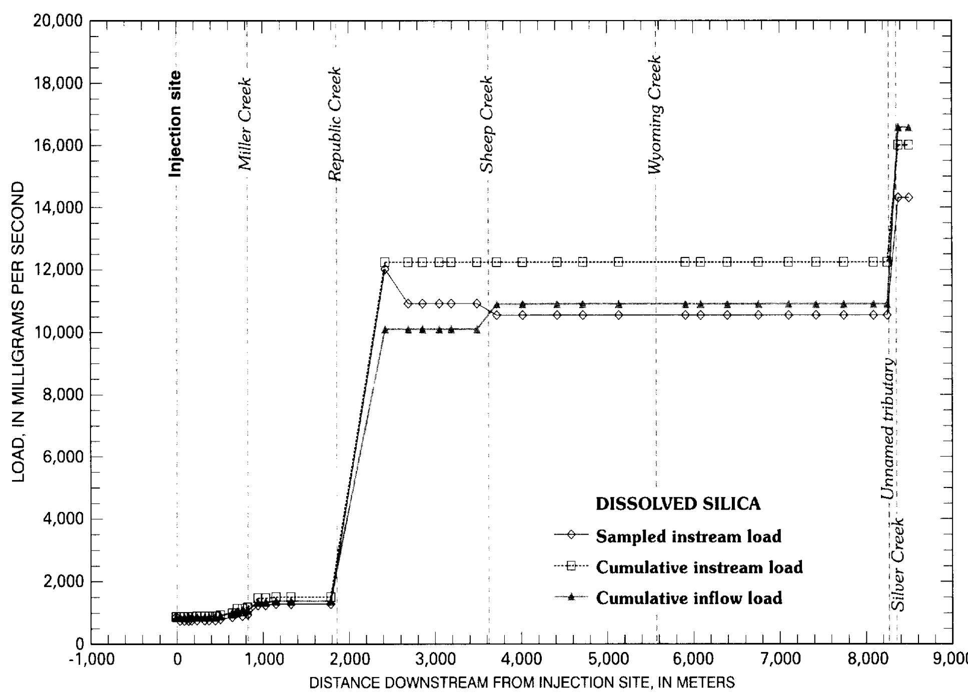


Figure 14. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved silica, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

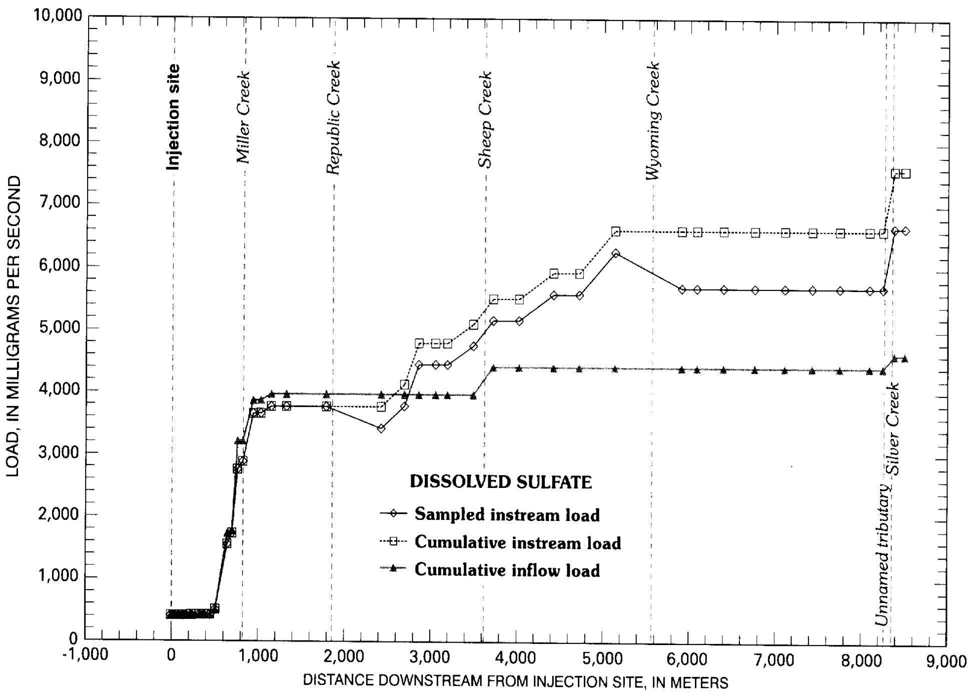


Figure 15. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved sulfate, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

Most of the cumulative inflow load of dissolved aluminum was contributed by the inflows between 1,785 m and 2,422 m (44 percent) and between 8,247 m and 8,379 m (50 percent) (fig. 18). The cumulative instream load was contributed mainly by inflows between 1,785m and 2,422 m (53 percent) and between 8,090 m and 8,379 m (23 percent). The cumulative instream load profile and sampled instream load profile diverge downstream of 2,422 m, indicating removal of aluminum by chemical or physical processes in that segment of the creek.

The total-recoverable aluminum load profiles (fig. 19) were very similar to those of total-recoverable iron (fig.17). The cumulative inflow load consisted mainly of the contributions from inflows between 1,785m and 1,922m (47 percent), and between 8,247 m and 8,379 m (45 percent). Significant contributions to the cumulative instream load came from inflows between 1,785 m and 2,172 m (52 percent), and between 8,247 m and 8,379 m (35 percent). The sampled instream load profile and cumulative instream load profile diverge downstream of 2,172 m, indicating removal of aluminum by chemical or physical processes in that segment of the creek.

Manganese concentrations were relatively low. Instream load profiles of elements detected at low concentrations tend to follow the shape of the discharge profile. The cumulative inflow load of dissolved manganese (fig. 20) consisted mainly of the contributions from the inflows between 505 m and 760 m (82 percent). The cumulative instream load was contributed mainly by inflows between 1,785 m and 2,422 m (52 percent), and between 8,247 m and 8,379 m (26 percent). The sampled instream load profile and cumulative instream load profile are identical, indicating no loss of dissolved manganese from the water column.

The cumulative inflow load of total-recoverable manganese consisted mainly of the contributions from inflows between 565 m and 760 m (80 percent) and between 1,785 m and 1,922 m (9 percent) (fig. 21). The

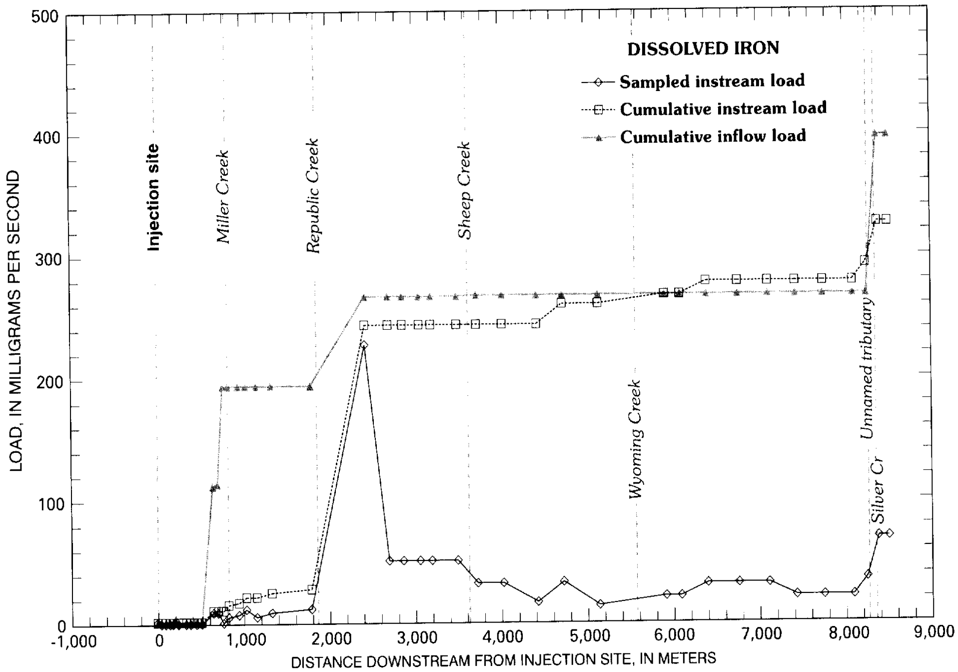


Figure 16. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved iron, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

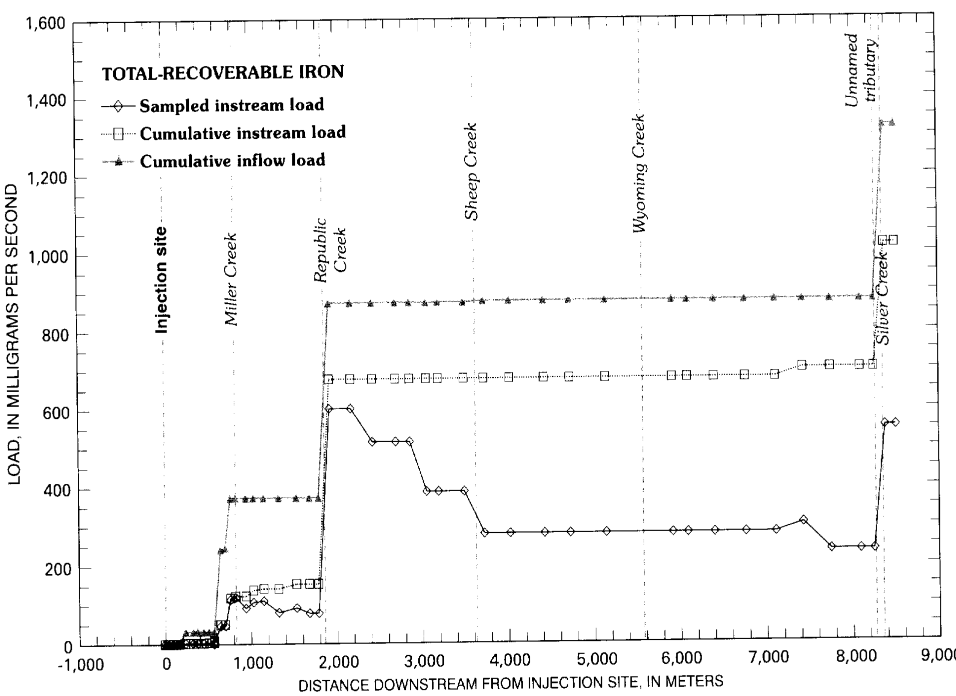


Figure 17. Sampled instream load, cumulative instream load, and cumulative inflow load of total-recoverable iron, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

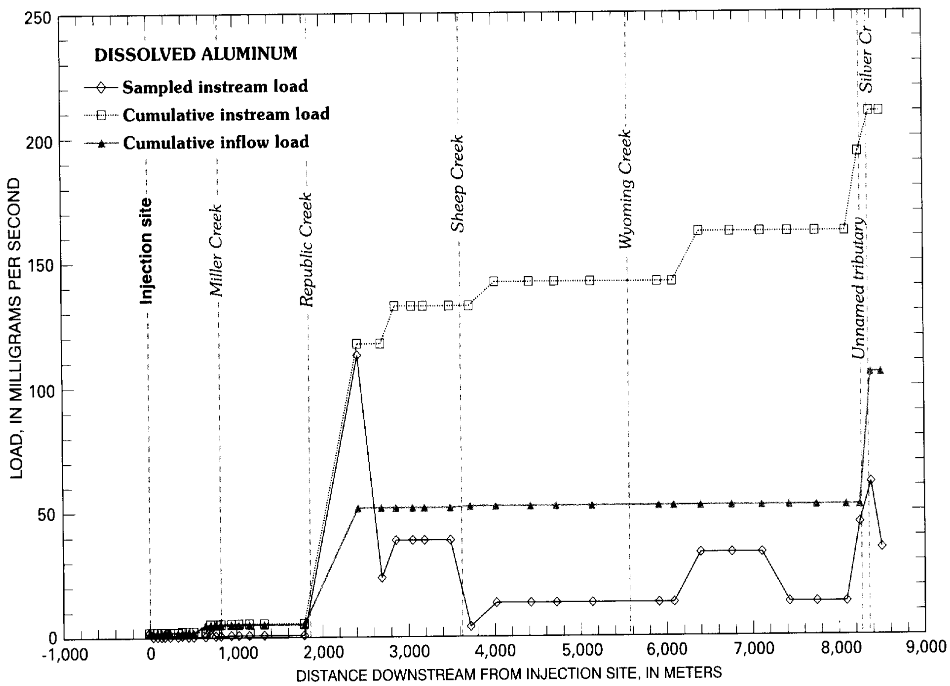


Figure 18. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved aluminum, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

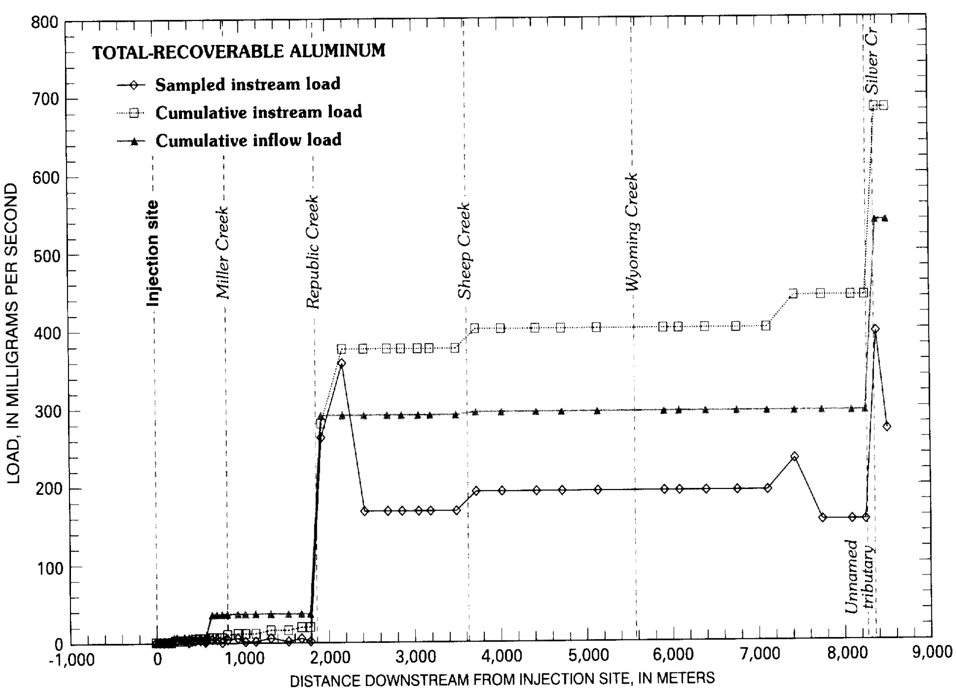


Figure 19. Sampled instream load, cumulative instream load, and cumulative inflow load of total-recoverable aluminum, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

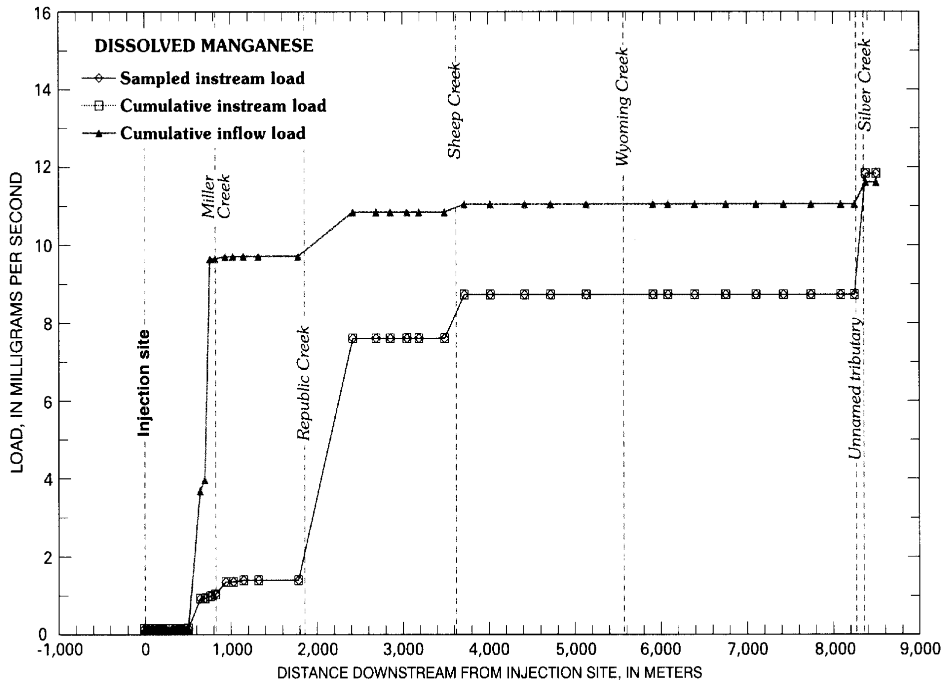


Figure 20. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved manganese, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

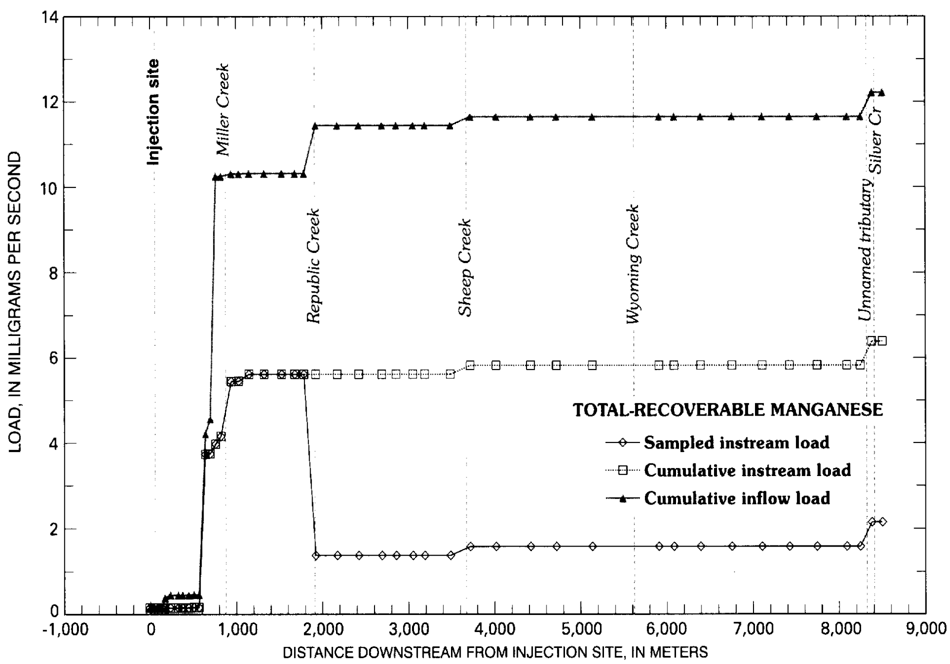


Figure 21. Sampled instream load, cumulative instream load, and cumulative inflow load of total-recoverable manganese, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

cumulative instream load was contributed mainly by inflows between 565 m and 940 m (83 percent). The sampled instream load profile and cumulative instream load profile are very similar except for the stream segment from 1,785 m to 1,922 m. Along this reach, the sampled instream load dropped from 5.6 mg/s to 1.4 mg/s because of chemical or physical processes occurring in the stream.

Loads were not calculated for cadmium, copper, lead, and zinc even though minimum reporting levels for these metals approached or exceeded water-quality standards for the protection of aquatic life. The highest total-recoverable concentrations of cadmium (0.063 mg/L), copper (6.08 mg/L), lead (0.603 mg/L) and zinc (0.772 mg/L) were detected in the synoptic sample collected from site 569 m (a seep from the McLaren Mine tailings impoundment) (append. C). However, cadmium, copper, and lead were not detected in any of the mainstem synoptic samples, while the highest total-recoverable concentration of zinc in the mainstem of Soda Butte Creek was 0.044 mg/L at site 2,172 m. The lack of detection of these metals in the downstream mainstem synoptic samples, probably because of sorption (coprecipitation and adsorption) to metal colloids in the stream, prevented meaningful load calculations of these constituents.

These results agree with those of previous studies conducted in the area. Researchers analyzing water-column samples have detected very low concentrations of these elements (Miller and others, 1997). Other researchers analyzing the aquatic biota have attributed a decline in stream health along this segment of the creek to elevated trace-element concentrations, particularly copper (Forstner and Wittman, 1983; Nimmo and Willox, 1996).

Iron-rich colloids that settle to the streambed or are trapped by algae on streambed cobbles are flushed by snowmelt runoff the following year (Kimball and others, 1999). The water sample collected at the USGS gaging station at the YNP boundary during peak snowmelt runoff contained the highest metal loads of any sample collected during the 1999 water year. The total-recoverable iron concentration in the June 22, 1999 sample was 6.26 mg/L (append. D).

Metal Sources

The loading of metals at different points in the stream was compared to isolate areas of surface or ground-water inflow that may be contributing metals to the stream or diluting them. The magnitude of different sources relative to the whole system also was compared. The highest inflow metal concentrations do not always indicate the most significant sources of metal loading.

Examined collectively, the metal-load profiles indicate three areas contributing most of the metals to Soda Butte Creek. The three major areas of concern are the inflows from the McLaren Mine tailings impoundment (between 505 m and 760 m), Republic Creek (1,859 m), and Unnamed Tributary (8,267 m). The McLaren mill site did not contribute to metal loading in Soda Butte Creek during the tracer-injection and synoptic-sampling study because the site was dry. However, significant rill erosion was evident at the mill site immediately upgradient of Soda Butte Creek. During the spring snowmelt season, as well as during significant summer rainstorms, the McLaren mill site probably contributes to the metal loading of Soda Butte Creek.

Results indicate that treatment or removal of the McLaren Mine tailings impoundment would greatly reduce metal loading of Soda Butte Creek upstream of YNP. However, removing only that single source may not reduce metal loads to acceptable levels. The sources of metal loading in Republic Creek and Unnamed Tributary merit further investigation.

SUMMARY

Acid drainage from historic mining activities has affected the water quality and aquatic biota of Soda Butte Creek upstream of Yellowstone National Park. A retrospective analysis of previous research on metal loading in Soda Butte Creek was completed to provide summaries of studies pertinent to metal loading in Soda Butte Creek and the effects of the loading on the water quality and aquatic biota. None of the studies conducted on Soda Butte Creek have included an examination of the effects of metal loading on the entire basin.

The research was divided into studies of surface-water quality, fluvial geomorphology, and aquatic biota. In general, the more recent studies indicate that the health of the aquatic ecosystem continues to be negatively impacted by historic mining activities. Flooding could expose buried tailings sediments, wash fresh tailings sediments into the stream, or carry metal-contaminated aquatic biota into Yellowstone National Park. Such an event would likely cause a significant increase in metal loading in Soda Butte Creek.

A critical gap in the existing data was identification and quantification of the sources of metal loading to Soda Butte Creek. Although the McLaren Mine tailings impoundment and mill site has long been identified as a source of metals, its contribution relative to the total metal load entering Yellowstone National Park was unknown. A tracer-injection and synoptic-sampling study was designed to determine metal loads in Soda Butte Creek upstream of Yellowstone National Park.

The tracer-injection and synoptic-sampling study was conducted on an 8,511-meter reach of Soda Butte Creek from upstream of the McLaren Mine tailings impoundment and mill site downstream to the Yellowstone National Park boundary in August 1999. Synoptic-sampling sites were selected to divide the creek into discrete segments. A lithium bromide tracer was added to the stream. Stream discharge values, combined with constituent concentrations obtained by synoptic sampling, were used to quantify constituent loading in each segment of Soda Butte Creek.

Much of the metal load was transported in the colloidal phase. Of particular concern are the colloidal iron hydroxides, as they accumulate on the streambed. This accumulation adversely affects the aquatic biota by altering the physical habitat of aquatic organisms. In addition, metals can sorb to the colloids and create a chronic source of toxicity (Kimball and others, 1999).

Loads were calculated for dissolved calcium, silica, and sulfate, as well as for dissolved and total-recoverable iron, aluminum, and manganese. Loads were not calculated for cadmium, copper, lead, and zinc because these elements were infrequently detected in the mainstem synoptic samples. All of these elements were detected at high concentrations in the seeps from the McLaren Mine tailings impoundment. The lack of detection of these elements in the downstream mainstem synoptic samples is probably because of sorption (coprecipitation and adsorption) to metal colloids in the stream. These results agree with those of previous studies conducted in the area. Researchers analyzing water-column samples have detected very low concentrations of these elements (Miller and others, 1997). Other researchers analyzing the aquatic biota of Soda Butte Creek have attributed a decline in stream health along this segment of the creek to elevated trace-element concentrations, particularly copper (Forstner and Wittman, 1983; Nimmo and Willox, 1996).

Most of the metal load that entered Soda Butte Creek was contributed by three areas. The three major areas of concern are the inflows that drain the McLaren Mine tailings impoundment (between 505 m and 760 m downstream from the tracer-injection site), Republic Creek (1,859 m), and Unnamed Tributary (8,267 m). The McLaren mill site did not contribute to metal loading in Soda Butte Creek during the tracer-injection and synoptic-sampling study because the site was dry. However, significant rill erosion was evident at the mill site immediately upgradient of Soda Butte Creek. During the spring snowmelt season, as well as during significant summer rainstorms, the McLaren mill site probably contributes to the metal loading of Soda Butte Creek.

Results indicate that treatment or removal of the McLaren Mine tailings impoundment would greatly reduce metal loading of Soda Butte Creek upstream of Yellowstone National Park. However, removing only that single source may not reduce metal loads to acceptable levels. The sources of metal loading in Republic Creek and Unnamed Tributary merit further investigation.

APPENDIX G
METALS SOURCE ANALYSES FOR SODA BUTTE CREEK

METALS LOADING SOURCE ANALYSES FOR SODA BUTTE CREEK

These different loading source analyses are based on several data sources and are meant to help determine significant source areas for setting load allocations, assist with restoration planning, and identify data gaps. Many of the loading comparisons along different stream segments are conservative, and it is recognized that a portion of a load delivered to Soda Butte Creek from Miller Creek on any given day, especially during low flows, may end up deposited to the streambed prior to reaching downstream locations such as Yellowstone National Park.

Soda Butte Creek Metals Sources, Low Flow Conditions

Copper (Low Flow Conditions)

At low flow conditions, the main copper source is the McLaren Tailings Area as identified by inflow samples all along Soda Butte Creek (Boughton, 2001). The copper from the McLaren Tailings enters Soda Butte Creek via seeps and other ground water flows discharging to the stream. Historic ground water concentrations of copper in the McLaren Tailings average 9300 ug/l (Pioneer, 2001a). Inflow copper concentrations from several seeps from the tailings and other mine disturbances around the tailings during August 1999 were greater than 200 ug/l and as high as 6080 ug/l (Boughton, 2001). Given these concentrations, it is estimated that the copper load is at least 0.05 lb/day.

It is likely that most of the copper entering Soda Butte Creek from the McLaren Tailings co-precipitates with and adsorbs to metal colloids primarily associated with iron precipitates (see discussion on high iron loads from the McLaren Tailings below). This copper then leads to elevated levels in stream sediments and contributes to impairment concerns associated with aquatic life.

Soda Butte Creek upstream of the McLaren Tailings provides minor, insignificant loads of copper. Miller Creek is possibly the only other significant low flow source of copper to Soda Butte Creek, generally at levels that alone would not cause Soda Butte Creek copper values to be greater than the water quality standard, but high enough to cause elevated levels based on concentration and flows from Miller Creek (Maxim, 2001a). Even so, Miller Creek low flow copper loads are generally less than 0.02 lbs/day based on estimated seep flows and estimated average concentrations.

The synoptic study results show that copper levels all along Soda Butte Creek remain below 12 ug/l, leaving open the possibility that some sections of the stream were above the approximate 7 ug/l aquatic life support standard, but always below 12 ug/l. Most other data sources indicate that low flow copper levels tend to remain below the standard with an occasional value slightly above the standard (Appendix B). Data from Nimmo et al. suggests the possibility of significant copper loading from downstream sources since dissolved copper concentrations remained fairly constant with increasing flow during one of three years of low flow sampling.

The *Final Site Evaluation Report for the Republic Mine and Mill Site* (Pioneer, 2001b) and the *Final Reclamation Investigation for the Great Republic Smelter Site* (Tetra Tech EM Inc. 1999) both indicate low copper levels in water and sediment samples in the Woody/Republic Creek drainage during low flow conditions. However, some of the specific mine waste samples (slags, etc.) in this drainage are elevated in copper.

Iron (Low Flow Conditions)

Figure 17 in Appendix F shows three primary sources of total recoverable iron loads to Soda Butte Creek during low flow conditions. These include the McLaren Tailings Area (in the vicinity of Miller Creek on Figure 17), the Woody/Republic Creek drainage (referred to as Republic Creek in the report), and the Unnamed tributary just upstream of SBC4. Although total loading from the McLaren Tailings Area is lower than the other two sources, the impact from the tailings is most pronounced because of the relatively low flow in this section of the stream. Iron concentrations at or near SBC2 from this study and several other sources (Maxim 2001a, Pioneer 2001a) are routinely above 1000 ug/l and can be over 3000 ug/l, and staining associated with iron precipitates are evident in this area. Corresponding iron concentrations and loads in Miller Creek and Soda Butte Creek upstream of the tailings are consistently low.

The iron from the McLaren Tailings enters Soda Butte Creek via seeps and other ground water flows discharging to the stream. Historic ground water concentrations of iron in the McLaren Tailings average 2,300,000 ug/l (Pioneer, 2001a). Inflow concentrations from several seeps from the tailings and other mine disturbances around the tailings during August 1999 were typically greater than 24,000 ug/l and as high as 418,000 ug/l (Boughton, 2001).

Based on the synoptic study, iron concentrations further downstream of the immediate tailings impact area generally remain elevated above the 300 ug/l domestic use/drinking water support standard. This is primarily due to increased loads from the Woody/Republic Creek drainage (iron concentration at 885 ug/l) and from Unnamed Creek (iron concentration at 1580 ug/l). Iron concentrations in Wyoming Creek (1440 ug/l) and a few other small tributaries (915 ug/l to 1860 ug/l) near Unnamed Creek are also very high, but loading to Soda Butte Creek is low because of low flows associated with these tributaries.

Other data sources (USGS, 2001 & Maxim 2001a) show that iron is occasionally above the 1000 ug/l aquatic life support level at or near sampling locations SBSW-102 and SBC-4.

The *Final Site Evaluation Report for the Republic Mine and Mill Site* (Pioneer, 2001b) reports iron levels upstream and downstream of mine disturbances in Republic Creek, which flows into Woody Creek, in the range of 300 to 350 ug/l during a low flow period. This indicates that a portion of the load in this area may be associated with natural conditions. In general, there appears to be a lack of iron data for the Woody, Republic, Wyoming, and Unnamed Creek drainage areas. An assessment of potential sources of elevated metals may also be lacking for a few of these streams.

Sample location SBSW-102 is conveniently located on Soda Butte Creek below Woody/Republic Creek. Sample results (Maxim 2001a) from this location during low flow conditions, particularly during early spring, indicate significant sources of iron between Woody Creek and SBC-4, consistent with the synoptic sample results.

Manganese (Low Flow Conditions)

At low flow conditions, manganese is only a concern in Soda Butte Creek just downstream from the McLaren Tailings. This is supported by data from several sources (Pioneer 2001a, Maxim 2001a, others). Appendix F; Figure 21 shows that the manganese load is primarily from the McLaren Tailings. This is supported by consistently low manganese concentrations at SBC1 and SW5 at low flows (Maxim, 2001a), and in the area of SBC4 (USGS, 2001 and Maxim, 2001a), all under low flow conditions.

The manganese from the McLaren Tailings enters Soda Butte Creek via seeps and other ground water flows discharging to the stream. Historic ground water concentrations of manganese in the McLaren Tailings average 2,000 ug/l (Pioneer, 2001a). Inflow concentrations from several seeps from the tailings and other mine disturbances around the tailings during August 1999 were typically greater than 1000 ug/l and as high as 7740 ug/l (Boughton, 2001).

Lead (Low Flow Conditions)

Lead has generally not been considered a low flow concern, although the McLaren Tailings contribute to elevated levels in the stream and possibly in stream sediments. Synoptic sample results show one seep location from the McLaren Tailings with a concentration of 603 ug/l (Boughton, 2001). Relatively high detection levels (130 ug/l) during this synoptic study make it difficult to identify other potential low flow sources of concern or to identify problem areas in Soda Butte Creek. Available data from established monitoring locations (Maxim, 2001a), using much lower detection limits, do not show any values greater than standards at low flows.

Aluminum (Low Flow Conditions)

Dissolved aluminum under low flow conditions appears to only be a concern in Soda Butte Creek just below the confluence with the Woody/Republic Creek drainage, as shown by Figure 18 in Appendix F. The synoptic report (Boughton, 2001) describes the source of this aluminum as follows:
"Aluminum and silica detected in the water result from both mining activities and natural weathering of feldspars and other aluminosilicate minerals in the watershed."

Soda Butte Creek Metals Sources, High Flow Conditions

Copper (High Flow Conditions)

Upstream of the McLaren Tailings, copper levels in Soda Butte Creek are low with a few values above detection up to the highest value of 6 ug/l (load = 0.9 lbs/day) measured at the highest flow (Maxim, 2001a). Based on a larger set of data, copper levels in Miller Creek during high flows at SW5 ranged from 9 ug/l to 200 ug/l, representing a copper load to Soda Butte Creek as high as 73 lbs/day. On the same high flow day that the above referenced upstream Soda Butte Creek load was 0.9 lbs/day, the Miller Creek copper load was 6 lbs/day. This indicates significantly higher copper loads from Miller Creek in comparison to the upper segment of Soda Butte Creek.

At or near sample location SBC-4, copper concentrations can be as high as 22.4 ug/l during the highest flows, with loads up to 70 lbs/day. High flow copper loads from Miller Creek alone could account for most of this load based on the limited amount of data. Some portion of the elevated copper load likely comes from the McLaren Tailings and copper precipitated to stream sediments.

Transport of copper from mine waste materials in the Woody/Republic Creek and other drainage areas represents another potential source of copper. As discussed under low flow copper sources, at least some of the mine waste materials in this drainage are high in copper. Additional loading may also come from floodplain deposits associated with the 1950 tailings dam failure and subsequent large flood events, or from other tributaries.

Iron (High Flow Conditions)

Upstream of the McLaren Tailings, iron levels in Soda Butte Creek (SBC1 data via Maxim, 2001(a)) ranged from 110 ug/l (load = 7.6 lbs/day) to 490 ug/l (load = 76 lbs/day) during the two highest flow sample events. This indicates probable elevated iron loads from this source area during high flows. It appears as though SBC1 is situated such that some of the loading may be contaminated soils eroded from the adjacent McLaren Mill site on the north side of the stream (Boughton, 2001). Based on a larger set of data, iron levels in Miller Creek during high flows at SW5 ranged from 70 ug/l to 3,220 ug/l, with most values being greater than 300 ug/l.

On the same day that the Soda Butte Creek iron load was 76 lbs/day at SBC1, the corresponding iron load from Miller Creek was 110 lbs/day based on a concentration of 540 ug/l. This indicates potentially similar loads from both source areas. At even higher flows, Miller Creek iron concentrations were greater than 3000 ug/l in three out of four samples, indicating even much higher loads to Soda Butte Creek up to and above 1500 lbs/day. Unfortunately there is no corresponding high flow data for the upstream segment of Soda Butte Creek.

There is a general lack of high flow data just below the McLaren Tailings. During one sample event (Maxim 2001a; 7/7/00 sample date), the iron load at SBC2 was significantly higher (36 lbs/day) than the combined loads from Miller Creek and upper Soda Butte Creeks (5 lbs/day). This particular event was not representative of the near peak runoff events, but does indicate that the McLaren Tailings Area continues to have negative impacts on water quality with increasing flow. Recent 2001 data also support this conclusion (Maxim, 2001a).

At or near SBC4 just upstream of Yellowstone National Park (USGS 2001), iron concentrations range from 300 to 6,260 ug/l when flows are between 100 cfs and 632 cfs, with the two highest levels (5200 and 6260 ug/l) corresponding to the two highest flows. Iron loads range from 179 lbs/day to over 17,000 lbs/day. If it were assumed that natural background iron concentrations during high flows were as high as the 300 ug/l standard, then the natural background load could be as much as 6% of the total load during high flow events. Based on the Miller Creek and upper Soda Butte Creek data discussed above, these streams combined may typically contribute as much as 20% of the load. This leaves as much as 74% of the load unaccounted for during the high flow conditions.

Some portion of the elevated high flow load comes from the McLaren Tailings, including re-suspension of iron precipitants that settled to the streambed during low flows. Figure 17 in Appendix F indicates that the McLaren Tailings contribute about 350 g/sec (about 66 lbs/day) load during low flow to Soda Butte Creek. Based on the difference between the sampled in-stream load and inflow load, it appears as though as much as 80% of this total recoverable load (53 lbs/day) is deposited to the streambed. If this represented the average load deposited during the lowest flowing 300 to 330 days of the year, and this load was then re-suspended during the highest flowing 15 to 30 days, then there could be an additional load of about 530 to 1166 lbs/day during those 15 to 30 highest flow days. This would be added to the 66 lbs/day coming from the tailings already, which could be even higher under higher ground water flow conditions anticipated during runoff periods. This analysis indicates that the McLaren Tailings load still may only account for about 5 - 10% of the total load at SBC4 under the highest flow conditions, but it would be a much greater percent of the total load in the vicinity of SBC2 (20 - 40%).

The iron concentrations reported in the synoptic study (Boughton, 2001) for Woody/Republic Creek, Wyoming Creek, and Unnamed Creek indicate that these drainage areas produce the majority of the additional iron loading. Additional loading may also come from floodplain deposits associated with the 1950 tailings dam failure and subsequent large flood events, or from other tributaries.

Manganese (High Flow Conditions)

Upstream of the McLaren Tailings, manganese levels in Soda Butte Creek remain low at higher flows (Maxim, 2001a). Based on a larger set of data, manganese levels in Miller Creek at SW5 were 110 ug/l (load = 30 lbs/day) to 130 ug/l (load = 62 lbs/day) for the two highest flow events, with all other values well below levels of concern.

At most high flows at or near SBC-4 (USGS 2001), manganese levels range from 6 to 58 ug/l, but at the two highest flows manganese levels are 210 ug/l (load = 565 lbs/day) and 155 mg/l (load = 523 lbs/day). If it were assumed that natural background concentrations during high flows were as much as 25 ug/l, then the natural background load could be as much as 15% of the total load during high flows. Based on the Miller Creek and upper Soda Butte Creek data discussed above, these streams combined may typically contribute as much as 25% of the load, most of it coming from Miller Creek. This leaves as much as 60% of the load unaccounted for at this highest flow scenario.

Some portion of this elevated load likely comes from the McLaren Tailings. Based on Figure 21 in Appendix F, it appears as though as much as 50% of the approximate 2 lb/day manganese load may end up deposited to the streambed. Using the same analysis as was done for iron, daily high flow manganese loads from the tailings are estimated to be in the range of 2 to 5% (11 to 23 lbs/day) near SBC4, and 20 to 60% of the total load in the vicinity of SBC2.

Another probable source of manganese is from the Republic smelter, mine and mill sites in the Woody/Republic Creek drainage area. Mine waste and soil samples in mining areas have significantly elevated levels of manganese when compared to background in this area (Pioneer, 2001b and Tetra Tech, 1999). Additional loading may also come from floodplain deposits associated with the 1950 tailings dam failure and subsequent large flood events, or from other tributaries.

Lead (High Flow Conditions)

Upstream of the McLaren Tailings, lead levels in Soda Butte Creek remain low at higher flows (Maxim, 2001a). Based on a larger set of data, lead levels in Miller Creek at SW5 were from 3 ug/l (load = 0.8 lbs/day) to 22 ug/l (load = 11 lbs/day) for the two highest flow events.

At flows greater than 100 cfs at SBC-4, lead levels range from < 1 to 58 ug/l, and lead loads can be as high as 40 lbs/day. If Miller Creek accounts for as much as 11 lbs/day, then this could represent 28% of the total load under worst case conditions. This leaves as much as 72% or more of the load unaccounted for at the highest flow scenarios. Some portion of this elevated load comes from the McLaren Tailings. A probable source of some of the lead is from the Republic smelter, mine and mill sites in the Woody/Republic Creek drainage area. Mine waste and soil samples near mining areas in this drainage have significantly elevated levels of lead when compared to background levels in this area (Pioneer, 2001b and Tetra Tech, 1999). Additional loading may also come from floodplain deposits associated with the 1950 tailings dam failure and subsequent large flood events, or from other tributaries.

Aluminum (High Flow Conditions)

The data at SBC4 (USGS 2001a) consistently show low dissolved aluminum concentrations at low and high flows over the past few years. Data is currently lacking at SBSW102 and SBC2 to sufficiently determine whether or not there is a high flow dissolved aluminum problem upstream of SBC4. There are potentially high loads of dissolved aluminum associated with both Woody/Republic Creek and Miller Creek, where dissolved aluminum data are lacking under high flow conditions. Miller Creek data does show a high load of total recoverable aluminum, which can contribute to dissolved aluminum loads under the right geochemical conditions.

APPENDIX H

CLEANUP/RESTORATION AND FUNDING OPTIONS FOR MINE OPERATIONS OR OTHER SOURCES OF METALS CONTAMINATION

CLEANUP/RESTORATION AND FUNDING OPTIONS FOR MINE OPERATIONS OR OTHER SOURCES OF METALS CONTAMINATION

There are several approaches for cleanup of mining operations or other sources of metals contamination in the State of Montana. Most of these are discussed below, with focus on abandoned or closed mining operations.

1.0 The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA is a Federal law that addresses cleanup on sites, such as historic mining areas, where there has been a hazardous substance release or threat of release. Sites are prioritized on the National Priority List (NPL) using a hazard ranking system with significant focus on human health. Petroleum related products and associated raw materials are not covered under CERCLA. Other Federal regulations such as Resource Conservation and Recovery Act and associated Leaking Underground Storage Tank cleanup requirements tend to address petroleum.

Under CERCLA, the potentially responsible party or parties must pay for all remediation efforts based upon the application of a strict, joint and several liability approach whereby any existing or historical land owner can be held liable for restoration costs. Where viable landowners are not available to fund cleanup, funding can be provided under Superfund authority. Federal agencies can be delegated Superfund authority, but cannot access funding from Superfund.

Cleanup actions under CERCLA must be based on professionally developed plans and can be categorized as either Removal or Remedial. Removal actions can be used to address the immediate need to stabilize or remove a threat where an emergency exists. Removal actions can also be non-time critical, which is the situation for the New World Mining District cleanup efforts under the direction of the United States Forest Service, as discussed in this document.

Once removal activities are completed, a site can then undergo Remedial Actions or may end up being scored low enough from a risk perspective that it no longer qualifies to be on the NPL for Remedial Action. Under these conditions the site is released back to the state for a "no further action" determination. At this point there may still be a need for additional cleanup since there may still be significant environmental threats or impacts, although the threats or impacts are not significant enough to justify Remedial Action under CERCLA. Any remaining threats or impacts would tend to be associated with wildlife, aquatic life, or aesthetic impacts to the environment or aesthetic impacts to drinking water supplies versus threats or impacts to human health. A site could, therefore, still be a concern from a water quality restoration perspective, even after CERCLA removal activities have been completed. This may end up being the situation for the McLaren Tailings.

Remedial actions may or may not be associated with or subsequent to removal activities. A remedial action involves cleanup efforts whereby Applicable or Relevant and Appropriate Requirements and Standards (ARARS), which include state water quality standards, are satisfied. Once ARARS are satisfied, then a site can receive a "no further action" determination.

2.0 The Montana Comprehensive Cleanup and Restoration Act (CECRA)

The 1985 Montana Legislature passed the Environmental Quality Protection Fund Act. This Act created a legal mechanism for the Department to investigate and clean up, or require liable persons to investigate and clean up, hazardous or deleterious substance facilities in Montana. The 1985 Act also established the Environmental Quality Protection Fund (EQPF). The EQPF is a revolving fund in which all penalties and costs recovered pursuant to the EQPF Act are deposited. The EQPF can be used only to fund activities relating to the release of a hazardous or deleterious substance. Although the 1985 Act established the EQPF, it did not provide a funding mechanism for the Department to administer the Act. Therefore, no activities were conducted under this Act until 1987.

The 1987 Montana Legislature passed a bill creating a delayed funding mechanism that appropriated 4 percent of the Resource Indemnity Trust (RIT) interest money for Department activities at non-National Priority List facilities beginning in July 1989 (§ 15-38-202 MCA). In October 1987, the Department began addressing state Superfund facilities. Temporary grant funding was used between 1987 and 1989 to clean up two facilities and rank approximately 250 other facilities. Beginning in fiscal year 1995, the 4 percent allocation was changed to 6 percent to adjust for other legislative changes in RIT allocations. Effective July 1, 1999, the 6 percent allocation was increased to 9 percent.

The 1989 Montana Legislature significantly amended the Act, changing its name to the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA) and providing the Department with similar authorities as provided under the federal Superfund Act (CERCLA). With the passage of CECRA, the state Superfund program became the CECRA Program. Major revisions to CECRA did not occur until the 1995 Legislature, when the Voluntary Cleanup and Redevelopment Act (VCRA), a mixed-funding pilot program, and a requirement to conduct a collaborative study on alternative liability schemes were added and provisions related to remedy selection were changed. Based on the results of the collaborative study, the 1997 Legislature adopted the Controlled Allocation of Liability Act, which provides a voluntary process for the apportionment of liability at CECRA facilities and establishes an orphan share fund. Minor revisions to CECRA were also made by the 1999 and 2001 Legislatures.

Currently, 208 facilities on the CECRA Priority List remain to be addressed; current actions are being conducted at 59 of those facilities. To date, 79 facilities are delisted because they are cleaned up or being addressed by another program. CECRA facilities are ranked maximum, high, medium, low and operation and maintenance priority based on the severity of contamination at the facility and the actual and potential impacts of contamination to public health, safety, and welfare and the environment. The Department maintains database narratives that explain contamination problems and status of work at each state Superfund facility. As of November 2001, final cleanup had been completed at 49 CECRA facilities, and interim cleanups had been completed at 78 facilities.

2.1 The Controlled Allocation of Liability Act (CALA)

The Montana Legislature added the Controlled Allocation of Liability Act (CALA; §§ 75-10-742 through 752, Montana Code Annotated (MCA)) to the Comprehensive Environmental Cleanup and Responsibility Act (CECRA; §§ 75-10-701 through 752, MCA), the state Superfund law, in 1997. The department administers CALA including the orphan share fund it establishes.

CALA is a voluntary process that allows Potentially Responsible Parties (PRP) to petition for an allocation of liability as an alternative to the strict, joint and several liability scheme included in CECRA. CALA provides a streamlined alternative to litigation that involves negotiations designed to allocate liability among persons involved at facilities requiring cleanup, including bankrupt or defunct persons. Cleanup of these facilities must occur concurrently with the CALA process and CALA provides the funding for the orphan share of the cleanup. Since CECRA cleanups typically involve historical contamination, liable persons often include entities that are bankrupt or defunct and not affiliated with any viable person by stock ownership. The share of cleanup costs for which these bankrupt or defunct persons are responsible is the orphan share. Department represents the interests of the orphan share throughout the CALA process.

The funding source known as the orphan share fund is a state special revenue fund created from a variety of sources. These include an allocation of 8.5 percent of the metal mines license tax, certain penalties and additional funds from the resource indemnity trust fund and 25 percent of the resource indemnity and groundwater assessment taxes (which will increase to 50 percent when the RIT reaches $100 million). The current balance of the Orphan Share Fund is around $4 million and revenues projected for the rest of this biennium are about $2 million.

In the absence of a demonstrated hardship, claims for orphan share reimbursement may not be submitted until the cleanup is complete. This ensures that facilities are fully remediated before reimbursement. The result is that a PRP could be expending costs it anticipates being reimbursed for some time before the PRP actually submits a claim.

CALA was designed to be a streamlined, voluntary allocation process. For facilities where a PRP does not initiate the CALA process, strict, joint and several liability remains. Any person who has been noticed as being potentially liable as well as any potentially liable person who has received approval of a voluntary cleanup plan can petition to initiate the CALA process. CALA includes fourteen factors to be considered in allocating liability. Based on these factors causation weighs heavily in allocation but is not the only factor considered.

2.2 The Voluntary Cleanup and Redevelopment Act (VCRA)

The 1995 Montana Legislature amended the Comprehensive Environmental Cleanup and Responsibility Act (CECRA), creating the Voluntary Cleanup and Redevelopment Act (VCRA) (Sections 75-10-730 through 738, MCA). VCRA formalizes the voluntary cleanup process in the state. It specifies application requirements, voluntary cleanup plan requirements, agency review criteria and time frames, and conditions for and contents of no further action letters.

The act was developed to permit and encourage voluntary cleanup of facilities where releases or threatened releases of hazardous or deleterious substances exist, by providing interested persons with a method of determining what the cleanup responsibilities will be for reuse or redevelopment of existing facilities. Any entity (such as facility owners, operators, or prospective purchasers) may submit an application for approval of a voluntary cleanup plan to the Department. Voluntary Cleanup Plans (VCPs) may be submitted for facilities whether or not they are on the CECRA Priority List. The plan must include (1) an environmental assessment of the facility; (2) a remediation proposal; and (3) the written consent of current owners of the facility or property to both the implementation of the voluntary cleanup plan and access to the facility by the applicant and its agents and Department. The applicant is also required to reimburse the Department for any costs that the state incurs during the review and oversight of a voluntary cleanup effort.

The act offers several incentives to parties voluntarily performing facility cleanup. Any entity can apply and liability protection is provided to entities that would otherwise not be responsible for site cleanup. Cleanup can occur on an entire facility or a portion of a facility. The Department cannot take enforcement action against any party conducting an approved voluntary cleanup. The Department review process is streamlined: the Department has 30 to 60 days to determine if a voluntary cleanup plan is complete, depending on how long the cleanup will take. When the Department determines an application is complete, it must decide within 60 days whether to approve or disapprove of the application; these 60 days also includes a 30-day public comment period. The Department's decision is based on the proposed uses of the facility identified by the applicant and the applicant conducts any necessary risk evaluation. Once a plan has been successfully implemented and Department costs have been paid, the applicant can petition the Department for closure. The Department must determine whether closure conditions are met within 60 days of this petition and, if so, the Department will issue a closure letter for the facility or the portion of the facility addressed by the voluntary cleanup.

The act is contained in §§ 75-10-730 through 738, MCA. Major sections include: § 75-10-732 - eligibility requirements; § 75-10-733 and § 75-10-734 - environmental property assessment and remediation proposal requirements; § 75-10-735 - public participation; § 75-10-736 - timeframes and procedures for Department approval/disapproval; and § 75-10-737 - closure process. Section 75-10-721, MCA of CECRA must also be met.

The Department does not currently have a memorandum of agreement (MOA) with the Environmental Protection Agency (EPA) for its Voluntary Cleanup Program. However, the Department and EPA are in the process of negotiating one. EPA has indicated that Montana's Voluntary Cleanup Program includes the necessary elements to establish the MOA. Currently, EPA is reviewing the latest draft of the MOA.

The Department has produced a VCRA Application Guide to assist applicants in preparing a new application; this guide is not a regulation and adherence to it is not mandatory.

As of November 2001, the Department has approved twenty voluntary clean plans for 19 facilities, including mining, manufactured gas, wood treating, dry cleaning, salvage, pesticide, fueling, refining, metal plating, defense, and automotive repair facilities. Applicants have expressed interest and/or submitted applications for voluntary cleanup at fifteen other facilities. The Department maintains a registry of VCRA facilities.

3.0 Abandoned Mine Lands Cleanup

The purpose of the Abandoned Mine Lands Reclamation (AML) Program is to protect human health and the environment from the effects of past mining and mineral processing activities. Funding for cleanup is via the Federal Abandoned Mine Fund, which is distributed to the State of Montana via a grant program. The Abandoned Mine Fund is generated by a per ton fee levied on coal producers and the annual grant it based on coal production. Expenditures under the abandoned mine program can only be made on "eligible" abandoned mine sites. For a site to be eligible, mining must have ceased prior to August 4, 1977 (private lands, other dates apply to federal lands). In addition, there must be no continuing reclamation responsibility under any state or federal law. No continuing reclamation responsibility can mean no mining bonds or permits have been issued for the site, however, it has also been interpreted to mean that there can be no viable responsible party under State or Federal laws such as CERCLA or CECRA. While lands eligible for the Abandoned Mine Funds include hard rock mines and gravel pits, abandoned coalmines have the highest priority for expenditures from the Fund. Cleanup of any eligible site is prioritized based primarily on human health, which can include health risks such as open shafts, versus risks only associated with hazardous substances, as is the case under CERCLA.

Montana's AML Program maintains an inventory of all potential cleanup sites, and also has a list of priority sites from which to work from. This includes sites such as the Republic Mine and Smelter Site discussed within this report. The Montana Department of Environmental Quality conducts cleanups under the Abandoned Mine Funds as public works contracts utilizing professional engineers for design purposes and private construction contractors to perform the actual work.

Mitigating impacts associated with discharging adits can be included within the cleanup, although ongoing water treatment is not pursued as a reclamation option to avoid long-term operational commitments, which are outside the scope of the program and funding source. Therefore, even after cleanup, an abandoned mine site could still represent a source of contaminant loading to a stream, especially if there is a discharging adit associated with the site. Where discharging adits are not of concern, cleanup may generally represent efforts to achieve all reasonable land, water, and soil conservation practices for that site.

A Guide to Abandoned Mine Reclamation (MDEQ, 1996) provides further description of the Abandoned Mine Lands Program and how cleanup activities are pursued.

4.0 Cleanup on Federal Agency Lands

A Federal land management agency may pursue cleanup actions outside of any requirements under CERCLA or CECRA where such activities are consistent with overall land management goals and funding availability. This is the anticipated solution for mines in the Cooke City TMDL Planning Area that are located on Forest Service property and meet certain criteria. This criteria would likely include the following: the site is part of the loading problem to Soda Butte Creek or other streams not addressed by New World Mining District Restoration and there does not appear to be a viable party or person other than the Forest Service.

5.0 Permitted or Bonded Sites

Newer mining sites that are or have been in recent operation are required to post bonds as part of their permit conditions. These bond and permit conditions help ensure cleanup to levels that will satisfy Montana Water Quality Standards during operation and after completion of a mining operation. Such sites also include larger placer mines greater than 5 acres in size. There are not any permitted or bonded sites in the Cooke City TMDL Planning Area.

6.0 Voluntary Cleanup Agreement

At least one location within Montana (the Upper Blackfoot Mining Complex) is being addressed via a voluntary cleanup approach based on an agreement between the responsible person and the State of Montana. Although similar in nature to the goals of CECRA, this cleanup effort is currently not considered a remedial action under CECRA. The responsible person is responsible for cleanup costs in this situation.

7.0 Landowner Voluntary Cleanup Outside of a State Directed or State Negotiated Effort

A landowner could pursue cleanup outside the context of CECRA or other state negotiated cleanup approaches. Under such conditions, liability would still exist since there is presumably a lack of professional oversight and assurance of meeting appropriate environmental and human health goals. Regulatory requirements such as where waste can be disposed, storm water runoff protection, and multiple other environmental conditions would still need to be followed to help ensure that the cleanup activity does not create new problems. This approach can be risky since the potential for additional future work would likely make it more cost effective to pursue cleanup under CECRA or some other state negotiated approach where PRP liability can be resolved.

8.0 State Emergency Actions

Where a major emergency exists, the State can undertake remedial actions and then pursue reimbursement from a responsible party. This situation does not exist in the Cooke City TMDL Planning Area.

FUNDING OPTIONS AND CONSIDERATIONS

Many of the above cleanup options to address mining related sites revolve around funding availability and therefore must be of adequate priority to tap into available funds. Funded actions in the Cooke City Planning Area appear to be limited to CERCLA actions as defined by the Consent Decree and also as defined by previous efforts that have focused on the McLaren Tailings; AML priority sites which include the Republic Mine and Smelter sites; and possibly some Forest Service actions to address individual mine locations outside the context of New World Mining District requirements. These funded activities will end up addressing the majority of the significant metals loading sources.

Additional assessment projects still need to be funded to better identify the relative load contributions during high and low flow conditions from many of the specific mining and other metals related sources outside the scope of the New World Mining District restoration efforts. Where specific sites are identified as significant sources of metals loading, then an approach needs to be identified to address the problem. In some situations, there may be PRPs that would be interested in pursuing cleanup under CECRA/CALA. Where a viable or voluntary party is not available, then funding options need to be identified and pursued to address cleanup efforts. One option involves funding via the yearly RIT/Resource Development Grant Program (RDGP), which can supply up to $300K to address environmental related issues. This money can be applied to sites that are AML eligible but of low enough priority where cleanup under AML is uncertain, and can also be used for further assessment/characterization work.

Another potential funding source is via the EPA Section 319 Nonpoint Source yearly grant program. This money is typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20K to $150K, with a 25 percent match requirement. RIT/RDGP and 319 projects typically need to be administered via a non-profit or local government such as a conservation district or a county.

There are likely several other grant programs and funding sources that could be utilized to help protect water quality and address environmental concerns, especially where such concerns are associated with the headwaters to Yellowstone National Park. State and Federal agencies are often able to provide some assessment-related support. Where sufficient funding can be obtained, then detailed assessment and cleanup such as might occur under VCRA, could be pursued.

APPENDIX I
DEQ RESPONSES TO PUBLIC COMMENTS

DEQ RESPONSES TO PUBLIC COMMENTS

<u>COMMENT</u>: The following two comments are closely related concerning the selection of aquatic life support targets.

- Refer to page 1-4, Table 1-2. Here and in other places "Cold Water Fish" is appropriately mentioned as a beneficial use not fully supported as a result of water quality impairment. We suggest adding where appropriate through the plan that, "full restoration of this use be evidenced by the presence of food organisms, spawning habitat and other requirements for sustainable populations of cold water fisheries". This would be one of the most comprehensive indicators of successful restoration.

- Refer to page 1-12, third paragraph. It states that, "Within Montana, the Soda Butte fishery is limited". We urge that a specific goal of this plan be that a viable, self-sustaining fishery be reestablished between the Miller Creek confluence and Yellowstone Park boundary.

> **<u>DEQ RESPONSE</u>:** Targets currently address macroinvertebrates and periphyton, which are critical to the food base for cold water fish. The non-toxic and percent fines conditions associated with other targets contribute to the health of the cold water fish as well as other aquatic life in these streams. These targets apply to all of Soda Butte Creek as well as other streams identified in this document. The following language has been added to the Executive Summary discussion on targets: "For aquatic life and cold water fish uses, the target goals are to provide stream conditions that can support a healthy aquatic life community based on stream capabilities. This includes the ability to support a self-sustaining fishery along with healthy macroinvertebrate and periphyton communities."

<u>COMMENT</u>: In the interest of providing the reader a comprehensive look at this complex issue, please consider adding a summary table or matrix (perhaps in the executive summary) that depicts for all three watersheds the major pollution source areas, the impairment and restoration targets, ongoing and planned restoration projects/programs and the respective responsible agencies.

> **<u>DEQ RESPONSE</u>:** Table E-1 in the Executive Summary has been expanded to address restoration strategies and other restoration plan components, and Table E-2 has been added to include a summary of the metals and pH restoration targets for all three water bodies.

<u>COMMENT</u>: The area of primary concern within the Cooke City TMDL Planning Area is delineated by Figure 1.1. It would be helpful to include a smaller scale locator map overlay so that the entire Cooke City Planning area could be viewed in context with the adjacent Boulder-Stillwater, Stillwater-Columbus, and Rock Creek-Red Lodge planning areas. There should also be some reference to the water quality conditions of those waters outside the areas of primary concern, but still within the TMDL planning area as defined by Figure 1.1.

DEQ RESPONSE: Although Figure 1-1 (now Figure E-1) was not changed, the following language has been added to the Section 1.1: "By addressing impairment conditions in these three watersheds, potentially significant impairment contributions and associated needed pollutant reductions for downstream water bodies in other TMDL planning areas are also addressed. The extent that these upstream pollutant reductions help address any downstream beneficial use support concerns will be evaluated further as restoration plans are developed for the downstream TMDL planning areas."

COMMENT: Agriculture and industry are listed among beneficial uses that are impaired for Daisy and Fisher Creeks (ref. Table 1-2). Please explain why these would be considered either present or forecast beneficial uses of water in those drainages.

DEQ RESPONSE: The following language has been added to Section 1.1.1 to address this question: "Note that a few water bodies are identified as not fully supporting the beneficial uses of agriculture and industry. State water quality standards are protective of multiple uses that always include agriculture and industry for A-1 or B-1 classified streams. The goal is to not only protect these uses within given water bodies, but to also protect these uses in downstream waters. This then ensures a healthy aquatic ecosystem while at the same time keeping pollutant levels low enough to support other existing or potential human related uses such as agriculture or industry."

COMMENT: Refer to page 1-6, second paragraph. This reads in part, "…the term restoration is used in a broad sense that includes water quality improvements …". Should restoration also refer to actions taken to reverse historic impacts that would not necessarily be corrected by measurable improvements in water quality?

DEQ RESPONSE: Language in Section 1.1.2 has been expanded as follows: "Throughout this document, the term restoration is used in a broad sense that includes water quality improvements realized through activities referred to as restoration or otherwise referred to as cleanup, remediation, treatment, or source control. These water quality improvements include a broad consideration of improvements to the chemical, physical, and/or biological components of the system. Note that water quality improvements address more than just a consideration of water column chemistry."

COMMENT: Refer to page 1-14, last paragraph. There is a discussion of water body classifications and beneficial uses. Our understanding is that when Soda Butte Creek enters Yellowstone National Park it takes on an additional "outstanding waters" classification. In addition, the Clarks Fork in Wyoming is included within the National Wild and Scenic Rivers System. Please address whether either of these stream classifications potentially have a bearing on the goals/requirements for the restoration of these impaired waters.

DEQ RESPONSE: These two additional designations have been noted in Section 1.4.1. Section 1.4.2 includes the following added language to address the Outstanding Waters designation: "Montana State law for outstanding waters (Montana Water Quality Act; Section 75-5-316) focuses on the need to prevent any new point or nonpoint sources from causing significant degradation, with focus on limiting impacts from toxic and other health related pollutants. The contaminant sources of concern, as identified within this document, are associated with existing nonpoint sources and cleanup of such sources. The outstanding resource designation appears to have no bearing on existing or proposed future activities within the Cooke City Planning Area, and restoration activities discussed within this plan are consistent with the outstanding waters designation that applies to portions of Soda Butte Creek."

The State of Wyoming and EPA were both provided the opportunity to comment and identify any deficiencies with the Clarks Fork targets in regards to protecting the National Wild and Scenic River designation. Section 3.4 includes the following added language to address the National Wild and Scenic River designation: "It appears as though the targets and TMDLs developed for the Clarks Fork River in Montana can also serve as the metals TMDLs and targets for the section of the Clarks Fork River within Wyoming. This would be protective of Wyoming's beneficial uses, satisfy Wyoming water quality standards, and be protective of the National Wild and Scenic River designation for this stream segment."

COMMENT: The points of compliance for numeric targets for the streams of interest should be presented in an additional table in Chapter 1.

DEQ RESPONSE: Figure 1-3 and several other figures identify individual monitoring sites that are later defined as measurement locations to determine progress toward meeting target goals.

COMMENT: Mention is made in several places that one of the restoration targets is restoration of biota equal to or greater than 75% of that found in a reference stream. We certainly support inclusion of biota restoration targets for all of the streams. Please explain the rationale for selection of 75%.

DEQ RESPONSE: The following language has been added to Section 1.4.2 to address this question: "Throughout this plan, several targets (reference Table E-2) are based on biota indicators being at or greater than 75% of a desired or reference condition. The 75% is directly from *Appendix A of Water Quality Assessment Process and Methods* (MDEQ, 2000). This number represents an interpretation of narrative standards, particularly those standards based on harmful conditions to aquatic life. Where any biota indicator is below 75% of reference, the stream is considered moderately impaired, and if the indicator is below 25%, the stream is considered non-supporting. Minor impairment is a situation where all biota indicators are greater that 75% of reference but still showing some negative impact(s). A stream is considered fully supporting of its beneficial uses where there is no impairment or only minor impairment. This approach recognizes that a stream where all biota indicators are at or above 75% can support a fully functioning aquatic community while also recognizing the variations in measurement methods and variations between streams that would make it difficult to justify the use of higher percentages. The approach takes into account the fact that limited minor impacts to a water body do not necessarily represent a violation of Montana's water quality standards, although they still may represent opportunities for water quality improvements. Where direct measures of biota are not available, the 75% approach is sometimes applied to habitat indicators, as is the case for the sediment targets associated with pebble counts in this plan."

COMMENT: Refer to page vi, third paragraph. We agree with the statement that excessive sediment accumulation in the streambed in many locations can smother aquatic life (including fish eggs), etc. Does this reference to sediment include the ferric oxide precipitate (sludge) that coats the streambed in many locations?

DEQ RESPONSE: Although this statement is made with sediment in mind, the sludge from metal deposits likely contributes to this condition. Satisfying both the sediment and metals targets will address both contributing conditions.

COMMENT: Page 2-9, section 2.2.2, 2nd paragraph, 5th sentence. Our interpretation of the data in table 2-3 is that, at a minimum, the 12.5% load attributed to the area north and west of the McLaren Mine is natural. The loads attributed to the moraine/landslide hill and to the manganese bog also are likely natural. Part of the copper load attributed to the southern and northern parts of the McLaren Mine likely is natural as well. Therefore, the range of copper loading attributable to natural background, based on table 2-3, likely ranges from 12.5% to 34.1% and possibly higher.

DEQ RESPONSE: The wording in this section has been modified to avoid being inconsistent with this comment, which came from the author of the study report. The 2% to 20% range has been deleted. The new wording is: "The data does not clearly distinguish between natural background loads and mining related loads. Some of the loading sources such as the moraine or landslide hill, the manganese bog, and the area north and west of the McLaren Mine may eventually prove to be indicators of natural background loads."

COMMENT: There are many small mining sites in the area that have not been pin pointed.

DEQ RESPONSE: It is acknowledged and recognized that future assessment efforts will need to address the potential that there are small mine sites that have yet to be identified and characterized. This is especially true for non-District property.

COMMENTS: The below subset of technical corrections were all responded to in the same manner.

- Page 1-12, 2nd paragraph. Upstream migration of fish in Miller Creek is probably prevented not only by steep gradients (as noted in the text) but also by a large waterfall about one-half mile upstream from the mouth of Miller Creek.

- Page 2-9, section 2.2.2, 1st paragraph. The text states that pH values increase consistently in Daisy Creek. On the basis of data in Nimick and Cleasby (2001), pH values are greater than 7 in the headwaters of the stream, decrease in the upper reaches where most metal loading occurs, and then start to increase continually downstream, as mentioned in the text.

- Page 2-9, section 2.2.2, 2nd paragraph, 3rd sentence. This sentence would be more accurate if ‘patterns of’ were inserted between ‘Similar’ and ‘’loads’ at the beginning of the sentence. The actual loadings (in pounds per day) for each metal are quite different.

- Page 3-11, last paragraph, 6th line from bottom. The statement that total recoverable values are not available appears to be incorrect. The total metals data reported by Kimball et al. (1999) can be considered total recoverable concentrations, as noted in table 2 of that report.

  DEQ RESPONSE: All four comments were addressed by making the appropriate additions or changes to the document where noted.

COMMENTS: The following comments focus on monitoring of individual restoration activities.

- Refer to Figure 3-1. Some of the waste dumps circled on this map were removed and areas rehabilitated in 2001. Monitoring of revegetation and site erosion remains.

- Figure 2-3 showing a map of roads and trails is somewhat misleading, as some of the roads in the Daisy Creek drainage were obliterated/ put to bed by Crown Butte Mining Inc. These areas need evaluation as to success of stabilization in terms of sediment contribution. Perhaps more discussion of this map is in order.

  DEQ RESPONSE: The monitoring of revegetated areas and success of erosion control and other restoration actions are an inherent part of the New World restoration strategy. *The Long-Term Revegetation Monitoring Plan* contained within Appendix E of *the Final Overall Work Plan* (Maxim, 1999) provides specific plans for revegetated areas and also addresses reclaimed roads. The monitoring of restoration work is an important component of the performance based load allocation approach for metals and pH, where it is stated in Sections 2.3.1.3, 3.3.1.3, and 4.3.3.1 that the performance based allocation approach "includes appropriate implementation monitoring and maintenance of restoration efforts to ensure success." If significant cumulative impacts exist from reclaimed source areas such as those mentioned in the comments, then in-stream monitoring and routine water quality monitoring will detect elevated levels of pollutants.

  The road network in Figure 2-3 and similar figures for the other drainages is now referred to as the “existing and historic” road network in recognition of ongoing or completed rehabilitation efforts. These obliterated roads still present a potential accelerated pathway for pollutants due to erosion where vegetation has yet to be reestablished. They also represent a potential accelerated pathway for pollutants to ground water or surface water where an increased exposure of mineralized material exists and will likely continue to exist to some extent.

<u>COMMENT</u>: The following comments are closely related and addressed with one response:

- Refer to page vii, second paragraph. It is stated, "An assumption within this plan is that meeting the TMDLs based on numeric standards is expected to satisfy all other metals related targets …". Do you believe that this statement applies to heavy metal deposits that have been found in stream sediments as well?

- Please expand the discussion on the restoration target stated as, "elimination of objectionable deposits and turbidity from metal precipitates…". These deposits inhibit macro invertebrate and fish production and do not appear to flush through the system naturally.

- Section 2.3.2.1, Sediment Targets. Is it anticipated that in order to achieve these restoration targets it will require some form of stream restoration work in addition to the correction of sediment source problems? This question applies to other drainages as well.

- Please add a summary of the recently completed research at Montana State University by Marcus, Myers and Nimmo on metal contaminants of stream sediments in Soda Butte Creek and comment on its implications for present and long-term impairment.

<u>DEQ RESPONSE</u>: As stated in Sections 2.3.1.2 and similar sections: "As metal loading is reduced to TMDL levels, the existing fine sediments with metals contamination will likely flush through the system at high flows as they have probably been doing over the years, the difference being that they will start being replaced by fewer and cleaner fine sediment deposits." Additional targets based on macroinvertebrates, periphyton, visible streambed deposits, and non-toxic sediment conditions are included as a check on this assumption. In addition, the following recommendation is added to Section 5.5.2 (sixth bullet) to help address this concern: "As metals loading sources are removed, sediment and floodplain metals concentrations should be evaluated to determine whether or not there should be removal efforts. Any such plans should take into consideration the extent of yearly flushing associated with stream sediments and the potential for significant damage to the physical structure of the stream from removal efforts."

At this time it is envisioned that stream restoration work that includes some form of channel disturbance may only be needed in locations directly adjacent to and physically impacted (i.e. channelized) by a mine site such as the McLaren Tailings. It is recognized that elevated levels of metals in sediments and floodplains are anticipated for a potentially long period of time in Soda Butte Creek and possibly other streams in the area. Although this is not a desirable situation, mechanical removal of contaminated sediment and floodplain material can create conditions that are more harmful to aquatic life and may generally not be needed from a restoration perspective. If a given depositional area was to be independently analyzed for removal, then it may become part of the updated restoration strategy if the benefits are found to outweigh the risks, although no such locations appear to have been identified at this time for any of the drainages.

<u>COMMENT</u>: Refer to page 3-17. "Water treatment options" are mentioned in several places as potential restoration actions. Please explain what is meant. Would this envision a one-time treatment of impounded water or some permanent/long term chemical treatment process? Installation and operation of a long-term chemical treatment facility would incur high O&M costs and most likely is inconsistent with the undeveloped character with the area, a requirement of the consent decree. Does the discussion of the 12 major source areas on pages 17 and 18 reflect current plans and scheduling? For which of these is relevant data insufficient or nonexistent?

> **<u>DEQ RESPONSE</u>:** Water treatment is a potential approach to address metals sources and can refer to one time treatment, treatment as a form of mitigation during cleanup of individual sites, passive treatment, or other options that should be all be considered, at least initially, for each significant source area. The Consent Decree states "the work will be selected taking into consideration the desirability of preserving the existing undeveloped character of the District and the surrounding area". Given this goal, treatment is less likely to include a permanent long-term type of treatment involving high operation and maintenance costs and/or causing significant impacts to the undeveloped character of the area.
>
> The 12 major source areas are from the Final Overall Work Plan (Maxim, 1999), and will all be addressed via the process identified within Section 5.1 of this document. This process involves the collection and analyses of additional data as needed to make informed restoration decisions, since such data is still needed for many of the source areas. It is recognized that as New World Restoration work progresses, there may be a need for modifications to how source areas are grouped and when they are addressed as long as the modification are consistent with the work plan or approved modifications to the work plan.

<u>COMMENT</u>: Refer to page 4-10, fourth paragraph. This reads, "Iron has an additional target for Soda Butte Creek of no visible streambed deposits resulting from human caused conditions". Please include a discussion of the strategy for accomplishing this goal, in this section (SECTION 5.0).

> **<u>DEQ RESPONSE</u>:** As pointed out in Section 4.3.2: "For iron, the TMDL based on the 300 ug/l drinking water/domestic use support condition will satisfy the additional target of no visible streambed deposits associated with fine materials from human causes." The overall strategy that identifies removal of the McLaren Tailings to meet the metals targets would accomplish this goal. Once the source is removed, scour action during high flows is expected to remove any streambed staining.

<u>COMMENT</u>: The three comments below are closely related and addressed together.

- Refer to page 1-9, second paragraph. This paragraph briefly describes the communities within the plan area. It is important to document that there exists numerous residences in the Soda Butte Creek valley between Cooke City and Silvergate that obtain their domestic water supplies from shallow wells presumably in the Soda Butte Creek alluvium, virtually a direct connection to the surface water.

- Soda Butte Creek is more than likely impacted by the many septic tanks of the area in addition to the mining impacts. Testing is needed.

- The nutrients in the domestic water supplies are of another concern. The numerous Cooke City and Silver Gate wells need to be tested to assess the concentrations of metals and other possible contaminates, the origin of the water flows into these water supplies also needs to be determined. Most are shallow wells of 20’ to 40’. Nutrients in the water have not been tested.

  DEQ RESPONSE: Metals data from private wells was not incorporated. The following language addressing the metals and ground water concern was added to Section 4.1.1: “There are drinking water wells in the Cooke City area where some residents obtain their domestic water from an alluvial system that is interconnected to Soda Butte Creek flows. The retrospective analysis of previous research (Boughton, 2001) provides a summary of previous ground water work and metals sampling. Based on the previous work, metal concentrations in wells are currently below levels of concern in area ground water supplies, presumably due to high levels of dilution in the ground water system and other hydrogeologic factors.”

  Assessment results for Soda Butte Creek do not indicate a nutrient impairment problem or threat, meaning that the impacts from septic tanks are not significant enough to cause water quality problems in the surface water. Therefore, nutrient levels in ground water are outside the current scope of this restoration plan since nutrient sources, such as septic systems, are not considered an impairment cause or significant threat to Soda Butte Creek. Nevertheless, it would be prudent to test for pathogens and elevated levels of nitrate or other nutrients when doing any sampling of private wells to help address potential human health concerns associated with septic systems and to provide baseline data for future trend analyses.

COMMENTS: The following two comments are closely related concerning Miller Creek metals loading (Section 4.2.2).

- Page. 4-6, 4th paragraph, last sentence. This sentence states that the Black Warrior dump location ‘appears to be a potentially significant source of most of the metals of concern.’ This sentence would better reflect the results of the USGS metal-loading study if it were restated. A possible rewording would be ‘appears to be a potentially minor source of some metals of concern.’ Dissolved and total-recoverable copper concentrations remained unchanged in Miller Creek at sites upstream and downstream from the inflow that drains the Black Warrior, while concentrations of total-recoverable aluminum, iron, lead, and zinc increased. However, these increases persisted only for a short distance downstream. Although the bed-sediment samples showed that leachable-metal concentrations were elevated in the inflow draining the Black Warrior site, concentrations at the mainstem site directly downstream from the Black Warrior were only slightly higher than at the mainstem site upstream from the Black Warrior.

- Page 4-6, 5th paragraph, 1st sentence. The issues and conclusions presented in this sentence will not be addressed by the USGS metal-loading study, and therefore the reference in this sentence is not appropriate. Please delete the reference to discussions with Tom Cleasby. In addition, the sentence would better reflect metal-loading conditions in the drainage if natural background sources were mentioned. The small metal loads that enter Miller Creek during low-flow conditions likely are influenced as much, if not more, by the local geology than by mining disturbances. For example, the copper in the three inflows with elevated copper concentrations upstream from SW-2 likely comes from a combination of natural and mining-related sources. Revised text that better reflects the results of our study would be:

> Results of the USGS synoptic study indicate that metal loading to Miller Creek during low flow was relatively small and had generally minor effects on metal concentrations in Miller Creek. Substantial differences in metal loading from mine-affected areas and areas influenced by local geology could not be readily determined. During the study, total-recoverable concentrations of copper, lead, and zinc in Miller Creek were less than the chronic aquatic-life criteria in all samples with the exception of one lead value.

DEQ RESPONSE: The first sentence in the 5th paragraph on Page 4-6 has been deleted as suggested. The suggested wording has been added, and the uncertainty associated with natural background loading has been stressed. Also added is clarification that chronic standards are only occasionally exceeded during low flow conditions based on substantial monitoring results from other data sources in addition to the USGS study. It is stressed that most of the water quality concerns are associated with medium to high flow where elevated metals concentrations are consistently detected. The reference to the Black Warrior mine has been removed due to loading uncertainties associated with this specific source area.

COMMENTS: The following comments pertain to the sediment impairment determination to Soda Butte Creek.

- Further on is mention of extremely high levels of fine sediment, associated with natural conditions, entering Soda Butte Creek via Woody Creek. We know there is evidence of historic mining activity in the Woody-Republic drainage. Have you been able to separate natural from man-caused sediment production in that drainage?

- Refer to subsection 4.1.2, Sediment Impairment Decision. We disagree with the MDEQ decision and the basis for the decision to not consider suspended solids/sediment as a cause of impairment. The contention in the report seems to be that the heavy sediment load in Soda Butte Creek is all from natural sources on tributary streams. While these tributaries are a sediment source, two very significant, man caused sources exist near the McLaren Tailings, though not from the tailings impoundment itself. They are;
  a. The McLaren Mill Site is located between the highway and Soda Butte Creek. This site of about 4 acres contains unprocessed ore containing heavy concentrations of metals and pyrite spread over the area about three to six feet deep and sloping toward the creek. Erosion rills up to two feet deep are evidence of active erosion of these sediments directly into Soda Butte Creek. The 1989 superfund response action (referenced in this plan) was intended to contain the creek to its banks in a 100-year return period streamflow event, and thereby prevent washout of the tailings impoundment, not to correct the active erosion on the north side of the creek. The mill site was investigated in 1988/89 by the

Bureau of Reclamation for the EPA, reported in "Analysis of Corrective Action Alternatives for the McLaren Tailings Site Cooke City, MT", March 1989. The report states (page 17) that, "Surface runoff from this area is taking place during higher intensity precipitation events as is evidenced by the abundance of small gullies in the area. It is highly probable that substantial transport of contaminants from this area to Soda Butte Creek is occurring during periods of high surface runoff." Total concentration and water-soluble analysis are reported on seven samples showing arsenic, copper, iron and lead.

b. At the time the tailings impoundment was constructed, Soda Butte Creek was relocated into a man-made channel, having a steep gradient, on the north side of the impoundment. This deeply incised channel shows substantial evidence of active bank erosion in the vicinity of the Miller Creek confluence.

DEQ RESPONSE: As discussed in Section 4.1.2; MDEQ did not list suspended sediment as an impairment cause in Soda Butte Creek because a review of available information and onsite assessment work revealed that the majority of the sediment load is from relatively steep, erosive tributary drainages. MDEQ does acknowledged that there are undesirable mining related sources of sediment, such as those mentioned in the comments, but there is evidence that such sources are not significant enough to require a sediment TMDL for Soda Butte Creek given the very high levels of natural background sediment loading as referenced in Section 4.1.2. As further discussed at the end of Section 4.1.2, it is anticipated than any mining related restoration work associated with the McLaren Mill site and perhaps other areas of mining disturbance will need to address sediment loading since such loading represents a pathway for metals transport to Soda Butte Creek.

COMMENT: Refer to page 4-20. Consider addressing the McLaren Tailings Impoundment and the McLaren Mill Site as separate source areas as they pose unique water quality problems and could be dealt with separately in terms of restoration.

DEQ RESPONSE: The monitoring site locations, particularly SBC-2, make it difficult to address these as two separate sites from an initial source assessment and allocation perspective. Furthermore, these sites are addressed together within the *Draft Final Expanded Engineering Cost/Cost Analysis; McLaren Tailings Site, Cooke City, Montana* (Pioneer, 2002). Nevertheless, restoration can be addressed separately for these individual sources while still achieving the overall goals of this plan.

COMMENTS: The following two comments are linked closely to the threat from failure of the McLaren Tailings dam.

- To bolster the documentation supporting the timely removal (which is clearly the best "Restoration/Implementation Strategy") of the McLaren Tailings, the Draft Plan should examine the risk of catastrophic failure which could occur as result of a high magnitude rainfall event. It appears that this discussion is within the purview of the TMDL planning process, possibly under a "margin of safety" determination.

- In addition to the discussion of the impairment of Soda Butte Creek under present conditions, the plan should acknowledge the catastrophic potential of the release of this very large tailings impoundment down the Soda Butte-Lamar River drainage. The report cited above (pages 40,41) describes a geotechnical analysis that concludes the tailings dam "exhibits only marginal static stability. It goes on to say, "…liquification of the structure is considered to be a potential threat because the dam is located in an area which has a significant probability for seismic activity".

DEQ RESPONSE: The following language acknowledging this additional threat has been added to Section 4.1.1: "An additional significant threat to Soda Butte Creek exists due to the McLaren Tailings dam and the potential for failure since the tailings dam is located adjacent to Soda Butte Creek where high flows can erode and saturate the dam causing an unacceptable risk of dam failure. Such a failure could cause significant damage to the physical habitat within Soda Butte Creek and release very large amounts of contaminated material that would likely deposit all along Soda Butte Creek and Lamar River valleys within Montana and within Yellowstone National Park." The resulting restoration requirement to satisfy a load allocation for the McLaren Tailings and address the associated threat from the tailings dam is further discussed in Section 4.3.3.2.1.3 where it is stated: "Given the high iron loading from the McLaren Tailings Area and the significant threat associated with a tailings dam failure, it is assumed that restoration requirements will result in the removal of these threats and will need to achieve at least a 99% reduction in total load for iron. This will then satisfy the iron load allocation….a 99% load reduction from the McLaren Tailings Area is also assumed for copper, manganese, lead, aluminum and any other metals of concern."

COMMENT: The following comments are closely linked to addressing sediment from forest roads and trails.

- There needs to be a mandated EIS trail and road study done by the USFS that would deal with the sediment in the streams as a result of trails and roads.

- Roads and trails are described as sources of sediment contributing to water quality impairment in all three watersheds. Our understanding is that the Gallatin National Forest is now beginning an EIS process to examine all Forest roads and trails in this area regarding their ultimate disposition; modification, maintenance, closure, removal, etc. We are told that their scoping process for that process will be during the summer, 2002. It appears that a strategy should be included in this plan to incorporate the FS road and trail planning process.

- Places in the report where mention is made of sediment source areas to be addressed under the FS project (e.g. page 2-17) it is stated that, "Roads within or accessing District Property will be evaluated…". Please check to be sure this statement is consistent with the New World Consent Decree and with the FS roads and trails planning process.

DEQ RESPONSE: Section 5.2.1 identifies the two categories of work as defined by the Natural Resources Working Group for the New World Mining District Response and Restoration Project. Category A is defined as "hazardous substances (i.e. mine waste) that are on District Property and non-hazardous substances (e.g. principally sediment from roads) on District Property. Work can be done prior to the receipt of the Notice of Completion from the United States Government." The New World Mining District

Response and Restoration Project will, therefore, address impacted natural resources, including sedimentation from roads. Natural resources restoration work will be included in contracts for cleanup contracts (response actions) to achieve the greatest cost efficiency and cleanup results. This work will initially be completed on District Property using the Engineering Evaluation/Cost Assessment process to determine which roads and other possible sediment sources will be addressed. Once the Notice of District Property Work Completion has been issued, any remaining cleanup funds can be used for work on non-District Property.

Section 5.2.1 also states that: "The Gallatin National Forest is now beginning a travel plan Environmental Impact Statement (EIS) process to examine all forest roads and trails in the Gallatin National Forest (including the Cooke City area). The travel plan will address the ultimate disposition; modification, maintenance, closure, removal, etc. for forest roads and trails. Preliminary information pubic meetings and scoping has started and the final EIS is scheduled for completion in the fall of 2004. The EIS will include disclosure of effects of roads on natural resources including water quality and sediment." The EIS process will then provide a linkage to restoration and sediment reduction goals and desirable water quality improvements for the Cooke City planning area, especially for those efforts that may eventually fall outside the scope of New World Restoration efforts.

COMMENTS: The following comments are associated with work potentially outside the scope of New World Mining District restoration efforts. They are all addressed by one response.

- The privately owned New World properties need to be addressed.

- I realize many of these concerns were not covered as a part of the consent decree, but the restoration of the entire district TMDL needs to take all areas into account before the overall water quality will meet specifications. The fact that many problems would "try to be taken care of", instead of mandating a remedy, does raise concerns.

- The preliminary draft report does a good job of presented the area's water quality problems on a watershed basis and establishing restoration targets. The next step is the problems on a watershed basis and establishing restoration targets. The next step is the development of restoration/implementation strategy for Daisy, Fisher, and Miller Creeks relies on the ongoing New World Mining District Response and Restoration Project to achieve the restoration targets for those watersheds. The executive summary states that the New World project is expected to "…address all significant pollutant sources of metals in the Daisy, Fisher and Miller Creek drainages." While the New World Project has identified pollutant sources within the New World mining district, the control actions only address those that are considered "District Properties". Pollutant sources on non-District private property in these drainages will not be addressed as part of the New World Mine Consent Decree. We therefore suggest that implementation strategies for those sources be developed in this document, separate from the New World actions.

- The New World Mining District appears to be fully encompassed within the Cooke City TMDL Planning Area. This preliminary plan seems fairly complete in addressing water quality impairment, pollution source areas, allocations, restoration targets and the restoration strategy for that portion of the New World Mining District that is included in the Forest Service' "New World Mining District Response and Restoration Project" (FS project). This is possible since specific program direction and funding has been available for data acquisition and planning for the FS project since the late 1990's. However, the plan is quite sketchy as it pertains to the remaining pollution source areas within the District. In order for this plan to be comprehensive in terms of total restoration of the Cooke City TMDL planning area, more specifics are needed regarding information and coordination requirements, governmental and private interests, potentially applicable programs and implementation strategies for the entire planning area.

- The Forest Service is currently working on a response action EE/CA for the Glengarry Mine area and tunnel complex and for Como Basin, all in the upper Fisher Creek drainage. A draft of the Glengarry portion is expected spring of 2002. These combined response actions, following the waste dump removals done in 2001, will cover most known metals, pH and sediment source areas from the Fisher Creek headwaters (Como Basin) to the Gold Dust Mine. This plan, then, should focus in more detail on remaining source areas in this basin for which there is no current programmatic capability.

- The Restoration Strategy section of this plan is especially important and potentially useful in presenting a comprehensive strategy for the eventual water quality restoration of the entire New World District. Considerable baseline data acquisition and planning has been completed or underway for the Forest Service District Properties. Other contaminant load sources not being addressed under the FS project are located on private property or other National Forest lands. Some of these source areas have investigation and planning work underway (McLaren Tailings/Mill Site and New Republic Smelter) while little is known about others.

- We realize the MTDEQ has long recognized that the McLaren Tailings should be removed in order to satisfy water quality standards. This document presents specific pollutant targets that would support removal. The New World Mine Restoration effort will not address the McLaren Tailings until all other district restoration activities have been addressed (5.2). The time line on completion may extend for years. In the meantime, the McLaren Tailing remain in place. We are aware of the discussions between the MTDEQ and the US Forest Service about a number of strategies, including removal of all or part of the McLaren Tailings to the NW on-site repository, or other USFS managed lands. Removal during the New World Project period would be the most efficient and effective solution to the majority of the Soda Butte Creek water quality problems. Funding strategies outside the New World account should be explored. To date, a logical solution to this serious problem appears unresolvable due to federal public land policy issues related to waste disposal. The MTDEQ, Abandoned Mines Program is about to release a draft Engineering Evaluation and Cost Analysis that presents other possible solutions. The TMDL planning team should review this document and add to the reference section.

- Montana Department on Environmental Quality's excellent brochure, *Introduction to TMDLs & Water Quality Restoration Planning,* state, "to meet EPA requirements it is necessary to develop a conceptual restoration/implementation strategy to demonstrate that, when implemented, the plan will result in achieving the proposed TMDL and restoration targets." We are disappointed that restoration/implementation strategies were not developed for Soda Butte Creek. Presumably, this is because, as the brochure states, "…there is a lack of firm commitments to address other sources of metals such as the McLaren Tailings" and "additional data is also needed along Soda Butte Creek and in key tributaries to Soda Butte Creek to identify and characterize sources of metal loads to Soda Butte Creek."

- Funding and additional data are needed, but this should not delay planning for addressing known significant pollution sources such as the McLaren Tailings and the Great Republic Smelter Site. The Montana Department of Environmental Quality (DEQ) Mine Waste Cleanup Bureau has prepared a reclamation plan for the Republic smelter site which is listed in the references section but not discussed in the restoration strategy section. The Bureau is also in the process of preparing an Engineering Evaluation /Cost Analysis for the McLaren Tailings Site. This water quality restoration plan should include and evaluate both proposals for their potential to attain the required loading reductions that are necessary from these facilities to meet water quality standards in Soda Butte Creek.

- Finally, we suggest a "road map" be included for implementing restoration strategies for each non-New World district property to assist property owners who wish to voluntarily undertake a cleanup of a pollutant source. Such guidance would greatly assist property owners to understand how they could do it; which Best Management Practices would be applicable; which programs could help with funding; which permits would be required; and which agencies would need to be involved. The more we can do to assist voluntary restoration, the better our chances for success.

DEQ RESPONSE: Much of the document has been rewritten and significant language has been added to better define the strategy for non-District Property and how it fits into New World Mining District restoration efforts. This includes additional language and significant changes to the performance based load allocation sections (Sections 2.3.1.3, 3.3.1.3, and 4.3.3.1) to better address non-District Property considerations and how they may or may not be addressed by New World Mining District efforts depending on whether the necessary restoration work falls within Category A or Category B. Section 5.2 *Additional Restoration Strategy Considerations by Drainage Area* is a completely rewritten section to better address both District and non-District Property consideration and does reference the *Draft Final Expanded Engineering Evaluation/Cost Analysis; McLaren Tailings Site, Cooke City, Montana* (Pioneer, 2002).

Section 5.3 *Restoration Approaches for Metals Sources*; and Appendix H: *Cleanup/Restoration and Funding Options for Mine Operations or Other Sources of Metals Contamination* are both new additions to help provide guidance and an overall road map for pursuing sources of metals contamination throughout the Cooke City TMDL Planning Area. Appendix H also discusses funding possibilities and both Section 5.3 and Appendix H discuss interagency and stakeholder coordination needs and responsibilities. Many of the previous and newly added bullets under Section 5.5 *Monitoring Strategy* focus on the need to characterize non-District property metals sources in a coordinated manner.

COMMENTS: The following comments are associated with agency coordination and implementation. Some are specific to coordination with the state of Wyoming.

- With so many private landowners and agencies, state and national, such as the U.S. Forest Service, Yellowstone National Park, U.S. Geological Survey, Montana Department of Environmental Quality, Montana Fish Wildlife, and Parks, and the state of Wyoming, involved; I would question the possibility of it happening unless it is mandated. Coordination between these agencies is a must if it is to be successful. I am bothered by the fact that many problems "might" be addressed.

- There are numerous governmental and private entities that have some interest and/or responsibility for portions of the total water pollution problem that exists in the New World Mining District; the Forest Service (on their District Properties and other lands), the EPA (regulatory oversight), the National Park Service (recipients of pollution impacts), the State of Wyoming, private landowners, Montana Fish, Wildlife and Parks, US Geological Survey and various interest groups. This paints a very complex picture of divided responsibilities and numerous programs that must somehow be coordinated to ensure a comprehensive final result.

- Refer to page 1-1, first paragraph. The goal of this plan is stated as, "The overall goal is to identify an approach to improve water quality to a level where beneficial uses are restored for all impaired water bodies in the Cooke City TMDL Planning Area and ensure that Montana water quality standards are not violated". That is certainly a laudable goal and one we would support. However, reaching this goal may not be possible without close cooperation with all other governmental entities having responsibilities in this area, including the State of Wyoming. We encourage you to consider some organizational framework that fosters this coordination among the agencies and concerned public. At the meeting on Jan. 15^{th} we discussed the idea of forming a "watershed group" to coordinate the many contributions toward this overall goal. We would be interested in exploring these ideas further.

- It is possible the state of Wyoming might not do a TMDL?

- Please add a discussion of MDEQ strategy for coordination with Wyoming. Overlapping interests seem to include Soda Butte Creek tributaries (possibly impaired) that originate in WY and Soda Butte Creek and the Clarks Fork (presently impaired) flowing into Wyoming. We presume Wyoming has responsibilities similar to those of Montana under section 303(d). Does the EPA have an interstate coordination role in this process?

  DEQ RESPONSE: The New World restoration efforts are mandated via the Consent Decree, and there is significant coordination among the agencies and entities identified. As discussed within Sections 5.2 and 5.3 as well as Appendix H, there are significant sources that will probably need to be addressed by other methods beyond the scope of New World restoration. Some of these sources do not have mandates or guaranteed funding, and a coordinated approach to identify, prioritize, and perform restoration activities on these sources is important. Some of this work has already occurred within the DEQ Abandoned Mines Program. Where additional opportunities for restoration occur, such as is the case for the Republic Mine and Smelter Site and the McLaren Tailings, the goal will be to ensure the work is coordinated among the various state and federal agencies and other stakeholders. This coordination often occurs in the form of identifying restoration options and public comment on proposed options and detailed plans. Section 5.3 includes language that stresses the need for coordination and also recognizes the potential benefits, such as stakeholder coordination, that can be provided by a watershed group.

Coordination with Wyoming will be especially important for Soda Butte tributary work, and EPA may have a role in facilitating this effort, as mentioned in Section 5.3. This is particularly important for any efforts to identify and remediate metal contaminant sources to stream segments located within Wyoming. As discussed in Section 3.4, Wyoming water quality standards are based on dissolved versus total recoverable, meaning that some streams which originate in Wyoming may not be identified as impaired water bodies in Wyoming because elevated levels of metals may be in the total recoverable form. Section 3.4 also points out that Montana is required to pay attention to Wyoming standards and that by meeting the standards in streams located in Montana, we will also be meeting the Wyoming standards where streams flow from Montana into Wyoming.

It is acknowledged that all restoration planning, particularly planning outside the scope of New World, will need to occur in a manner that ensures a comprehensive final result, which is part of the implementation strategy defined throughout Section 5.0. Again, formation of a watershed group can be an effective approach to assist with this overall coordination.

COMMENT: Soda Butte restoration planning is acknowledged to be different than the other water bodies (5.4). It appears that the most significant sources of pollution, the McLaren Tailings, is destined to fall into Target Category #3 (5.3): “The target is not achieved and will not likely be achieved due in part to a failure to implement all applicable restoration efforts in a manner that is considered sufficient application of all reasonable land, soil, and water conversation practices.”

DEQ RESPONSE: Target Category #3 is intended to be a temporary condition that forces additional restoration work as needed to ensure that all targets eventually fall into Categories #1 or #2, and therefore represent conditions where Montana Water Quality Standards are satisfied. It is not appropriate to apply these target categories to a specific source, such as the McLaren Tailings. They instead apply to the pollutants in the stream, such as iron or manganese. It is acknowledged within Section 5.4 (formally Section 5.3) that the McLaren Tailings, as well as other potentially significant sources, could end up being the primary reason that one or more targets fall into Category #3 for a substantial amount of time due to funding limitations and firm restoration commitments.

COMMENT: We agree with the adaptive management approach described, which weighs restoration results against, "sufficient application of all reasonable land, soil and water conservation practices". This approach, if properly employed, should avoid expenditure of an inordinate amount of resources on one source area for little or no improvement, while other source areas remain untreated. The public should have involvement in the decisions that place source areas within the three categories described.

DEQ RESPONSE: Agreed, and language has been added to Sections 5.4 and 6.0 to stress the fact that the public has involvement during key phases of New World Mining District restoration efforts as well as involvement with restoration planning efforts outside the scope of New World. The specific restoration approaches, which take public comment into account, will help determine "sufficient application of all reasonable land, soil and water conservation practices". Furthermore, the public is involved with any modifications to water quality standards, which may be the situation prior to any final determination involving the use of Target Category #2. The public will also have opportunity to comment on modifications to future 303(d) lists and modifications to this water quality restoration plan which could include target determinations as defined in Section 5.4. Section 6.0 also includes the following language that supports public involvement and how it can be obtained for target category determinations: “Public comment on target categories could be facilitated via comment on New World Mining district restoration plans, agency decisions associated with temporary standards or water body classifications, and/or comment on restoration plans outside the context of New World Mining project efforts.”

COMMENT: We note that the Forest Service' 2002 McLaren Pit Response Action EE/CA is directed to the major sources in this drainage, where temporary water quality standards are in place. The FS plan calls for water quality monitoring during construction and long-term, from which to judge results. Does MDEQ believe that this planned response action is sufficiently comprehensive as to address all of the water quality restoration targets for this basin? If not, what actions will remain?

DEQ RESPONSE: The monitoring proposed by the Forest Service addresses the majority of monitoring needed to track progress on a yearly basis as discussed within Section 5.5.1. Section 5.5.3 identifies additional monitoring, such as pebble counts, that DEQ will likely need to do in order to evaluate progress toward meeting restoration targets. Sections 5.5.1 and 5.5.2 identify some additional monitoring recommendations and needs for long-term and source assessment monitoring purposes, some of which would apply to the Forest Service’s New World Restoration efforts.

COMMENT: Refer to Section 2.2.2, Metals and pH Source Assessment. The report correctly points outs that higher concentrations of metals occur during base flow periods, suggesting high ground water contributions. Our hope and expectation is that the pending response action that is designed to consolidate the mine waste materials and isolate them from direct precipitation and runoff infiltration will eventually reduce the loading and acidity from groundwater discharges to Daisy Creek. Long term monitoring will be needed to detect any resulting improvements.

DEQ RESPONSE: Much of the District monitoring addresses these concerns over the next several years, although there appears to be uncertainty associated with monitoring beyond the temporary standards period and beyond completion of Consent Decree actions. The MDEQ Monitoring and Data Management Bureau also performs monitoring to track progress toward meeting targets at least once every five years, which would continue beyond District cleanup as needed. Even with the MDEQ target evaluation monitoring, there may still be a need for additional monitoring to evaluate success of specific restoration actions. The following language addressing the need for continued long-term monitoring has been added to Section 5.5.1: "The New World Mining District Monitoring Plan extends through the temporary standards period of 2014. Plans need to be put in place to extend the monitoring as needed beyond this date for select parameters starting 2015. This should include monitoring at established stream locations as well as monitoring the success of individual restoration sites including monitoring for potential leakage from any repository site(s)."

COMMENTS: The following two comments are closely related.

- Refer to page 3-9. The acknowledged unknown regarding copper loading to the Clarks Fork from Lady of the Lake Creek should be reflected in the data acquisition strategy in Section 5.0.

- The narrative and tables in previous sections acknowledge a need for additional data (Soda Butte Cr. tributaries, Lady of the Lake Creek, Miller Creek) in order to present a complete picture of load allocations and source contributions. Please consider adding a subsection on specific data needs and a strategy for acquiring this data, to this section.

DEQ RESPONSE: Sections 3.2.2, 3.4, and 5.5.2 include recommendations for source characterization. Several of the Section 5.5.2 bulleted recommendations specifically address the above comments. Appendix H provides some potential strategies for pursuing restoration and associated characterization, as well as funding considerations.

COMMENT: Monitoring to be done in conjunction with the FS project should include the condition of the streambed sediments, size gradation (pebble counts), presence of precipitate sludge and the presence of aquatic organisms as described in this plan. Have these requirements been discussed with the FS and is MDEQ satisfied their monitoring protocols in this regard?

DEQ RESPONSE: This type of monitoring (reference Section 5.5.3) is generally performed by DEQ as part of their five-year target evaluations, and also as a part of the efforts to further define reference stream conditions for the Fisher Creek sediment target. This does not preclude using data acquired by the FS or other qualified entities. Although most of the monitoring activities, such as those associated with pebble counts and aquatic organisms, are based on standard protocols, it is acknowledged that coordination will be important where different entities are collecting similar data types.

COMMENT: We invite MDEQ to make a return visit to Cooke City this summer, when more of the seasonal residents are available to participate, to give a presentation on a revised version of this plan. BA would be pleased to assist with arrangements and local publicity.

DEQ RESPONSE: MDEQ will continue to work with local stakeholders on various outreach efforts associated with this plan and implementation of the plan and appreciates offers of assistance. Any outreach and implementation will need to be balanced with requirements to develop and implement similar restoration plans and associated TMDLs across the state.

<u>COMMENTS</u>: The following comments are acknowledged, with no response needed.

- The document points out that "…New World Mining District Response and Restoration activities are expected to address all significant pollutant sources of metals in the Daisy, Fisher, and Miller Creek drainages". These activities are related to work on "District Properties" as defined in the "Consent Decree" which is the legal guidance for the work being done by the US Forest Service. The TMDL document content and data greatly benefits from the New World Work Plan and these activities. Conversely, the New World Restoration Project now has clearer water quality goals and guidance. This is especially true when efforts turn to addressing sediment loading sources that may or may not be mineralized, but can be ameliorated through best management practices including road closure.

- The preparation of a comprehensive water quality restoration plan is an important step towards our shared goal of improving the area's water quality to a level where Montana's water quality and drinking water standards are met and insuring that park resources and values, including aquatic life, are not impaired.

- We agree with your description of the present condition of impairment and that TMDL development is not needed for the Stillwater River above Daisy Creek.

- Refer to page 3-5, Impairment Conditions Associated with Sediment. We agree with your basis for adding a sediment target TMDL for Fisher Creek.

- We believe that this Water Quality Restoration Plan could be a most useful tool for guiding the comprehensive restoration of the entire TMDL planning area, and encourage MDEQ to continue development of it. BA stands ready to assist from our perspective as a representative of local interests.

- We recognize that this 303(d) process could be the much-needed vehicle for comprehensively addressing water quality restoration needs of the entire New World Mining District. BA is interested in working with the MDEQ to help ensure that this be a meaningful process toward achieving our shared goals.

- Refer to page 2-19, third full paragraph, last sentence. This text appears to suggest an adaptive strategy be applied to sediment targets following implementation of reasonable control measures. We agree with that approach, especially in view of the rather crude estimates that are characteristic of sediment yield models. Preference would be to direct available program funding to known contaminant source areas rather than expend large sums attempting to achieve unrealistic levels of sediment yield reduction.