Record of Decision

Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

U.S. Environmental Protection Agency Region 8
10 West 15th Street
Suite 3200
Helena, Montana 59626

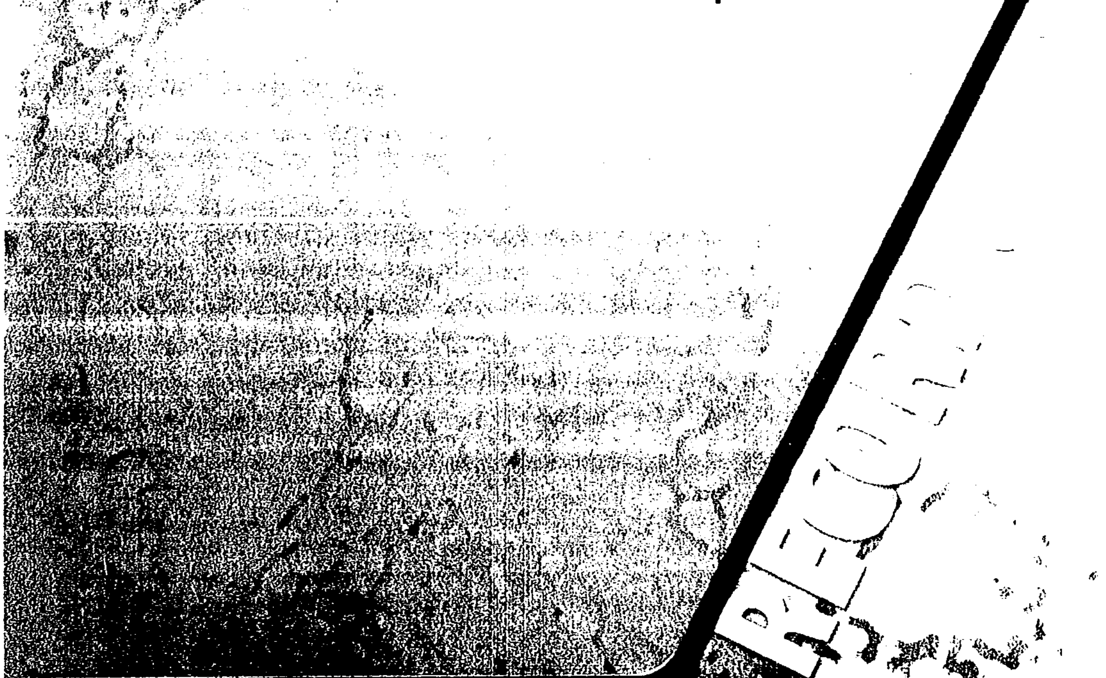
April 2004

UNITED STATES ENVIRONMENTAL PROTECTION

ADMINISTRATIVE RECORD

Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site



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April 2004

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 8, MONTANA OFFICE

Clark Fork River Operable Unit

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Record of Decision

April 2004

Issued by:

U.S. Environmental Protection Agency Region 8
10 West 15th Street, Suite 3200, Helena, Montana 59626

With Support from:

CH2M HILL, Inc.
700 Clearwater Lane
Boise, Idaho, USA

and

Reclamation Research Unit
Montana State University
Bozeman, Montana, USA

Bitterroot Restoration, Inc.
Corvallis, Montana, USA

Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Part 1: Declaration

U.S. Environmental Protection Agency Region 8

10 West 15th Street
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Helena, Montana 59626

April 2004

Contents

Part 1: Declaration

Site Name and Location

Site Name:	Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site (OU #3)
CERCLIS Identification Number:	MTD980717565
Site Location:	Missoula, Granite, Powell, and Deer Lodge Counties, Montana

Statement of Basis and Purpose

This decision document presents the Selected Remedy for the Clark Fork River Operable Unit (Clark Fork River OU) of the Milltown Reservoir/Clark Fork River Superfund Site, in Montana, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Contingency Plan (NCP). This decision is based on the Administrative Record file for this site.

The State of Montana concurs with the Selected Remedy.

Assessment of Site

The response action selected in this *Record of Decision* is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

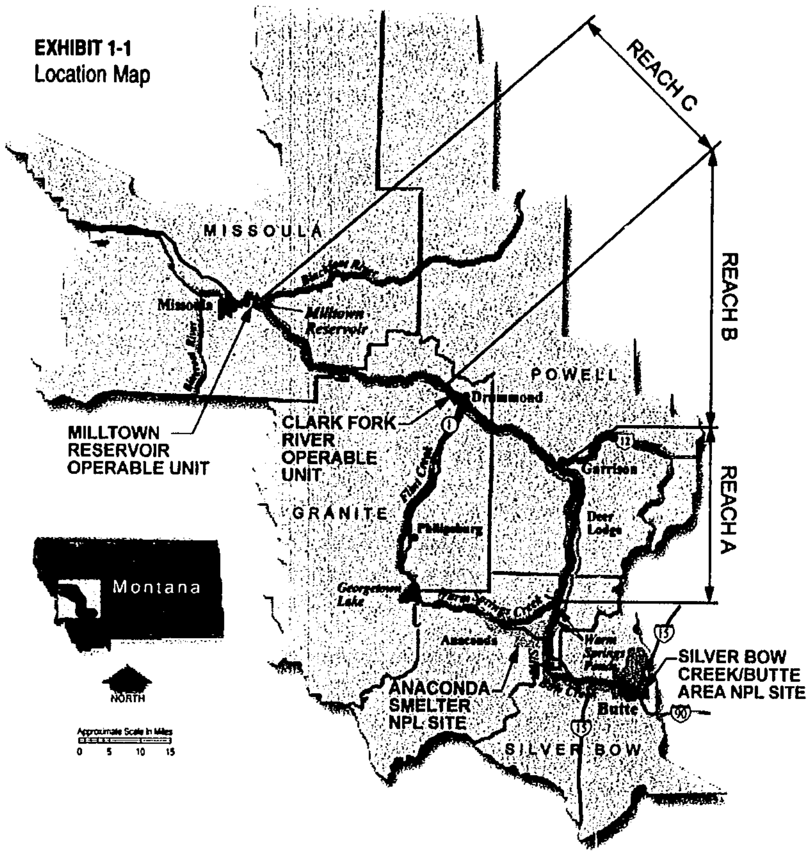
Description of Selected Remedy

The Environmental Protection Agency's (EPA's) selected remedy for the Clark Fork River OU combines portions of three alternatives that were analyzed. The following is the Selected Remedy for Reach A and for limited areas within Reach B. No action is proposed for Reach C (see Exhibit 1-1, *Location Map*):

- The *Record of Decision* defines exposed tailings areas. Exposed tailings will be removed, and the excavated area revegetated, with a limited exception. The limited exception is for exposed tailings that are 400 square feet or less, less than approximately 2 feet in depth, and contiguous with impacted soils and vegetation areas. When this exception is present, in-situ treatment will be done.

- The *Record of Decision* defines areas of impacted soils and vegetation. In most instances, areas of impacted soils and vegetation will be treated in place, using careful lime addition and other amendment as appropriate, soil mixing, and re-vegetation.
- Some impacted soils and vegetation areas (impacted areas) will be removed where depth of contamination prevents adequate and effective treatment in place, where saturated conditions make in-situ treatment unimplementable, or where post treatment arsenic levels, after one re-treatment attempt, remain above the human health action level for the current or reasonably anticipated land use. Further definition of the exceptions for depth and saturation is contained in Part 2, Sections 13.3 and 13.6 of this *Record of Decision.*
- The Clark Fork River Riparian Evaluation System (CFR RipES) process will be used in remedial design to identify exposed tailings and impacted areas, and areas where the exceptions to removal or in-situ treatment will apply.
- Streambanks will be stabilized primarily by "soft" engineering (with limited hard engineering where conditions warrant) for those areas classified, through the use of the CFR RipES process, as Class 1 or Class 2 streambanks, and an approximate, flexible 50-foot riparian buffer zone will be established on both sides of the river. This will lessen the high rate of erosion and contaminant input from streambanks, prevent or reduce the

EXHIBIT 1-1
Location Map



uncontrolled release of contaminants, and partially address potential stream braiding as a result of overbank flows. Stream stabilization techniques are further described in the *Record of Decision*, and include an emphasis on protecting against shear stresses on unstable banks. Subsequent remedial design activities and the CFR RipES process will define the streambank classifications, the most practical and effective methods, and the exact locations for streambank stabilization. The riparian buffer zone width will be flexible, depending on landowner needs and the nature of the stream at a given location.

- Opportunity Ponds will be used for disposal of all removed contamination.
- Weed control for in-situ treatment, streambank stabilization, and removal areas is a major component of the Selected Remedy. It is further described in Part 2, Section 13.10 of this *Record of Decision*.
- Best Management Practices (BMPs) will be used throughout Reach A and in limited areas of Reach B to protect the remedy. BMPs are to be contained in landowner specific plans, and will be used to ensure land use practices are compatible with the long-term protection of the Selected Remedy.
- Institutional Controls (ICs) and additional sampling, maintenance, and possible removal or in-situ treatment of contamination will be required to protect human health. The trestle area in Deer Lodge is a recreational area that will be addressed under the *Record of Decision*. Specific ICs identified as necessary are as follows: continued county zoning regulations, deed restrictions and permanent funding for Arrowstone Park, and a groundwater sampling program and use controls to prevent domestic consumption of contaminated groundwater until the groundwater reaches cleanup levels.
- Monitoring during construction, construction BMPs, and post-construction environmental monitoring are required.
- Because the National Park Service has specific cleanup needs and responsibilities under the laws that govern National Historic Sites, such as the Grant-Kohrs Ranch National Historic Site, the Selected Remedy is modified and expanded in this *Record of Decision* for this area. Those components of the *Record of Decision* are described in Part 2, Section 13.7.

Role of the Clark Fork River Operable Unit

The Clark Fork River OU is one of three OUs in the Milltown Reservoir/Clark Fork River Superfund Site. The other OUs are the Milltown Water Supply OU and the Milltown Reservoir Sediments OU.

The Clark Fork River OU will address principal and low level unacceptable threats to human health and the environment for the Clark Fork River. The Deer Lodge Valley Historically Irrigated Lands Time Critical Response Action is a removal action within the Clark Fork River OU being implemented to address threats to human health in areas near Deer Lodge, Montana, by cleaning up known yards and fields that exceeded risk-based criteria for arsenic in soils. It will become part of the Clark Fork River OU Selected Remedy. The Milltown Reservoir Sediments OU and the related Milltown Water Supply OU are a separate geographical area located downstream of the Clark Fork River OU.

Description of Contaminants of Concern and Source Areas

The heavy metals and arsenic in the Clark Fork River OU, listed below, are from historic mining, milling, and smelting processes linked primarily to the Anaconda Copper Company operations in Butte and Anaconda:

- Cadmium
- Arsenic
- Lead
- Copper
- Zinc

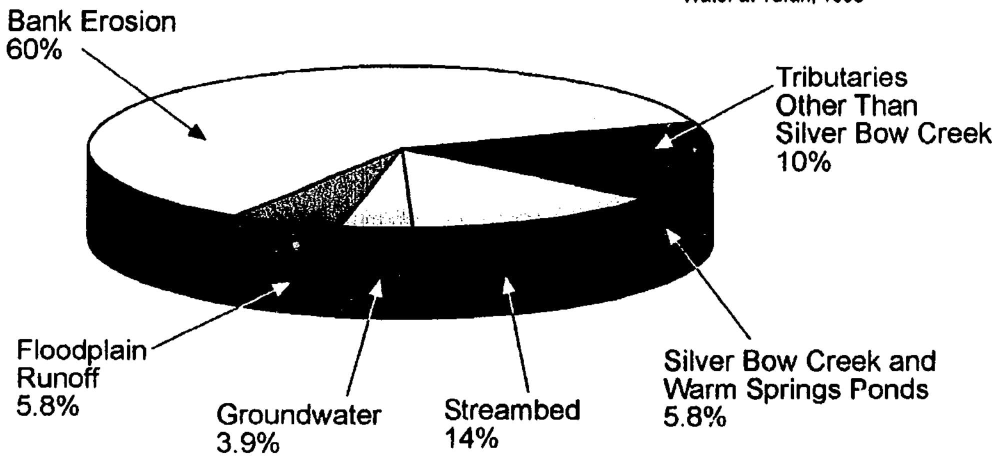
Copper contamination is emphasized in the Selected Remedy because it is present in significant concentrations within the mining and smelting wastes, it has a large and consistent data set, it is the most toxic of the metals to aquatic life in this river system, it can be toxic to plants in the floodplain, and it is used as an indicator for other contaminants. In addition, specific soil cleanup levels for arsenic, the major contaminant affecting human health and a potential contributor to risks to aquatic life, are set forth in this *Record of Decision* in Part 2, Section 13.11. Performance standards address all of the contaminants of concern.

The primary sources of contamination in Reach A are tailings and tailings mixed with soil in streambanks and the historic floodplain. These sources provide pathways to plant and animal life, and to humans who come in contact with the soils. Contaminants move from tailings and impacted soils through the process of erosion, directly into the river and other surface waters. This movement provides pathways to terrestrial and aquatic life. In addition to erosion of tailings and impacted soils, metals are leached directly from the tailings into groundwater and surface water.

Following is a list of exposure pathways of concern at the Clark Fork River OU:

1. **Surface water**: Surface water runoff from tailings and contaminated soils into the river transports both dissolved and particulate-bound metals and arsenic to aquatic life and creates surface water contamination. Erosion of banks also provides contaminants to surface water and aquatic life.
2. **Groundwater**: Movement of groundwater through tailings and contaminated soil causes groundwater to become contaminated.
3. **Streambed sediments**: Stream sediments receive surface water contaminants and contain metal contamination.
4. **Historically irrigated fields**: Irrigation ditches and fields historically irrigated with Clark Fork River water have been contaminated by surface water contaminants. Arsenic from this deposition may create unacceptable human health risks for residences near or on such fields. Sediments in irrigation channels may also present risks to certain workers, particularly at the Grant-Kohrs Ranch National Historic Site.
5. **Biological resources**: Contaminant uptake in plants is a well-documented occurrence that prevents or limits the establishment of vegetation on the land. Aquatic plants and animals receive the contaminants through direct consumption of contaminated sediment, contaminated food sources, or through absorption in water. Wildlife may receive contamination through soil, plant, and animal ingestion.

EXHIBIT 1-2
Sources of Copper to Surface Water at Turah, 1998



6. **Air resources:** Fugitive dust and air impacts are unlikely, including during earthwork and transporation.

The floodplain is severely impacted by the presence of mining wastes. Tailings materials present in the root zone of riparian area soils are toxic to terrestrial plants. The most obvious instances of this toxicity are slickens areas—areas of exposed tailings that generally lack vegetation.

During normal hydrologic conditions, the largest source of copper to surface water in Reach A of the Clark Fork River is bank erosion (see Exhibit 1-2, *Sources of Copper to Surface Water at Turah, 1998*). Exhibit 1-2 shows that floodplain runoff is responsible for only 5.8 percent of the total copper load (primarily dissolved copper). However, it is this source of copper during pulse events (thunderstorms that create runoff into the river) that EPA believes to be the most harmful of all sources of copper to fish and other aquatic life. These estimates represent copper loading during normal hydrologic conditions and do not account for the additional erosion that occurs as a result of floodplain runoff. During overbank flows, it is likely that bank erosion and floodplain runoff increase in significance and volume for contaminant release. Copper loading from both bank erosion (particulate copper) and overland runoff (dissolved copper) must be significantly reduced in order to achieve protectiveness and meet or come close to meeting applicable or relevant and appropriate requirements (ARARs). Streambed sediments make up 14 percent of the copper loading—the second highest source.

Based on these findings and the entire administrative record, EPA has determined that eroding and sparsely vegetated streambanks in Reach A and limited portions of Reach B, and areas of exposed tailings or slickens in the same area, constitute the principal threat waste at the Clark Fork River OU. Other areas, called impacted soils and vegetation areas in the *Feasibility Study*, also present a risk. These areas of impacted soils and vegetation are due to buried tailings and contaminated soils.

Additional Discussion of Vegetation Impacts and Project Sequencing

The lack of floodplain vegetation is caused primarily by metal contamination and related acid generation. This fundamental problem at the Clark Fork River OU leads to a host of other impacts:

- Accelerated bank erosion and channel migration, causing unacceptable chronic risks to aquatic life and land use problems
- Vulnerability of floodplain to destabilization
- Potential and actual environmental hazards to terrestrial and aquatic life, especially from pulse and flood events
- Degraded groundwater quality
- Poor agricultural productivity
- Degraded surface water as a result of metals and sediments loading

To eliminate or reduce these impacts and the other impacts and risks of concern, EPA must address the problem of stressed or absent vegetation and the resulting surface water contamination.

The Selected Remedy is protective and complies with ARARs or is ARAR waiver compliant, reflects a fair balance among the long-term permanence and effectiveness, short term effectiveness, reduction of mobility, toxicity, or volume, and implementability balancing criteria established by the NCP, and takes into account State and community concerns and acceptance. Removal of slickens, in most cases, and removal of impacted soils and vegetation areas as appropriate, reduces reliance on long-term BMPs, ICs, and operation and maintenance. Use of in-situ treatment for significant portions of the impacted soils and vegetation areas will lessen short-term safety risks for workers and the community, lessen environmental impacts, and allow for a faster remedial action construction period. ARAR waivers for copper in surface water and State floodplain and solid waste regulations for waste removal are justified. During implementation, EPA and the Montana Department of Environmental Quality (DEQ) will address concerns regarding the length of time and the intrusiveness of remediation by focusing on sequencing actions to allow for cleanup at various areas and on applying a combination of techniques in a given area.

The five main areas for action and general priority and preference for the type of remedial action in each area is as follows:

1. **Class 1 Streambanks**: Removal of mining contamination, and reconstruction and revegetation of streambanks where chemical conditions do not allow the effective establishment of woody and herbaceous vegetation.
2. **Exposed Tailings or Slickens areas**: Removal of exposed tailings with the limited exception. The limited exception is for exposed tailings that are 400 square feet or less, less than approximately 2 feet in depth, and contiguous with impacted soils and vegetation areas. When this exception is present, in-situ treatment will be done.

3. **Class 2 Streambanks:** Revegetate streambanks where chemical conditions (demonstrated by some level of woody and herbaceous vegetation) allow effective establishment of vegetation. Reconfiguring banks (e.g., scalloping or selective removal) could be required where other treatments may not be effective.
4. **Impacted Soils Areas with Impacted Vegetation:** Perform either in-situ treatment or removal, to be decided by the criteria described in this *Record of Decision* in Part 2, Section 13.6.
5. **Class 3 Streambanks:** Continue or apply BMPs on all other streambanks with deep binding woody vegetation and root-mass that maintains bank stability as appropriate. BMPs are described in this *Record of Decision* in Part 2, Section 13.9.

CFR RipES is a decision making tool described in Part 2, Section 13.6, of this *Record of Decision* that will be used to clearly identify areas for action. For example, the CFR RipES score for each area will help determine whether a streambank area is Class 1, 2, or 3; which areas have impacted soils and vegetation; and which areas have exposed tailings. CFR RipES will be developed so that it will accurately reflect the removal and in-situ treatment criteria set forth in the Selected Remedy. Additionally, BMPs will be necessary for all of Reach A and portions of Reach B addressed in this action. EPA and DEQ plan to work cooperatively with landowners and the Conservation District to establish and maintain these plans.

While the general approach will be to work from the headwaters down, the agencies believe remediation can be done more quickly and effectively and with less threat to river stability by working on discontinuous stretches of the river.

The Selected Remedy calls for remediating Class 1 streambanks as the top priority. Once the Class 1 streambank segments are identified, the adjacent exposed tailings and impacted soils and vegetation areas will be evaluated for necessary remediation and be remediated at the same time on a property-by-property basis. Where slickens or buried channel deposits are present, they will be cleaned up at the same time. Likewise, areas with impacted soils and vegetation will be evaluated for treatment or removal and done at the same time. This will minimize disruption to the floodplain and each individual landowner.

Exposed tailings isolated from streambanks would also be a priority and will be remediated as described above. Class 2 streambanks would be third on the priority list for action. Fourth on the list of priorities for action are the impacted soils and vegetation areas that require in-situ treatment or removal as described above.

Timing of the remedial actions is an important implementation issue. One objective is to minimize the inconvenience to individual landowners. The overall project timeline for the 43 miles of river in Reach A and portions of Reach B is projected to be up to 10 years. This estimate may change during the design and construction phase. Individual landowner operating needs, availability of irrigation water, and the end land use determinations will also impact project schedules and timing.

Statutory Determinations

The Selected Remedy is protective of human health and the environment, is cost-effective, uses permanent solutions and alternative treatment technologies to the maximum extent practicable, and complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action except for the waivers listed below and described in additional detail in this *Record of Decision*:

- A waiver of the State's WQB7 water standard for copper is invoked for this remedy. The proposed waiver is based on the technical impracticability from an engineering perspective described at section 121(d)(4)(C) of CERCLA. EPA's analysis and basis for this determination is the current modeling projections indicating that none of the alternatives proposed, including total removal of all exposed and buried tailings, would achieve complete compliance with the standard. The substitute standard will be the Federal water quality criteria for copper. The performance standard goal for this replacement standard is to be in compliance during all conditions (low, normal, and high flow, as well as ice conditions) throughout the Clark Fork River.
- State of Montana floodplain and solid waste ARARs require removal from the floodplain of any treated or actively managed mine waste (tailings and soils mixed with tailings) unless a CERCLA waiver condition is invoked. For certain wastes in the floodplain, EPA is invoking the use of the technical impracticality waiver found in CERCLA Section 121(d)(4)(c). The waiver would apply to either exposed tailings areas or impacted soils and vegetation areas designated for in-situ treatment in the selected remedy description. EPA has determined that there exists sufficient uncertainty regarding the technical practicability from an engineering perspective for the very large-scale removal of all mining wastes and contaminated soils, because the heterogeneity and distribution of the contamination would not provide for reliable removal of all the contamination and would not allow the remedy to be implemented within a reasonable time frame. The waiver does not apply to those contaminated areas designated for removal in the Selected Remedy.

The Selected Remedy also satisfies the statutory preference for treatment as a principal element of the remedy (that is, it reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment), by utilizing the in-situ treatment technology for the impacted soils and vegetation areas.

Because the Selected Remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, statutory reviews will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

Data Certification Checklist

The following information is included in the *Decision Summary* section of this *Record of Decision*. Additional information can be found in the Administrative Record file for this site.

Information Item	Page Numbers in *Record of Decision*
Chemicals of concern and their respective concentrations	2-22 to 2-33
Baseline risk represented by the chemicals of concern	2-17, 2-18, 2-26, 2-27, 2-39 to 2-47
Cleanup levels established for chemicals of concern and the basis for these levels	2-49, 2-50, 2-87 to 2-91, 2-126 to 2-137, 2-143 to 2-145
How source materials constituting principal threats are addressed	2-75, 2-76, 2-79, 2-81 to 2-86, 2-89 to 2-91
Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater use in the baseline risk assessment and the *Record of Decision*	2-35 to 2-37
Potential land and groundwater use that will be available at the site as a result of the Selected Remedy	2-35, 2-36, 2-139 to 2-144; especially Section 13
Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected	2-138, 2-143, 2-156
Key factor(s) that led to selecting the remedy (that is, describe how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision	Sections 7 to 11, 2-81, 2-82, 2-89 to 2-91, Section 14

Authorizing Signatures

The U.S. Environmental Protection Agency (EPA), as the Lead Agency for the Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site (MTD980717565), formally authorizes this *Record of Decision*.

4/29/04

Max H. Dodson
Assistant Regional Administrator
Ecosystems Protection and Remediation
EPA Region 8

Date

The State of Montana Department of Environmental Quality (DEQ), as the Supporting Agency for the Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site (MTD980717565), formally concurs with this *Record of Decision*. DEQ has prepared a separate concurrence letter, which is attached to the *Record of Decision* as Appendix F.

Tom Livers

4/29/04

for Jan Sensibaugh, Director
State of Montana
Department of Environmental Quality

Date

Part 2
Decision Summary

Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record Of Decision

Part 2: Decision Summary

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

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Exhibits **Page**

1 Site Name, Location, and Brief Description

Site Name:	Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site (OU #3)
CERCLIS Identification Number:	MTD980717565
Site Location:	Missoula, Granite, Powell, and Deer Lodge Counties, Montana
Lead Agency:	U.S. Environmental Protection Agency
Support Agency:	State of Montana Department of Environmental Quality
Source of Cleanup Monies:	Potentially Responsible Party Enforcement or Settlement
Site Type	River and floodplain corridor impacted by historic mining and smelting wastes

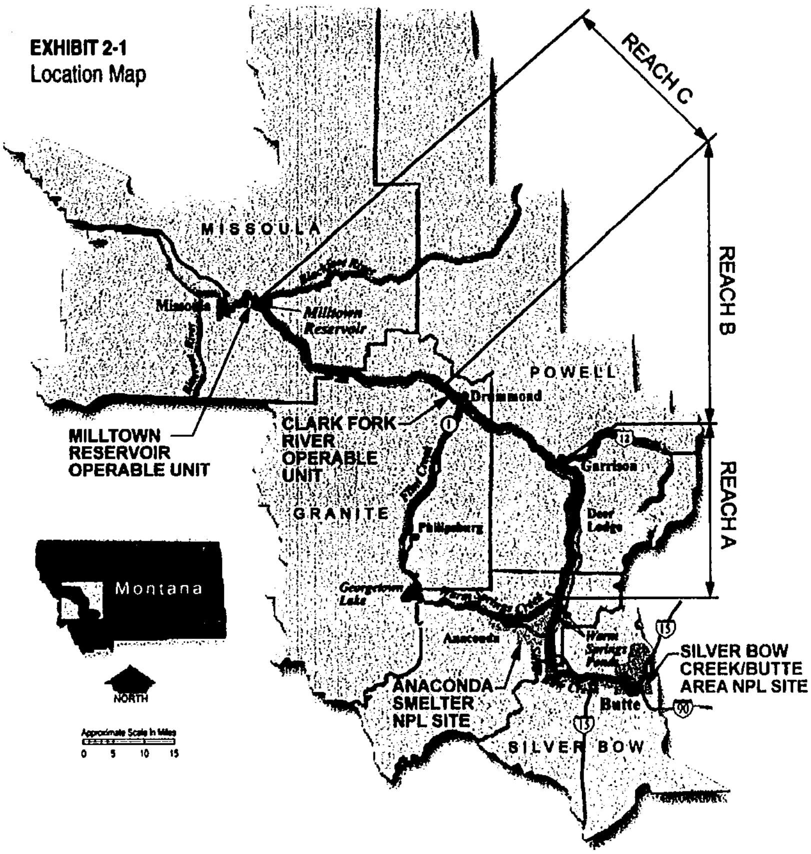
The U. S. Environmental Protection Agency (EPA), in consultation with the Montana Department of Environmental Quality (DEQ), is authorizing the Selected Remedy described in this *Record of Decision* to address about 120 river miles of the Clark Fork River, from the headwaters at Warm Springs Creek to Milltown Reservoir (just east of Missoula). Approximate boundaries are shown in Exhibit 2-1, *Location Map*.

EPA is the lead agency for the Clark Fork River Operable Unit (OU), and DEQ is the supporting agency. Numerous other entities, including government agencies, local governments, the Confederated Salish and Kootenai Tribes, academic research groups, landowners and public interest groups, have participated in the Superfund process up to the present. The potentially responsible party (PRP) is the Atlantic Richfield Company.

The Clark Fork River OU consists of surface water, stream bed sediments, tailings, impacted soils, groundwater, aquatic resources, terrestrial resources, irrigation ditches and related sediment deposition and contaminated property, and air located within and adjacent to the 100-year historic floodplain of the Clark Fork River. The OU extends from the confluence of the old Silver Bow Creek channel with the reconstructed lower Mill-Willow bypass, to the maximum Milltown Reservoir pool (see Exhibit 2-1, *Location Map*).

From its headwaters, the Clark Fork River flows north for approximately 43 river miles past the towns of Galen, Deer Lodge, and Garrison (this stretch is **Reach A**). The river then runs northwest for approximately 77 river miles to the headwaters of the Milltown Reservoir near Bonner (this includes **Reach B** and **Reach C**).

EXHIBIT 2-1
Location Map



Mining for gold, silver, and especially copper began in the late 19th Century in the Butte-Silver Bow Creek area. Milling and smelting of these ores produced vast wealth and concurrently a variety of mining, milling, and smelting wastes, including mine waste rock, mill tailings, and mill process waters that were released into Silver Bow Creek as late as 1982 and continue to be re-released to the present day throughout the Clark Fork Basin.

These various mining wastes retained the mineral signatures of the ore bodies and typically contained elevated levels of metals and arsenic as well as the acid producing mineral iron pyrite. The finer sized mining wastes mixed with streambed sediments as they were hydraulically transported downstream. Sediment transport rates varied depending on stream flow conditions caused by precipitation patterns. Large flood events, particularly in 1908, distributed the metal bearing sediments along the entire upper Clark Fork River floodplain. Sedimentation ponds constructed at Warm Springs in 1918 and the late 1950s altered the amounts and size ranges of contaminated sediments reaching the upper Clark Fork River from Silver Bow Creek. Wastes from mines, mills, and from the Old Works Smelters in Anaconda were also transported as contaminated sediments via Warm Springs Creek and other creeks into the upper Clark Fork River. Aerial deposition from the large Anaconda Smelters also contributed to the contamination of the Clark Fork River.

In addition to fluvial deposition of metals contaminated sediments within the historic 100-year floodplain, agricultural fields were irrigated with water from the Clark Fork River that at times contained elevated concentrations of metals in the dissolved form and as suspended sediment. This caused ongoing contamination, at low levels, of the fields. In some instances, irrigation ditches overflowed or were breached, flooding fields downgradient of the ditches with river water. Soils in these irrigated fields and ditches now contain elevated concentrations of metals and arsenic resulting from these historic irrigation practices. The irrigated fields are located on terraces above the influence of metals and arsenic impacts associated with flood deposition.

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2 Site History and Enforcement Activities

Placer mining for primarily gold began in the mid to late 1800s in the Butte-Silver Bow Creek area. These early activities contaminated local areas, but did not contribute extensive tailings to the river. As mining activity increased, underground mining began for gold, silver, copper, and other metals. The mining and milling of deeper copper sulfide ores in Butte and Anaconda began during the 1880s and contributed much of the mining waste residuals now found in the Clark Fork River OU. The introduction of electricity in the early 1900s enhanced mining, milling, and smelting practices and production rates increased significantly, thereby increasing mine wastes discharged to Silver Bow Creek.

In the Butte area, mining companies routinely disposed of mining and milling wastes directly into Silver Bow Creek. The mining wastes were carried away and mixed with river bed sediments by the various higher seasonal flow events in Silver Bow Creek and much was subsequently carried into the upper Clark Fork River. Large quantities of wastes from the Anaconda Company's operations in Anaconda reached the Clark Fork River by washing down Warm Springs Creek and other tributaries. Aerial deposition from the Anaconda Smelter operations also contributed to the metal levels in the Deer Lodge Valley, and to the runoff of these metals into the river.

In early 1908, the largest flood event on record for the Clark Fork drainage occurred during late winter when a warming trend resulted in heavy rains that fell on snow and frozen ground. This resulted in flooding down the entire Clark Fork drainage. During this event, extensive quantities of waste, contaminated soils, and contaminated sediments were deposited on the floodplain.

Because of complaints of ranchers and farmers on the Clark Fork River, in 1918 the first two of three sedimentation ponds were constructed on Silver Bow Creek at Warm Springs to reduce the amount of contaminated sediments being transported downstream. A third, much larger settling pond was built in the late 1950s. It was estimated in the Warms Springs Pond *Remedial Investigation* (EPA 1989) that more than 19 million cubic yards of sediments are contained in the three settling ponds. From 1918 to the present day, the Warm Springs Ponds system, although only partially efficient and relatively simple, prevented significant quantities of mining and milling wastes from moving downstream into the Clark Fork River.

Since 1990, significant remedial and removal action clean-up efforts have been conducted upstream of the Clark Fork River, including the Warms Springs Ponds OUs, which substantially improved the efficiency of the sedimentation ponds, ongoing cleanup of Silver Bow Creek, and other cleanups completed in the Butte area, such as Lower Area One (LAO).

Since 1987, numerous investigations, clean-up studies and demonstration projects have been conducted on the Clark Fork River OU. The Atlantic Richfield Company prepared major portions of the final Clark Fork OU *Remedial Investigation* and *Feasibility Study*, completed several in-situ demonstration projects and streambank stabilization projects, and conducted a Time Critical Removal Action (TCRA) at Eastside Road in Deer Lodge. EPA, in consultation with DEQ, provided oversight of the *Remedial Investigation* and *Feasibility Study* activities conducted by the Atlantic Richfield Company. EPA produced the *Human Health* and *Ecological Risk Assessments,* including addendums, and the geomorphological studies. EPA also produced the Clark Fork River OU *Proposed Plan.*

Key documents regarding the Clark Fork River OU include the following:

- Clark Fork River Screening Study—1991, CH2M HILL, Chen-Northern, and Montana State University (MSU) Reclamation Research Unit.
- Clark Fork River OU *Remedial Investigation Report Final Draft*—The Atlantic Richfield Company 1998, approved by EPA.
- Clark Fork River OU *Human Health Risk Assessment.*
- Geomorphology, Floodplain Tailings, and Metal Transport in the Upper Clark Fork Valley, Montana—USGS and the Atlantic Richfield Company 1998.
- Clark Fork River OU *Ecological Risk Assessment*—prepared by Syracuse Research Corporation for EPA—2001.
- *Human Health Risk Assessment* addendum—prepared by Syracuse Research Corporation for EPA—2001.
- National Remedy Review Board (NRRB) Presentation Package, Clark Fork River OU of the Milltown Reservoir Sediments Superfund Site—EPA Region 8, Montana office, April 2001.
- Clark Fork River OU *Feasibility Study, Public Review Draft*—The Atlantic Richfield Company 2002, approved by EPA. This report contains a detailed list of ARARs.
- Responses to Issues Posed by the EPA NRRB regarding Phytostabilization of the Clark Fork River OU, Milltown Sediments Superfund Site—EPA Region 8, Montana Office, December 2001.
- Superfund Program Clean-up Proposal, Clark Fork River OU of the Milltown Reservoir/Clark Fork River Superfund Site (*Proposed Plan*)—EPA Region 8, Montana office, August 2002.

2.1 Chronology of Enforcement Activities and PRPs

Following is the chronology of enforcement activities and identification of PRPs, as shown on Exhibit 2-2, *Site History Timeline*:

- 1864 to 1900: Localized gold, silver, and copper mining by a variety of companies and owners in the Clark Fork Basin.
- 1885 to 1910: War of the Copper Kings. The Anaconda Company acquires most of the copper properties and facilities in Butte and constructs the Anaconda facilities.

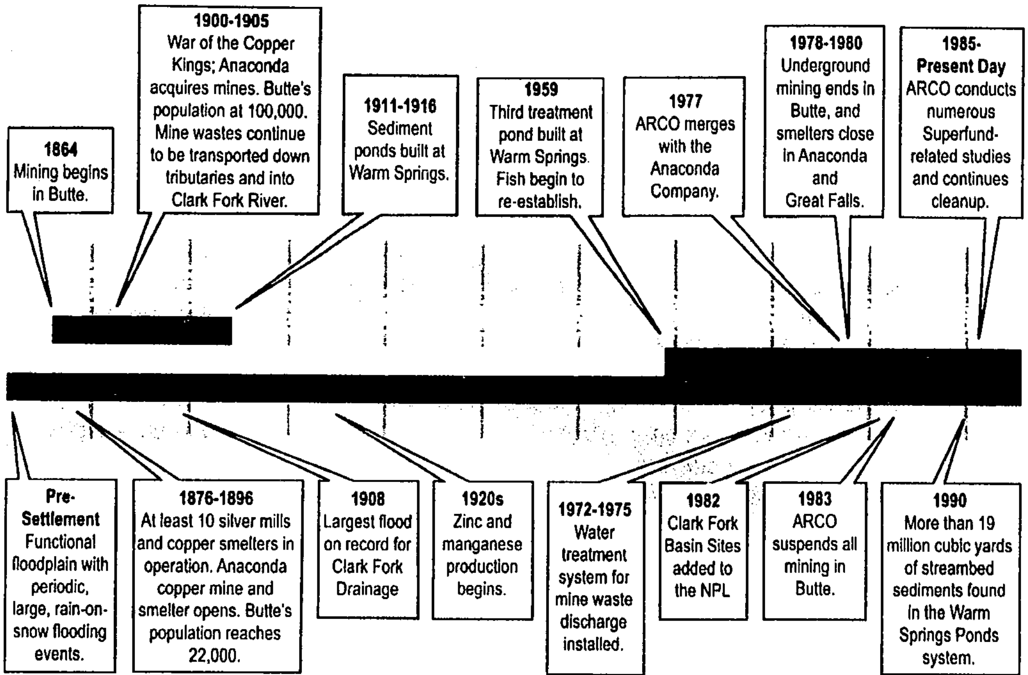


EXHIBIT 2-2
Site History Timeline

Key:

Mine tailings deposited in river

Periodic fish kills continue in river
Clark Fork River water used for upland irrigation

- 1900s to 1970s: Essentially uncontrolled releases of mining and milling wastes to Silver Bow Creek continued.
- 1977: The Atlantic Richfield Company merges with the Anaconda Company.
- 1982: Three sites are added to the National Priority List (NPL): the Silver Bow Creek/Butte Area Site, the Anaconda Smelter Site, and the Milltown Reservoir Site.
- 1983: The Atlantic Richfield Company suspends all mining activity in Butte, after shutting down the Anaconda smelter.
- 1985: Washington Corporation purchases Butte operations from the Atlantic Richfield Company, and begins operations of Continental Pit and Weed Concentrator a year later, eventually under the name of Montana Resources.
- 1989: United States sues the Atlantic Richfield Company for reimbursement of costs at the three sites; litigation is ongoing, although stayed and partially settled.
- 1991: State of Montana actively pursues its natural resource damages litigation against the Atlantic Richfield Company.

3 EPA, State, and Community Participation in the RI/FS Process

The *Remedial Investigation* began in 1995 with extensive public involvement. Concurrently, EPA, in consultation with DEQ, prepared a community relations plan to identify and set forth agency and community interaction during the *Remedial Investigation* and the *Feasibility Study* (RI/FS). Under the plan, EPA conducted community interviews and issued several fact sheets. EPA also extended a technical assistance grant to the Milltown Technical Assistance Committee (later renamed the Clark Fork Technical Assistance Committee [CFRTAC]) to provide the public with independent technical reviews of EPA and DEQ Clark Fork River RI/FS activities, reports, and meetings. During the first year, many stakeholders were interviewed and numerous public meetings were held throughout the river basin. Upstream landowners and downstream environmental organizations expressed widely disparate views of the river's health and how it should be cleaned up. For example, EPA's *Human Health Risk Assessment* (1998a) found minimal risk to humans, because relatively few opportunities exist for direct exposure to floodplain contamination. But some groups criticized EPA's findings of minimal risk, citing concern about "hot spots" of arsenic in the floodplain. EPA worked with the Agency for Toxic Substances and Disease Registry (ATSDR), a Federal agency that focuses on public health issues, and issued an Addendum to the *Human Health Risk Assessment* to address these concerns. EPA also conducted a series of public meetings and discussion groups on the *Ecological Risk Assessment*. EPA responded to comments from the Atlantic Richfield Company and others on the risk assessment. EPA also sought and responded to comments on the *Remedial Investigation* report. The State and other natural resource damage trustees were consulted in the development and issuance of these documents.

The *Feasibility Study* began in March 2000. EPA facilitated a *Feasibility Study* technical advisory group, composed of as many as 40 to 45 interested individuals, including public interest group representatives, county government officials, and Federal, Tribal, and State agency representatives. This group met monthly during the development of the *Feasibility Study* from March through October 2000 to review data, track the progress of the Atlantic Richfield Company's efforts on the *Feasibility Study*, and provide input toward the development and analysis of *Feasibility Study* alternatives.

After the preliminary draft *Feasibility Study* was submitted by the Atlantic Richfield Company to the agencies, EPA facilitated the gathering of a smaller group of stakeholders. A few of the individuals in this "working group" (15 to 20 members) had participated in the larger technical advisory group. However, the latter group did not include Federal, State, or Tribal agency representatives. Rather, it was composed of representatives from local governments (four separate county governments), landowners, and environmental organizations. This working group, with the assistance of a professional facilitator, met several times in a setting that was conducive to understanding each other's interests and needs and supportive of development of a dialogue between "upstream interests" and "downstream interests."

During EPA and DEQ review of the Atlantic Richfield Company's preliminary draft Clark Fork River *Feasibility Study*, serious shortcomings were noted relative to the lack of alternatives developed and evaluated for reducing the extent of streambank erosion and providing geomorphic stability of the river's banks and floodplain. EPA, in consultation with the State, prepared comments back to the Atlantic Richfield Company requiring that a series of subalternatives be developed utilizing a streambank riparian buffer zone and streambank stabilization concept to mitigate this problem. The Atlantic Richfield Company was required to modify the final draft Clark Fork River *Feasibility Study*, which was released March 2002, to include and evaluate such subalternatives.

Both the technical advisory group (including CFRTAC) and the working group participated in various technical and policy discussions about the Clark Fork River OU. These discussions also assisted the remedy selection process: the advice, recommendations, and expressed concerns added significantly to EPA's understanding of community views of the proposed remedy. In May 2001, EPA Region 8 presented its suggested remediation strategy to the EPA NRRB. The State of Montana and some participants of the two working groups provided the NRRB with their perspectives on the proposed cleanup action. Various questions regarding the suggested remedy raised by the NNRB were subsequently responded to by EPA Region 8 and a symposium on in-situ treatment was held.

Stakeholder interaction continued throughout the development of the *Proposed Plan*. Meetings were held with individual landowners, the groups described in this section, and the community at large. An information video was prepared to present the various viewpoints on what should be done with the site. EPA hosted two open houses about the site in April 2002.

The *Proposed Plan* was released in August 2002, along with a Fact Sheet summarizing the plan. The RI/FS reports and the *Proposed Plan* were made available to the public at this time or previously, placed in the Administrative Record, and made available at several information repositories located throughout the Clark Fork River Basin. A 60-day public comment period began. Two extensions were granted, giving the public nearly 4 months to provide input to the remedy selection. Two public meetings were held during the first month of the comment period: one meeting in Deer Lodge, Montana, and a second meeting in Missoula, Montana. At these meetings, EPA and DEQ representatives presented information, answered questions, and receive public comment for the record. EPA's response to the comments received during the public comment period is included in the *Responsiveness Summary*, which is Part 3 of this *Record of Decision*.

4 Scope and Role of OU or Response Action

The Clark Fork Basin Superfund complex is made up of four contiguous sites broken into OUs for easier management:

- Silver Bow Creek/Butte Area Site—established 1982
  - Butte Priority Soils OU and several related removal OUs
  - Lower Area One/Ecological Risk Assessment OU
  - Mine Flooding/Berkley Pit OU
  - Westside Soils OU
  - Butte Active Mine Area OU
  - Rocker OU
  - Streamside Tailings OU
  - Warm Springs Ponds OUs (Two remedial and one removal)
- Montana Pole Site—established 1987
- Anaconda Smelter Site—established 1982
  - Smelter Demolition Removal OU
  - Mill Creek Temporary Relocation Removal OU
  - Mill Creek Final Relocation Remedial OU
  - Anaconda Yards Removal OUs
  - Old Works Removal OU
  - Flu Dust OU
  - Old Works/East Anaconda Development OU
  - Anaconda Community Soils OU
  - Anaconda Warm Springs Creek Removal OU
  - Anaconda Regional Water, Waste, and Soils OU
- Milltown Reservoir Sediments Site—established 1982
  - Milltown Water Supply OU
  - Milltown Reservoir Sediments OU
  - Clark Fork River OU and the related East Side Road Removal

The combined sites include more than 140 miles from the headwaters of Silver Bow Creek north of Butte to the Milltown Dam near Missoula. The four sites are shown in Exhibit 2-1, *Location Map*, page 2-2. EPA and DEQ have been methodically addressing these sites over the last 20 years. The Clark Fork River OU final remedy is one of the last cleanup decisions needed for the Clark Fork River Basin complex.

The Clark Fork River OU is one of three remedial OUs within the Milltown Reservoir Sediments Site. The other OUs are the Milltown Water Supply OU and the Reservoir Sediments OU. Although these sites are contiguous, the OUs within them have been divided such that actions in one site or OU are not dependent on activities in other areas. As noted earlier, the Deer Lodge irrigated lands TCRA is addressing clear human health threats at the Clark Fork River OU by using EPA's removal authority. That action's remaining components will become part of this final Clark Fork River OU Selected Remedy. The Clark Fork River OU Selected Remedy is meant to address comprehensively the human health and environmental risks and other response action issues identified for this area. It does not address natural resource damage claims related to the establishment of baseline conditions at the Clark Fork River OU—these will be addressed separately by the State and Federal natural resource damage trustees.

5 Site Characteristics

5.1 Conceptual Site Model

The primary source of contaminants of concern in the Clark Fork River floodplain is tailings mixed to various degrees with surface and near surface soil deposits within the historic 100-year floodplain. Secondary sources include contaminated surface water and shallow groundwater from the alluvium within the Clark Fork River OU. Other secondary sources include streambed sediments and some historically contaminated irrigation ditches and fields.

The primary pathways by which contaminants move within and between media include tailings and soils, groundwater, surface water, and airborne transmissions. Fate and transport of contaminants by these media are listed below and shown in Exhibit 2-3, *Conceptual Model*:

- Tailings, Sediments, and Impacted Soils
  - Oxidation of tailings produces acid, releases metals into surface and groundwater
  - Plants uptake contaminants from soil into roots
  - Overbank flow from flooding, rainfall, and streambank erosion transport total and dissolved metals into river; aquatic flora and fauna exposed
- Groundwater
  - Infiltration and vadose zone transport
  - Vadose zone pore-water and groundwater interaction
  - Groundwater flow
  - Groundwater and surface water interaction
  - Streambank storage
- Surface Water
  - Surface water runoff from tailings
  - Surface water and sediment interaction
  - Streambank and floodplain erosion by the Clark Fork River
- Streambed Sediments
  - Streambed material coated with metal oxides, sulfides, and hydroxides – potential dissolution into the river water.
- Historically Irrigated Fields
  - Soil entrainment by wind, potential inhalation and ingestion by residents
  - Dermal contact with soil, potential for ingestion by children
  - Ingestion potential through garden vegetables

- Biological resources
  - Soil and aquatic organisms exposed through consumption of contaminated soils or absorption of water. Runoff from summer thunderstorms represents a mechanism for transport of contaminants.
- Airborne Transmissions
  - Dust entrainment

The factors influencing the conceptual site model are discussed in more detail throughout this section. Primary pathways by which humans may be exposed to contaminants are presented in Exhibit 2-4, *Conceptual Model for Human Exposures*. Ecological risk pathways are presented in Exhibit 2-5, *Conceptual Model for Ecological Exposures*.

5.2 Site Overview

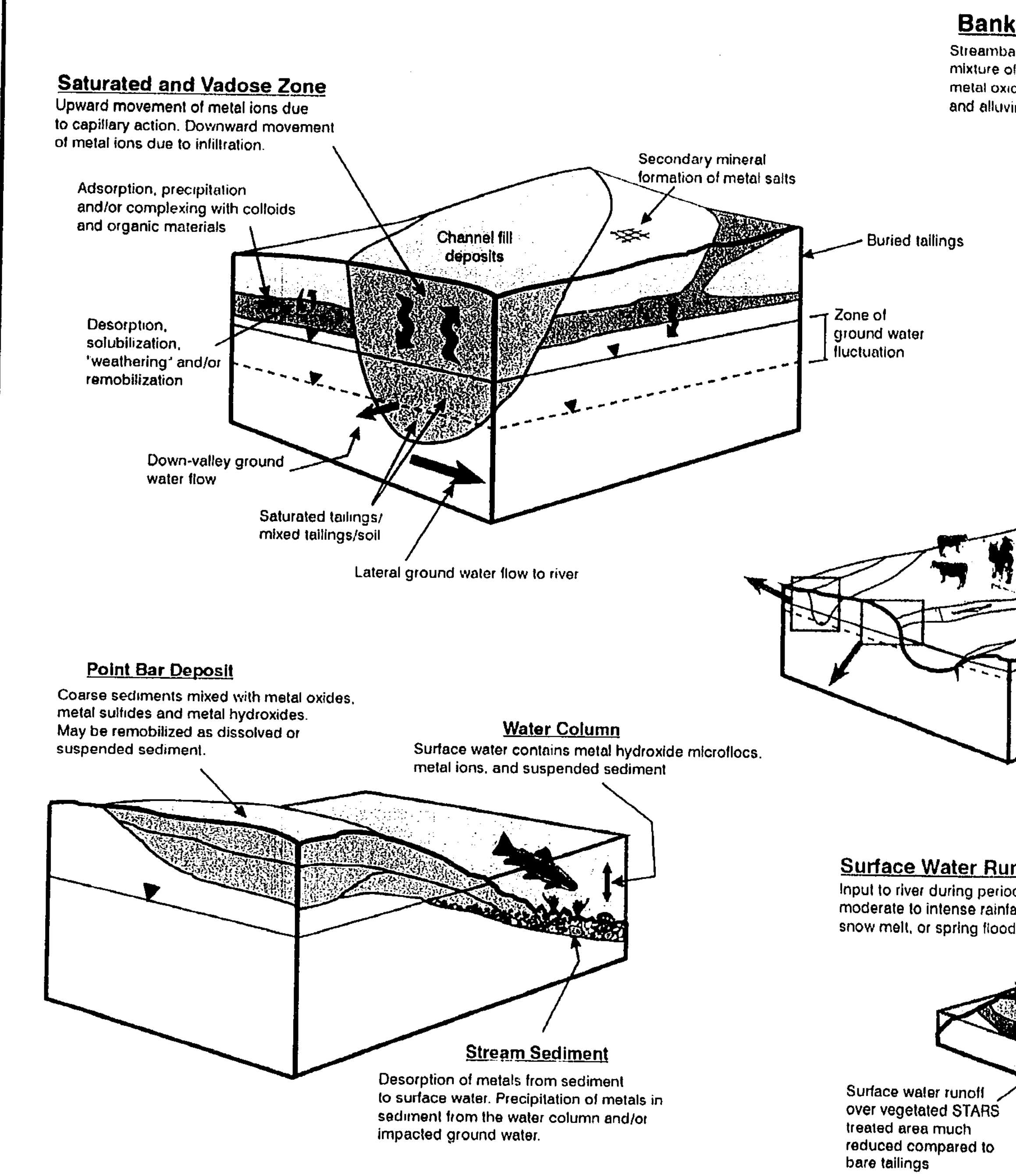
5.2.1 Site Size, Geography, and Topography

The Clark Fork River is an easterly tributary of the Columbia River and is the major drainage system of Montana's mountains west of the Continental Divide. The river flows generally northwest to enter Lake Pend Oreille in northern Idaho. The waters exit Lake Pend Oreille near Sandpoint, and flows through the Pend Oreille River to the confluence with the Columbia River in British Columbia, Canada.

The Clark Fork River OU consists of 120 river miles of floodplain and irrigated fields at the upper end of the Clark Fork River Basin. Along the many portions of the OU, the river is bounded or traversed by Interstate 90 (I-90), secondary roads, and two railroads (one active, one abandoned). The placement of these structures has diverted and channelized the natural course of the river in some areas, primarily in Reaches B and C (as described below).

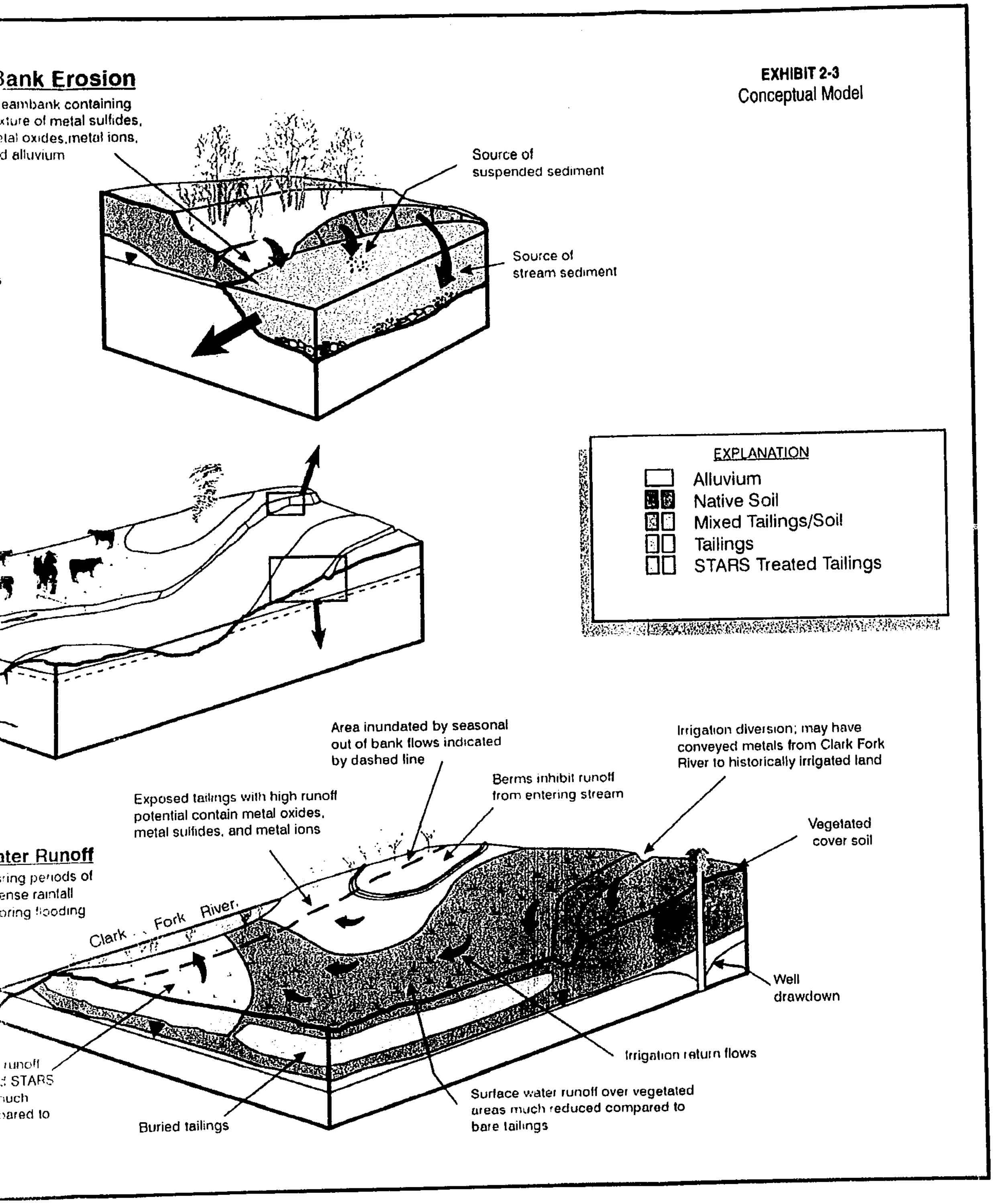
The Clark Fork River flows through the Deer Lodge Valley, which is a structural depression filled with Tertiary basin-fill and Quaternary alluvium eroded from the surrounding highlands. The sediments in the Deer Lodge Valley are as much as 5,000 feet thick and include a heterogeneous mixture of gravel, sand, silt, and clay. The broad, meandering form of the Clark Fork River in Deer Lodge Valley reflects this depositional history. The valley becomes more narrow and the river less meandering after Garrison, where the gradient increases and the lithology changes to sedimentary rocks. The metamorphosed sandstones and shales encountered downstream of Bearmouth Canyon are more resistant to erosion than the dominantly carbonate sedimentary rocks of the Garrison to Bearmouth section.

To study and evaluate the best application of remedy solutions, the Clark Fork River was divided into three reaches based on physical features of the landscape, proximity to historic mining, and intensity of impacts.



Note: This conceptual model does not address overbank flooding

EXHIBIT 2-3
Conceptual Model



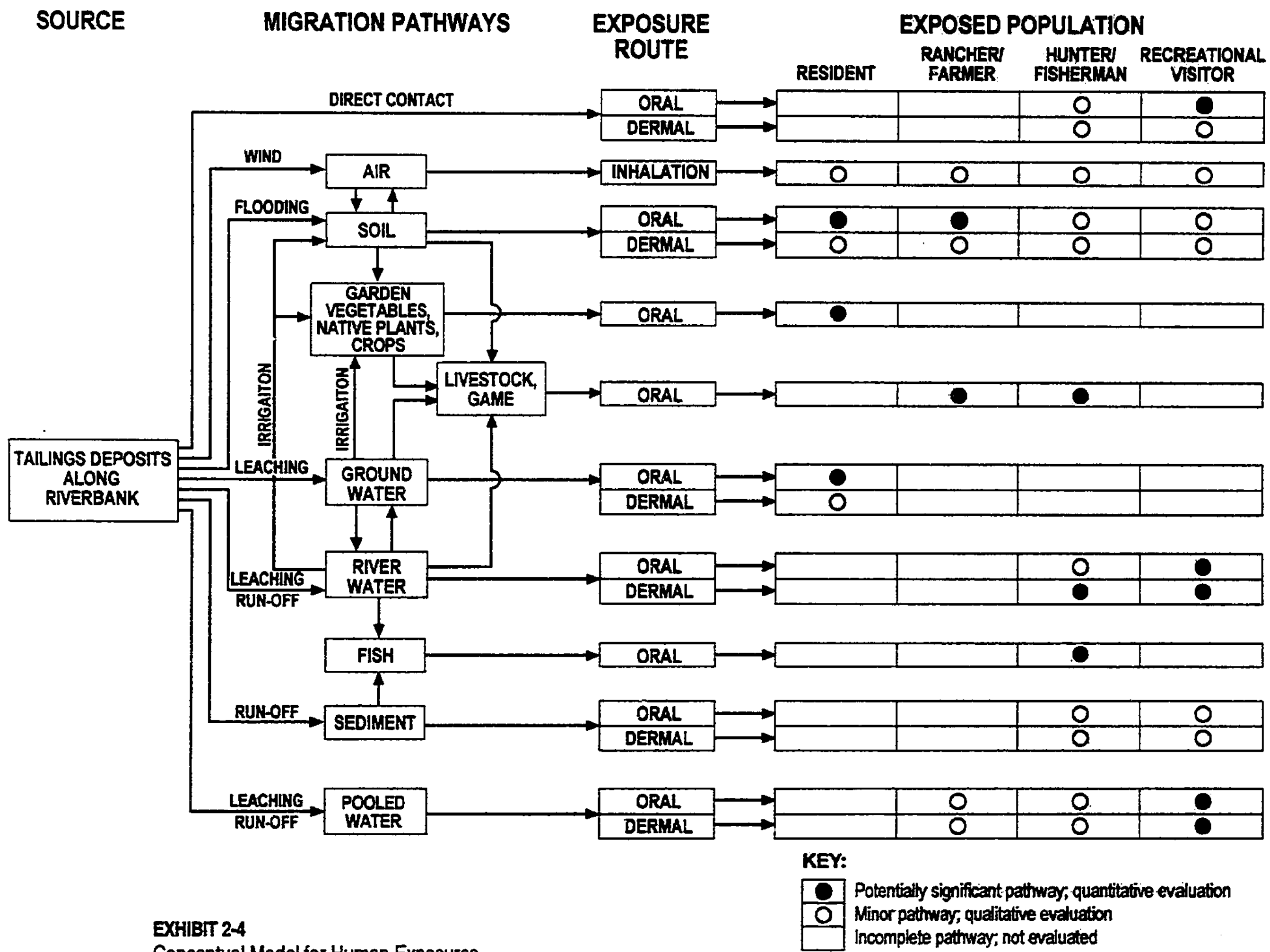
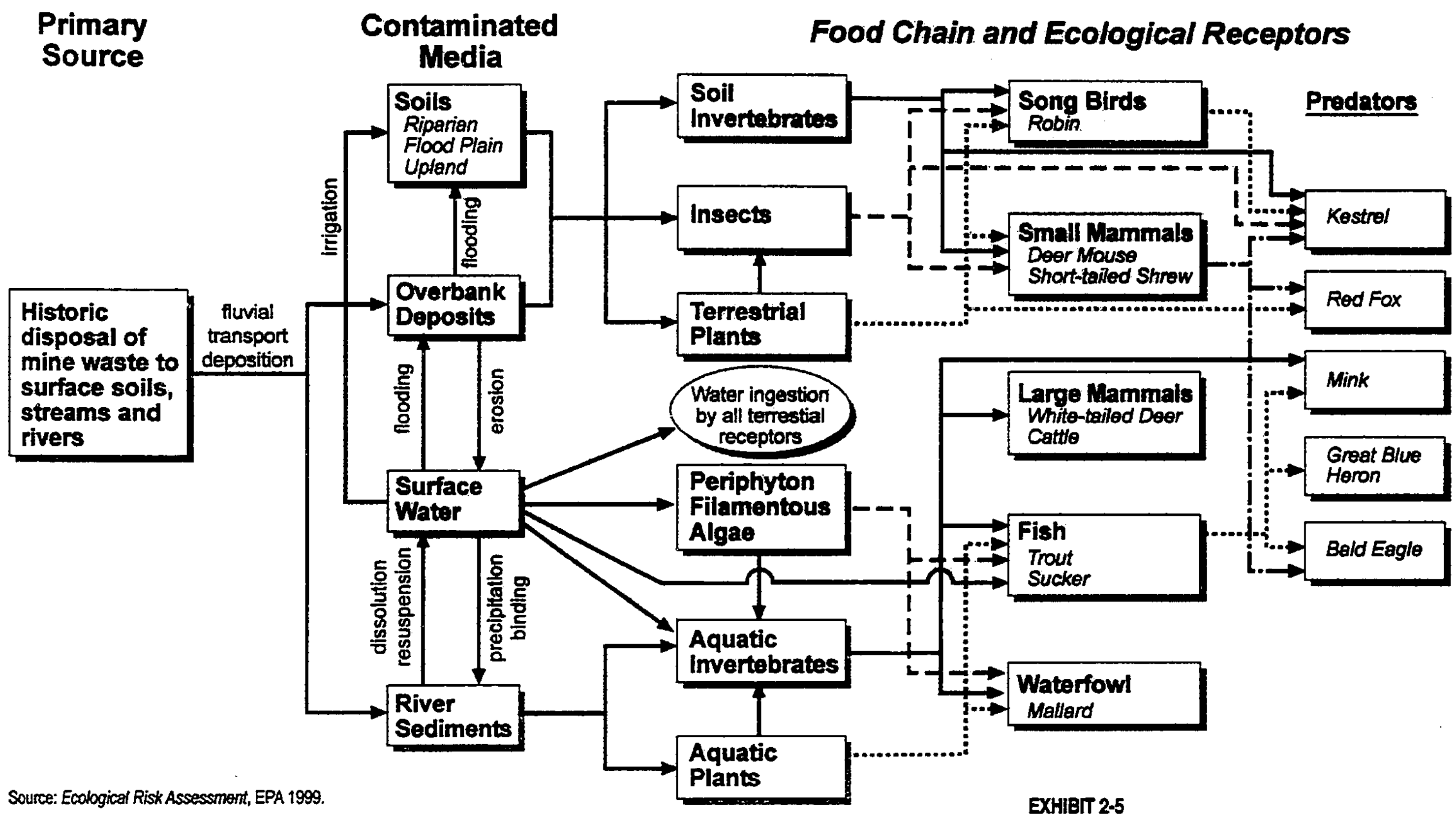


EXHIBIT 2-4
Conceptual Model for Human Exposures

Source: *Human Health Risk Assessment*, EPA 1998a.



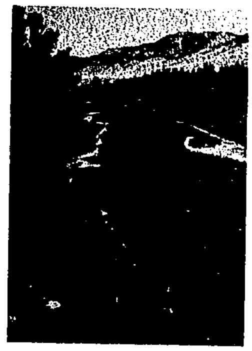
Source: *Ecological Risk Assessment*, EPA 1999.

EXHIBIT 2-5
Conceptual Model for Ecological Exposures

These reaches are described and illustrated below:

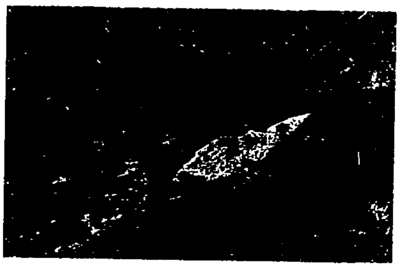
Reach A: Deer Lodge Valley, View from Garrison looking upstream.

- **Reach A—Deer Lodge Valley Reach:** Extends from the southeastern tip of the OU near river mile 0 at Warm Springs Creek to just upstream of Garrison at river mile 43. Reach A has the broadest extent of the 100-year floodplain and is nearest to historic mining and milling sites in Butte and Anaconda. Extensive exposed tailings and unstable streambanks, as well as stressed vegetation, exist in this area.
- **Reach B—Drummond Valley Reach:** Extends from immediately upstream of Garrison, where the Little Blackfoot River enters the Clark Fork, to downstream of Drummond at river mile 76, for a total of 31 river miles. At the starting point for this reach, the addition of water from the Little Blackfoot River may, under certain flow conditions, nearly double the Clark Fork's flow. The floodplain is more narrow and the gradient higher than Reach A, and exposed tailings are far less extensive.



Reach B: Clark Fork Valley; view near Drummond as valley narrows.

- **Reach C—Bearmouth Canyon Reach:** Extends 47 river miles from Drummond to the northwest tip of the OU area. Through this reach the floodplain is constrained by a narrow valley, roads, and railroad grades. Here, the flow is augmented by several tributaries and the reach is farther away from historic mining sites. No exposed tailings are evident.



Reach C: Bearmouth Canyon; river bordered by steep rock walls.

Studies performed for the *Remedial Investigation* and the *Feasibility Study* have shown that a focused cleanup effort in Reach A results in the greatest reduction in mine waste contamination. Efforts in Reach B would be expected to provide limited additional benefit. Reach C has more limited risks and no clear clean-up alternatives because of the widespread contamination and mixing of the contamination with fluvial soils, and the lack of feasible alternatives.

5.2.2 Important Archeological and Historical Features

Because of the size and complexity of this site, a unique, three-phase approach was used at the Clark Fork River OU to investigate cultural and historic resources:

- First, existing public information was summarized during the *Remedial Investigation.*
- Second, potential impacts to archeological and historical features were evaluated in the *Feasibility Study* based on the information gathered during the *Remedial Investigation* phase.
- The third investigation, if needed, will be a detailed inventory conducted during the remedial design phase of the project following publication of this *Record of Decision.*

The State Historic Preservation Office (SHPO) file search revealed 53 potential cultural resource sites in the Clark Fork River OU and adjacent areas. Two of these sites are currently included in the National Registry of Historic Places: the Grant-Kohrs Ranch National Historic Site and the William K. Kohrs Memorial Library in Deer Lodge. Twenty-five sites are potentially eligible for listing, 21 sites are indeterminate, and 3 sites have been declared ineligible.

Additionally, the Confederated Salish and Kootenai Tribes are conducting a survey to identify protected cultural, historical, and religious resources that have not been previously identified, under cooperative agreement funding from EPA. These results will be incorporated into the remedial design process according to procedures outlined in an agreement between EPA and the Tribe.

5.2.2.1 The Grant-Kohrs Ranch: A National Historic Site within a Superfund Site

A Survey of Historic Sites and Buildings was administered by the U.S. Department of the Interior (DOI) in 1957. The program was intended to identify and evaluate nationally significant properties throughout the United States and, with owner consent, designate them as National Historic Landmarks. Ultimately, these were eligible for consideration for inclusion in the National Park System.

One of the properties identified during this process was a working cattle ranch owned by Conrad Kohrs Warren at Deer Lodge, Montana. Now known as the Grant-Kohrs Ranch National Historic Site, it was the site of one of Montana's earliest ranches, and it eventually became one of the largest cattle raising operations in the West. This property was designated a National Historic Landmark on December 19, 1960. The legislation that designated the ranch as a National Historic Site was signed into law on August 25, 1972, and in November of that year, the National Park Service purchased the land.

Today, the Grant-Kohrs Ranch National Historic Site embraces 1,618 acres and 88 structures. The site is maintained as a working ranch. Emphasis at the ranch is on providing the visitor with "an understanding of the evolution of American cattle ranching, from open range to early farm-ranch cattle raising…." The site is located within Reach A.

The National Park Service (NPS) has identified the Organic Act and associated designation legislation as an Applicable or Relevant and Appropriate Requirement (ARAR) to be applied to the Grant-Kohrs Ranch National Historic Site remedial action. EPA received extensive public comment on the *Proposed Plan*, urging adequate consideration of these unique ARARs in addressing remediation of the ranch. EPA has worked closely with the NPS to develop a description of how the Selected Remedy would be adapted and applied at the Ranch to meet the ARAR and protectiveness issues unique to the ranch. The description is found in Section 13.7, page 2-107.

5.2.3 Flood/Storm Event History and Geomorphic Features

Floods and other large storm events are the predominant natural force affecting the transport, mixing, and deposition of tailings and streambed sediments in the Clark Fork River historic 100-year floodplain. Although data from streamflow gauging stations upstream from Garrison are limited to the past 22 years, data are available for the past 100 years from gauging stations near Missoula.

In the early 1800s, and for centuries before, many of the meandering portions of Reach A of the Clark Fork River were likely impounded by beaver and supported dense populations of riparian shrubs. The beaver played an important role in shaping the floodplain, but were presumably eradicated by trapping in the early to mid-1800s. In Reaches B and C, the higher volume of water from the addition of the Little Blackfoot River and the steeper canyons resulted in a steeper river gradient, fewer meanders, and a reduced beaver population in these lower reaches.

The transport and mixing of acid generating mine wastes with streambed sediments and soils impacted to varying degrees the streambank and floodplain vegetation on Silver Bow Creek and the upper Clark Fork River. Existing streambanks and the denuded floodplain areas were also exposed to erosion and deposition. During significant flooding and storm events in the late 1800s and particularly in 1908, any remaining beaver ponds along the upper Clark Fork River probably contributed to the deposition of the thick layers of fine sediment and tailings on to the Silver Bow Creek and Clark Fork River floodplains. As a result, significant vegetation losses occurred on the banks and floodplain in Reach A because of the tailings and contaminated soils, primarily through acid releases resulting from the oxidation of the sulfides contained in the mine wastes (phytotoxicity).

Data from a stream flow gauge near Missoula indicate that large floods occurred in 1899 and 1908. Other large-magnitude floods likely occurred in 1887, 1892, and 1894. The 1908 flood lasted from May 25 to June 5, and resulted in the average deposition of channel sediments and tailings 1 to 3 feet thick in Reach A. Deposition of these silt-based mixed tailings could have occurred only if river flow over-topped the main channel and flowed into depositional areas across the floodplain. The depositional pattern also suggests that the floodplain was covered with substantial willow thickets that enabled the river to sustain its single-thread channel rather than become braided.

In Reaches B and C, the flows during floods, especially the 1908 flood, were likely higher and the bank vegetation was dominated by cottonwoods. Mixed tailings and sediments were likely deposited behind the cottonwoods in thin layers, but most of the tailings and soils were likely incorporated into the active bed of the channel.

The deposited, contaminated sediments, particularly in Reach A, were toxic to the riparian vegetation as the tailings materials began to oxidize, releasing acid and dissolved metals into the soils, surface waters and groundwaters. This loss of streambank vegetation, combined with other land use impacts such as farming and grazing, have made the banks susceptible to erosion. Since 1908, large peak flows have been recorded in 1948, 1964, and 1975. These and other storm water events continued to move contaminated waste into the Clark Fork River or re-released and mixed the existing contaminated sediments.

Currently, the portion of the upper Clark Fork River that meanders through the Deer Lodge valley (Reach A) is vulnerable to high rates of streambank erosion as a result of the loss of riparian woody vegetation. This condition is in addition to the other pathways, releases, and threats from the contamination that now resides along the Clark Fork River. The initial—and certainly the most significant—impacts to lost riparian woody vegetation occurred repeatedly throughout the late 1800s and into the early 1900s, as large quantities of mining and milling wastes were disposed of in the river's headwaters. Each successive flood, whether major or minor, carried the mining wastes farther downstream and distributed them more broadly over the floodplain. Thus, the current floodplain, lacking extensive woody vegetation on the banks and in the riparian corridor throughout the Deer Lodge valley, is highly susceptible to ongoing streambank erosion and to potential catastrophic floodplain destabilization, or unraveling. As noted in the other sections of the *Record of Decision*, the contamination also presents other pathways and problems of significance that are addressed by the Selected Remedy.

5.3 Remedial Investigation Strategy

Because the Clark Fork River OU is such a large, complex site, much of the data gathering concerning sources of contamination, pathways of migration, and impacts on receptors needed for the *Remedial Investigation* relied on information from earlier treatability studies and demonstration projects, other Upper Clark Fork River Basin sites, and similar sites throughout the region. EPA, in concert with DEQ and the Atlantic Richfield Company, established specific Data Quality Objectives (DQOs) for reviewing studies and qualifying existing data sets for incorporation into the overall understanding of site conditions, and ultimately formation of a conceptual model. Work groups (focused around specific disciplines) consisting of EPA, DEQ (and other agencies), Atlantic Richfield Company, consultants, and other interested groups were formed under EPA direction to compile and evaluate existing information, and guide subsequent investigations through the formulation of work plans and Sampling and Analysis Plans, which would be used to fill data gaps and complete the characterization of environmental conditions. An example of one of the primary work groups was the geomorphology work group lead by U.S. Geological Survey (USGS) representative Dr. Jim Smith. This group was tasked with reviewing all existing information relevant to the physical processes (e.g., rate of erosion) that were influencing the dynamics and morphology of the Clark Fork River within the bounds of the OU. If deficiencies in the information were detected, this group made specific recommendations to generate the information needed. Pertinent studies and projects for all disciplines are cited in detail in the *Remedial Investigation* and the *Feasibility Study*.

5.4 Affected Media and Contaminant Types

As described in Section 5.1, *Conceptual Site Model*, page 2-13, the contaminants are found in media affected by mine wastes. The key media affected by contaminants in the Clark Fork River floodplain include the following:

- **Tailings and sediments and impacted soil:** The primary sources of contaminants are the tailings and impacted soils in streambanks and/or floodplain deposits. As shown in the conceptual model, several pathways exist from tailings and impacted soils to various biological receptors. Oxidation of the sulfides in the mining wastes is the key contaminant dissolution mechanism, producing acidity and dissolved metals that can migrate and contaminate surface water and groundwater. Plants can uptake contaminants directly from the soil through their roots, often resulting in phytotoxicity. Streambank erosion can increase total metals and suspended sediment in the river, which can then be ingested by aquatic life. Also, contaminated surface water runoff from exposed tailings or slickens (pulse events), can enter surface water and subsequently be available to aquatic, plant, and animal receptors. These areas, along with the historically irrigated areas, also provide a pathway for human uptake, via dermal contact, inhalation, or ingestion.

- **Groundwater:** Movement of contaminated shallow groundwater and groundwater infiltration through tailings and soil causes both upward and downward movement of certain metal and arsenic ions. Groundwater flow to surface water can also occur.
- **Surface water:** Surface water runoff, including overbank flows, as well as erosion from floodplain tailings and contaminated soils into the river, transports both dissolved and sediment-bound metals and arsenic. Inflow of contaminated groundwater can also increase levels of contamination in the surface water.
- **Streambed sediments:** Stream sediments can contain various metal precipitates from the water column and groundwater. Streambed sediments can be mixed or coated with metal oxides, sulfides, and hydroxides in point bar deposits and in other parts of the streambed and can contribute to contaminant concentrations in the river.
- **Historically irrigated fields:** Irrigation ditches and fields historically irrigated with Clark Fork River water containing mining related contaminants are also sources of concern. All potentially contaminated fields, including fields outside the historic 100-year floodplain, will be evaluated for human health concerns during remedial design. EPA is presently involved in a TCRA to address impacted soils at Eastside Road residences, the known area of unacceptable arsenic levels in these fields. Although landowners of all historically irrigated fields in this area have been notified of the potential threat to their health, some landowners have not yet provided the needed approval to complete the response actions on their properties.
- **Biological resources:** Metals can be delivered to aquatic and terrestrial organisms from any of the contaminated media listed above. Organisms, including benthic macroinvertebrates, receive the contaminants through direct consumption of contaminated sediment or through absorption in water. These organisms are in turn part of the food chain—for example, macroinvertebrates are eaten by fish and, if contaminated, have been shown to potentially reduce growth of trout (Stratus 2002). Contaminant uptake in plants is a well-documented occurrence and the source of problems for streambanks and impacted vegetation areas. Loss of vegetation adversely affects local wildlife habitat. In the past, pulse events, triggered by intense summer thunderstorms, have carried acidic, metal laden runoff from nearby slickens into the river, and have resulted in documented fish kills and impacts on other aquatic life. Likewise, spring runoff, floods, and ice scour events generate sediment that is detrimental to benthic macroinvertebrate populations, fish spawning success, other fish, and aquatic mechanisms.
- **Air resources:** Because of the location and relatively small areas noted as slickens, and the various levels of existing vegetation located on the impacted soils areas, fugitive dust emanating from these areas is not significant and any resulting adverse air impacts are considered to be highly unlikely. Therefore, this air pathway is not of further concern except during remedial action construction.

The remedial actions defined in the Selected Remedy, when implemented, will have beneficial mitigative and corrective effects on the affected media.

For the purposes of discussion, an example segment of Reach A in map view and cross-section is illustrated to represent the variety of contaminant sources within the Clark Fork River OU. Exhibit 2-6, *Map View and Cross-Section of an Existing River Meander Bend,* shows several key features of the floodplain, including the floodplain tab within the meander, exposed tailings, impacted soils, and sparse vegetation.

Contaminants present in the Clark Fork River OU are from historic mining and smelting processes upstream of the Clark Fork River. The contaminants of concern for the site are arsenic, cadmium, copper, lead, and zinc. Copper is the prime contaminant associated with environmental risk, and arsenic is the primary contaminant associated with human risks. Exhibit 2-7 shows results from one study that measured metals and arsenic in several different floodplain deposits. Concentrations of metals and arsenic were quite variable, but the geometric average copper concentration in "tailings" was 1,760 ppm. Since copper is the key contributor to aquatic risks (particularly from exposed tailings), additional copper data from other historic studies were reviewed and compared with this data. The geometric average copper concentrations from a total sample base of 164 "tailings" samples from five other studies (which did not meet EPA's initial rigorous DQO criteria, yet are still indicative of site conditions) ranged from 1,600 to 2,877 ppm (Lipton 1993; Lipton et al. 1995b; Brooks 1998; Nimick 1990; CH2M HILL 1991, Atlantic Richfield Company 2002).

More recent soils data collected by EPA in July 2003 (part of the CFR RipES field confirmation process—reported by MSU and Bitterroot Restoration Inc., RRU and BRI 2003) measured copper and arsenic concentrations in tailings and impacted soils areas along with co-located measurements of riparian vegetation function. Where vegetation was severely impacted (slickens), the copper and arsenic geometric average concentrations were 1,950 and 630 ppm, respectively. Where vegetation was only slightly impacted, copper and arsenic geometric average concentrations were much lower (640 and 160 ppm, respectively). These differences in metals and arsenic concentrations are important considerations in the degree of remediation that may need to be undertaken for various impacted areas of the floodplain.

The *Ecological Risk Assessment* was conducted, concentrations of contaminants were considered, and the subsequent risks to aquatic, wildlife, and terrestrial resources were determined. The *Ecological Risk Assessment* found unacceptable risks from the metals contamination to plants and aquatic life within the Clark Fork River OU. Slickens and impacted soils and vegetation areas show the impacts from these risks most clearly. Fish populations in the Clark Fork River OU are also impacted by these risks. The *Ecological Risk Assessment* also found the possibility of risks to wildlife, although significant uncertainty exists regarding these risks. In tandem with these findings, the fluvial geomorphology studies conducted primarily by the USGS found excessive rates of erosion along streambanks in the upper reaches of the Clark Fork River OU and found that there was the possibility of severe braiding or unraveling of the upper river in large floods. While there is also uncertainty regarding this latter finding, this braiding, even if limited to small sections of the river, would cause large inputs of contaminants and sediment into the river. A more detailed description of the risk assessment is found in Section 7, *Summary of Site Risks,* page 2-39.

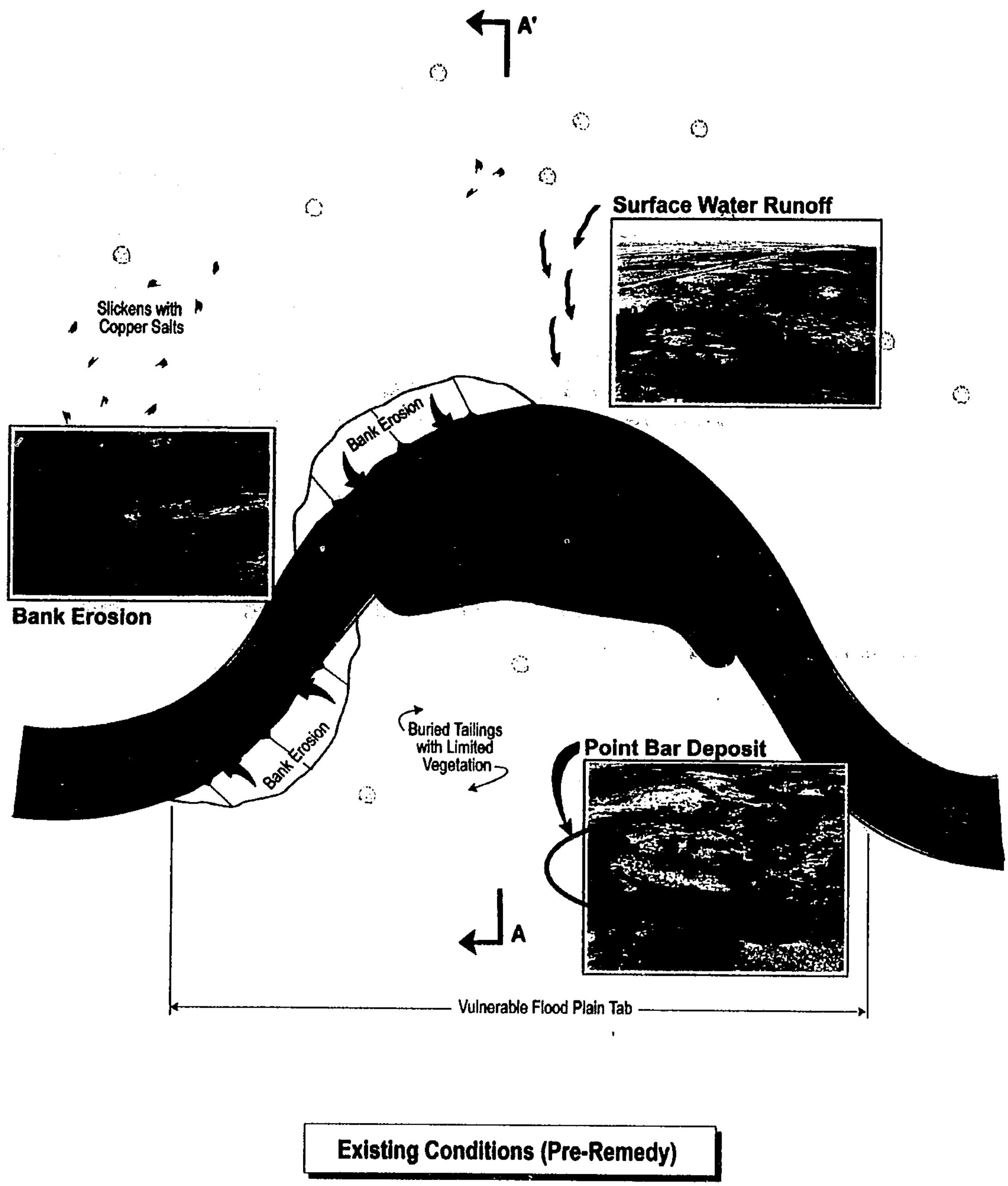
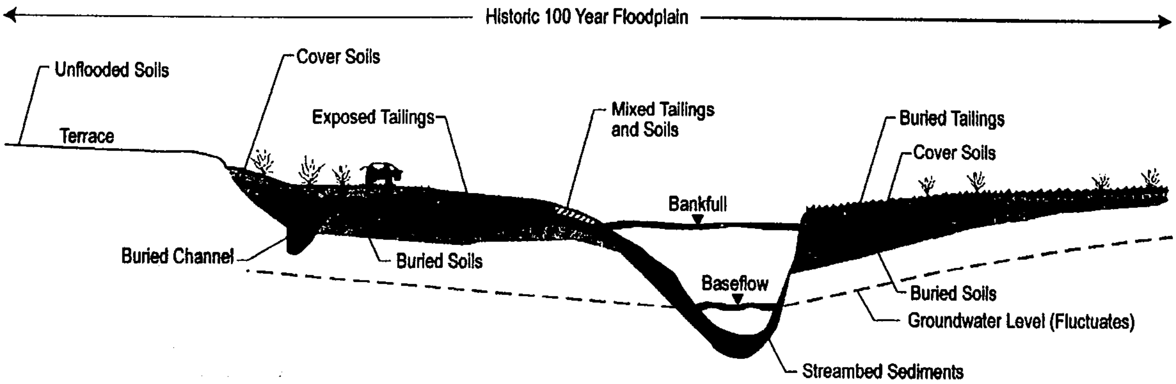


EXHIBIT 2-6
Map View and Cross-Section of an Existing River Meander Bend



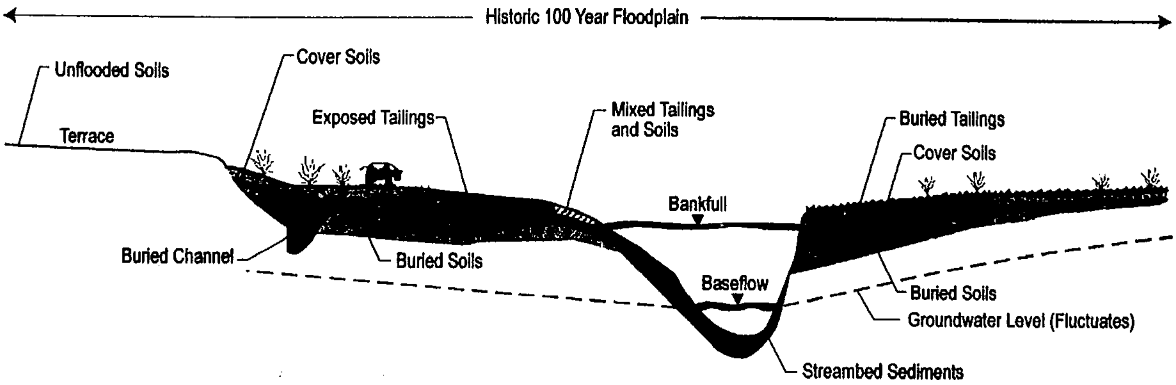
Cross Section of Meander Bend

EXHIBIT 2-7
Geometric Mean Concentrations of Total Arsenic and Metals in Floodplain Sediments in Reach A of the Clark Fork Valley, Montana

Soil-material type	Number of samples	Geometric mean concentration (milligrams per kilogram)			
		Arsenic	Copper	Lead	Zinc
Tailings	21	766	1,760	665	1,530
Mixed soil/tailings	24	419	2,360	359	2,320
Buried soil	37	32	373	42	410
Buried alluvium	3	203	1,330	270	1,190
Cover soil	22	330	1,980	318	2,060
Unflooded soil	30	63	303	60	401

Source: Smith et al. 1998, Table 5, page 24. Data was also cited in the *Remedial Investigation*, Atlantic Richfield Company 1998.

The *Human Health Risk Assessment* identified arsenic as the contaminant of concern for assessing human health risks from the Clark Fork River OU contamination. Land use along the Clark Fork River riparian zone is primarily recreational or agricultural. The Clark Fork River *Human Health Risk Assessment* (EPA 1998a) and the *Human Health Risk Assessment Addendum for Recreational Visitors at Arrowstone Park* (EPA and ATSDR 2001) evaluated the human health risks arising from exposures to heavy metals and arsenic within tailings deposits, soils, and groundwater along the river. The studies concluded that, based upon the understanding that no residential development exists within the floodplain, and that exposures are limited to ranch (or farm) workers and recreators (fishermen, tubers, and children at parks), the human health risks are generally acceptable. On historically irrigated lands, however, where residential development has occurred or where it may occur in the future, the risk assessment concludes that risks may be unacceptable. NPS conducted a



Cross Section of Meander Bend

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Human Health Risk Assessment for the Grant-Kohrs Ranch National Historic Site (Foster Wheeler 2003) and found potential risks to workers from contaminated sediments in irrigation ditches that may be unacceptable.

In summary, the primary source of contaminants in the Clark Fork River channel, streambanks, and historic 100-year floodplain is the presence of mine wastes, which have been mixed to varying degrees with channel sediments and soils. Contaminants have moved from this primary source to media that can serve as secondary sources, including groundwater, surface water, and streambed sediments. In addition, other sources of contaminants, such as historic mining operations in other tributaries, could also have affected the distribution of contaminants in the Clark Fork River basin to a limited degree. Sources of these contaminants are described below, along with the overall characteristics of the various media at this OU.

5.4.1 Tailings Residuals and Impacted Soils

Tailings residuals may be generally visually identified by color in the Clark Fork River floodplain as yellow, orange, and tan fine sandy silt to silty sand. In some areas, known as slickens, the tailings residuals are generally unvegetated, and a white to blue colored mineral salt crust may form and then accumulate at the surface at certain (usually dry) times of the year. These soluble metallic salts can be washed into the river during periods of thunderstorms, causing pulse events that lower the pH in areas of the river and, at the same time, increase the metals concentration.

In most places, tailings residuals are mixed with or are covered with a thin layer of light brown soil material that occasionally supports vegetation. Exposed and buried tailings almost always overlie an historic, buried, organic-rich soil horizon. Soil data used in the *Ecological Risk Assessment* were in a depth interval of 0 to 2 feet because most plant species have roots within this zone and burrowing mammals are more likely to be exposed in this zone. The following conclusions were based on the *Remedial Investigation* sampling results:

- The concentration of each metal of concern is highly variable in different soil samples. Within a soil type category (exposed tailings, buried tailings, cover soil, and buried soil), a two orders of magnitude difference can exist between the minimum and maximum concentrations.
- Among soil type categories, metal concentrations decrease from upstream to downstream and from riparian areas to uplands.
- The widest variation in soil pH, from 3 to 9, is exhibited throughout the historic floodplain in Reach A.

5.4.2 Groundwater

Groundwater is a pathway for migration of contaminants in the Conceptual Model, and sampling has revealed low concentrations of metals in groundwater. The limited available data, collected during the *Remedial Investigation* and used for human health risk assessments, suggest that elevated metals and arsenic concentrations in groundwater are generally restricted to within the top few feet of the shallow water table in localized areas near tailings deposits. According to the *Feasibility Study*, arsenic concentrations in waters from 11 percent of all wells (domestic and non-domestic uses) were above the Montana dissolved groundwater standards of 18 micrograms per liter (µg/L). Each of these samples were within 8 feet of the ground surface. According to the *Feasibility Study*, exceedances of the State's standards were observed in 5 percent of the samples for cadmium, lead, and zinc. No exceedances were found for copper. No samples exceeding Montana Water Quality Act standards were found below 22 feet of the ground surface.

The final groundwater arsenic standard for this *Record of Decision* is 10 µg/L, based on the recently promulgated Federal Safe Drinking Water Act standard. This likely expands the boundaries of the areas of concern for shallow groundwater contamination. Applying the new arsenic standard to the results of the 76 domestic wells that were sampled in 1987 (CH2M HILL et al. 1991) illustrates an exceedance in 5 percent of the domestic wells. That is, water from four of the sampled domestic wells would have exceeded the new arsenic standard. Arsenic concentrations in water samples from these wells were determined at 12, 13, 15, and 42 µg/L. Although in-situ treatment may mobilize arsenic into groundwater, EPA believes that the removal of slickens areas, increased vegetative cover, and decreased percolation rates will lead to groundwater compliance within a reasonable period of time.

5.4.3 Surface Water

The *Remedial Investigation* and the *Ecological Risk Assessment* concluded that concentrations of contaminants are higher in the Clark Fork River than in the reference streams and are often above State water quality standards, especially for copper and arsenic. Also, the concentrations of metals and arsenic in river water are higher in Reach A and decrease in downstream reaches, primarily because of dilution by tributary streams. Contaminants are supplied to the river as streambank tailings and contaminated sediments are eroded into the river. Also, water quality may change dramatically in response to storm events and overbank flows.

5.4.4 Streambed Sediments

The streambed sediments of the Clark Fork River are primarily coarse-grained with less than 5 percent of the streambed sediment in riffle areas consisting of silts and clays (less than 0.063 millimeters diameter). Extensive data have been collected on contaminant concentrations in Clark Fork River bed sediments. Concentrations of contaminants vary considerably based on location and time. This variability is caused by streambed erosion and deposition of streambed material that occurs naturally. Generally, metal and arsenic concentrations are three to five times higher in the finer fractions of the sediments than in the bulk fractions. Sediments from riffle areas were also investigated, and concentrations of metals were found to be 30 to 40 percent lower in these areas than in depositional areas, as expected. Also, copper concentrations in streambed sediment decrease as grain size increases.

5.4.5 Historically Irrigated Fields

Based on historic records, approximately 14,600 acres of land within the Clark Fork River OU were estimated to have been irrigated with Clark Fork River water. As reported in the *Feasibility Study*, investigations identified 120 acres of historically irrigated land that had lower vegetation cover, impacted vegetation communities, and metals- and arsenic-enriched soils that are generally acidic. Irrigated lands are often located outside the 100-year floodplain. The remaining irrigated acreage was found to have no vegetation impact discernible from aerial photo interpretation and soils sampling and analysis. Portions of the 120 acres of irrigated land had been subdivided into nominal 5-acre residential lots with homes (Eastside Road, Deer Lodge). A TCRA to protect human health of residents whose yards were contaminated was partially implemented to reduce arsenic concentrations to acceptable levels. The contaminated soils around residences were removed and transported to an offsite disposal repository, or in some cases re-incorporated into pasture soils, and the residential sites were backfilled with clean soils and revegetated. In addition, the vegetation and soils on properties adjacent to the residential areas (used primarily as pastures), which were also impacted by metals levels and low pH resulting in phytotoxic conditions, were remediated by in-situ methods. Appropriate lime additions were made to the soils to assure neutralization. Properties were then deep plowed using several passes to mix the lime with the soils up to 2 feet deep. Confirmation sampling was conducted to ensure that the response action was effective. Planting of appropriate seed mix and vegetation completed the process. The response action was effective for historically irrigated lands of participating landowners (some follow-up maintenance work is required). At least three residences with likely impacted soils refused access to conduct sampling or to work on their lands. These impacted lands will be cleaned up and other re-vegetation and operation and maintenance issues will be addressed under the post-*Record of Decision* remedial action.

In addition, two demonstration projects involving portions of pastures at two other nearby locations, again having impacted vegetation because of phytotoxic soils as a result of historical irrigation practices, were remediated by similar in-situ techniques. Again, confirmation sampling and analysis and ongoing vegetation monitoring have generally confirmed that remediation goals were met. These areas are currently undergoing monitoring and maintenance activities, which will be continued under this *Record of Decision*.

Other lands possibly impacted by past irrigation may be identified as this *Record of Decision* is implemented in Reaches A and B.

5.4.6 Biological Resources

5.4.6.1 Terrestrial Resources

Terrestrial resources have been studied most intensively in the riparian zone. Common trees in the Clark Fork River OU include black cottonwood, quaking aspen, and rocky mountain juniper. Common shrubs are water birch, snowberry, sandbar willow, booth willow, Bebb willow, and woods rose. Thirty-six other shrubs are present, but occur less frequently. Redtop, tufted hairgrass, baltic rush, smooth brome, and quackgrass are the most common grasses. Alfalfa, clover, Canada thistle, leafy spurge, spotted knapweed, and common silverweed are common broad-leafed plants. Noxious weeds are present throughout the valley, but are particularly prevalent in Reach C. Slickens areas support little vegetation, but occasionally are sparsely populated by hardy, metals-tolerant pioneer plants, such as tufted hairgrass and redtop. Metals are found at elevated concentrations in plant tissues, and concentrations of these metals vary by plant type. The highest concentration occurred in tufted hairgrass and willows. Riparian polygon health ratings from the University of Montana show gradual improvement in ratings in the downstream direction. Most of the floodplain within Reach A is currently comprised of riparian pastures for livestock and hayfields, which in their present condition are not as productive as they might be absent phytotoxic conditions.

Land use is a significant factor influencing the presence of terrestrial fauna. Livestock frequently occupy the habitat along the Clark Fork River. A portion of the riparian corridor in Reach C is occupied by roads and a railroad. However, the area supports at least 86 bird species and 23 mammal species.

5.4.6.2 Aquatic Resources

As a result of suspected impacts from mining related contamination, aquatic resources have been a focus of numerous studies and surveys. The aquatic macrophyte canopy covers 5.5 percent (Reach A) to 1.2 percent (Reach C) of the channel bottom, and is dominated by white water-crowfoot and fennel-leafed pondweed. Benthic macroinvertebrates are generally abundant in the upper Clark Fork River and include filter-feeding caddisflies, mayflies, stoneflies, blackflies, and other invertebrates. However, some "less metal tolerant" species are reduced in the upper reaches. Six species of salmonids, including bull trout (protected under the Federal Endangered Species Act [ESA]), four species of minnows, three species of suckers, several types of sunfish, and sculpins inhabit the Clark Fork River. Coarse scale and longnose suckers contribute the largest fraction of total fish biomass. Brown trout and mountain whitefish make up a significant portion of the total biomass in Reach A. State studies show trout populations are significantly depressed compared to reference streams in Montana (Lipton et al. 1995a).

5.4.7 Air Resources

Contaminants of concern (COCs) could potentially be carried by the wind under certain conditions. Although no direct data are available to quantify airborne transport of contaminants, historic air quality monitoring in Deer Lodge suggest airborne transmission is not a significant pathway for metals and arsenic transport. Dust and contaminant control during remedial activities is an important concern. ARARs that require dust control and that address this pathway will be implemented during construction.

5.5 Extent of Contamination

Exhibit 2-8, *Estimated Quantities of Exposed and Buried Tailings, Cover Soil, and Buried Soil,* shows the extent of contamination in Reach A and Reach B. No visually identified tailings have been observed in Reach C, so this reach is not included on the exhibit. This exhibit was taken from the *Remedial Investigation* and is based on 1996 data. Several investigation methods were used to estimate the extent of contamination.

During the *Remedial Investigation,* approximately 156 acres of exposed tailings and 3,339 acres of buried tailings were estimated in Reach A. In the *Feasibility Study,* the number of acres of exposed tailings in Reach A was estimated to be 167 using aerial photography and geographic information system (GIS) mapping techniques (actual acreage could be as high as 250 acres). Tailings deposits range in thickness from less than 1 inch to 34 inches. Since 1996, response actions, and demonstration projects, have been conducted within Reaches A and B. Exhibit 2-9, *Estimated Quantities of Exposed and Buried Tailings, Cover Soil, and Buried Soil With and Within Demonstration Projects,* shows the extent of treated and untreated tailings in the floodplain. The total volume of tailings in Reach A is approximately 7.6 million cubic yards. Reach B is estimated at 1.6 million cubic yards.

EXHIBIT 2-8
Estimated Quantities of Exposed and Buried Tailings, Cover Soil, and Buried Soil

Reach	River Gradient	Media Division	Area (acres)	Volume (cubic yard)[2] 25th percentile	50th percentile	75th percentile
A[1]	Low	Exposed tailings[3]	167	306,300	358,000	403,300
A[1]	Low	Buried tailings[3]	3,339	1,713,000	2,498,900	3,098,000
A[1]	Low	Cover soil	3,339	1,011,300	1,067,500	1,460,400
A[1]	Low	Buried soil[5]	3,494	3,758,600	3,758,600	3,758,600
Total Reach A[1]				**6,789,200**	**7,683,000**	**8,720,300**
B[6]	Low	Exposed tailings[4]	14	33,500	33,500	33,500
B[6]	Low	Buried tailings	780	174,300	300,700	419,300
B[6]	Low	Cover soil	780	343,800	343,800	439,300
B[6]	Low	Buried soil[5]	794	854,000	854,000	854,000
B[6]	High	Exposed tailings	0	0	0	0
B[6]	High	Buried tailings	47	6,300	12,600	19,000
B[6]	High	Cover soil	47	29,700	31,200	39,000
B[6]	High	Buried soil[5]	47	50,500	50,500	50,500
Total Reach B[6]				**1,492,100**	**1,626,300**	**1,854,600**

[1]Areas and volumes for Reach A include extrapolation based on air photos. Reach A exposed tailings areas and volumes reflect only those areas large enough to have been mapped individually in the *Remedial Investigation* and/or the *Feasibility Study*. Additionally, approximately 35 acres of exposed tailings exist in Reach A as "spot" tailings too small to have been mapped individually.

[2]Volumes calculated by summing the 25th, 50th, and 75th percentile thickness for each thickness class.

[3]Mean thickness value used for all volume estimates for tailings greater than 24 inches because of the small number of observations (n=5).

[4]Mean thickness (18 inches) for the depth class 12-24 inches is used for 25th, 50th, and 75th percentile because n=1.

[5]Eight-inch thickness value used for buried soils based on decrease in total copper concentration with depth.

[6]Volumes for Reach B reflect only those portions of the reach which were mapped.

Volumes are estimated as in-situ quantities.

Sources: 1) *Remedial Investigation* (Atlantic Richfield Company 1998), Table 3-4. 2) *Feasibility Study Report* (Atlantic Richfield Company 2002), Appendix D.

EXHIBIT 2-9
Estimated Quantities of Exposed and Buried Tailings, Cover Soil, and Buried Soil With and Without Demonstration Projects

Tailings and Soil Class	Reach A		Reach B	
	Area (acres)	Volume (cubic yards)	Area (acres)	Volume (cubic yards)
Without Demonstration Project Areas				
Exposed Tailings	132	271,000	14	33,500
Buried Tailings	3,075	1,882,000	828	292,000
Cover Soil	3,075	951,000	828	413,000
Buried Soil	3,208	3,450,000	842	906,000
Subtotal	*NA*	*6,554,000*	*NA*	*1,644,500*
With Demonstration Project Areas				
Treated Tailings/Impacted Soils	101	416,440	NA	NA
Untreated Tailings	263	349,000	NA	NA
Untreated Cover Soil	263	88,800	NA	NA
Untreated Buried Soil	263	283,000	NA	NA
Subtotal	*NA*	*1,137,240*	*NA*	*NA*
Total	**NA**	**7,691,240**	**NA**	**1,644,500**

Notes:

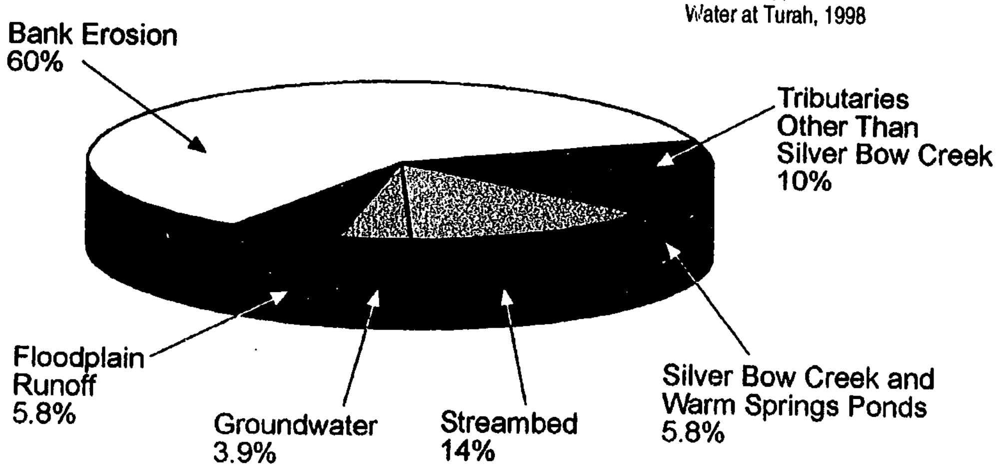
1. Demonstration Project Areas include the Governor's Demonstration Project, the Resource Indemnification Trust Demonstration Project, and the South Deer Lodge Entryway Improvement Project.
2. Reach A exposed tailings areas and volumes reflect only those areas large enough to have been mapped individually in the *Remedial Investigation* and/or the *Feasibility Study*. Additionally, approximately 35 acres of exposed tailings exist in Reach A as "spot" tailings too small to have been mapped individually. These "spot" areas and volumes were mapped as inclusions within the buried tailings areas.
3. Areas were queried directly, and volumes were calculated by multiplying the queried area by the midpoint of the thickness class for tailings and cover soil.
4. The thickness of the buried impacted tailings was taken to be 8 inches, which is the depth below tailings at which an order of magnitude drop in copper concentration typically occurs in both Reach A and Reach B.
5. Demonstration Project Area tailings, cover soils, and buried soils were treated with lime amendment, tilled, and revegetated unless overlain by existing good vegetation cover.

Sources: 1) *Remedial Investigation* (Atlantic Richfield Company 1998), Table 3-4. 2) *Feasibility Study Report* (Atlantic Richfield Company 2002), Appendix D.

5.6 Fate and Transport

As previously noted, a mass-balance model was used to quantify loading of total copper from the floodplain to the fluvial system. Copper was chosen as an indicator for this study because it is representative of mining and smelting wastes, highly toxic to aquatic and terrestrial receptors, and has the largest and most consistent data set. Model methods and results were included in the *Remedial Investigation* and a USGS report (Smith et al. 1998). The model predicted inputs during normal flow events. The results of the model indicate that streambank erosion is the largest source of total recoverable copper to the river, comprising approximately 60 percent of the total copper input along the 120-mile OU river reach, as shown on Exhibit 2-10, *Sources of Copper to Surface Water at Turah, 1998*. Tributaries and combined surface water runoff and groundwater inflow account for about 10 percent each, and upstream sources account for 6 percent of the total. The streambed accounts for approximately 14 percent of the total input. The mass balance also indicates that under current conditions, only about 56 percent of the average annual copper input to the river is transported past Turah Bridge (farthest downstream point of Reach C). The rest is deposited on point bars along the Clark Fork between Warm Springs Ponds and Turah Bridge.

EXHIBIT 2-10
Sources of Copper in Surface Water at Turah, 1998



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6 Current and Potential Future Land and Water Uses

The total population within or adjacent to the Clark Fork River OU is approximately 16,240 people (U.S. Census Bureau 2000). Approximately 28 percent (4,500) of the total population lives in or near Reach A (the Deer Lodge Valley) between Warm Springs and Garrison. Major population centers within the Deer Lodge Valley are located at Galen, Dempsey, Montana State Prison, Deer Lodge, and Garrison. Approximately 89 percent of the land within Reach A of the Clark Fork River area is privately owned, with the remaining 11 percent managed by Federal and State agencies. The City of Missoula, with a population of 57,000, lies approximately 7 river miles downstream of the OU.

The entirety of the Clark Fork River OU is contained within the aboriginal territory of the Confederated Salish and Kootenai Tribes, who claim an ownership interest in natural resources in the OU based on the Hellgate Treaty of 1855. Lands within the Clark Fork River OU are subject to certain treaty-reserved uses by members of the Tribes.

6.1 Current and Anticipated Future Land Uses

The primary land use in the Deer Lodge Valley is agricultural. The income from agriculture is a significant portion of the total income for Powell, Deer Lodge, and Granite counties. Ranching (raising livestock) provides the significant source of the agricultural income in the Deer Lodge Valley, supplemented by the raising of certain crops. Hay is the major irrigated crop and is used locally to support the livestock industry. The high terraces on either side of the Clark Fork River valley are primarily dryland-farmed. Property without river frontage or surface water rights is commonly used as rangeland. The National Forest surrounding the Clark Fork River OU is used as summer range for livestock.

In addition to agricultural land uses, various private and public recreational land use areas exist along all three Clark Fork River reaches. These include Arrowstone Park near Deer Lodge, private campgrounds, a wildlife management area, a national historic site, fishing access points, a State recreation area, highway rest areas, and other non-designated areas, such as the trestle area in Deer Lodge. According to Montana Fish, Wildlife, and Parks (MFWP), use of the river and riparian corridor for fishing, camping, and floating is increasing (MFWP 2003). Some residential use occurs in historically irrigated properties, primarily in the Eastside Ditch area. There is some potential for future residential use in this area as well, although the primary use is agricultural.

The State of Montana and the counties of Deer Lodge and Powell regulate land use and building activities in the 100-year floodplain. Deer Lodge, Powell, and Granite counties have adopted floodplain regulations mandated by the State and based on minimum requirements specified by State statute (Montana Codes Annotated [MCA] § 76-5-201 *et seq.*). Regulations in these counties provide for creating floodplain, floodway, and floodway fringe districts. Certain activities are prohibited in the floodplain, such as building residential structures, and many uses in the floodplain require a permit, except for agricultural uses. Although new residential structures are prohibited in the floodplain, some residential uses, such as yards, are not prohibited.

Future land use was assessed by contacting the planning offices in Deer Lodge, Powell, and Granite counties. The counties confirmed that the end land use—both current and future—is agricultural or recreational. Overall, local land uses are not expected to change significantly during the next 20 years in these counties within the Clark Fork River OU.

In Deer Lodge County, rural agricultural growth and associated development is expected to remain stable. The intent of the *Anaconda Deer Lodge County Comprehensive Master Plan* is to encourage growth in existing developed areas and away from agricultural operations. The county plan also includes provisions for creating open space uses, including a greenbelt, in the Clark Fork River OU (Anaconda-Deer Lodge County 1992).

Similarly, Powell County has zoned much of the Clark Fork River OU (Reach A) within its county boundary as Agricultural Districts 3 and 4, except for the community centers of Goldcreek and Garrison and the City-County Planning Area at the town of Deer Lodge. Agricultural District 3 encompasses the area north of the Clark Fork River downstream of Garrison. Agricultural District 4 includes both the east and west sides of the Clark Fork River upstream from Garrison. The future land uses in both districts promote agricultural operations and other related activities. Residential development is discouraged in Agricultural District 3; if allowed, the density would be low. Agricultural District 4 can accommodate residential development, but only if it is consistent with and does not have negative consequences for agricultural operations (Powell County 1996).

As noted previously, some limited, historically irrigated areas near Deer Lodge are or may be residential. Most of the historically irrigated areas are likely to remain agricultural.

6.2 Groundwater and Surface Water Uses

The principal, current source of groundwater used by humans in the Clark Fork River OU is an unconfined aquifer located in unconsolidated and semi-consolidated alluvium along the valley floor. Depth to groundwater varies from near zero to more than 150 feet. Groundwater generally flows to the north-northwest, following the river valley. A well inventory conducted in 1987 (CH2M HILL et al. 1991), identified more than 500 wells within and directly adjacent to the Clark Fork River floodplain. The well inventory was not all inclusive, but the following types and numbers of wells were identified: domestic, 438; irrigation, 22; stock, 19; public supply, 22; and unused, 37. Water samples from 76 domestic wells that met specific criteria were collected and analyzed for specific physical and chemical constituents. The arsenic water standard (18 µg/L) was exceeded for one well, revealing a concentration of 42 µg/L. Re-examination of the 1987 survey data indicates waters from four wells within the OU would exceed the most recent Federal drinking water standard (10 µg/L) for human consumption.

The State has classified all groundwater within and near the OU as a potential drinking water source. Groundwater contamination generally extends only to 10 feet.,Based on the State's classification of the groundwater, there is the potential use of shallow groundwater that would pose a threat (this is documented in the *Human Health Risk Assessment*). There is also the potential that shallow groundwater contamination could be drawn deeper if extensive groundwater development occurred and the shallow contamination was unaddressed.

Surface water from the river is used mainly for irrigation, with numerous withdrawal points along the river. Most of this water is used for production of hay for livestock. The river is also used for recreational purposes, with numerous points of public access for fishing, camping, and general public recreation. Surface water uses are not expected to change significantly. The State of Montana has classified the uses for the Clark Fork River as drinking water, culinary, agricultural, and fishery propagation.

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7 Summary of Site Risks

7.1 Human Health Risks

The Clark Fork River *Human Health Risk Assessment* (EPA 1998a) evaluated the likely scenarios for human exposure to the contaminants of concern for the Clark Fork River OU. Arsenic in soils and tailings is the primary concern for human exposures at this site. In order to assess and manage risks where arsenic is present in soils, EPA developed Risk Concentration Levels (RBCs). RBCs for arsenic are presented in Exhibit 2-11.

EXHIBIT 2-11
Arsenic RBCs

Land Use	Concentration
Residential	150 ppm
Recreational	680 ppm (children at Arrowstone Park and other recreational scenarios)
	1,600 ppm for fishermen, swimmers and tubers along the river
Rancher/Farmer	620 ppm

Source: 1) EPA 1998a. 2) EPA and ATSDR 2001.

The *Human Health Risk Assessment* provided text to help interpret the RBCs and states that "RBC values should be interpreted by comparison to concentration values which represent the arithmetic mean and/or UCL (upper confidence level) of the mean of a chemical averaged over an appropriate exposure unit and should not be interpreted as a 'not-to-be-exceeded' value on a sample-by-sample basis."

If an exposure area has an average arsenic-in-soils concentration that is less than the RBC for a particular use, then EPA considers the risks to be within an acceptable range and no cleanup action is proposed. In contrast, EPA found several residential yards and horse pastures south of Deer Lodge where average soil arsenic concentrations where higher than the RBCs for residential use. These risks were deemed unacceptable, and a cleanup of most of these soils was conducted where landowners granted access as part of the Deer Lodge Valley Irrigated Lands TCRA. The remaining components of that response action will be part of the selected remedy.

The following is a summary of the major findings of the *Human Health Risk Assessment (1998)*:

- Arsenic is the chemical of principal concern for human health in tailings, mixed tailings, and soils located along the Clark Fork River. Other mining-related elements pose no unacceptable human health hazard or risk at the concentrations found within the OU.
- If people were to live in areas where they have repeated (daily) contact with tailings, especially in Zone 1 of Reach A, risks from arsenic could be in a range of concern for both noncancer effects and for cancer effects. Zone 1 was defined in the Baseline Human

Health Risk Assessment as a relatively narrow strip of land adjacent to the river. Aerial and land surveys evaluated during the risk assessment indicated that no permanent residences were located in Zone 1 of Reach A. In remedial design, more detailed residential use survey information may be considered.

- Residential areas in Deer Lodge, including areas within the floodplain, were systematically sampled. Estimated risks for those residences did not exceed levels of concern for residential use. ATSDR did a health survey for the area that did not show elevated levels of arsenic in participating residents of Deer Lodge. The reasonably anticipated land use for this area is agricultural, and the Selected Remedy provides for institutional controls (ICs) to prevent future residential development in Zone 1 and other portions of the floodplain in Reach A.
- For people who have only intermittent or occasional contact with tailings (recreational visitors who hike along the river, swimmers who raft down the river, and hunters or fishermen along the river), arsenic levels in tailings and contaminated soils do not result in unacceptable non-cancer or cancer health risks.
- Fields or pastures that were historically flooded or irrigated with highly contaminated river water may contain arsenic levels that are unacceptable for residents if their homes are located directly in areas of high impact. These same fields do not appear to pose an unacceptable risk to farmers or ranchers because their exposure to the soils is limited in terms of time and frequency and the level of contamination is below the agricultural action level.
- Arsenic levels in all but four domestic wells are below the proposed State and current Federal drinking water standards of 10 μg/L. The wells were completed in the shallow water table, and were sampled in June 1987. The wells were located in Deer Lodge, Montana, and are to be re-sampled as part of the Selected Remedy.
- Arsenic levels in locally produced beef, fish from the Clark Fork River, and in waterfowl from the Warm Springs Ponds (located at the head of the river), are within the normally acceptable risk range.
- Arsenic levels in surface water of the Clark Fork River do not pose unacceptable human health risks for people who wade or swim in the river.
- Direct bio-monitoring of arsenic levels in urine and hair of 60 area residents did not detect unacceptable levels. The bio-monitoring for arsenic was conducted in 1997 and 1998 by the ATSDR.

Since the *Human Health Risk Assessment* was released, a local public park (Arrowstone Park) was developed in Deer Lodge. This park has different use patterns than those evaluated in the *Human Health Risk Assessment*. As a consequence, EPA and ATSDR prepared a *Human Health Risk Assessment Addendum* for recreational visitors at Arrowstone Park (2001) that focused on characterizing chronic arsenic exposure to children aged 1 to 10 years old visiting Arrowstone Park up to 48 times per year. A chronic RBC for arsenic in soil of 680 ppm for child recreational users was determined. Concurrently, the ATSDR concluded that the existing data for the park did not adequately characterize park conditions and recommended further sampling and analysis of soils for arsenic concentrations. A team from ATSDR collected soil samples from several areas within the park that represented different exposure units in 2001. EPA and ATSDR subsequently prepared the *Human Health Risk Assessment* addendum to evaluate potential and current exposures to children. Conclusions of this work (EPA and ATSDR 2001) were as follows:

- The two developed subareas (1 and 2) in Arrowstone Park were determined by EPA and ATSDR to be safe—that is, they did not pose an unacceptable risk, assuming chronic exposures as described in EPA's *Human Health Risk Assessment Addendum* for children 1 to 10 years old who visit the park up to 48 times per year for many years.
- There is no concern at present for undeveloped subareas (3 and 4) of the park, since arsenic levels and/or use are low.
- The sampling effort was designed to characterize risk of chronic exposure to arsenic in soils of the park—the data cannot be used to assess risk from acute arsenic exposures to children who may eat contaminated soils.

The ATSDR report also made the following recommendations (EPA and ATSDR 2001):

- If subareas 3 and/or 4 are developed, ATSDR recommends further arsenic sampling and/or cleanup.
- ATSDR recommends that Powell County proceed with its efforts to educate parents about the risks to children from eating soil.

In public comments of EPA's *Proposed Plan,* ATSDR identified the trestle area near Deer Lodge as an area that likely presented current unacceptable risks to recreational users. EPA will conduct additional sampling of this area as needed to supplement existing data. If recreational levels are exceeded, remedial actions will be implemented.

The NPS conducted a *Human Health Risk Assessment* for the Grant-Kohrs Ranch National Historic Site (NPS 2003). This risk assessment is generally consistent with EPA's *Human Health Risk Assessments*. However, the NPS risk assessment did find risks within a range of concern to workers from sediment associated with the irrigation ditches at the ranch. This risk exists even if the NPS risk assessment is adjusted by using site-specific bioavailability assumptions developed by the Atlantic Richfield Company. This exposure scenario is not unique to the Grant-Kohrs Ranch National Historic Site. Additional sampling will be performed, on an as needed basis in suspect irrigation ditches in other areas of the OU as part of remedial design, to determine if unacceptable risks are present, and, if so, how the risks can be mitigated. This aspect of the Selected Remedy is described in Section 13.8.3, page 2-119.

Shallow groundwater along the river corridor (but generally not under historically irrigated lands) is contaminated with metals and arsenic. Isolated areas of shallow groundwater contain contamination above the Federal standard of 10 µg/L. If shallow wells (25 feet or less) are developed within the floodplain in these areas, for domestic purposes, unacceptable human health risks could result because of arsenic contamination.

The overall conclusion that human health risks are generally low along the river is not because the contaminants are without the potential for causing harmful effects, but because human exposures to contaminants along the near-river corridor are low. Risks could be in a range of concern if permanent residences were maintained within the active floodplain.

There, arsenic concentrations in soils and tailings, as well as in shallow groundwater, often exceed acceptable levels for residential exposure (several hours of contact every day for many years). In addition, risks could be in a range of concern where residences have been constructed on lands that were historically irrigated with Clark Fork River water. EPA believes that the practicing of traditional cultural activities by members of Native American tribes in the floodplain may result in exposures similar to those expected from taking part in recreational activities.

7.2 Ecological Risks

The *Ecological Risk Assessment* established clear risks to the terrestrial environment along Reach A of the Clark Fork River OU. Limited risks were identified for Reaches B and C. Exposed tailings generally lack vegetation and impacted soils and vegetation areas sustain reduced terrestrial plant species diversity and cover. This unacceptable risk is particularly important to some landowners within the Clark Fork River OU. The geomorphic studies and evaluations have emphasized this risk by noting that the Clark Fork River suffers from excessive erosion and loss of land and by hypothesizing the potential for river unraveling in a severe flood event. While many of the erosional aspects of this geomorphic evaluation are documented in the geomorphology reports and understood, significant uncertainty is associated with the hypothesized floodplain unraveling risk.

Surface water runoff from barren slickens or impounded water on barren slickens can contain very high concentrations of contaminants. Maximum concentrations in runoff water from barren slickens were reported to be 7,380 mg/L copper, 2,350 mg/L zinc, and 23 mg/L arsenic (Atlantic Richfield Company 1997). Because of the high level of contaminants in runoff from bare slickens, EPA made screening level calculations of acute risk to wildlife (birds and mammals, including cattle) from ingestion of surface runoff water. Results presented in the *Ecological Risk Assessment* (EPA 1999) indicated that under these maximum concentration conditions of contaminants in surface runoff waters, ingested doses might be of acute concern to birds and even large mammals.

According to EPA's *Ecological Risk Assessment*, historic impacts of mine waste on the Clark Fork River were severe. The report indicates "essentially no fish existed in the upper Clark Fork River dating from the late 1800s into the 1950s." Fish populations began to re-establish to some degree after construction of the third Warm Springs sediment pond in 1959, and a new water treatment system for mine water discharge was installed in Butte between 1972 and 1975 that resulted in improved water quality. Documented fish kills, however, continued as late as 1991 and State studies show a significantly reduced trout population.

The *Ecological Risk Assessment* evaluated several factors and investigation results relating to chronic risks to Clark Fork River aquatic macroinvertebrates and fish. The State also submitted a study during the public comment period that demonstrated harmful chronic effects on fish from arsenic exposure. The data from these studies are consistent with the hypothesis that copper concentrations (and possibly arsenic and other metals) in the aquatic environment (surface water, diet) impose low-level chronic stress on aquatic macroinvertebrates, trout, and other fish. The most likely manifestation of this stress is decreased growth. It is unknown to what degree this chronic stress or an avoidance response contribute to the decrease in fish population in the river. The State believes this is an important area of risk and has produced detailed reference stream studies that indicate the Clark Fork River has six times fewer salmonid fish populations than reference streams in Montana with similar characteristics but without metals and arsenic concentrations.

EPA considers it likely that acute exposures to pulses of metals or other high-concentration events are more important than chronic stresses to both fish and other important aquatic invertebrates, since even intermittent fish kills from pulse events could lead to reductions in fish population. Such pulse events are also responsible for the intermittent fish kills that have occurred since fish populations began to re-establish in the 1950s. It is also considered likely that decreases in fish populations in the Clark Fork River may also be due in part to other factors, such as sedimentation caused by excessive erosion as a result of mining wastes. Considering all the available information, EPA has concluded that the risks to the aquatic system are unacceptable.

EPA must also give special consideration to bull trout in the Clark Fork River. Bull trout are listed as a threatened species under the ESA, and EPA has a responsibility under the National Contingency Plan (NCP) to ensure that such species are sufficiently protected through remedy selection and implementation.

Finally, the *Ecological Risk Assessment* described potential risk to wildlife along the Clark Fork River corridor. There is considerable uncertainty associated with this potential risk, and EPA is evaluating follow-up studies associated with this pathway and receptor group.

Supporting data, documenting the concentrations of metals in each medium and trout toxicity data, are provided in the remainder of this section.

The location of surface water sample sites is shown in Exhibit 2-12, *USGS Surface Water Gaging Stations Along the Mainstem of the Clark Fork River OU.* As shown in Exhibit 2-13 *Surface Water Summary Statistics (1991 to 1996),* the maximum and median concentrations of contaminants is higher in the Clark Fork River than in the reference streams (Rock Creek, Gold Creek, Little Blackfoot River and Blackfoot River [EPA 1999]). Also, the concentrations of metals in river water are higher in Reach A and decrease in downstream reaches. Contaminants are constantly supplied to the river as streambank tailings and contaminated sediments are eroded into the river.

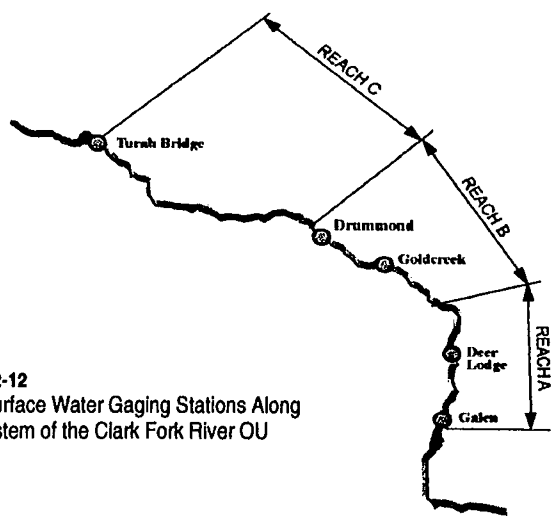


EXHIBIT 2-12
USGS Surface Water Gaging Stations Along the Mainstem of the Clark Fork River OU

EXHIBIT 2-13
Surface Water Summary Statistics (1991 to 1996)

		Concentration (µg/L)											
		Galen N=53		Deer Lodge N=52		Goldcreek N=42		Drummond N=42		Turah Bridge N=46		Reference Stream N=73	
Chemical	**Statistic**	**Tot**	**Diss**	**Tot**	**Diss**	**Tot**	**Diss**	**Tot**	**Diss**	**Tot**	**Diss**	**Tot**	**Diss**
Arsenic	Max	78.0	53.0	220.0	36.0	75.0	20.0	62.0	20.0	33.0	13.0	14.0	7.0
	Median	16.0	13.0	19.0	13.0	16.0	10.0	16.5	11.0	8.0	5.0	1.0	1.0
Cadmium	Max	1.0	0.5	5.0	0.5	2.0	0.3	2.0	0.2	1.0	0.5	0.5	0.5
	Median	0.5	0.05	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1
Copper	Max	150.0	32.0	960.0	85.0	440.0	36.0	360.0	21.0	180.0	19.0	16.0	7.0
	Median	25.0	10.0	51.0	10.0	43.0	7.0	40.0	6.0	17.0	4.0	2.0	0.5
Lead	Max	24.0	3.0	140.0	5.0	73.0	0.6	56.0	1.2	33.0	1.0	25.0	2.0
	Median	2.0	0.3	5.0	0.3	6.0	0.3	9.0	0.3	3.0	0.3	0.5	0.3
Zinc	Max	180.0	39.0	1,100.0	50.0	510.0	26.0	490.0	21.0	270.0	22.0	50.0	24.0
	Median	50.0	11.0	60.0	11.0	50.0	8.4	65.0	7.5	30.0	6.0	5.0	1.5

Diss = Dissolved
Tot = Total
Reference Stream Summary Stats for – Rock Creek, Gold Creek, Little Blackfoot River and Blackfoot River
Source: EPA 1999. Table 4-1; data collected by USGS

Water quality changes dramatically in response to storm events. As noted, EPA's *Ecological Risk Assessment* focussed on sporadic events where rain or runoff washes metal salts from tailings and into the river (EPA 1999). Surface water quality response to each thunderstorm high flow event is unique. For example, Exhibit 2-14, *Surface Water Quality in Response to a Rainstorm Event on 7/5/94 Clark Fork River Below Warm Springs Creek,* shows that total and dissolved copper increases dramatically during a storm runoff event. This increase is variable based on the location and the amount of metal salts available at that location for runoff.

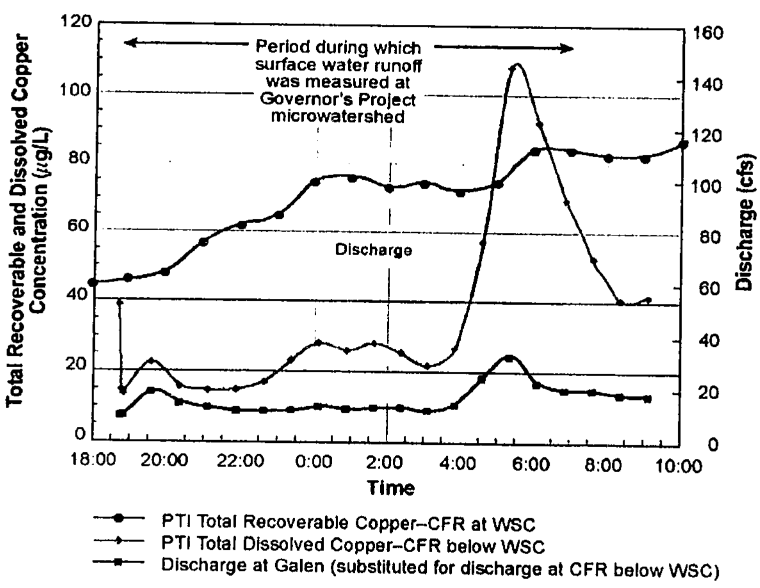
Exhibit 2-15, *Copper Concentrations (1993-1999), Total Recoverable and Dissolved,* page 2-47, presents summary statistics of the concentration of copper in surface water at various sites. This exhibit compares water samples at six locations on the Clark Fork River (Galen, Deer Lodge, Goldcreek, Drummond, and Turah Bridge) to Silver Bow Creek above the Warm Springs Ponds. The total recoverable (TR) concentrations are intended to be compared to the State's water quality standard for copper. The dissolved copper concentrations (DISS) are intended to be compared to Federal Ambient Water Quality Criteria (FAWQC). White numbers on Exhibit 2-15 exceed the given standards. Silver Bow Creek above the Warm Springs Ponds supports no fish population, and the macroinvertebrate community structure is severely impaired by metals, particularly dissolved copper.

Taken together, the data from these studies are consistent with the hypothesis that copper concentrations (and possibly arsenic and other metals) in the aquatic environment (surface water, diet) impose low-level chronic stress on aquatic macroinvertebrates, trout, and other fish. It is unknown to what degree this chronic stress or the avoidance response contribute to the decrease in standing fish population, and it is considered likely by EPA that acute exposures to pulses or other high-concentration events are more important than chronic stresses, since even intermittent fish kills from pulse events can lead to significant reductions in fish population. The State believes that chronic stress factors are more important. EPA also recognizes that aquatic life problems in the Clark Fork River OU may be due in part to other factors, such as stream embeddedness, nutrient loading, stream dewatering, channelization, increased water temperature and reduced oxygen. However, these conditions are also typical of other streams in Montana, whereas the presence of high levels of heavy metals and arsenic in the river and floodplain are not.

As noted earlier, USGS has concluded that reduced woody vegetation has produced a high risk of floodplain unraveling. The unraveling of the floodplain in a high flow event would virtually destroy the aquatic environment of the upper Clark Fork River and make any recovery extremely costly. EPA also recognizes the uncertainty associated with this view. What is clear is that the lack of vegetation already causes excessive erosion of land and generates increased sedimentation. These conditions are harmful to terrestrial health, land use, and aquatic receptors at the Clark Fork River OU.

EXHIBIT 2-14

Surface Water Quality in Response to a Rainstorm Event on 7/5/94 Clark Fork River Below Warm Springs Creek



Source: ARCO 1998.

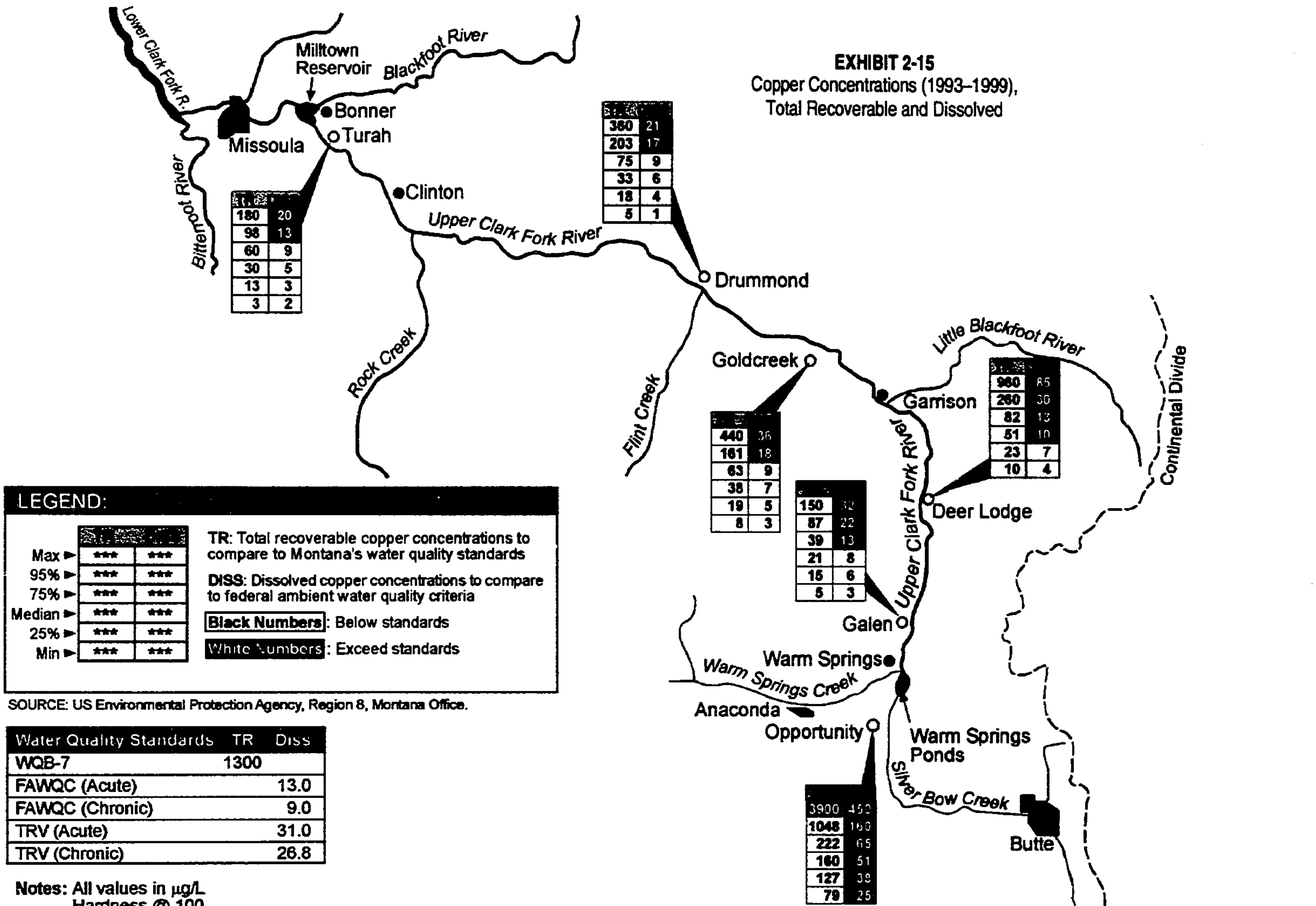
Notes: Discharge from USGS hourly flow data at Perkins Lane Bridge (CFR near Galen). This station is approximatly 2 miles downstream from Clark Fork River (CFR) below Warm springs Creek (WSC). Surface Water Runoff Period at Governor's Project is in response to the thunderstorm event.

cfs = cubic feet per second
ug/L = micrograms per liter

7.3 Basis for Response Action

Based on the entire administrative record, including the *Ecological Risk Asessment* and the *Human Health Risk Assessment* and *Addendum*, and geomorphology reports and other USGS work, EPA's conclusion is that widespread unacceptable terrestrial and aquatic risk exists in Reach A and portions of Reach B of the Clark Fork River OU. EPA, in consultation with DEQ, has determined the response action selected in this *Record of Decision* is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

EXHIBIT 2-15
Copper Concentrations (1993–1999),
Total Recoverable and Dissolved



SOURCE: US Environmental Protection Agency, Region 8, Montana Office.

Water Quality Standards	TR	Diss
WQB-7	1300	
FAWQC (Acute)		13.0
FAWQC (Chronic)		9.0
TRV (Acute)		31.0
TRV (Chronic)		26.8

Notes: All values in µg/L
Hardness @ 100
FAWQC = Federal Ambient Water Quality Criteria
TRV = Trout Toxicity Reference Value

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8 Remedial Action Objectives

For floodplain tailings and impacted soils, the Remedial Action Objectives (RAOs) are as follows:

1. For human health—prevent or inhibit exposure to arsenic-contaminated soils/tailings where ingestion or contact would pose an unacceptable health risk.
2. For the environment—prevent or reduce unacceptable risk to ecological (including agricultural, aquatic, and terrestrial) systems degraded by contaminated soils/tailings.

For groundwater, the RAOs are as follows:

1. Return contaminated shallow groundwater to its beneficial use within a reasonable timeframe.
2. Comply with State groundwater standards, including nondegradation standards.
3. Prevent groundwater discharge containing arsenic and metals that would degrade surface waters.

For surface waters, the RAOs are as follows:

1. Reduce or eliminate "pulses" of metals to the river, including those caused by snowmelt and thunderstorm events.
2. Achieve compliance with surface water standards, unless a waiver is justified.
3. Prevent ingestion of, or direct contact with, water posing an unacceptable human health risk.
4. Achieve trout Toxicity Reference Values (TRVs) and acute and chronic Federal Ambient Water Quality Criteria (AWQC).
5. Comply with stormwater ARARs.

Remedial Goals (RGs) corresponding to these objectives are presented in Exhibit 2-16. The final *Human Health Risk Assessment* (1998a) and its addendum (EPA and ATSDR 2001) provide numeric goals for the protection of human health and are the basis for the soil level RGs. The RGs for surface water and groundwater based on State and Federal ARARs are shown in Exhibit 2-16.

These RGs are important performance standards for Reach A and Reach B remediation action, to be achieved site-wide after remediation is complete. These are based on State WQB-7 Standards for Surface Water, except for copper, which is waived (see Section 14.2, page 2-148). The copper standard is based on Federal water quality criteria issued by EPA under the Clean Water Act. Groundwater standards are based on State WQB-7 Standards for groundwater except for arsenic, which is based on the more stringent Federal Standard promulgated under the Safe Drinking Water Act.

EXHIBIT 2-16
Surface Water and Groundwater RGs

	Surface Water (µg/L)[a]			
Metals	**Acute**	**Chronic**	**Human Health**	**Groundwater (Dissolved, µg/L)**
Arsenic[b]	340	150	10/18	10
Cadmium	2	0.25	5	5
Copper[c]	13	9	1,300	1,300
Iron	-	-	-	300
Lead	81	3.2	15	15
Zinc	119	119	2,100	2,100

Notes:
[a] Based on 100 mg/L hardness, total recoverable, acute, and chronic

[b] Arsenic standard for ground and surface water is for dissolved concentrations based on the application of the Federal standard promulgated under the Safe Drinking Water Act. For surface water, the State WQB-7 standard, 18µg/l, measured as total recoverable, is applicable. Final determination of whether these standards will be consistently attained will depend on upstream source control as well as implementation of this remedy.

[c] Copper standard is for dissolved concentrations that match the Federal Aquatic Water Quality Criteria (Gold Book 1986).

The RBCs for residential, recreational, and agricultural exposure are listed below. These RBCs are for arsenic concentrations in soils, as averaged over exposure units. EPA considers acceptable exposure levels to be concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} (1 in 10,000 probability) to 10^{-6} (1 in 1,000,000 probability), with 10^{-6} as the point of departure. EPA is proposing the following arsenic concentrations, which represent a 10^{-4} excess cancer risk:

- Residential—150 parts per million (ppm)
- Recreational (non-cancer)—680 ppm (children at Arrowstone Park and other recreational scenarios), 1,600 ppm for fishermen, swimmers, and tubers along the river
- Rancher/Farmer—620 ppm

The RAOs and associated RGs and performance standards are straightforward expressions of what the remedy should accomplish at the Clark Fork River OU. They are based on the State of Montana's classification and use designations for the Clark Fork River and the groundwater aquifer along the river described earlier, and on the risk information described in Section 7, page 2-39. Protecting human health from arsenic contamination (see RAOs, previous page) at the Clark Fork River OU will address the contaminant identified by the *Human Health Risk Assessment* as the driving human concern at this site. Finding ways through the remedy to effectively and permanently address plant growth, aquatic impacts, erosion and streambank stability, and agricultural land use (see RAOs, previous page) will address the unacceptable environmental risk findings described in the previous sections of this *Record of Decision*.

9 Description of Alternatives

9.1 Remedy Components for Each Alternative

In the *Feasibility Study*, eight primary alternatives were evaluated in detail. Many of these alternatives incorporate sub-alternatives that change some aspect of their remedial performance. The sub-alternatives specify varying streambank lengths, different streambank treatments, and removal or in-situ treatment of varying estimated acreage of impacted soils. In total, 23 different approaches are evaluated, including no further action. The eight primary alternatives and sub-alternatives are described in Exhibit 2-17, *Remedy Components of Evaluated Alternatives*. The range of costs for each of the alternatives is also shown in Exhibit 2-17. The cost breakdown for each alternative, which was prepared in 2002 for the *Feasibility Study*, is provided in Exhibit 2-18, page 2-56. These costs have been updated for the selected remedy and are presented in Section 13.13, page 2-138.

The *Feasibility Study* screened out active treatment of groundwater, streambed sediment, and surface water alternatives prior to the development and detailed analysis of alternatives because EPA's preference is to address the source of contamination and because of implementability concerns. Therefore, the detailed alternatives only address solid media on the floodplain or in irrigated areas for remedial action.

The process of developing media-specific and combined-media alternatives for the Clark Fork River OU included a series of open meetings. Input was solicited from agency representatives, local governments, and members of public interest groups. Technology options for tailings and impacted soils, and eroding streambanks, were developed and assembled into eight primary alternatives. EPA approved the eight primary alternatives as the final list of alternatives to be carried into the detailed analysis of the *Feasibility Study*. Several details associated with the eight conceptual alternatives, such as estimated acreage and depth of tailings, were discussed and refined at a series of open working meetings spanning 6 months immediately prior to the release of the draft *Feasibility Study*. Generally, all alternatives except no action include the use of Best Management Practices (BMPs) or land use management activities designed to protect the remedy of the floodplain and the streambanks.

EXHIBIT 2-17
Remedy Components of Evaluated Alternatives

Description of Alternatives	Sub-alternatives
Alternative 1: No Further Action (Cost $8,782,000)—Involves no further remedial action, beyond those currently in place or undertaken. Provides the baseline conditions against which the other remedial action alternatives are compared. Evaluation required by Superfund regulations.	Not applicable
Alternative 2: In-Place Reclamation of Exposed Tailings (167 acres) (Cost $13,393,000)—In-situ reclamation of exposed tailings areas. Areas of buried tailings and impacted soils with or without impacted vegetation would not be reclaimed. These areas may be assigned "no further action," or may receive best management practices (BMPs) or land use management activities designed to enhance or allow natural recovery. Streambanks with tailings or impacted soils would be addressed with BMPs or land use management approach.	Not applicable
Alternative 3: In-Place Reclamation of Exposed Tailings and Other Impacted Soils and Vegetation Areas (Range of costs $16,369,000 - $29,310,000)—In-situ reclamation of exposed tailings and in-situ reclamation of buried tailings areas with impacted vegetation. Areas of buried tailings without impacted vegetation would not be actively remediated. These areas may be slated for no further action, or they may be addressed with BMPs or a land use management approach. Two different reclamation acreages were developed for this alternative and for Alternatives 4, 5 and 6.) The alternative was divided into 3A and 3B sub-alternatives for the two acreages. These areas differ because two different methods have been used to estimate areas of impacted vegetation.	• Alternative 3A: In-situ Reclamation of Exposed Tailings and Other Impacted Soils and Vegetation Areas (285 acres). – 167 exposed – 118 buried • Alternative 3B: In-situ Reclamation of Exposed Tailings and Other Impacted Soils and Vegetation Areas (867 acres). – 167 exposed – 700 buried
Alternative 4: In-Place Reclamation of Exposed Tailings and Other Impacted Soils and Vegetation Areas with Streambank Stabilization (Range of costs $18,897,000 - $64,504,000)—Treatment of exposed tailings and buried tailings areas with impacted vegetation (the same as Alternative 3.) Alternative 4 goes a step further by addressing certain streambanks with a combination of BMPs, land use management, or in-situ stabilization. Similar to Alternative 3, two different sub-alternative methods (4A and 4B) have been used to estimate areas of impacted vegetation. The sub-alternatives are further differentiated by four different streambank lengths identified for stabilization. Additionally, sub-alternatives 4A4 and 4B4 include a 50-foot buffer zone on each side of the active channel. Site conditions (including the presence of healthy woody vegetation) and the size and configuration of the floodplain tabs will dictate the choice and use of the following remedial activities within the riparian corridor buffer zone:	• Alternative 4A: In-situ Reclamation of Exposed Tailings and Other Impacted Soils and Vegetation (285 acres) with Streambank Stabilization. Includes 167 acres of exposed tailings and 118 acres of buried tailings with impacted vegetation. Further divided by amount of streambank treated: – Alternative 4A1: 22,367 feet of streambank. – Alternative 4A2: 72,777 feet – Alternative 4A3: 160,450 feet – Alternative 4A4: 264,000 feet plus 50-foot riparian corridor

EXHIBIT 2-17
Remedy Components of Evaluated Alternatives

Description of Alternatives	Sub-alternatives
• Maintaining the status quo for a particular section (where there is existing vegetation, particularly willows, sections of streambank will not be disturbed other than to incorporate more dense vegetation) • In-situ treatment or select removal of near-channel tailings that would not otherwise support vegetation Woody vegetation capable of developing deep binding root mass and reducing shear stress against denuded banks will be established within the corridor buffer zone.	• **Alternative 4B**: In-situ Reclamation of Exposed Tailings and Other Impacted Soils and Vegetation (867 acres) with Streambank Stabilization. Includes 167 acres of exposed tailings and 700 acres of buried tailings with impacted vegetation. Further divided by amount of streambank treated: – Alternative 4B1: 22,367 feet of streambank. – Alternative 4B2: 72,777 feet – Alternative 4B3: 160,450 feet • Alternative 4B4: 264,000 feet plus 50 foot riparian zone
Alternative 5: Removal of Exposed Tailings and In-Place Reclamation of Other Impacted Soils and Vegetation, Opportunity Ponds Disposal Option (Range of costs $36,310,000 - $84,327,000)—Removal of exposed tailings only. Tailings areas with impacted vegetation would be reclaimed in place, and areas of buried tailings without impacted vegetation would not be reclaimed, but would be addressed with BMPs or a land use management approach. Where removal of exposed tailings intercepts streambanks, those streambanks would be reconstructed. Streambanks without tailings or impacted soils would be slated for no action or for BMPs and land use management. Alternative 5 requires removal and replacement of the approximately 167 acres of exposed tailings in Reach A. Removal options, presented as sub-alternatives 5A, 5B, 5C, and 5D, include removal of tailings plus 4 inches of underlying soil or removal of tailings plus 12 inches of underlying soil. Removed tailings and contaminated soils will be transported either to the Opportunity Ponds or to a series of local repositories located outside of the 500-year floodplain. **EPA's Selected Remedy most closely resembles 5D, and adds elements from 4B4 and 6C.**	• Alternative 5A: – 167 acres of exposed tailings removed, plus 4 inches of soil – 118 acres of impacted soils and vegetation treated in place – Reconstruct 18,370 feet of streambank – Tailings transported to Opportunity Ponds • Alternative 5B: – 167 acres of exposed tailings removed, including 4 inches of soil – 700 acres of impacted soils and vegetation treated in place – Reconstruct 18,370 feet of streambank • Alternative 5C: – 167 acres of exposed tailings removed, including 12 inches of soil – 700 acres of impacted soils and vegetation treated in place – Reconstruct 18,370 feet of streambank – Tailings transported and deposited in local repositories built outside of 500-year floodplain

EXHIBIT 2-17
Remedy Components of Evaluated Alternatives

Description of Alternatives	Sub-alternatives
	• **Alternative 5D:** – 167 acres of exposed tailings removed, including 4 inches of soil – 660 acres of impacted soils and vegetation areas treated in place. – Stabilize 264,000 feet of streambank – Incorporates 50-foot buffer zone, similar to Alternative 4 (158 acres removal, 264,000 feet remediated streambank) – Disposal at Opportunity Ponds
Alternative 6: Removal of Exposed Tailings and Other Impacted Soils and Vegetation, Opportunity Ponds Disposal Option (Range of costs $48,225,000 - $110,478,000)—Alternative 6 calls for removal of exposed tailings and removal of areas of buried tailings with impacted vegetation. No in-situ reclamation is proposed under Alternative 6. Areas of buried tailings without impacted vegetation would not be actively reclaimed, but would be addressed with BMPs or a land use management approach. Where removals intercept streambanks, the banks would be reconstructed. The amount of streambank reconstruction would be greater for Alternative 6 than for Alternative 5 because the additional removals would affect more streambank locations. Alternative 6 requires removal and replacement of the 167 acres of exposed tailings in Reach A plus all areas of buried tailings with impacted vegetation. Removal acreages in Alternatives 6A and 6B differ because two different methods have been used to estimate areas of impacted vegetation.	• Alternative 6A: – 285 acres of exposed tailings and other impacted soils and vegetation removed, including 4 inches of soil below each deposit – 43,845 feet of streambank stabilized • Alternative 6B: – 867 acres of exposed tailings and other impacted soils and vegetation removed, including 4 inches of soil below each deposit – 95,000 feet of streambank stabilized • **Alternative 6C:** – 827 acres of exposed tailings and other impacted soils and vegetation removed, including 4 inches of soil below each deposit – 264,000 feet of streambank stabilized – Incorporates 50-foot buffer zone, similar to Alternative 4B4 (158 acres removal, 264,000 feet remediated streambank)

EXHIBIT 2-17
Remedy Components of Evaluated Alternatives

Description of Alternatives	Sub-alternatives
Alternative 7: Total Removal Unless Overlain by Woody Vegetation, Opportunity Ponds Disposal Option (Range of costs $161,614,000 - $179,381,000)—Alternative 7 is the near-total removal alternative that excludes removal in areas with existing woody vegetation. This alternative is intended to allow for as much removal as possible while leaving existing woody vegetation in place. Under Alternative 7, areas of exposed tailings without woody vegetation would be removed, areas of buried tailings with impacted vegetation but without woody vegetation would be removed, and areas of buried tailings without impacted vegetation or woody vegetation would be removed. Removals would occur in areas without woody vegetation within existing demonstration projects and other areas within the floodplain where tailings or metals-impacted soils were previously reclaimed using in-situ reclamation techniques. Any buried tailings and metals-impacted soil areas that have woody vegetation would be addressed with BMPs, similar to Alternatives 2 through 6, and land use management. Where removals intercept streambanks, the banks would be reconstructed. Removal would be to a depth of 4 inches below the tailings, for an estimated total volume of 3.8 million cubic yards.	• Alternative 7A: Total Removal Unless Overlain by Woody Vegetation with Removal to the Opportunity Ponds Disposal Area: – 2,483 acres removed – 131,583 feet of streambank reconstructed • Alternative 7B: Total Removal Unless Overlain by Woody Vegetation to the Opportunity Ponds Disposal Area with Streambank Stabilization and a Riparian Corridor Buffer: – 2,365 acres removed – 264,000 feet of remediated streambank – Incorporates 50-foot buffer zone, similar to Alternative 4B4 (158 acres removal, 264,000 feet remediated streambank)
Alternative 8: Total Removal, Opportunity Ponds Disposal Option (Range of costs $355,370,000 - $368,438,000)—Alternative 8 is the total removal alternative. Areas of exposed tailings would be removed, and all areas of buried tailings, with or without impacted vegetation and with or without woody vegetation, would be removed. Where removals intercept streambanks, the banks would be reconstructed as described below. Streambanks without tailings or impacted soils would be slated for no action or for BMPs and land use management, similar to Alternatives 2 through 7. Removal would be to a depth of 12 inches below the tailings, for an estimated total volume of 9.1 million cubic yards.	• Alternative 8A: Total Removal with Transport to the Opportunity Ponds for Disposal: – 3,570 acres removed – 345,000 feet of streambank reconstructed • Alternative 8B: Total Removal with Transport to the Opportunity Ponds for Disposal plus Streambank Stabilization and Riparian Corridor Buffer: – 3,412 acres removed – 264,000 feet of streambank stabilized – Incorporates 50-foot buffer zone, similar to Alternative 4B4 (158 acres removal, 264,000 feet remediated streambank)

EXHIBIT 2-18
Reach A Alternative Cost Estimate Summary

Alternative	Sub-Excavation Depth (inches)	Capital Cost (000s)	Annual Monitoring and Maintenance Cost (000s)	Miscellaneous Costs (000s)	Net Present Value (000s)
1. No Further Action	NA	—	$708	—	$8,782
2. In-situ Reclamation of Exposed Tailings (167 acres)	NA	$2,962	$742	$1,239	$13,393
3A. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres)	NA	$4,853	$764	$2,038	$16,369
3B. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres)	NA	$13,111	$862	$5,507	$29,310
4A1. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (20,592 feet), Criteria 1	NA	$6,383	$792	$2,681	$18,897
4A2. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (67,584 feet), Criteria 2	NA	$9,672	$855	$4,062	$23,348
4A3. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (149,429 feet), Criteria 3	NA	$13,792	$949	$5,793	$31,359
4A4. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization and Riparian Corridor Buffer (298,848 feet), Criteria 4	NA	$24,879	$1,359	$10,449	$52,092
4B1. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (20,592 feet), Criteria 1	NA	$14,631	$890	$6,145	$31,822
4B2. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (67,584 feet), Criteria 2	NA	$17,919	$953	$7,526	$37,273

EXHIBIT 2-18
Reach A Alternative Cost Estimate Summary

Alternative	Sub-Excavation Depth (inches)	Capital Cost (000s)	Annual Monitoring and Maintenance Cost (000s)	Miscellaneous Costs (000s)	Net Present Value (000s)
4B3. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (149,429 feet), Criteria 3	NA	$22,039	$1,047	$9,257	$44,284
4B4. In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization and Riparian Corridor Buffer (298,848 feet), Criteria 4	NA	$32,801	$1,445	$13,776	$64,504
5A. Removal of Exposed Tailings and In-situ Reclamation of Other Impacted Soils (118 acres In-situ, 167 acres Removal, 20,000 feet Streambank Removal), Opportunity Ponds Disposal Option	4	$17,637	$908	$7,408	$36,310
5B. Removal of Exposed Tailings and in-situ Reclamation of Other Impacted Soils (700 acres In-situ, 167 acres Removal, 20,000 feet Streambank Removal), Opportunity Ponds Disposal Option	4	$26,845	$1,015	$11,275	$50,717
5C. Removal of Exposed Tailings and In-situ Reclamation of Other Impacted Soils (700 acres In-situ,167 acres Removal, 20,000 feet Streambank Removal), DCCA Disposal Option	12	$29,413	$1,062	$12,353	$54,943
5D. Removal of Exposed Tailings and In-situ Reclamation of Other Impacted Soils (700 acres In-situ, 167 acres Removal), Opportunity Ponds Disposal Option with Streambank Stabilization and Riparian Corridor Buffer (298,848 feet)	4	$45,572	$1,581	$19,140	$84,327
6A. Removal of Exposed Tailings and Other Impacted Soils (285 acres Removal, 70,000 feet Streambank), Opportunity Ponds Disposal Option	4	$25,232	$999	$10,597	$48,225
6B. Removal of Exposed Tailings and Other Impacted Soils (867 acres Removal, 95,000 feet Streambank), Opportunity Ponds Disposal Option	4	$45,903	$1,251	$19,279	$80,712
6C. Removal of Exposed Tailings and Other Impacted Soils, Opportunity Ponds Disposal option with Streambank Stabilization and Riparian Corridor Buffer (298,848 Streambank feet)	4	$62,322	$1,771	$26,175	$110,478

EXHIBIT 2-18
Reach A Alternative Cost Estimate Summary

Alternative	Sub-Excavation Depth (inches)	Capital Cost (000s)	Annual Monitoring and Maintenance Cost (000s)	Miscellaneous Costs (000s)	Net Present Value (000s)
7A. Total Removal Unless Overlain by Woody Vegetation (2,600 acres Removal, 150,000 feet Streambank Reconstruction), Opportunity Ponds Disposal Option	4	$97,782	$1,834	$41,068	$161,614
7B. Total Removal Unless Overlain by Woody Vegetation (2,600 acres Removal), Opportunity Ponds Disposal Option with Streambank Stabilization and Riparian Corridor Buffer (298,848 feet Streambank)	4	$106,811	$2,233	$44,861	$179,381
8A. Total Removal (3,500 acres Removed and 350,000 feet Streambank Reconstruction), Opportunity Ponds Disposal Option	12	$222,011	$3,233	$93,245	$355,370
8B. Total Removal, Opportunity Ponds Disposal Option, with Streambank Stabilization and Riparian Corridor Buffer (298,848 feet Streambank)	12	$227,713	$3,633	$95,640	$368,438

Note: This exhibit was prepared in March 2002 for the *Feasibility Study*. These costs may be somewhat out of date, but reflect the source of the bulk of the costs for each alternative, such as operations and maintenance and capital costs. The current cost range for the selected remedy is presented in Section 13.13, page 138. Cost had to be revised because the selected remedy is a combination of various alternatives.

9.2 Expected Outcomes of Each Alternative

None of the alternatives, if implemented individually, would completely achieve all the EPA-identified RAOs, particularly meeting WQB-7 surface water quality for copper, because of continued loading from tributary, upstream, and residual contamination sources left onsite. Upon completion of construction, Alternatives 2 through 8 would reduce or eliminate the potential for dissolved metals pulse events by reclaiming or removing exposed tailings areas. However, Alternative 2 would not address terrestrial risks in impacted areas or chronic aquatic and erosional risks along streambanks, and therefore would not be protective or ARAR compliant. Alternatives 3 through 8 would fully address these risks to varying degrees in ways more fully described below. Groundwater RAOs would be achieved more quickly under Alternatives 7 and 8, as compared to other alternatives. Alternatives 4 through 6 may achieve these groundwater RAOs over a longer period of time, and Alternatives 2 and 3 would take the longest period of time for compliance and may not achieve compliance at all. Alternatives 2 through 8 could all be utilized to add on to human health protection components.

9.2.1 Alternative 1—No Further Action

Because no further action would be taken under this alternative, the expected outcome would be that slickens (which are presently almost 100 years old) and the high streambank erosion rates that landowners experience today would likely continue for the foreseeable future. Impacted areas may improve over time, but many risks and impacts would remain for many years. Certain human health risks and ecological impacts would be likely. ARARs and replacement standards would not be achieved, terrestrial risks at exposed tailing areas would not be addressed, and erosion and stream instability would continue.

9.2.2 Alternative 2—In-Place Reclamation of Exposed Tailings

Because this alternative provides only in-situ reclamation of exposed tailings areas, the expected outcome would be to possibly address the lack of vegetation on slickens and to stop pulse event contributions to the river. However, there would be substantial uncertainty as to the success of vegetation in these areas and long term potential intrusive operation and maintenance relating to the treated areas. The objective for in-situ reclamation of exposed tailings could be met within a few years, but the remaining buried tailings, impacted soils, and contaminated streambanks would continue to cause vegetation and aquatic impacts and land use would be inhibited. Continued ecological impacts would be likely. ARARs and replacement standards would not be achieved, and erosion and stream instability would continue.

9.2.3 Alternative 3—In-Place Reclamation of Exposed Tailings and Other Impacted Soils and Vegetation Areas

Alternative 3 calls for in-situ reclamation of exposed tailings and in-situ reclamation of buried tailings areas with impacted vegetation, but has no streambank stabilization component. Areas of buried tailings without impacted vegetation would not be actively remediated. These areas may be slated for no further action, or they may be addressed with a BMPs/land use management approach. The slickens areas would be subject to the same uncertainty and intrusive operation and maintenance as described above for Alternative 2.

This alternative would take a long period of time for ARARs compliance and may not achieve compliance at all. It would not address erosion and stream stability. Continued ecological impacts would be likely.

9.2.4 Alternative 4—In-Place Reclamation of Exposed Tailings and Other Impacted Soils and Vegetation Areas with Streambank Stabilization

Alternative 4, like Alternative 3, calls for in-situ reclamation of exposed tailings and in-situ reclamation of buried tailings areas with impacted vegetation. Under Alternative 4, areas of buried tailings without impacted vegetation would not be actively remediated, but would be addressed with BMPs and a land use management approach. Adding the streambank stabilization component would address the risk and erosional problems at the Clark Fork River OU and inhibit the migration of waste left in place into the river. The treated slickens areas would be subject to the same uncertainty and intrusive operation and maintenance activities as described above in Alternative 2. ARARs and replacement standard compliance would be achieved more quickly than Alternative 3, although there would be some uncertainty regarding groundwater ARAR compliance. There would be less construction impact to the valley as compared to the alternatives below.

9.2.5 Alternative 5—Removal of Exposed Tailings and In-Place Reclamation of Other Impacted Soils and Vegetation with Streambank Stabilization

Alternative 5 calls for the removal of exposed tailings in Reach A. Other impacted soils and vegetation areas would be reclaimed in place. Alternatives 5A, 5B, and 5C would only remove exposed tailings. Areas of buried tailings would be addressed in the same manner as described for Alternative 4. Under Alternatives 5A, 5B, and 5C, when removal of exposed tailings intercepts streambanks, those streambanks would be reconstructed. Areas not addressed by the removal or the in-situ reclamation, including streambanks, may be addressed by BMPs and a land use management approach. This approach takes aggressive action to address the slickens, a principal threat waste, and avoids the potential uncertainties and intrusive operation and maintenance activities for these areas. The in-situ treatment of the impacted areas addresses the remaining waste impacted areas in a manner that is likely to be successful, but will require monitoring and operation and maintenance and careful land use. The streambank component addresses the risk and erosional problems at the Clark Fork River OU, and inhibits the migration of waste left in place into the river. The approach also limits the amount of replacement soils needed, consequently preserving more of the intact floodplain. Construction impacts would be somewhat more intrusive than those for the previous alternatives, but they would be manageable and similar to impacts for similar cleanup projects in the Clark Fork Basin. Many of the normal land uses could be continued following construction, with some ICs and land management planning. ARARs and replacement standard compliance would be achieved in a reasonable time, with some lesser uncertainty remaining regarding groundwater ARAR compliance.

9.2.6 Alternative 6—Removal of Exposed Tailings and Other Impacted Soils and Vegetation with Streambank Stabilization

Alternative 6 calls for removal of exposed tailings and removal of areas of buried tailings with impacted vegetation. Because no in-situ reclamation is proposed, the remaining impacted soils would be subject to the natural healing that would take place during the next century. The streambank stabilization component would be the same as described in Alternatives 4 and 5. All uncertainties associated with the use of in-situ treatment would be eliminated under this alternative. Construction impacts would be significantly higher, and costs would be substantially elevated. EPA is not confident that construction impacts from the additional removal activities could be managed successfully. There would be less land use planning required under this alternative. The streambank component would address the risk and erosional problems at the Clark Fork River OU. ARAR and replacement standard compliance would be likely, with less groundwater ARAR compliance uncertainty.

9.2.7 Alternative 7—Total Removal Unless Overlain by Woody Vegetation

Because Alternative 7 is intended to allow for as much removal as possible, while leaving existing woody vegetation in place, risks would be addressed without uncertainty. It could take a dozen or more years before construction is complete and exposed tailings have been removed. Construction impacts would be substantial during this time frame and very difficult to manage. Replacement soils could be difficult to find in sufficient quantities. Costs would be substantially elevated. The streambank component would address the risk and erosional issues at the Clark Fork River OU. Because any buried tailings and metals-impacted soil areas underlying woody vegetation would remain, minor long-term ecological impacts may continue. As noted, ARAR and replacement standard compliance would be achieved in a shorter amount of time and with even greater certainty. The removal process would create significant short-term impacts.

9.2.8 Alternative 8—Total Removal

Because Alternative 8 is the total removal alternative, it could take 24 years or more before construction is complete and all exposed and buried tailings areas have been removed. It would have the same positive risk reduction and ARAR compliance effects as described in Alternative 7. The removal process would create significant short-term and potentially long-term impacts because the entire floodplain of the Clark Fork River would essentially be totally reconstructed. Many of these risks may not be manageable. Costs would increase substantially over prior alternatives.

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10 Comparative Analysis of Alternatives

10.1 EPA's Nine Evaluation Criteria

The NCP at 40 CFR § 300.430(e)(9)(iii) and (f)(1)(i) requires EPA to utilize and evaluate the nine criteria listed at Section (e)(9)(iii) to select a remedial action for a site. Section 300.430(f)(5) requires EPA to document how the evaluation of the nine criteria were used to select a remedy. The major objective of this activity is to evaluate the relative performance of each alternative with respect to each criteria, and consider the tradeoffs of each, selecting one, or the combination of several, as a comprehensive remedy. This helps ensure that advantages and disadvantages of each alternative are clearly understood. The nine evaluation criteria are as follows:

- **Threshold Criteria**—*Must be Addressed*
  1. Overall Protection of Human Health and the Environment
  2. Compliance with ARARs
- **Balancing Criteria**—*Must be Considered*
  3. Long-Term Effectiveness and Permanence
  4. Reduction of Toxicity, Mobility, and Volume
  5. Short-Term Effectiveness
  6. Implementability
  7. Capital and Operating and Maintenance Cost
- **Modifying Criteria**—*Must be Considered*
  8. State Acceptance
  9. Community Acceptance

A brief description of each criterion follows in the remainder of this section (10.1). Section 10.2, *Comparison of Alternatives for Each Evaluation Criteria,* contains a text description of how the alternatives compared within each evaluation criterion, including State and community acceptance. This represents EPA's final evaluation of the criteria following receipt of public comments. Next, Exhibit 2-19, *Comparative Analysis of Alternatives for the Clark Fork River Feasibility Study,* summarizes the evaluation of the first seven criteria that was presented in the *Feasibility Study* (Atlantic Richfield Company 2002). Because this ranking was completed long before the issuance of the *Proposed Plan* and the public comment period, the modifying criteria of State and community acceptance were not included in this analysis. Since the public comment period, these two factors were analyzed in the *Responsiveness Summary* (Part 3 of this *Record of Decision)* and in the consideration by EPA of the public comments and in further discussions with the State.

10.1.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through removal, treatment, engineering controls, or ICs. The extent to which each alternative met the following was evaluated:

- Returns the soils and terrestrial vegetation to an acceptable performance level.
- Protects human health exposures to arsenic for current and reasonably anticipated land uses.
- Eliminates or significantly reduces contaminated runoff pulses, which are acute risks to aquatic receptors.
- Reduces chronic risks to aquatic receptors; these risks are primarily associated with copper loading and sedimentation during typical and high flows.
- Contributes to floodplain stability by reducing streambank erosion.
- Contributes to retaining the inherent geomorphic features of a cobble-bed, single-thread, meandering river.
- Conducts cleanup in a timely manner (7 to 10 years versus 20 or more years); achievement of floodplain integrity in as short a time as possible, which is important.

10.1.2 Compliance with ARARs

Section 121(d) of CERCLA and NCP 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless ARARs are waived under CERCLA Section 121(d)(4). A complete list of ARARs and invoked waivers is included as Appendix A to this *Record of Decision*. That appendix contains appropriate definitions and descriptions of terms relevant to the ARAR identification and compliance analysis for this site. The ability of each alternative to meet the following key ARARs is highlighted in the analysis.

- **Contaminant Specific ARARs**—Includes Montana surface water standards and the ability of each alternative to achieve these water quality standards, and compliance with water quality standards under events such as thunderstorm pulse events, high flows, and ice scour events. The Montana groundwater standards are also important.
- **Location Specific ARARs**—Includes Montana's Solid Waste and Floodplain Management Standards and ARARs for protected resources. Care was given to looking at ARARs specific to the Grant-Kohrs Ranch National Historic Site.
- **Action Specific ARARs**—Mine reclamation standards that specify requirements for re-establishing remediated areas were examined, along with solid waste and floodplain requirements.
- **Waived ARARs**—A waiver of the State's surface water standards for copper is appropriate for this site. The replacement standard is the Federal ambient water quality criterion for copper. A waiver of certain State solid waste and floodplain management standards for areas designated for in-situ treatment is also appropriate.

10.1.3 Long-Term Effectiveness and Permanence

Long term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels are achieved. This criteria is an important one to the State, other Trustees, and the public, and is emphasized in the NCP and its preamble. Key issues examined under this criteria include the following:

- **Magnitude of Residual Risk**—Considered the future effects on surface water and aquatic systems, groundwater, vegetation, and terrestrial ecosystems, and contribution to enhancing the geomorphic integrity of the floodplain.
- **Adequacy and Reliability of Controls**—Considered the use and adequacy of institutional controls and BMPs.

10.1.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the technologies that may be included in a given remedy. As applied to this site, reduction in mobility and volume of contamination within the floodplain is an important balancing consideration. The effectiveness of the in-situ treatment technology and its resultant reduction in toxicity of site contaminants was also important.

10.1.5 Short-Term Effectiveness

Short term effectiveness addresses the period of time need to implement a remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved. Detailed issues specific to this site and important to landowners and others that were especially considered for each alternative are as follows:

- **Protection of Community and Workers During Remedial Actions**—Considered the volume of materials proposed to be dealt with and the time and safety elements. Alternatives that involved more in-situ treatment rather than total removal could generally be implemented in a shorter period of time with less truck activity and traffic on local roads, and were therefore considered more protective in the short term.
- **Environmental Impacts of Implementation**—Addressed impacts on wetlands and terrestrial ecosystems, turbidity and other impacts to water quality resulting from proposed activities, and short-term impacts on the stability of geomorphic features and the floodplain.
- **Time Until Remedial Action Objectives are Achieved**—Considered how long the remedial action would take, once implemented, to achieve RAOs.

10.1.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Generally, factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are considered. Key issues for this site highlighted in the analysis of this criterion are as follows:

- **Technical Feasibility**—The ability to construct and operate the technology, time required for implementation, reliability of the technology, ability to monitor effectiveness, and ease of undertaking additional actions should they be necessary at some future date.
- **Administrative Feasibility**—The ability to obtain approvals and coordinate with other agencies. This included working with landowners, counties, municipalities, and Federal regulatory and non-regulatory authorities.
- **Availability of Services and Facilities**—Considered the availability of necessary equipment, specialists, materials (including backfill materials), and the availability of offsite facilities for disposal of wastes, if necessary.
- **Backfill Availability and Landowner Access**—These factors are especially important considerations at this site, where concerns increase as removed waste volumes increase.

10.1.7 Capital and Operating and Maintenance Cost

This criteria involved the comparison of net present worth costs for each alternative as proposed. Cost effectiveness was then considered, as described in NCP section 300.430(f)(ii)(D).

10.1.8 State Acceptance

Evaluation of State acceptance is required and, because this is a modifying criteria, EPA has worked closely with the State of Montana to develop a remedy that is acceptable to the State. The State would not accept Alternatives 1 through 4, because of its concern for long term permanence and effectiveness and compliance with ARARs. The State's view is that in-situ treatment is not appropriate for the exposed tailing areas. The State has a general preference for removal of contamination from a floodplain. The State has concurred in this Selected Remedy in the State's concurrence letter, provided in Appendix F.

EPA also worked closely with the NPS regarding the Selected Remedy and its application to the Grant-Kohrs Ranch National Historic Site. DOI concurs in this remedy.

10.1.9 Community Acceptance

Similar to State acceptance, community acceptance is not necessarily required, but is critical to actual implementation of the Selected Remedy. There was a large amount of public comment on the *Proposed Plan* for this site. Most commenters generally supported EPA's plan. Most of the impacted areas (approximately 89 percent) within the Clark Fork River OU are located on private lands, and landowner acceptance is important for gaining access, implementing ICs, and ensuring a successful project. EPA carefully considered landowner and Powell County concerns relating to land use impacts and safety, and modified the Selected Remedy from the *Proposed Plan* to address some of these issues while still meeting other CERCLA remedy selection requirements. There were several hundred public commenters on the *Proposed Plan*, and EPA carefully considered this input as well. Some public commenters wanted EPA to carefully review streambank components to ensure the long term reliability of this component. Many public commenters and the DOI urged EPA to give special consideration to ARARs associated with the Grant-Kohrs Ranch National

Historic Site. These comments are reflected in the Selected Remedy, which was modified from the *Proposed Plan* to address these concerns.

10.2 Comparison of Alternatives for Each Evaluation Criteria

EPA worked to identify the best combination of Alternatives 4, 5, and 6 in order to match its technical evaluation of in-situ treatment with the overall aspects of removal. Additional detail about how the alternatives compared based on the nine evaluation criteria is provided in the remainder of this section. This analysis expands on and modifies the *Feasibility Study* analysis.

10.2.1 Overall Protection of Human Health and the Environment

As previously noted, each alternative except Alternative 1 can include the important human health protection components, so these pathways are not differently addressed under the active alternatives. Alternative 1, the No Action Alternative, does not address the unacceptable risks and pathways and therefore was not considered further. Alternatives 2 and 3 do not reliably address the environmental risk pathways for slickens and leave large amounts of contaminants subject to residual risk within the ecosystem. The lack of a streambank component leaves a major risk and pathway unaddressed under these alternatives, which is not acceptable.

Alternatives 4, 5, and 6 each can meet the threshold criteria of overall protectiveness. However, each of these alternatives have benefits and drawbacks as demonstrated in the *Feasibility Study*. The sub-alternative for streambank and riparian corridor protection developed by EPA and made a part of each of these alternatives was judged to be crucial for addressing overall protection of the environment. It addresses sediment copper loading, erosion risks, and related exposure pathways. Other streambank protection sub-alternatives do not fully address these pathways and are not reliable over time, leaving Alternatives 4B4, 5D, and 6C as the only acceptable versions of these alternatives. Alternatives 7 and 8 would also meet the protectiveness threshold criteria, although both would take a long time to implement, which could present the risk of floodplain instability if major flooding occurred during construction.

10.2.2 Compliance with ARARs

ARARs compliance presents difficult issues for the Clark Fork River OU. According to modeling projections for copper and sediment, none of the alternatives were expected to fully comply with all water quality standards in surface water, and a waiver of the copper standard is justified for this site. There is also some uncertainty as to whether any of the alternatives could meet groundwater standards within the shallow aquifer for arsenic within a reasonable time frame. Alternatives 2 and 3 present great uncertainty, Alternatives 4 through 5 present some uncertainty, and Alternatives 6 through 8 present less uncertainty for the ability to meet these groundwater ARARs. Waivers for important State solid waste and floodplain protection ARARs were considered possible for Alternatives 5 through 8, for in-situ treatment of impacted areas. The State did not agree that a waiver was appropriate for Alternative 4.

When compared to Alternative 4B4, Alternatives 5D and 6C are more likely to lead to groundwater improvement and possible compliance with groundwater ARARs. Although in-situ treatment may mobilize arsenic into groundwater, EPA believes that removal of slickens areas, increased vegetative cover, and decreased percolation rates will lead to groundwater compliance within a reasonable period of time. These alternatives are also projected to move closer to State water quality standards than Alternative 4B4, and would reduce the amount of fine-grained contaminated sediment in the river bed.

Overall, Alternatives 5D through 8 could comply with ARARs or justify a waiver. Alternatives 6C, 7, and 8 achieve ARAR compliance more fully than Alternative 5. These alternatives, however, have some other criteria shortcomings.

10.2.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence criteria considers the expected residual risk and the ability to maintain reliable protection of human health and the environment after implementation of the remedy. Alternatives 1 and 2 leave large volumes of impacted soils without some form of remediation, resulting in residual risk within the ecosystem, and are not considered reliable or permanent. Alternative 4B4 relies on in-situ treatment of a principal waste—slickens—and there was uncertainty as to the long term reliability of this technology when applied to slickens wastes that have low pH, low organic content, and relatively higher levels of contamination. Alternatives 7 and 8 propose an aggressive removal of large volumes of materials from the floodplain with less uncertainty about success, but increase risks relating to flooding during implementation. Alternative 5C effectively and permanently addresses exposed tailings and streambank contamination, and relies on in-situ treatment for impacted areas. EPA believes that in-situ treatment is reliable in these areas because of the existing organic material present there, and the more favorable pH and contaminant conditions. EPA recognizes some uncertainty with regard to the long term permanence in these areas, but believes that careful implementation of the in-situ treatment technology in these areas will result in long term effectiveness and permanence. Alternative 6C, removal of exposed tailings and impacted soils and vegetation, eliminates all in-situ treatment uncertainty and better addresses long-term effectiveness and permanence than Alternative 5, and Alternative 5 addresses this criterion better than Alternative 4.

10.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 7 and 8 address reduction in mobility and volume to a greater degree than other alternatives because they remove more contamination from the floodplain, where it is likely to become mobile over time.

Alternative 4B4 reduces toxicity through in-situ treatment of large areas. It does not reduce mobility or volume. Alternatives 5D and 6C provide some reduction in mobility and volume by removal of contaminants from the floodplain. Alternative 5D addresses the principal waste—slickens and phytotoxic streambanks—in a more reliable manner by removing these wastes from the floodplain and thereby decreasing mobility and volume of metals. Excavation of slickens will remove approximately 750 tons of arsenic and 1,900 tons of copper from the floodplain. It also decreases toxicity by using in-situ treatment in impacted areas. Alternative 6C, removal of exposed tailings and impacted soils and vegetation, better addresses reduction of toxicity and mobility than Alternatives 4 and 5 because it reduces mobility for a large volume of contamination. Alternative 5 also relies on in-situ treatment, but in areas where organic content is present and some vegetation has established over time. EPA considers in-situ treatment in these areas to be reliable in the long term, as long as it is designed, carefully implemented, and monitored over time and therefore effective in reducing toxicity. Alternatives 2 and 3 do not reduce mobility or volume of metals at all. Both reduce toxicity to some extent, although Alternative 2 does so in a limited area.

10.2.5 Short-Term Effectiveness

Because of the large volumes of material that would be removed in Alternatives 7 and 8, these alternatives pose a potential for greater short-term risk based on potential for traffic and equipment related accidents, risks to the stability of the floodplain, and the duration of the remedial activity before full implementation occurs. Alternative 6 exhibits concerns in this area as well, but to a lesser degree. These alternatives would take a relatively longer period of time to implement, but would achieve performance standards more quickly. Alternatives 3 through 5 tend to rely more exclusively on in-situ treatment or a combination of in-situ and removal of specifically targeted areas including riparian areas and streambanks. These alternatives create less traffic and construction risks as a result. These alternatives would take a relatively moderate amount of time to implement (EPA estimates 10 years). They would achieve performance standards in a greater amount of time than Alternatives 6, 7, and 8. Variations of Alternatives 4 and 5 tend to rank high by limiting the volume of materials for removal, reducing the impacts of treatment on the floodplain, and promoting a relatively short healing process for recovery. Alternatives 2 and 3 rank highest for implementability, because of minimal truck traffic and a minimal period of implementation. These alternatives exhibit low short term effectiveness problems since the performance standards are not achieved in the short term if at all.

10.2.6 Implementability

Because of the large volumes of material that would be removed in Alternatives 7 and 8, these alternatives are difficult to implement in a timely fashion, would require considerable effort to coordinate approvals with multiple landowners and agencies, and may tax the local resources to implement removals, transport to repositories, and backfill excavations. Alternative 6C, removal of exposed tailings and impacted soils and vegetation, also has some of the same shortcomings regarding implementability because of the increased need for backfill and potential difficulties with landowner access. Alternatives 3, 4, and 5, which apply in-situ treatment and could be readily implemented on smaller areas in shorter periods of time, ranked higher under this criteria. Specifically, Alternatives 4B4 and 3B lead the ranking under this criteria because of the exclusive use of in-situ treatment. Alternative 5D will require backfill, but EPA believes that careful design, which may look for opportunities to create wetlands and minimize backfill needs, will make this a manageable problem. EPA also believes that modifications to the *Proposed Plan* regarding careful attention to landowner needs, in combination with CERCLA's access provisions, will meet implementability concerns regarding land owner access and cooperation.

10.2.7 Cost

Alternatives 1 and 2 are least costly, but do not achieve basic threshold criteria. Because of the large volumes of material that would be removed in Alternatives 7 and 8, they are much more costly than the other alternatives. Alternative 8 is the most costly; Alternative 7 would be approximately one-half the cost of Alternative 8. Depending on the amount of material treated or removed in the sub-alternatives, Alternatives 3 through 6 range from 25 to 75 percent of the total cost of Alternative 7. Using the criteria found in NCP section 400.300(f)(ii)(D), EPA believes that Alternatives 7 and 8 would not be cost effective, and that the overall effectiveness of Alternative 5 best meets the cost effectiveness criteria.

10.2.8 State Acceptance

The State's consistent interpretation that removal is more protective and more fully complies with Montana ARARs than in-situ treatment influenced the final decision. DEQ believes removal of contamination offers a more permanent and effective remedy where contamination can feasibly and reliably be removed. DEQ's concerns on the Clark Fork OU focus on surface and groundwater protection as well as ARAR compliance. DEQ considered public comment received on both the *Proposed Plan* and *Feasibility Study* prior to making its determination as to State concurrence. EPA has worked closely with the State in developing the Selected Remedy. The State's Concurrence Letter is provided in Appendix F.

10.2.9 Community Acceptance

In response to the *Proposed Plan,* EPA received numerous comments expressing a variety of opinions. EPA values public input and has incorporated public input where possible and consistent with statutory and regulatory mandates and EPA guidance. The *Record of Decision* has been modified in response to comments on the *Proposed Plan*. The changes are explained in Section 15, page 2-159. Many of these changes were addressed towards landowners' concerns.

Of the public comments received on the *Proposed* Plan, most of the people who specifically stated an opinion about the plan (fully support, conditionally support, or oppose), support the Selected Remedy. In fact, 88 percent of those who stated an opinion fully supported the Selected Remedy as described in the *Proposed Plan*. A segment of the community expressed concern about the long term effectiveness of in-situ treatment. Another segment of the community expressed concern about adequate protection and ARARs compliance for the Grant-Kohrs Ranch National Historic Site. Some commenters emphasized the need for secure streambank stabilization. A segment of the community does not support alternatives that will take a long period of time to implement, cause safety concerns, or intrude on landowner uses. Powell County representatives strongly support this view. Certain landowners at this site have expressed these concerns to EPA. On the other hand, Anaconda-Deer Lodge County representatives and certain landowners expressed a preference for more removal of the contamination.

In summary, EPA has received strong support for a clean-up of the Clark Fork throughout the Deer Lodge Valley. The *Proposed Plan* integrated elements of Alternatives 4, 5, and 6. EPA supports the use of a variety of remedial tools to assist with the clean-up effort, including careful monitoring and implementation of in-situ treatment, serious consultation with individual landowners in planning activities on their property, and weed control. EPA worked closely with NPS to modify the *Record of Decision* to address NPS ARAR concerns. EPA recognizes the potential hardship to landowners and plans to coordinate the remedy with landowners. EPA also intends to continue to work closely with the community and landowners to formulate a successful clean-up.

10.2.10 Conclusion of Alternative/Criteria Evaluation

EPA combined elements of Alternatives 4B4, 5D, and 6C as the Selected Remedy. The Selected Remedy most closely resembles Alternative 5D. The Selected Remedy reflects a fair balance between the long-term and short-term effectiveness and permanence, reduction of mobility, toxicity, and volume, and implementability issues associated with these alternatives. Long term effectiveness and permanence weighed heavily in EPA's decision to require the removal of most slickens, where uncertainty is greatest regarding the effectiveness of in-situ treatment. Reduction in mobility and toxicity associated with removal and in-situ treatment also influenced the choice of the Selected Remedy. EPA carefully examined the short term effectiveness and implementability criteria, and believes these issues can be managed under EPA's Selected Remedy. ARAR compliance with appropriate waivers will be achieved under the Selected Remedy with moderate uncertainty. Removal of slickens, in most cases, with in-situ treatment of impacted soils and vegetation areas in most cases, as defined in Section 12, page 2-77, ensures overall protectiveness and long-term effectiveness. Use of in-situ treatment for significant portions of the impacted soils and vegetation areas will lessen short-term safety and environmental impacts, and allow for a faster remedial action construction period. EPA believes the Selected Remedy is cost effective and will achieve benefits and effectiveness proportional to the expected costs. EPA and DEQ aim to address public concerns regarding the length of time and the intrusiveness of remediation by focusing on sequencing actions to allow for cleanup at various areas and a combination of techniques in a given area, and by working closely with landowners during implementation. Finally, State acceptance was important to EPA so removal of some contamination, as a more permanent and effective remedy, is reflected in the *Selected Remedy*.

EXHIBIT 2-19
Comparative Analysis of Alternatives Summary versus Performance Criteria for the Clark Fork River *Feasibility Study*

		Performance Evaluation of Remedial Alternatives Against Detailed Analysis Criteria							
		Threshold Criteria		Balancing Criteria					
	Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Capital Operating and Maintenance Cost	Total
1.	No Further Action	NR	NR	NR	NR	NR	NR	NR	NR
2.	In-situ Reclamation of Exposed Tailings (167 acres)	1.0	2.0	2.8	2.0	3.2	4.0	5.0	20.0
3A.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres)	1.0	2.0	2.8	2.0	3.2	3.9	5.0	19.9
3B.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres)	1.5	2.1	3.0	3.0	3.6	3.7	4.0	20.9
4A1.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (22,367 feet), Criteria 1	1.5	2.1	3.2	2.0	3.6	3.6	5.0	21.0
4A2.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (72,777 feet), Criteria 2	2.0	2.3	3.2	2.0	3.2	3.6	4.0	20.3
4A3.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (160,450 feet), Criteria 3	2.5	2.4	3.2	2.0	2.8	3.6	4.0	20.5
4A4.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (272 acres) with Streambank Riparian Buffer Zone (158 acres removal, 264,000 feet remediated streambank), Criteria 4, Opportunity Ponds Disposal	3.0	2.5	3.2	2.0	3.6	3.6	3.0	20.9
4B1.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (22,367 feet), Criteria 1	2.5	2.7	3.6	3.0	3.4	3.6	4.0	22.8
4B2.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (72,777 feet), Criteria 2	2.5	3.0	3.6	3.0	3.2	3.3	4.0	22.6
4B3.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (160,450 feet), Criteria 3	2.5	3.1	3.4	3.0	3.0	3.1	4.0	22.1
4B4.	In-situ Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Riparian Buffer Zone (158 acres removal, 264,000 feet remediated streambank), Criteria 4, Opportunity Ponds Disposal	4.0	3.6	4.0	3.0	3.4	3.7	3.0	24.7
5A.	Removal of Exposed Tailings and In-situ Reclamation of Other Impacted Soils (118 acre in-situ, 167 acres removal, 18,370 feet streambank reconstruction), Opportunity Ponds Disposal	1.0	2.8	3.2	3.0	3.8	3.6	4.0	21.4
5B.	Removal of Exposed Tailings and In-situ Reclamation of Other Impacted Soils (700 acres in-situ, 167 acres removal, 20,000 feet streambank reconstruction), Opportunity Ponds Disposal	2.5	2.4	3.0	3.0	3.2	3.1	3.0	20.2
5C.	Removal of Exposed Tailings and In-situ Reclamation of Other Impacted Soils (700 acres in-situ, 167 acres removal, 18,370 feet streambank reconstruction), DCCA Disposal (12 inches)	2.5	2.4	3.0	3.0	3.4	2.8	3.0	20.1

EXHIBIT 2-19
Comparative Analysis of Alternatives Summary versus Performance Criteria for the Clark Fork River *Feasibility Study*

	Alternatives	Performance Evaluation of Remedial Alternatives Against Detailed Analysis Criteria							
		Threshold Criteria		Balancing Criteria					
		Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Capital Operating and Maintenance Cost	Total
5D.	Removal of Exposed Tailings and In-situ Reclamation of Other Impacted Soils (660 acres in-situ, 167 acres removal, 14,164 feet streambank reconstruction), Opportunity Ponds Disposal with Streambank Riparian Buffer Zone (158 acres removal, 264,000 feet remediated streambank), Opportunity Ponds Disposal	3.5	3.6	4.0	4.0	3.4	3.4	3.0	24.9
6A.	Removal of Exposed Tailings and Other Impacted Soils (285 acres removal, 43,845 feet streambank reconstruction), Opportunity Ponds Disposal	2.5	2.9	3.4	3.0	3.0	3.1	4.0	21.9
6B.	Removal of Exposed Tailings and Other Impacted Soils (867 acres, 95,000 feet streambank reconstruction), Opportunity Ponds Disposal	2.5	3.3	3.6	4.0	2.4	3.1	3.0	21.9
6C.	Removal of Exposed Tailings and Other Impacted Soils (827 acres removal, 82,500 feet streambank reconstruction) with Streambank Riparian Buffer Zone (158 acres removal, 264,000 feet remediated streambank), Opportunity Ponds Disposal	3.0	3.6	4.0	4.0	2.8	3.3	2.0	22.7
7A.	Total Removal Unless Overlain by Woody Vegetation (2,432 acres removal, 131,583 feet streambank reconstruction), Opportunity Ponds Disposal	2.5	3.1	3.6	4.5	1.8	2.1	2.0	19.6
7B.	Total Removal Unless Overlain by Woody Vegetation (2,316 acres removal, 13,168 feet streambank reconstruction), 158 acres removal, 264,000 feet remediated streambank) Opportunity Ponds Disposal	2.5	3.4	4.0	4.5	2.0	2.3	2.0	20.7
8A.	Total Removal (3,570 acres removed, 345,163 feet streambank reconstruction), Opportunity Ponds Disposal	2.0	3.6	3.6	4.5	1.0	2.1	1.0	17.8
8B.	Total Removal (3,412 acres removal, 189,000 feet streambank reconstruction) with Streambank Riparian Buffer Zone (158 acres removal, 264,000 feet streambank reconstruction), Opportunity Ponds Disposal	2.0	3.4	4.0	4.5	1.0	2.1	—	18.0

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11 Principal Threat Wastes

11.1 Principal Threat Determination

Principal threat wastes are source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner or present a significant risk to human health or the environment should exposure occur. The NCP establishes an expectation that EPA will use treatment to address principal threats posed by a site wherever practicable (NCP § 300.430(a)(1)(iii)(A)), but recognizes that treatment is not always possible. A source material is one that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or acts as a source for direct exposure.

Arsenic in tailings, mixed tailings, and soils has been determined to be the principal threat to human health within the Clark Fork River OU. If people were to live in areas where they have repeated, daily contact with tailings, risks from arsenic could be in the range of concern for both non-cancer and cancer (*Human Health Risk Assessment*, EPA 1998).

The slickens, which are low pH, exposed tailings that can form highly contaminated and mobile metal salts, present the major principal threat waste at the Clark Fork River OU. These wastes are present in the floodplain and are commonly toxic to terrestrial plants. Acidic runoff from exposed tailings, and particularly the green-blue copper salts that appear on slickens under dry climatic conditions, has the potential to contribute high concentrations of dissolved copper to the river. Copper is highly toxic to aquatic life and this source and pathway present an acute risk to aquatic life in the Clark Fork River OU. The other principal threat wastes at the Clark Fork River OU are contaminated streambanks within Reach A that are not well vegetated (Class 1 streambanks). During normal flows, these areas contribute large amounts of copper and other contaminants to the aquatic system and enable high erosional rates and geomorphic instability along the river.

These principal threat wastes lead to a lack of floodplain vegetation resulting from metal contamination and related acid generation. Other impacts include the following:

- Accelerated streambank erosion and stream channel migration, causing unacceptable chronic risks to aquatic life, as well as land management problems
- Vulnerability of floodplain to destabilization
- Potential and actual environmental hazards to terrestrial and aquatic life, especially from pulse and flood events
- Degraded groundwater quality
- Poor agricultural productivity
- Degraded surface water as a result of metals, arsenic, and sediments loading

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- Vulnerability of floodplain to destabilization
- Potential and actual environmental hazards to terrestrial and aquatic life, especially from pulse and flood events
- Degraded groundwater quality
- Poor agricultural productivity
- Degraded surface water as a result of metals, arsenic, and sediments loading

Section 430(a)(1)(iii)(A) and EPA guidance states EPA's expectation that principal threat wastes will be addressed with reliable "treatment." For mobile waste in floodplains associated with acute risks, such as the exposed tailings and phytotoxic streambanks, removal and permanent disposal outside of the floodplain is required. EPA has thus focused its most aggressive remedial actions towards these principal waste areas. Other areas that are addressed in this remedy, such as the impacted areas that are not principal threat waste areas, present unacceptable risk conditions. EPA believes in-situ treatment and a BMP approach to these areas is an appropriate remedy for these non-principal threat wastes.

12 Definition and Description of Impacted Areas

The *Proposed Plan* (EPA 2002) summarized the types of riparian, floodplain, and upland areas that may be contaminated, the wastes that each media may contain, and how the remedy approach addresses each of these. The *Proposed Plan* was presented to the public and comments were received from many individuals, organizations, State and Federal trustees, and other groups. EPA has responded to all comments. These comments and responses are found in Part 3, *Responsiveness Summary*, of this *Record of Decision*. Responses to specific comments on the *Proposed Plan* received from Atlantic Richfield Company are also provided in Part 3, *Responsiveness Summary*. The contaminated areas are defined and described in this section, and general priorities for action are also given. The remedy is described in Section 13, page 2-81.

12.1 Definitions

Specific definitions for riparian and floodplain components as described in the *Proposed Plan* (EPA 2002) are provided below. These definitions are further refined in a detailed description of the Selected Remedy, which is the next section of this *Record of Decision* document.

- **Streambank**—The corridor from the active channel up to 50 feet out on either side. The streambank and riparian corridor buffer is delineated by measuring from the "bankfull" stage on each side of the river out a flexible or variable distance *OR* where the 100-year floodplain elevation is reached. In other words, areas outside the 100-year floodplain are not included in the streambank and riparian corridor buffer; and in cases where high banks are reached, the buffer will be less. Bankfull flow for the Clark Fork River at Deer Lodge has been calculated to be about 1,900 cubic feet per second (cfs; Griffin and Smith 2001). This equates to approximately a 7-year flood event. At this stage, the flow begins to spill out of the channel and disperse onto the floodplain.
- **Class 1 Streambanks**—Phytotoxic conditions exist as demonstrated by inability of the active channel areas to support and sustain significant amounts of woody and herbaceous vegetation. Streambanks are actively eroding and are significant contributors to contaminant release to the river. Remedial actions for this class include removal of phytotoxic materials and revegetation with deep, binding, woody vegetation. These actions may be implemented from a line at the lateral extent of inundation at bankfull stage out to approximately 50 feet from that line. Specific actions at a given Class 1 streambank will be determined in accordance with *Record of Decision* specifications and after consideration of site-specific design factors. Site-specific design factors include depth of removal (this is not necessarily the same as depth of contamination), depth to the water surface, depth to groundwater, current streambank stability, current vegetation status, infrastructure (bridges, culverts, etc.), surface drainage, future land use, BMPs, and others.

- **Class 2 Streambanks**—Generally non-phytotoxic conditions exist as demonstrated by some current woody and herbaceous vegetation, but streambanks are contaminated, not stable, and are eroding. Remedial actions for this class include supplemental revegetation and planting of deep, binding, woody vegetation. Reconfiguration of the streambanks may require minor removal or in-situ treatment. Design factors include current streambank stability, current vegetation status, infrastructure, surface drainage, future land use, BMPs, and others.

- **Class 3 Streambanks**—These streambanks are contaminated but they may have varying amounts of deep, binding, woody vegetation holding the streambank in place. Remedial actions possible for these areas include no action or minor actions to enhance woody vegetation within the buffer corridor and/or BMPs. Design factors include current vegetation status, current streambank stability, knowledge of underlying contamination, and current and future land use.

- **Slickens (exposed tailings)**— These sites generally lack vegetation (have less than 25 percent canopy cover) and present the principal waste in the Clark Fork River OU, along with Class 1 Streambanks. Estimated in the RI/FS at about 167 acres, but possibly up to 250 acres in Reach A with limited slickens in Reach B, these slickens areas are contaminated, causing largely bare ground. Scattered throughout Reach A, the areas number in the hundreds, are usually fractions of an acre in size, and are too toxic to support most vegetation or soil organisms. These areas are usually easy to recognize. Remedial action for most of these areas is removal, except as described in Section 13.3, page 2-85. Removal of slickens areas adjacent to the active channel would be done as part of streambank remedial actions.

- **Impacted Soils and Vegetation Areas**—Estimated in the RI/FS at about 700 acres, but possibly up to 1,760 acres in Reach A, these sparsely vegetated areas amount to everything between slickens and slightly impacted soils and vegetation areas that have an ecologically-sound plant community. Impacted soils and vegetation areas will generally be treated in-situ, except as described in Section 13.3, page 2-85.

- **Slightly Impacted Soils and Vegetation Areas**—These areas do not meet the characteristics or definitions of streambank and riparian corridor buffer, slickens (exposed tailings), or impacted soils and vegetation area. They are generally well vegetated and display no visible evidence of contaminated tailings, although the soil may contain copper concentrations above 300 ppm. Remedial actions for these areas are no action, or BMPs and ICs. They may be included in a land management plan along with adjacent areas being addressed by the remedy.

12.2 Priorities

The cleanup plan has three basic components:

1. Removal of tailings/slickens with soil replacement and revegetation
2. In-situ treatment of impacted soils and vegetation, followed by revegetation
3. Streambank stabilization

The basic cleanup approach is to perform in-situ treatment and tailings/slickens removal with soil replacement, followed by establishment of appropriate vegetation. A remedial design tool specifically developed for the Clark Fork River guides remedial design decisions for remedial action for a specific piece of land or polygon. This design tool is called CFR RipES. The system is described in Section 13.6.1, page 2-91. In addition, full details of the draft CFR RipES system are provided in the final CFR RipES document (EPA 2004).

In addition to the human health component of the remedy, there are five main areas for action and general priority and preference for the type of remedial action in each area. These actions are described below, in order of priority. These actions are further refined in a detailed description of the Selected Remedy, which is the next section of this *Record of Decision*.

1. **Class 1 streambanks**: Removal of contamination, reconstruction, and revegetation of streambanks where chemical conditions do not allow the effective establishment of woody and herbaceous vegetation. Further detail about this type of action is provided in Section 13, *Selected Remedy*.
2. **Exposed tailings or slickens areas**: Removal of exposed tailings with the exceptions as described in Section 13, *Selected Remedy*.
3. **Class 2 streambanks**: Revegetate streambanks where chemical conditions (demonstrated by some significant level of woody and herbaceous vegetation) allow effective establishment of vegetation. Reconfiguring banks (e.g., scalloping or selective removal) could be required where other treatments may not be effective. Further detail about this type of action is provided in Section 13, *Selected Remedy*.
4. **Impacted soils areas with impacted vegetation**: In-situ treatment or removal, to be decided by the criteria described in Section 13, *Selected Remedy*.
5. **Class 3 streambanks**: Continue or apply BMPs on all other streambanks with deeply bound woody vegetation and a root-mass that maintains streambank stability. BMPs are described in Section 13, *Selected Remedy*, in further detail.
6. **Slightly impacted soils and vegetation areas:** Although not actively addressed in a remedial action, these areas may be included, along with adjacent areas of the floodplain being addressed by a remedial action, in a property-specific land management plan.

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13 Selected Remedy

13.1 Rationale for the Selected Remedy

The upper reaches of the Clark Fork River (Warm Springs to Drummond) can be characterized as follows: this river has intermittent areas of exposed tailings, often barren of vegetation, or supporting stressed vegetation along its banks and across its floodplain. These conditions have created a series of interrelated environmental and human health problems, including sedimentation (both contaminated and uncontaminated), channel instability, excess soil erosion, reduced agricultural potential, and ecological hazard. The absent and stressed vegetation resulted from phytotoxic environments, which in turn were caused by low pH and elevated metals in tailings and contaminated soils deposited along the banks and floodplain of the river. Hazards to both aquatic and terrestrial receptors are well documented in EPA's *Ecological Risk Assessment* (1999). The risks to human populations are documented in EPA's *Human Health Risk Assessment* and its *Addendum* (EPA 1998a and EPA and ATSDR 2001). The Selected Remedy addresses these risks in a manner consistent with CERCLA and the NCP.

Under normal hydrologic conditions, approximately 60 percent of the copper load in the river's surface water is from streambank erosion, with smaller contributions from other sources, such as floodplain runoff and groundwater discharge, that together contribute about 12 percent. Although the contribution of floodplain runoff is itself only about 6 percent of the total copper load, it is the principal source of dissolved copper during pulse or storm events and presents the most severe threat to aquatic life. The Selected Remedy removes exposed deposits of tailings (slickens), treats in-situ impacted soils and vegetation, maximizes the re-establishment of vegetation that can provide stability to the banks of the river, and significantly reduces environmental hazards arising from movement of contaminants via floodplain runoff. The Selected Remedy also increases the stability of the floodplain and reduces environmental risks that arise during flood events.

EPA, in consultation with DEQ, considers general program goals and expectations found in the NCP at 40 CFR § 300.430(a) when proposing a preferred remedy and ultimately selecting a final remedial action. Section 430(a)(1)(iii)(A) and EPA guidance states EPA's expectation that principal threat wastes will be addressed with reliable "treatment." For mobile waste in floodplains associated with acute risks, such as the exposed tailings and phytotoxic streambanks, this means removal and permanent disposal outside of the floodplain. Section 430(a)(1)(iii)(F) emphasizes the importance of restoring groundwater to beneficial uses or, at least, preventing migration and exposure to contaminated groundwater. The Selected Remedy, through removal of most of the slickens areas, better achieves ARARs compliance and provides for a more long-term and permanent remedy. Section 430(a)(1)(i) describes an important goal of maintaining protection over time, and the slickens removal and streambank and riparian corridor portion of the remedy is the best suited among the streambank protection options to meet this goal.

The Selected Remedy was chosen because of the following analysis of Threshold, Balancing, and Modifying Criteria:

- It provides for overall protection of the environment through incorporation of streambank and riparian corridor stabilization, and removal/treatment of exposed tailings and mixed soils.
- It provides for long-term effectiveness and permanence by removal of slickens (in most cases), in-situ treatment of impacted soils and vegetation, and vegetative stabilization to curtail excessive erosion.
- It provides for a reduction of toxicity, mobility, and volume through removal of slickens to a local repository, in-situ treatment of impacted soils, and application of in-situ techniques for stabilizing streambanks.
- It provides for short-term effectiveness by utilizing in-situ treatment where appropriate, helps shorten the implementation time for the remedy, and reduces truck traffic and associated safety concerns. Sequencing of activities at different locations throughout the river corridor will promote an efficient and timely remediation schedule, and will help to maintain the integrity of the floodplain should an extreme flood event occur during the remedial action period.
- It provides an implementable approach to the remedy, which is technically and administratively feasible, and can be supported by a local resource pool of equipment, specialists, and materials, including a viable location for depositing wastes.
- It provides a cost effective approach to complete a protective and permanent remedy in a reasonable period of time.
- It provides for some flexibility in design to address significant landowner concerns, and it has received State concurrence, as described in the State's concurrence letter (Appendix F).
- It addresses many concerns raised in the public comment period (see Section 15, page 2-159, and Part 3, *Responsiveness Summary*) and tries to balance the many views received from the commenters on the *Proposed Plan*.

The proposed removal of slickens, in most cases, with in-situ treatment of impacted soils and vegetation areas, promotes overall protectiveness and long-term effectiveness. This balanced approach reduces potential reliance on long-term BMPs, ICs, and monitoring and maintenance. Use of in-situ treatment for significant portions of the impacted soils and vegetation areas will lessen short-term safety risks and environmental impacts, and allow for a shorter remedial action construction period. The Selected Remedy approach is implementable and cost effective. EPA intends to address concerns regarding the length of time and the intrusiveness of remediation through careful sequencing of actions, application of a combination of remedial techniques, and coordinating concurrent cleanup at various areas. Through these actions, the Selected Remedy strives to meet the remedial action objectives set for floodplain tailings and impacted soils, groundwater, and surface water.

13.2 Overview of the Selected Remedy

As previously noted, the *Proposed Plan* contained a preferred remedy that consisted of a combination of various technologies. These technologies were previously described as portions of other alternatives in the Clark Fork River *Feasibility Study*. The preferred remedy was composed principally of certain components contained in Alternatives 5D, 4B4, and 6C. It most closely resembled Alternative 5D. The preferred remedy proposed a combination of remedial technologies including the following:

1. Stabilizing eroding streambanks and providing an approximately 50-foot wide protective riparian corridor on both sides of the river
2. Removal of exposed tailings or slickens to a central disposal area and replacement with clean soils
3. In-situ treatment of areas of impacted soils and vegetation
4. Necessary revegetation of the riparian corridor and other treated or removal areas

The preferred remedy was proposed to be implemented along the erosive streambanks and the historic 100-year floodplain of virtually all of Reach A, and in small, localized areas of Reach B. Following the public comment period for the *Proposed Plan*, and taking the various comments received into consideration, EPA has determined the Selected Remedy for the Clark Fork River OU.

The Selected Remedy is comprised of the following:

- The *Record of Decision* defines exposed tailings areas. Exposed tailings will be removed, backfilled with cover soil, and revegetated, with a limited exception. The limited exception is: exposed tailings that are 400 square feet or less, less than approximately 2 feet deep, and contiguous with impacted soils and vegetation areas that will be treated in-situ. When these conditions are present, in-situ treatment will be applied.
- The *Record of Decision* defines areas of impacted soils and vegetation. The areas of impacted soils and vegetation will be treated in place, using careful addition of lime and other amendments, soil mixing, and re-vegetation.
- Some impacted soils and vegetation areas will instead be removed where depth of contamination prevents adequate and effective treatment in place or where saturated conditions make in-situ treatment unimplementable; or post-treatment arsenic levels would be above the human health action level after one re-treatment for the current or reasonably anticipated future land use. Further definition of the exceptions for depth and saturation is contained in Section 13.3, page 2-85.
- Streambanks will be stabilized by "soft" engineering (and hard engineering techniques, when warranted) for those areas classified as Class 1 or Class 2 streambanks, and an approximate 50-foot riparian buffer zone will be established on both sides of the river. This will lessen the high rate of erosion and contaminant input from streambanks, and will prevent or reduce the uncontrolled release of contaminants and potential stream braiding during flooding. Stream stabilization techniques are further described in Section 13.6.4, page 2-106, and include an emphasis on protecting against shear stresses

on unstable banks. Subsequent remedial design activities will define the most practical and effective methods and the exact location for streambank stabilization. The riparian buffer zone width will be flexible and considerate of landowner concerns and the nature of the stream at a given location.

- The removed wastes will be conveyed to the Opportunity Ponds for proper placement and/or disposal. Closure of the Opportunity Ponds will be accomplished under the authority of the Anaconda Regional Water, Waste, and Soils Remedial Design/Remedial Action (RD/RA).
- Weed control for in-situ treatment, streambank stabilization, and removal areas is an important component of the Selected remedy. It is further described in Section 13.10, page 2-123.
- BMPs will be used throughout Reach A and in limited areas of Reach B to protect the remedy. BMPs will be contained in landowner specific plans, and will be used to ensure land use practices are compatible with long-term protection of the Selected Remedy.
- ICs and additional sampling, maintenance, and possible removal or in-situ treatment of contamination will be required to protect human health. The trestle area in Deer Lodge is a recreational area that will be addressed under the *Record of Decision*. Specific institutional controls identified as necessary are as follows: continued Anaconda and Deer Lodge County zoning regulations (prohibits building a permanent residence within the Clark Fork River floodplain), deed restrictions and permanent funding for Arrowstone Park, and groundwater use controls to prevent domestic consumption of contaminated groundwater.
- Monitoring during construction, construction BMPs, and post-construction environmental monitoring will be required.
- Continued removal of arsenic contamination in the East Side Road area as needed and further evaluation of irrigated land for human health reasons.

Because NPS has specific cleanup needs and responsibilities under the laws that govern National Historic Sites, such as the Grant-Kohrs Ranch National Historic Site, the remedy is modified and expanded in this *Record of Decision* for this area. Those components of the *Record of Decision* are described in Section 13.7, page 2-107.

The Selected Remedy will be implemented along the erosive streambanks and the historic 100-year floodplain of virtually all of Reach A and small, localized areas of Reach B. The remedy for Reach C is no action.

Implementation of the Selected Remedy will be initiated with the RD/RA phase of the project. Each property will be surveyed to refine the surface topography, and then evaluated utilizing the CFR RipES tool. CFR RipES is a special assessment process developed as a detailed design tool specifically for the Clark Fork River OU that determines differing erosive conditions and lengths of streambanks, notes pertinent detail regarding existing riparian corridor conditions, and defines and locates specific areas of exposed tailings or slickens, and areas of impacted soils and vegetation to the edges of the floodplain. This critical data and information will then be mapped in conjunction with the refined topographical information. Landowners will be consulted on certain design elements and allowances will be made for implementation of natural resource damage actions and/or consideration of Department of Agriculture programs.

Sufficient, detailed information will then be available to develop a site-specific design for a particular property. Necessary design elements will include the following:

- Landowner communication, overview of land use (desired and current), and interaction of remedy components onto property overlay.
- Specific locations and areas of slickens, and other areas slated for removal, including depths of tailings that defines the required excavation depths and volumes of removed material.
- Amounts of clean fill that will be required to backfill excavated areas.
- Lengths, locations, and erosive conditions of various classes of streambanks, both on the river and along associated tributaries, to permit the utilization of site-specific designs to stabilize the various eroding portions of the streambanks.
- Information for laying out the required routes and design specifications of necessary temporary haul roads and bridges.
- Establishment of liming and other amendments requirements, and areas and depths of mixing for in-situ treatment of impacted soils.
- Establishment of revegetation designs for both the riparian corridor and remaining floodplain areas.

Once the property design is completed, with input from the property owner, and approved by the implementing agency, the remedial action or implementation phase (i.e., the construction phase) planning and scheduling can begin.

13.3 General Clean-up Strategy

The general clean-up strategy involves the following components:

- The human health provisions as defined in Section 13.4, page 2-87, will be implemented as a priority, following remedial design for this component.
- EPA and DEQ will seek cooperation of all landowners on the river to apply the CFR RipES evaluation tool for their particular property. At the beginning of the CFR RipES process, each landowner will be interviewed and preliminary design issues and concerns they may have will be discussed and notations made. Upon completion and evaluation of the CFR RipES property data, and acquisition of specific design information, the landowner will be advised of the preliminary site specific design for their property and can provide input to the final design for their individual property. Final design decision will be made by the agency.
- Exposed tailings, referred to as slickens, will be removed, with a limited exception. Slickens that are less than 400 square feet and less than 2 feet in depth and not too wet will be treated in-situ if they are next to or contained within an impacted soils and

vegetation area that is designated to be treated in-situ. These small slickens within or next to areas to be treated in-situ will be removed if they are thicker than 2 feet or too wet to treat. Areas of healthy vegetation that contain isolated small slickens will not be disturbed by trying to access and remove the small slickens. This will allow the established soil-binding vegetation to be preserved. These areas will be treated in-situ if practicable.

- Impacted soils and vegetation areas will generally be treated in-situ, unless certain exceptions apply. Areas of impacted soils and vegetation that have tailings and impacted soils extending deeper than 2 feet will be removed rather than treated in-situ. Such areas will also be removed if they are too wet to effectively treat in-situ.
- Old oxbow channels and wetlands will be evaluated by CFR RipES. If they have high quality vegetation they will not be remediated. If they have impacted vegetation and the contaminated tailings and soils are deeper than 2 feet or the soil is too wet, they will be removed and replaced in a manner that re-establishes a productive and healthy wetland. If the tailings and contaminated soils in these impacted areas are less than 2 feet in an old oxbow channel and it is not too wet, the area will be treated in-situ (see Section 13.8.3, page 2-119).
- Irrigation ditches that conveyed historically contaminated water will be sampled through a representative sampling program to be developed to ensure that contaminant concentrations do not cause unacceptable risks to human health or the environment, as further described in Section 13.8.3, page 2-119.
- The three classifications of eroding streambanks defined previously will be identified by CFR RipES and the appropriate site-specific designs developed for each. Streambank erosion will be controlled using appropriate bio-treatment methods relative to each erosive class. The associated riparian corridor vegetation, the soils of which can be remedied using removal and in place techniques, will then be supplemented with the additional plantings of various sized deep, binding woody vegetation, primarily sandbar willows.
- Weed management will be a high priority consideration during all remedial design activities, and during implementation of the remedy. BMPs will be utilized during construction and post construction to protect the water quality of the river, air quality, and other adjacent critical assets of the landowner, including existing vegetation. Construction and post construction monitoring of water, air, soil, vegetation, and other environmental parameters will be required. Land use BMPs will be developed in conjunction with each landowner to ensure long term protectiveness.

The agencies will work with the Conservation District and other agencies to ensure that the land use BMPs are consistent with good land use practices employed by the landowner, both short and long term. Continued enforcement of human health protective ICs, continued monitoring and maintenance of appropriate environmental media, including all remediated recreational, farming/ranching and residential locations throughout Reaches A and B, will be required. Responsibility for the enforcement of BMPs, which will be monitored through oversight activities, will be an important issue that will need to be addressed as outlined in Section 13.6.5, page 2-107.

13.4 Selected Remedial Actions to Address Human Health Risks and Pathways

The actions required to address human health considerations are as follows:

1. The Selected Remedy sets action levels for arsenic in soils within the Clark Fork River OU:
   - Residential – 150 ppm
   - Rancher/Farmer – 620 ppm
   - Recreational – 680 ppm for children at Arrowstone Park and other similar recreational scenarios, and 1,600 ppm for fishermen, swimmers, and tubers along the river only.
2. The trestle area in Deer Lodge was identified by ATSDR as an area where current data indicates an exceedance of the recreational level established above. Early sampling of this area shall be undertaken as needed to supplement existing data. If levels identified above for recreational exposure (680 ppm arsenic) are exceeded, contaminated soils will be removed and replaced with appropriate backfill, and revegetation shall be implemented. Disposal of excavated materials will be in Opportunity Ponds. Other known recreational areas will be evaluated, using existing data where possible, to determine if they exceed the recreational level. If exceedances are found, they will be dealt with in a similar manner.
3. The NPS provided a risk assessment indicating potential risks to workers from arsenic contaminated irrigation ditches at the Grant-Kohrs Ranch National Historic Site. Additional sampling will be performed in coordination with the NPS to determine if unacceptable risks are present, and, if so, contamination will be removed and disposed of at Opportunity Ponds.
4. Some residences are identified under the Deer Lodge Valley Historically Irrigated Lands TCRA as exceeding the action level for arsenic in residential areas and were not addressed under the TCRA. These areas will be revisited and remediated consistent with that action. Other follow-up operation and maintenance activities from this action will be implemented.
5. EPA does not believe that other historically irrigated lands within the Clark Fork River OU exceed EPA's action level for reasonably anticipated land use for those lands. This shall be confirmed via sampling of these lands if necessary and confirmation that residential development is not planned for these areas. As noted in later portions of this section, confirmation sampling for in-situ treated areas is also required to ensure that these areas are below action levels for current and reasonably anticipated uses (which is likely to be agricultural for most lands) after treatment.
6. Three ICs will be implemented to further protect human health:
   - Continued implementation, including funding, will be provided for Powell County's and Anaconda Deer Lodge County's zoning ordinances, which

prohibits building a permanent residence within the floodplain of the Clark Fork River in that county. Since this IC does not prevent residential yards within the floodplain associated with residences just outside of the floodplain, the county will be funded to monitor and report on any such use. Appropriate remedial action will be taken if such yards are found or created, and if arsenic levels exceed EPA's residential action level.

- Permanent deed restrictions and use funding are required for Arrowstone Park near Deer Lodge, to ensure that this area is maintained and dedicated for use as a recreational area.

- All previously sampled domestic wells that exceeded MCLs will be resampled, as well as any new private domestic well located in or near the floodplain. Appropriate ICs to address groundwater use in the shallow aquifer shall be implemented and funded. A survey of well use in the floodplain of Reach A is necessary. Domestic wells identified that are near contamination sources will be sampled, and appropriate action to ensure safe water supplies for domestic users will be taken if exceedances of groundwater performance standards (which for domestic wells will be based on total, rather than dissolved, analysis) are found. Additional ICs beyond existing State statutory protections can range from ground water control areas through the State Department of Natural Resources and Conservation (DNRC) to ordinances or deed restrictions. The exact nature of this IC component will depend on land use and contamination severity.

7. Educational efforts for recreational users within the river corridor area, concerning the need to prevent soil intake by children and maintain other health practices to prevent unnecessary exposure to soils, shall be undertaken or funded, in cooperation with local and State health authorities.

Some locations within the riparian area possibly contain soils or tailings at treatable depths with mean arsenic levels that may exceed 620 ppm when mixed. According to the *Remedial Investigation*, the geometric mean arsenic level (25 and 75 percentile levels) for tailings in Reach A is 766 ppm (483 and 1,134 ppm). The remedial action for barren tailings is removal, so exposure to arsenic from barren tailings will be eliminated. Samples of mixed soils and tailings have arsenic concentrations of 419 ppm (geometric mean), with 25 and 75 percentile levels of 190 and 1,532 ppm. It is possible that some of these areas will also be removed as part of the remedial action if in-situ treatment does not obtain low enough (mixed soil) profile arsenic levels. All areas scheduled for in-situ treatment will be pre-sampled and post-sampled for arsenic to ensure the treatment will meet arsenic action levels. If the exposure unit (usually the treated area) exceeds the health-based action level, the area will be retreated. If the exposure unit still exceeds the action level after one re-treatment, the area will be removed. Under the Selected Remedy, previously treated areas will be re-evaluated to determine if additional treatment or removal is needed. Levels of surface soil arsenic in treated areas are generally expected to be below the human health RBCs for the farmer/rancher, the recreational user, and the swimmer/rafter.

As the ATSDR suggested, EPA evaluated this pathway and believes that the Selected Remedy, which provides for streambank stabilization, removal of the slickens areas, and treatment of areas with moderately dysfunctional plant communities (impacted areas), will provide protection to recreational users. Development of any future recreational areas, or areas known now to be recreational areas, must ensure that contaminant levels in soil are reduced below the recreational RBCs of 680 ppm for chronic exposure to children aged 1 to 10, and 1,600, ppm for swimmers and rafters. Residential areas within the TCRA area that have not yet been addressed will be assessed using the residential soil action level of 150 ppm.

13.5 Selected Remedial Actions to Address Environmental Risks and Pathways

Based on ecological studies conducted within the Clark Fork River OU, especially the *Ecological Risk Assessment* (EPA 1999), EPA determined that widespread unacceptable terrestrial and aquatic risks exist in Reach A and portions of Reach B. Areas of primary concern are phytotoxic soils and subsequent lack of or reduced vegetation, impacts on livestock and wildlife, and unacceptable risks to aquatic receptors, principally benthic macroinvertebrates and fish.

13.5.1 Acute Aquatic Risks

EPA recognizes the importance of both acute and chronic aquatic risks in selecting the remedial action, and identified removal of slickens and in-situ treatment of less impacted contaminated areas, along with significant streambank stabilization, as an appropriate and balanced means to address these risks. Historically, there has been a clear association between storm events and the occurrence of fish kills in the Clark Fork River. This is thought to be due to surface water run-off from exposed tailings areas, since these surface flows generally contain high concentrations of copper and other metals, and are also acidic. Maximum concentrations in runoff water from barren slickens were reported to be 7,380 mg/L copper, 2,350 mg/L zinc, and 23 mg/L arsenic (Atlantic Richfield Company 1997). In this regard, it is important to note that not all storms cause acute lethality. Rather, the key factor appears to be the formation of metal salt crusts on the tailings, which in turn requires an appropriate set of meteorological conditions to form initially. In a review of a major fish kill in 1989, it was postulated that concentrations of metals in these salts, in readily soluble form, were responsible for rapid increases in river water metal levels, and subsequently the lethal concentrations of metals, especially copper, in fish tissues (Munshower et al. 1997). Because tailings are the principal waste or source material (barren slickens and reoccurring metal salts), and because run-off waters from exposed tailings are known to contain very high levels of metals and are acidic, it is concluded that the risk of acutely lethal pulses remains unless these source materials, or principal wastes, are removed.

Removal of barren slickens areas, which produce these soluble metal salts that can then be washed into the river during storm events, will eliminate this potential acute risk to aquatic receptors.

13.5.2 Chronic Aquatic Risks

In the *Ecological Risk Assessment* (EPA 1999) several factors and investigation results relating to chronic risks to Clark Fork River fish were evaluated. These included chronic exposure to contaminated surface waters, site-specific fish survival tests, avoidance studies, exposure to contaminants from diet and from sediments, and comparative fish density studies. In a recent laboratory fish feeding study (Stratus 2002), juvenile rainbow trout were fed live diets exclusively of *Lumbriculus variegatus* (common names include California blackworm, blackworm, and mudworm). The *Lumbriculus* were cultured in metal-contaminated sediments collected from Silver Bow Creek and the Clark Fork River. Significant growth inhibition was reported for fish fed the contaminated diets over the 67-day trial period. Growth inhibition was statistically related to metals and arsenic in the diets and to levels found in fish tissues. The best statistical correlations were reported for arsenic. The study suggests that *Lumbriculus variegatus* grown in metal-contaminated sediments can pose a risk to juvenile rainbow trout through an exclusive dietary exposure pathway. Taken together, the data from these studies are consistent with the hypothesis that copper (and possibly arsenic and other metals) in the aquatic environment (surface water, diet) impose low-level chronic stress on aquatic macroinvertebrates, trout, and other fish.

EPA's Selected Remedy is an appropriate response to these unacceptable acute and chronic risks to Clark Fork River fish. The removal of most barren slickens areas addresses the principal waste and acute risk in a permanent manner without residual risk. The in-situ treatment component addresses other impacted soils and vegetation and related terrestrial risk found at the site. The streambank stabilization component addresses the erosion, stream stability, and chronic aquatic risks found at the site.

13.5.3 Livestock and Wildlife

The Ecological Risk Assessment (EPA 1999) predicted the overall hazard to range cattle to be moderate. The primary source of the risk is from ingestion of copper from soil, not from normal drinking water sources. See Section 7.2, page 2-42, for additional risk discussion.

13.5.4 Terrestrial Vegetation

Mining wastes prevalent in denuded streambanks are generally phytotoxic as demonstrated by the many barren slickens areas and areas of impacted vegetation, which support limited plant species and provide low agricultural production. The Selected Remedy is a combination of slickens removal, treatment of impacted areas, and streambank stabilization. Establishing appropriate woody and herbaceous vegetation is key to the success of the Selected Remedy. Reduction or elimination of phytotoxic conditions will be accomplished by removal of principal threat wastes (barren slickens), treatment of areas with vegetation communities impacted by contamination, and establishment of deep binding root mass along the river's banks. Woody vegetation on meander tabs will reduce overland erosion within the riparian buffer zone and help stabilize the tabs so that meander cutoffs do not occur at accelerated rates. The Selected Remedy provides a mix of mature and less mature vegetation within the newly established riparian corridor to ensure short-term and long-term geomorphic stability along the river. The buffer corridor with deep, binding woody vegetation will reduce erosion, contaminant loading to the river, and sedimentation.

Excavation of tailings and replacement with cover soils that meet specific chemical, physical, and biological requirements, followed by establishment of vegetation appropriate for the land use, will be implemented on approximately 170 acres. In-situ treatment involves the addition of neutralizing amendments to control acidity and reduce bioavailability of metals. Other amendments, such as phosphorus to minimize arsenic mobility, may be considered as part of the remedial design. When soil arsenic levels exceed 1,000 mg/kg measured before treatment, additional phosphorus is to be incorporated into the treatment zone. Both organic matter and fertilizer are added to develop a hospitable rootzone. Vegetation appropriate for the land use will be established on these treated areas currently estimated to be 700 acres. Vegetation established on both cover soil and treated areas as well as within the riparian corridor, will reduce wind and water erosion, thus reducing the movement of metals in dusts and surface water runoff. The quality of the runoff water will also be markedly improved. Increased vegetation will maximize infiltration while plant use of water will reduce deep percolation, thereby reducing the flux of contaminants to groundwater.

13.6 Detailed Description of the Selected Remedy

The detailed description of the Selected Remedy is provided in this section by subject area.

13.6.1 The Selected Remedy, CFR RipES, and the Landowners

Nearly 100 landowners live along the Clark Fork River within Reach A, where most of the cleanup is expected to occur. However, more than 71 percent of the Clark Fork River streambanks in Reach A is owned by 14 landowners. Implementation of the Selected Remedy is estimated to require approximately ten construction seasons to complete. Implementation of the Selected Remedy will create both short and long term impacts for each affected landowner. Short term impacts, typically up to 2 years in duration (or possibly longer for larger property owners), will be created during the additional data gathering, design, and construction phases required for implementation of this remedy. The design and construction of the Selected Remedy phases will be carefully coordinated with the landowner and executed in such a manner as to minimize impacts to the landowner. Weed control will be a highlighted concern addressed during remedial design.

As mentioned previously, BMPs will be utilized during construction. Some typical examples of construction BMPs include wetting haul roads and excavated materials and using covered haul trucks to minimize dusting, using silt fencing and straw bales for filtering rain water runoff prior to entering a drainage ditch or the river, and not operating during high winds to avoid generating excessive dust. After construction is completed, establishment of longer term BMPs and land use practices will be contained in a property management plan that may include riparian corridor restrictions, a weed management program, a grazing management plan, an irrigation plan, and other management actions. These post-construction BMPs, which will impact the landowner, are necessary to protect the success of the remedy, both short and long term. Maturation of herbaceous vegetation will require up to 3 years; maturation of woody vegetation to provide the necessary streambank erosion protection will require up to 10 years, depending on vegetation performance. After 10 years, management plans may be modified appropriately.

To implement the Selected Remedy, EPA and DEQ will seek the cooperation of each landowner on the river to allow access to evaluate the landowner's property. This property-by-property analysis will be conducted using the CFR RipES evaluation tool and will include gathering additional topographic and other survey data. In this initial meeting, additional information will also be obtained from the landowners that will be considered during the remedy design and implementation process for their property. Other topics may be discussed, such as minimizing impacts on ranch operations, future monitoring and maintenance activities, maximizing future land productivity, the short and long term implications regarding the uses of BMPs, construction methods, procedures and safety practices, interim land uses, interim irrigation practices, and other issues.

Upon completion and evaluation of the data obtained from the CFR RipES process on a particular property, preliminary detailed designs that are consistent with the Selected Remedy can then be developed for each remedial component of the Selected Remedy applicable to said property. The landowner will then be advised of this preliminary site-specific design, and through additional discussion, provide any additional input. The implementing agencies' goal will be to seek voluntary access and a design plan agreement for each landowner.

Subsequent to the implementing agency's approval of a final detailed design, construction would be scheduled in the most efficient way to minimize the amount of time and disruption on the landowner's property.

13.6.1.1 CFR RipES

Overview. CFR RipES is a tool that allows the *Record of Decision* requirements to be implemented on a site-specific, refined, and definitive basis. The purpose of CFR RipES is to provide a data predicated decision tool to identify and categorize polygons (delineated areas of land) based on landscape stability and plant community attributes within the Clark Fork River OU. CFR RipES will be used to make classifications and determine actions consistent with the standards set forth in the *Record of Decision*. The system contains the following elements:

- Definitions and scoring for three types of soils polygons and three types of streambank and riparian corridor buffer polygons
- A 100 percent accounting of all areas in the historic 100-year floodplain within the Clark Fork River OU among the three types of soil polygons in Reach A and portions of Reach B
- Numerical components with threshold scores that distinguish the severity of contamination of the floodplain soils, and thresholds that separate streambank riparian corridor buffer polygons into three classes
- A process for identification of data and information required to complete remedial designs for each polygon

The numerical portion of the system is based upon the Land Reclamation Evaluation System (LRES) developed for the Anaconda Smelter NPL Site (EPA 1998b, CDM and RRU 1999, and Atlantic Richfield Company 2000b), and the Riparian and Wetland Health Assessment protocols (Hansen et al. 1995 and 2000), which are used extensively in the western United States and Canada. The health assessment protocols (Hansen et al. 1995 and 2000), upon which the numerical evaluation of the ecological aspect of CFR RipES is based, were initiated in 1986 in a series of iterative steps wherein inter-disciplinary teams of natural resource professionals and scientists collaborated using the Delphi Method or Expert

Opinion Method (Delbecq et al. 1975, Schuster et al. 1985) to write, field-test, and refine the protocols.

This document describes the CFR RipES system in relation to the CERCLA RI/FS process and the CERCLA RD/RA process. It builds on the initial CFR RipES document (RRU and RWRP 2000) and integrates the thinking and rationale supporting the selected remedy as stated in this *Record of Decision*. CFR RipES will also be used to establish performance standards, evaluate land reclamation designs, evaluate post-action effectiveness, and in monitoring and maintenance programs for reclaimed areas.

Structure. Areas within the Upper Clark Fork River floodplain are classified for purposes of determining specific remedial actions based on landscape stability, contamination, and plant community dysfunction. Of first concern are those areas most in jeopardy of being eroded into the river channel. The OU is divided into smaller units of land, called **polygons**, which are delineated and classified as candidates for the various kinds of treatment.

Four major types of sites are defined below for the purpose of identifying areas for the various remedial actions:

1. Streambank and riparian corridor buffer
2. Slickens areas (exposed tailings)
3. Impacted soils and vegetation areas
4. Slightly impacted soils and vegetation areas

Miscellaneous types are also identified (i.e., irrigation ditches, contaminated upland areas, tributary streams, etc.), and remedial actions for these are defined in this document. Characteristics of the major types of sites and remedial actions for each type are provided below.

Streambank and Riparian Corridor Buffer. The streambank and riparian corridor buffer is a zone of approximately 50 feet in width on each side of the river that may vary in width, depending on site-specific conditions. For example, a severely eroding outer streambank may require more than 50 feet, while on inside banks with point bars and along straight reaches of the stream where the erosive forces are minimal, the corridor may be less. For cost analysis in the *Feasibility Study*, a 50-foot zone was used along the entire stream corridor. Appendix B, *Clark Fork River OU Streambank Stabilization Design Considerations and Examples*, contains figures illustrating erosional processes and remedies.

The streambank and riparian corridor buffer is delineated by measuring from the "bankfull" stage on each side of the stream out a flexible or variable distance (see preceding paragraph), ***or*** where the historic 100-year floodplain elevation is reached. In other words, areas outside the historic 100-year floodplain are not included in the streambank and riparian corridor buffer. In cases where high banks are reached, the buffer may be narrower. Bankfull flow for the Clark Fork River at Deer Lodge has been calculated to be about 1,900 cfs (Griffin and Smith 2001). This equates to approximately a 7-year flood event. At this stage, the flow begins to spill out of the channel and disperse onto the floodplain.

The approximate 50-foot streambank and riparian corridor buffer zone on each side of the river will be broken into preliminary polygons based on live vegetative canopy cover, canopy cover of deep, binding, woody vegetation, and/or lengths of streambank erosion.

The minimum mapping unit of these polygons is 20 linear feet of streambank with a maximum length of 500 feet. Polygon units will not cross land-ownership boundaries. These polygon units will be scored using the CFR RipES Field Form for Streambank and Riparian Corridor Buffer Polygons, thereby classifying streambanks into one of three categories designated as Class 1, 2, or 3 streambanks.

- **Class 1 Streambanks**—Phytotoxic conditions exist as demonstrated by inability of the active channel areas to support and sustain significant amounts of woody and herbaceous vegetation. Streambanks are actively eroding and are significant contributors to contaminant release to the river. Remedial actions for this class include removal of phytotoxic materials and revegetation with deep, binding, woody vegetation. These actions will be implemented from a line at the lateral extent of inundation at bankfull stage out to approximately 50 feet from that line. Specific actions at a Class 1 streambank will be determined in accordance with *Record of Decision* specifications and after consideration of site-specific design factors. Site-specific design factors include depth of removal (this is not necessarily the same as depth of contamination), depth to the water surface, depth to groundwater, current streambank stability, current vegetation status, infrastructure (bridges, culverts, etc.), surface drainage, future land use, BMPs, and others.

- **Class 2 Streambanks**—Generally non-phytotoxic conditions exist as demonstrated by some current woody and herbaceous vegetation, but streambanks are contaminated, not stable, and are eroding. Remedial actions for this class include supplemental revegetation and planting of deep, binding, woody vegetation. Reconfiguration of the streambanks may require minor removal or in-situ treatment. Design factors include current streambank stability, current vegetation status, infrastructure, surface drainage, future land use, BMPs, and others.

- **Class 3 Streambanks**—These streambanks are contaminated but they may have varying amounts of deep, binding, woody vegetation holding the streambank in place. Remedial actions possible for these areas include no action or minor actions to enhance woody vegetation within the buffer corridor and/or BMPs. Design factors include current vegetation status, current streambank stability, knowledge of underlying contamination, and current and future land use.

Special Cases: Tributary Systems and Secondary Channels. Streambank and riparian corridor buffer polygons will be delineated for evaluation and classification for appropriate remedial actions on sites beyond the main channel of the Clark Fork River within the OU. These are tributary streams and secondary channels of the Clark Fork River. These "special case" sites may be classified as Class 1, 2, or 3 streambanks with the application of CFR RipES.

- **Tributary streams**—Tributaries within the OU (e.g., Lost Creek, Warm Springs Creek, Dutchman Creek, Racetrack Creek, Cottonwood Creek, and others) may have transported contaminants from other NPL sites in the basin, or may have been contaminated during depositional flood events from the Clark Fork River. Tributaries having perennial flow will be protected with a streambank buffer 25 feet wide within the OU, unless this width extends outside the historic 100-year floodplain of the Clark Fork River.

– **Secondary channels of the Clark Fork River**—Also of concern are secondary channels forming islands on the Clark Fork River floodplain. Secondary channels with perennial flow throughout their length and having connection to the main channel of the river at both ends will also be protected with a flexible or variable streambank and riparian corridor buffer of 25 feet, unless this width extends outside the historic 100-year floodplain of the Clark Fork River.

Historic 100-Year Floodplain Contaminated Soils. Contaminated soils within the historic 100-year floodplain may consist of slickens, impacted soils and vegetation areas, or slightly impacted soils and vegetation areas.

Slickens (exposed tailings). These areas generally lack vegetation (have less than 25 percent canopy cover) and present the principal waste in the Clark Fork River OU, along with Class 1 Streambanks. Estimated in the RI/FS at about 167 acres, but possibly up to 250 acres in Reach A with limited slickens in Reach B, these slickens areas are contaminated, causing largely bare ground. Scattered throughout Reach A, the areas number in the hundreds, are usually a fraction of an acre in size, and are too toxic to support most vegetation or soil organisms. These areas are usually easy to recognize. Remedial action for most of these areas is removal, except as described below. Removal of slickens areas adjacent to an active channel is part of the streambank remedial action.

Slickens (exposed tailings) are characterized as follows:

1. Because of phytotoxic condition, these areas are generally devoid of vegetation, supporting less than 25 percent live plant canopy cover.
2. Tufted hairgrass (*Deschampsia cespitosa*) is present, if there is any live vegetation.
3. Efflorescent metal salts are visible on the soil surface during dry periods.

Slickens (exposed tailings) and underlying contaminated soil that meet these criteria will be removed, with a limited exception. For the exception to occur, all of the following criteria as defined by CFR RipES must be met:

- The slickens area is small—less than 400 square feet
- The contamination is less than 2 feet deep
- The contamination is widely dispersed or separated by vegetation
- The contamination is contiguous with impacted soils and vegetation areas that will be treated in place
- The area is not too wet or otherwise unable to be treated effectively

Slickens that are less than 400 square feet and less than 2 feet in depth and not too wet will be treated in-situ if they are next to or contained within an impacted soils and vegetation area that is designated to be treated in-situ. These small slickens within or next to areas to be treated in-situ will be removed if they are thicker than 2 feet or too wet to treat.

Isolated, small slickens areas (less than 400 square feet) that are not contiguous with impacted soils and vegetation areas will not be removed in most cases. These areas are too small to bring in removal equipment without significant destruction of the surrounding unimpacted areas. In-situ treatment will be done in these areas where practicable. These areas will also not be mapped under the CFR RipES protocols.

Impacted Soils and Vegetation Areas. Estimated in the RI/FS at about 700 acres, but possibly up to 1,760 acres in Reach A, these sparsely vegetated areas amount to everything between slickens and slightly impacted soils and vegetation areas that have an ecologically sound plant community. Impacted soils and vegetation areas will generally be treated in-situ, unless the tailings and impacted soils in a given area extend more than 2 feet below ground surface. In that case, the tailings and impacted soils will be removed. Other impacted soils and vegetation areas that are too wet for implementation of in-situ treatment techniques will also be removed. Old river channels (oxbows) and wetlands in the floodplain will be evaluated using CFR RipES. If they have high quality vegetation and score 75 percent or more on CFR RipES, they will not be remediated. If they have impacted vegetation and soils, and the contaminated tailings and soils are deeper than 2 feet, or the soil is too wet, they will be removed and replaced in a manner that re-establishes a productive and healthy wetland. If the tailings and contaminated soils are less than 2 feet deep in an old oxbow channel, and it is not too wet, the area will be treated in-situ.

Impacted soils and vegetation areas are characterized as follows:

1. The degree of phytotoxicity in these areas is quite variable, but they do sustain at least 25 percent live plant canopy cover.
2. Tufted hairgrass (*Deschampsia cespitosa*) has greater than 1 percent canopy cover.
3. Efflorescent metal salts may be visible on the soil surface during dry periods.
4. Small individual areas of exposed tailings (that appear as small slickens) may be present.
5. Concentrations of COCs within the soil profile exceed the geometric mean values for unimpacted soils for Reach A of the Clark Fork River OU. Copper is used as a surrogate for the COCs; soils with copper concentrations exceeding 300 ppm within the profile are considered impacted by mining-related activities.
6. The minimum polygon size is 400 square feet.

Slightly Impacted Soils and Vegetation Areas. These areas do not meet the characteristics or definitions of streambank and riparian corridor buffer, slickens (exposed tailings), or impacted soils and vegetation area. They are generally well vegetated and display no visible evidence of contamination from tailings, although the soil may contain copper contamination above 300 ppm. Remedial actions for these areas are no action, or BMPs and ICs. These may be included in a land management plan along with adjacent areas being addressed by the remedy.

Slightly impacted soils and vegetation areas are characterized as follows:

1. The area expresses no evidence of phytotoxicity and has less than 1 percent bare ground caused by contaminated tailings.
2. Tufted hairgrass (*Deschampsia cespitosa*) has less than 1 percent canopy cover.

3. No efflorescent metal salts are visible on the soil surface during dry periods.
4. Concentrations of COCs within the soil profile exceed the geometric mean values for unimpacted soils for Reach A of the Clark Fork River OU. Copper is used as a surrogate for the COCs; soils with copper concentrations exceeding 300 ppm within the profile are considered impacted by mining-related activities.
5. The minimum polygon size is 400 square feet.

CFR RipES Application. The characterization of contaminated soils above will account for the majority of land within the Clark Fork River OU that is to be considered for remedy. (CFR RipES is not applicable to the historically irrigated upland areas. Historically irrigated lands will be evaluated for human health risks and remediated if necessary, as described above.) After a polygon has been delineated using the delineation criteria described above, application of the flow-chart keys in Exhibits 2-20, 2-21 and 2-22 will provide the correct classification, and Exhibit 2-23 will indicate the correct subset of remedial actions from which to draw the remedial design.

Miscellaneous Site Types. There are several landscape areas or features that may contain contaminated materials by having one of the following:

1. Conveyed contaminated waters, i.e., drainage ditches
2. Contamination through historical irrigation, i.e., current or abandoned ditches
3. Subsequent separation of the historic 100-year floodplain from the present Federal Emergency Management Agency (FEMA) 100-year floodplain by human structures such as highways and railroads

These areas, with the exception of historically irrigated fields (which will be evaluated under the human health component), are to be considered in the remedial design. If this consideration shows soil contamination above action levels or impacted soils and vegetation communities, appropriate remediations will be designed for these areas.

These miscellaneous site types are further defined as:

1. Old river channels and oxbows that may be well vegetated, but may have thick deposits of buried contaminated tailings in contact with groundwater. (These sites do not meet the criteria for slickens or impacted soils and vegetation areas as defined in this document.)
2. Irrigation ditches, drainage ditches, and canals that may have conveyed contaminated waters and sediment. Irrigation ditches that conveyed historically contaminated water will be sampled through a representative sampling program to be developed to ensure that contaminant concentrations do not cause unacceptable risks to human health or the environment, as further described in Section 13.8.3, page 2-119.

EXHIBIT 2-20. Generalized Key for Categorizing CFR RipES Polygons

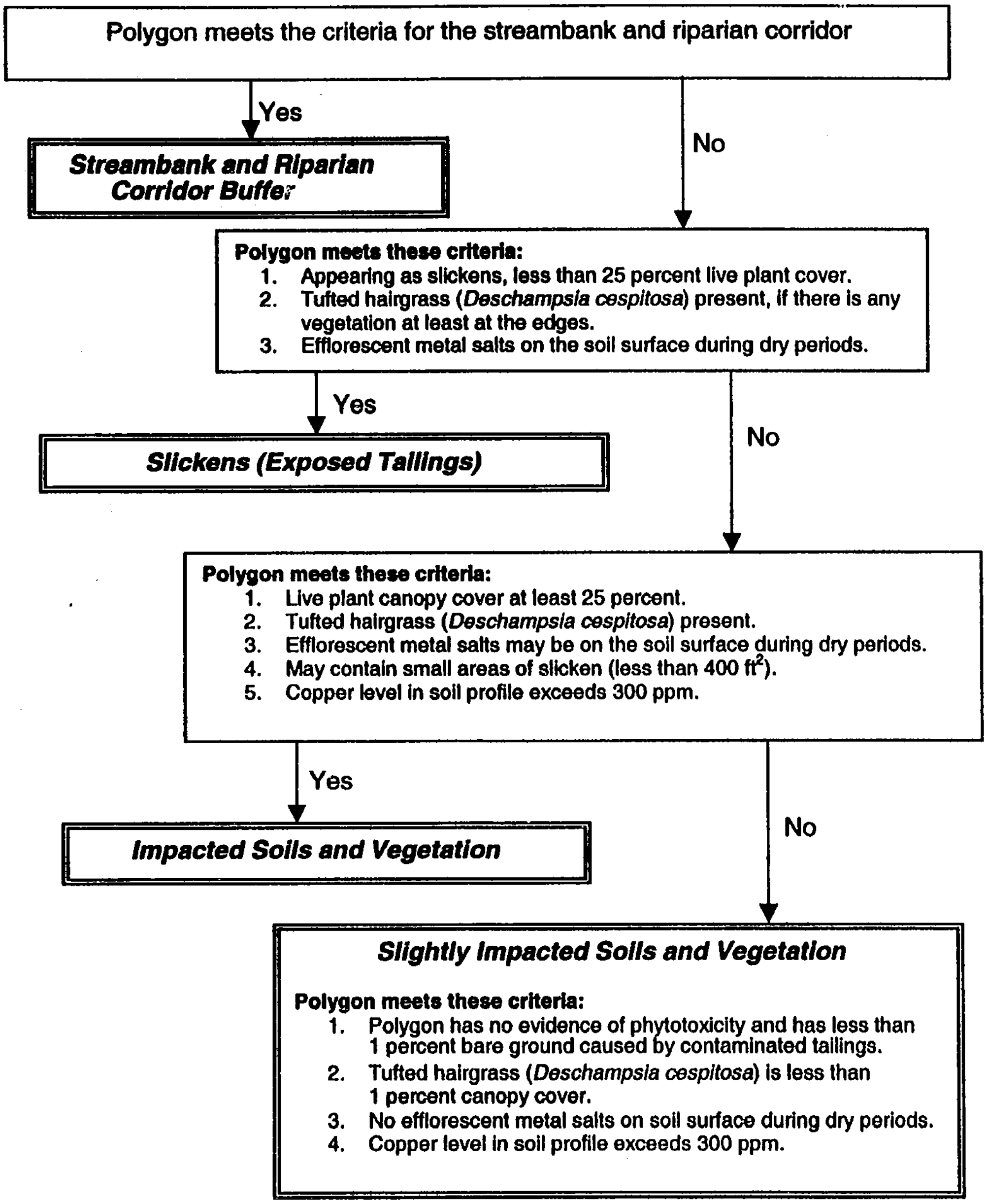

EXHIBIT 2-21. Polygon Characterization Within the Historic 100-Year Floodplain

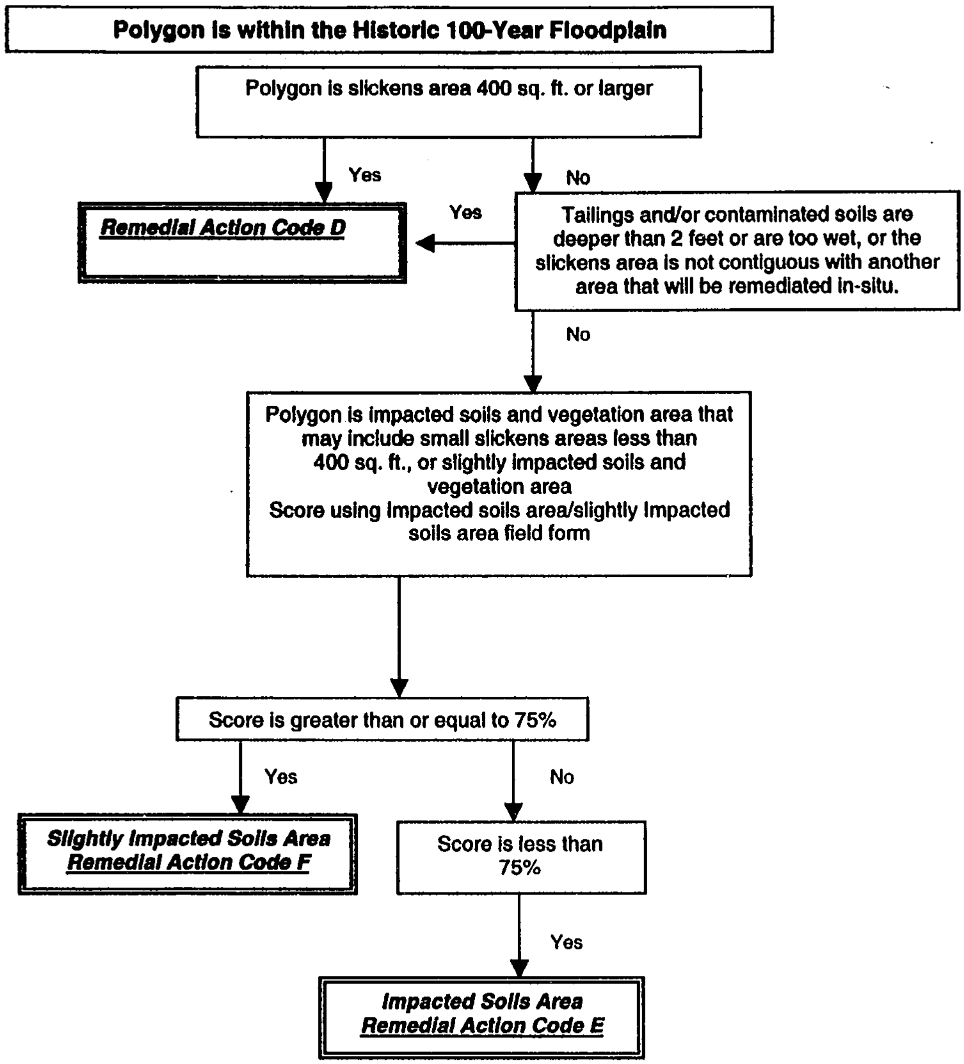

EXHIBIT 2-22. CFR RipES Polygon Categorization Within The Streambank Buffer Corridor

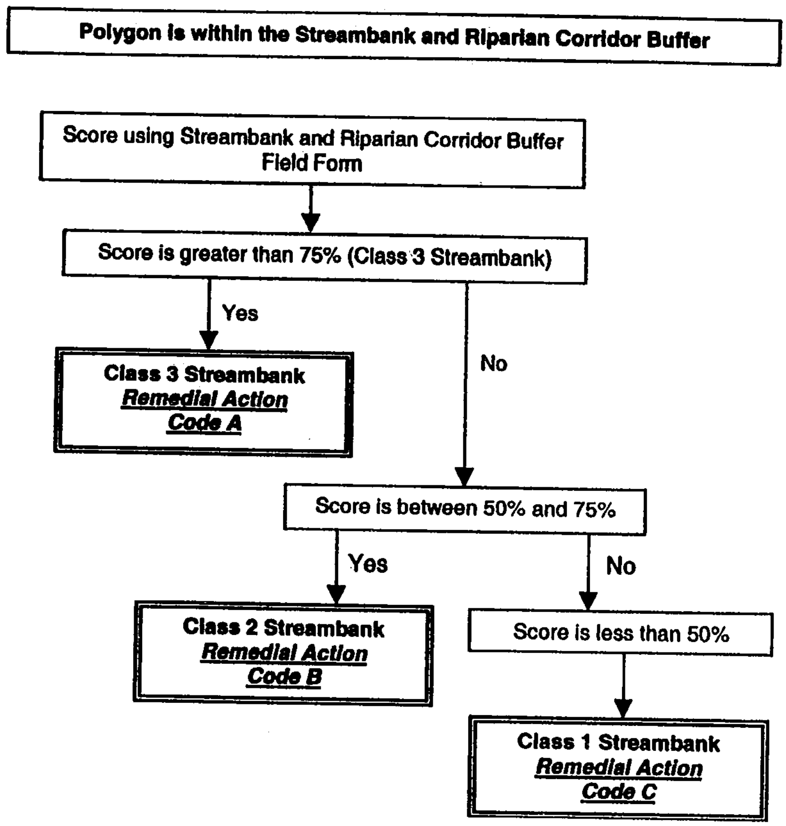

EXHIBIT 2-23
Preliminary Remedial Action (RA) Codes for Major CFR RipES Polygon Categories

CFR RipES Polygon Category	RA Code	Preliminary Remedial Action Recommendations[1]
Class 3 Streambank	A	Remedial actions include no action or minor actions to enhance vegetation within the buffer corridor and/or BMPs.
Class 2 Streambank	B	Polygons with Class 2 streambanks will receive remedial actions intended to secure streambank stability through establishment of appropriate deep, binding, woody vegetation. Remedial actions may include reconfiguration of the bank, minor removal/replacement and/or in-situ treatment of contaminated materials, followed by supplemental planting of deep, binding, woody vegetation and revegetation with appropriate herbaceous species and BMPs.
Class 1 Streambank	C	Class 1 streambanks will receive treatment(s) chosen from a set of remedial actions depending upon site-specific characteristics. Remedial actions for this class include removal of phytotoxic materials and revegetation with deep, binding, woody vegetation, and an understory of appropriate herbaceous species. BMPs.
Slickens (Exposed Tailings)	D	Remedial action for most of these areas is removal, with the exception as noted on page 2-95. Removal of slickens areas adjacent to active channel are part of the streambank remedial actions, BMPs, and ICs.
Impacted Soils and Vegetation Areas	E	Impacted soils and vegetation areas will generallv be treated in-situ, with two exceptions: 1) when the tailings and contaminated soils in a given area extend more than 2 ft below ground surface (in which case, all of the material will be removed), and 2) when the tailings and contaminated soils are in a saturated condition which makes in-situ treatment impracticable (in which case, the contaminated material will be excavated). Old river channels in the floodplain will be addressed as described on page 2-96, along with BMPs and ICs.
Slightly Impacted Soils and Vegetation Areas	F	Remedial actions are no action, or BMPs.

[1]Data gaps need to be identified in order to define remedial action(s) and to satisfy initial remedial design specifications. These may include pH, concentrations of COCs in the soil profile, depth to permanent groundwater level, thickness of contaminated materials, acid-base account, organic matter level, and others.

3. Perennially or seasonally flooded wetlands that may contain contaminated sediment with hydrologic connectivity to groundwater and surface waters.

4. Contaminated areas that may be located within the historic floodplain, but outside the current FEMA defined floodplain. Some of these areas are separated from the main part of the floodplain by I-90, railroad berms, and other built structures.

These minor site types may contain much higher levels of contamination than adjacent areas because of particular historic circumstances. Removal, if feasible, will often be required. Therefore, these areas will be delineated as separate CFR RipES polygons, and evaluated accordingly for their potential need for remediation.

CFR RipES Process and Integration With Remedial Design. The CFR RipES process is to be applied to all lands within the historic 100-year floodplain of the Clark Fork River. The CFR

RipES process is a critical detail design component which, for a specific landowner, involves a series of steps beginning with delineation of land ownership boundaries and noting areas having similar ecological attributes on aerial photographs, and ends by delineating specific locations of slickens, impacted soils and vegetation, slightly impacted soils and vegetation and classification of Class 1, 2, and 3 streambanks. While at the property, additional design data and information will also be collected necessary to complete remedial design. It is envisioned that during remedial design, coordinated teams of ecologists and engineers will work together, with the ecologists scoring polygons and engineers surveying the polygons, and both working to produce GIS maps of the landscape, and collecting samples and other required design data and information for analyses. The general remedial design data gathering process is as follows:

1. Delineate existing land ownership boundaries, irrigation ditches, and fencelines on aerial photographs.
2. Delineate preliminary polygons on aerial photography for the following soil categories (minimum mapping unit size is 400 ft^2; and this must account for 100 percent of the property that lies within the historic 100-year floodplain):
   a. Slickens (exposed tailings)
   b. Impacted soils and vegetation areas
   c. Slightly impacted soils and vegetation areas
3. Delineate a preliminary streambank and riparian corridor buffer zone approximately 50 feet wide, on aerial photographs along both sides of the streambank. The buffer zone extends back approximately 50 feet from the bankfull stage on each side of the river. The actual width of the approximate 50-foot buffer zone is a function of the geomorphic characteristics of the river. For example, in those instances where the river abuts a high bank that is considered upland, the buffer zone width is reduced.
4. Conduct initial consultation with the landowner about present and future management desires (e.g., grazing pasture versus alfalfa field) and any potential modifications to remedial design such as location of temporary haul roads.
5. Obtain access from the landowners to conduct a CFR RipES evaluation of their property.
6. Conduct CFR RipES field reconnaissance, adjust preliminary polygon boundaries, and sample and collect data for scoring and classifying the following polygons:
   a. Soils polygons (slickens, impacted soils and vegetation areas, and slightly impacted soils and vegetation areas)
   b. Streambank polygons (Class 1, 2, and 3 streambanks)
7. Delineate the approximate 50-foot streambank and riparian corridor buffer zone into preliminary polygons based on live vegetative canopy cover and/or canopy cover of deep, binding, woody vegetation. There is a strong bias for leaving existing deep, binding, woody vegetation undisturbed. The minimum mapping unit of these polygons is 20 linear feet of streambank with a maximum length of 500 feet.
8. Delineate areas of deep, binding, woody vegetation outside the approximate 50-foot streambank and riparian corridor buffer zone. These represent areas where mature

woody vegetation may be obtained and utilized as tipped over willows in streambank treatment types 3 and 4 (these conceptual streambank treatment designs are summarized in item 10 of this list and described in Appendix B). There is a strong bias to leaving deep, binding, woody vegetation undisturbed.

9. Further subdivide (categorize) the streambank based on actively laterally cutting streambanks/critical shear stress areas. Assign a streambank treatment type to each subdivision. The minimum mapping unit length for this purpose is 10 linear feet of streambank. Data will be collected to determine the critical shear stresses associated with each streambank.

10. Conceptual streambank treatment designs were developed as examples for the upper Clark Fork River and are described in Appendix B. The conceptual treatments are as follows:

    a. No treatment necessary—This applies to streambanks where there is adequate deep, binding, woody vegetation already in place, and no additional work on the site is necessary.
    b. Treatment 1 (vegetation augmentation)—This treatment requires augmenting existing deep, binding, woody vegetation with additional woody vegetation.
    c. Treatment 2—This treatment is for streambanks where low critical shear stresses are acting on the immediate streambank. This treatment involves the use of pre-vegetated coir roll-sod with a toe protection of fiber-rolls pre-vegetated with sandbar willow (*Salix exigua*).
    d. Treatment 3—This treatment is for streambanks where moderate critical shear stresses are acting on the immediate streambank. This treatment involves the use of pre-vegetated coir roll-sod with a toe protection of fiber-rolls pre-vegetated with sandbar willow (*Salix exigua*) on top of a rock roll. Also included is tipped over mature willow on a spacing that will depend on river morphology along the streambank to deflect and dissipate the energy of the stream.
    e. Treatment 4—This treatment is for streambanks where high critical shear stresses are acting on the immediate streambank. This treatment involves the use of pre-vegetated coir roll-sod with a toe protection of rock mattress. Also included is tipped over mature willow on a spacing that will depend on river morphology along the streambank to deflect and dissipate the energy of the stream.

    Other site-specific conditions may dictate design modifications.

11. Identify data needs to be filled to define remedial action(s) and to satisfy initial remedial design specifications. These may include pH, concentrations of COCs in the soil profile, depth to permanent groundwater level, thickness of contaminated materials, acid-base account, soil organic matter level, and others identified. Sampling will be conducted on the polygons to fulfill these gaps using a Sampling and Analysis Plan developed for the OU. The intent is to sequence the CFR RipES scoring and sampling concurrently so that data are collected in an efficient manner and landowner disturbance is minimized.

12. Develop a preliminary design for the property. Components of preliminary design include the following:

    - Base map with layer displaying 1-foot contours

- Location of CFR RipES-defined polygons for streambanks, slickens, impacted soils, and vegetation areas
- Transportation corridors and existing roads
- Locations of temporary fences
- Locations of potential staging areas
- Locations of wetlands and irrigation and drainage ditches
- Locations of water access points for livestock
- Locations of temporary bridges
- Locations of vegetation that is to be removed during clearing and grubbing, and locations of salvageable vegetation that can be used during remediation
- Other appropriate data and information

13. Present preliminary remedial design and preliminary construction schedule for the property to the landowner, including weed management plan, preliminary grazing management plan, BMPs, and ICs. Obtain landowner feedback.
14. Prepare revised design and construction schedule based on landowner feedback.
15. Submit to appropriate agencies for review. Obtain agencies' approval, and then obtain landowner access for implementation.

13.6.2 Removal of Exposed Tailings

Specific areas of exposed tailings or slickens areas, as defined previously (determined by CFR RipES to be slickens areas resulting from phytotoxicity), and contaminated soils beneath these areas, within the entire floodplain, will be removed to the required depths determined by CFR RipES sampling and analysis. Removal utilizes the excavation of severely impacted soils with low pH and generally higher metals and arsenic concentrations, followed by replacement with appropriate soils that can then be successfully revegetated.

Typical types of excavation equipment, such as backhoes, hydraulic excavators, bulldozers, front-end loaders, and 10 to 12 cubic yard dump trucks, will likely be used for this task. In some locations, it may be possible to utilize scrapers or larger capacity off-road haul trucks effectively, depending upon specific circumstances. Within the near-river channel riparian corridor, removal will be conducted with the appropriate smaller sized equipment to avoid disruption of existing streambank stability, including the streambank toes and existing woody vegetation with valuable deep binding root mass. Live deep binding woody vegetation would not be disturbed. Soils can be removed at higher excavation rates in areas away from the river; whereas along or near the streambank, excavation must be slower and more precise so as not to damage the stability of the riverbank or existing woody vegetation.

Post removal confirmation sampling will be required to verify that a sufficient depth of soils have been removed prior to starting backfill operations. Visual examination for tailings material, as well as discrete soil sampling at predetermined locations and depth intervals, are initially suggested. Further details will be determined during remedial design.

To accommodate the use of different types of equipment at various slickens locations, temporary haul roads must be built to provide access points to and from existing public roads. In addition, the use of temporary bridges or other special equipment may be necessary to move materials across the river, if no access to public roads is available (generally a problem on the west side of the river south of Deer Lodge). Once on public roads, the excavated slickens materials will be transported and placed into the Opportunity Ponds Waste Management Area Repository. Closure of this area is a responsibility under Anaconda Regional Water and Waste Soils Operable Unit (ARWWSOU) remediation. Depending upon location, portions of certain public roads may need to be upgraded to carry the required loads and to ensure safe conditions. Construction BMPs, such as watering haul roads, wetting temporary stockpiles of excavated materials, use of covered haul trucks to minimize fugitive dust emissions, use of traffic safety haulage plans, and the use of silt fences and runoff straw bales, will be mandated and utilized during removal, backfilling, or when other disturbances occur on site. The U.S. Fish and Wildlife Service (FWS) Biological Opinion and continued consultation with the FWS may mandate additional BMP measures.

After removal, and as appropriate depending on the land use (to be determined during design), an equivalent volume of clean soil backfill will be brought to the site and placed in the excavations, leveled, and compacted for revegetation. Backfill material will be selected based on considerations of in-situ compacted density, and will be tested to determine its suitability as a growth media for both riparian and herbaceous vegetation. Consideration will be given to reducing backfill needs, where possible. Borrow material source areas must be carefully planned to minimize amount of disturbed land, and must be adequately reclaimed. The backfill soils must meet the criteria listed below (see also Section 13.8.2.1, page 2-113):

- Match strict chemical and physical specifications (e.g., soil type, grain size, metal and arsenic concentrations, percent organic, etc.)
- Be free of weeds and weed seeds
- Contain the required quantity of organic materials and other nutrients necessary for growth media

Wetlands, ponds, and marshes are also common along the floodplain. Despite the contamination that usually resides within the underlying soils of these wetlands areas, they are generally biologically robust. The Selected Remedy seeks to enhance areas near existing wetlands, ponds, and marshes, and to create new wetlands where there are willing landowners and where ideal opportunities for new wetlands present themselves during remedy implementation. Such areas must be sufficiently distant from the active channel so as not to contribute to the floodplain's susceptibility to destabilization during remedy implementation. Old channels and oxbows that are filled with tailings and impacted soils from previous floods will be addressed through the CFR RipES process (as described in Section 13.3, page 2-85). Such features, after removal of contaminated materials without backfill, would rapidly fill from high groundwater and become healthy wetlands, ponds, and marshes.

13.6.3 Treatment of Impacted Soils and Vegetation Areas

As an initial step in remedial design, CFR RipES will be utilized to locate and map all areas within the OU on the landowner's property containing impacted soils and vegetation communities, including specific additional information on the affected soils, at various depths. Areas containing slightly impacted soils vegetation communities will be located and mapped as well. Areas defined to contain impacted soils and vegetation will be remediated using in-situ treatment, with the exceptions described previously. Areas containing slightly impacted soils and vegetation will not require any active remediation.

In-situ treatment utilizes the incorporation and intimate mixing of chemical amendments into moderately impacted soils (prior to treatment, the soils typically exhibit low pH values). The treatment is designated to raise the pH, attenuate and dilute metals and arsenic, and allow these soils to be successfully revegetated.

The use of in-situ treatment techniques first requires the determination of the acid generation potential of the soils and the depths to which the soils are impacted. Numerous soil samples will be collected to appropriate depths during the CFR RipES investigations. The samples will be composited appropriately and analyzed for pH, acid base account, specific metal and arsenic concentrations, soil organic content, and other factors. This data will be reviewed and evaluated as part of the remedial design process.

Prior to the addition of chemical amendments, the areas to be treated are typically cleared and grubbed of dead woody vegetation to facilitate the spreading and incorporation of lime. The chemical amendment typically consists of a mixture of minus 60 mesh agricultural grade limestone ($CaCO_3$) and calcium oxide (CaO), applied in sufficient quantities to the grubbed areas to exceed the acid generating capacity of the existing impacted soil. Techniques for adding the lime amendment involve the use of typical agricultural lime spreaders where the rate of application can be varied to the needs of the soil. Where access to areas may be limited, placement may be done by smaller equipment such as a small front end loader or even by manual application. Lime is applied and then incorporated by deep plow, agricultural tiller, or special mixers, depending upon depth. A number of passes with the plow, tiller, or mixer are typically needed to assure complete mixing with the soil. Agricultural tillage up to depths approaching 12 inches can be completed with a disc, chisel, or moldboard plow. For deeper tilling, incorporation and mixing of lime and soil has been successfully completed to depths up to 30 inches with the use of a Baker disc type plow being pulled by a large tractor or bulldozer, again using several right or acute angle passes. Other large or small rotary-type mixers have also been used to very effectively mix and incorporate amendments in dry conditions. These application techniques can be utilized in areas with shallow groundwater, if the area is not too wet to permit equipment access, and if the mixer blends amendments without the formation of unmixed "balled-up" materials.

13.6.4 Streambank Stabilization, and Re-Vegetation of the Riparian Corridor and Historic 100-Year Floodplain

This component of the *Selected Remedy* is intended to significantly reduce streambank erosion from each impacted property along Reach A and isolated portions of Reach B of the Clark Fork River OU, and to re-establish both a protective riparian vegetative corridor as well as healthy herbaceous vegetation in the remainder of the historic 100-year floodplain.

This component of the Selected Remedy, when implemented, should significantly improve surface water quality over the long term.

The design condition should represent the most adverse condition likely to occur on the stream, but this is not typically the largest flood. Generally, some intermediate discharge in the 2- to 10-year return frequency exerts the greatest force against the channel boundary and is selected as the design discharge (Fischenich 2003). All streambank stabilization treatments will be designed to withstand a 10-year return flow flood event from the time of installation without the benefit of expected future plant growth. Selection of these criteria is based on the following assumptions:

1. Planting prescriptions are correct to achieve the stated objectives.
2. All coir and other materials employed in streambank stabilization treatments will have an effective lifespan of 10 years.
3. All plantings, including those in pre-vegetated coir products, will achieve growth within 10 years sufficient to take over the task of holding the streambank together from the coir (i.e., hold the streambank from eroding) without further dependence on the coir matrix. In other words, *Salix exigua* (sandbar willow) will have achieved approximately 75 percent or more of its potential growth form in 10 years and all other woody plants will have achieved between 50 to 75 percent of their potential growth form during this same timeframe.
4. Initial plants have sufficient water to achieve maximum growth. In other words, water is not a limiting factor.

Appendix B contains a detailed description of the Clark Fork River hydrology and design considerations as they apply to the Selected Remedy. This appendix also contains examples and illustrations of streambank stabilization applications that will be used in the Selected Remedy.

13.6.5 Access and BMP Enforcement

The Clark Fork River OU remedial action may be implemented by PRPs under EPA order or judicial decree, or it may be implemented by the agencies. EPA orders and decrees require PRPs to pay reasonable compensation to landowners or tenants for access. The loss of production from the land affected by implementation of the remedial actions, including remedial components such as road building and staging areas, will be an important issue that must be addressed in any access agreement.

BMPs are an important part of the remedy and are discussed in detail in Section 13.9.1, page 2-120. BMP implementation and other maintenance and monitoring functions such as fence maintenance will also be important issues to address when BMP agreements are developed. Lost land use and reasonable compensation will be important components of these discussions.

EPA will work cooperatively with landowners and tenants as the implementers of the remedial action seek access and long term BMP agreements. EPA will insist on fair and reasonable compensation for remedial activities that affect productive land use.

BMP implementation and enforcement will require additional post-ROD discussion among interested parties. Clearly defined BMPs and the ability to ensure that BMPs are implemented is very important to the success of the remedy. As noted in Section 13.9.1, page 2-120, EPA will work with the PRP, other stakeholders, and the Department of Agriculture to develop an effective, funded, and enforceable BMP program.

13.7 National Park Service: Grant-Kohrs Ranch National Historic Site

As discussed in Section 5.2.2.1, page 2-20, the Grant-Kohrs Ranch National Historic Site (Grant-Kohrs), a unit of the National Park System administered by NPS, lies within Reach A of the Clark Fork River OU. EPA and NPS have identified location-specific ARARs with respect to hazardous substance releases within or potentially affecting Grant-Kohrs. These location-specific ARARs are derived from the NPS Organic Act, 16 U.S.C. §§ I et seq. (the Organic Act), and the enabling legislation for Grant-Kohrs Ranch (Pub L. 92-406, 86 Stat 7632 [1972]; Grant-Kohrs Act). As described further in Part 3, *Responsiveness Summary*, and within this section of the *Record of Decision*, attainment of these ARARs requires remedial measures that ensure the historic ranch landscape of the late nineteenth century is reestablished, preserved, and sustained for future generations in a condition unimpaired by hazardous substances.

Specifically, the Grant-Kohrs Act, read in combination with the Organic Act, establishes location-specific requirements for the Grant-Kohrs Ranch National Historic Site; the attainment of which is necessary to enable this national historic site to fulfill the statutory purposes for which it was established. These location-specific ARARs translate into defined performance standards for the remedial action to attain. These performance standards require that the selected remedial action re-establish self-producing and sustaining native riparian vegetative communities and species that are required by the ARAR standard.

The NPS has undertaken extensive research to define specifically the native riparian vegetative species that should be used as indicators to determine whether these performance standards are attained. This research indicates that 17 different plant communities should be found within the riparian zone of the Grant-Kohrs Ranch National Historic Site (see Exhibit 2-24). The number of species ranges from 5 to 35 depending on the community. (For the detailed species list from which each community will be formed, and the minimum number of species that will be required in each community, see Appendix E.) These baseline plant communities would be present today, if the past and ongoing releases of hazardous substances from upstream mining activities had not occurred. Each plant community has been defined in terms of the composition of native plant species that would be expected within each community and the relative abundance of each species.

To attain site-specific ARARs for the Grant-Kohrs Ranch National Historic Site, the CFR RipES system will be applied as described in Section 13.6.1.1, page 2-92. Polygon delineation will identify areas that fall within one of the six major categories of sites defined by CFR RipES. Slickens areas will be excavated and removed in the same manner as other slickens areas within the Clark Fork River OU. Areas within the approximate 50-foot streambank buffer zone from which tailings and contaminated soils are excavated will be backfilled to

EXHIBIT 2-24
Plant Community Baseline List for the Grant-Kohrs Ranch National Historic Site

Habitat Type (HT) or Community Type (CT) Name	Deer Lodge Valley Distribution Category[1]	Estimated Percentage of Grant-Kohrs Remediated Area	Floodplain Position Where the Type Is Located
Tree Dominated Types			
Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/ Cornus stolonifera*) CT	Minor	8-12	Recent point bars and low floodplain terraces
Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT	Incidental	<1	Slightly moist to mesic floodplain sites
Shrub Dominated Types			
Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT	Major	18-23	Drier areas in old oxbows, floodplain terraces
Water Birch (*Betula occidentalis*) CT	Major	12-18	Moist areas, old oxbow banks, streambanks
Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT	Major	12-18	Moist areas, old oxbow, streambanks
Sandbar Willow (*Salix exigua*) CT	Minor	8-12	Recent point bars, streambanks
Woods Rose (*Rosa woodsii*) CT	Minor	1-3	Drier areas on upper floodplain terraces
Western Snowberry (*Symphoricarpos occidentalis*) CT	Minor	1-3	Drier areas on upper floodplain terraces
Mountain Alder (*Alnus incana*) CT	Minor	1-3	Moist areas, old oxbow banks, streambanks
Graminoid Dominated Types			
Beaked Sedge (*Carex rostrata*) HT	Minor	5-8	Wet sites, old oxbow, or slough bottoms
Bluejoint Reedgrass (*Calamagrostis canadensis*) HT	Minor	3-6	Moist areas, old oxbow, and streambanks
Western Wheatgrass (*Agropyron smithii*) HT	Minor	3-6	Drier open areas away from the river channel
Water Sedge (*Carex aquatilis*) HT	Minor	2-4	Wet sites, old oxbow, or slough bottoms
Common Spikesedge (*Eleocharis palustris*) HT	Incidental	<1	Ponded areas, water edges
Forb Dominated Types			
Common Cattail (*Typha latifolia*) HT	Minor	2-4	Ponded areas, old oxbow, and slough bottoms

[1]A *major type* occupies extensive acreages in at least some portion of the riparian or wetland zone; a *minor type* seldom occupies large acreages but may be common on smaller areas within the riparian or wetland zone; and an *incidental type* rarely occurs within the region, or is limited to narrow site conditions and/or very localized occurrence.

the pre-remedy elevations where necessary for streambank stability. Areas outside the 50-foot streambank buffer zone may be backfilled or not, based on NPS preference. Backfilling with uncontaminated soils appropriate to floodplain conditions, as defined in Section 13.8.2, page 2-113, will occur along streambanks where needed for bank stability after removal of phytotoxic material.

Impacted soils and vegetation areas identified using CFR RipES will generally be treated in-situ. During remedial design, EPA and the NPS will carefully evaluate site-specific conditions to confirm the efficacy of in-situ treatment as a means to attain NPS ARARs. If EPA and the NPS determine that in-situ treatment is not suitable to attain such ARARs, excavation and removal will be considered and implemented as appropriate to attain ARARs.

Impacted soils and vegetation areas that receive in-situ treatment will be monitored using defined performance standards, described in Section 13.11, page 2-126, and additional criteria developed jointly by EPA and NPS during remedial design. Monitoring will continue beyond the irrigation period to determine survival rates under natural hydrologic conditions. In consultation with NPS, a 10-year vegetation monitoring plan will be developed during the remedial design phase. The 10-year period is appropriate because of the arid nature of the Deer Lodge Valley climate, the likelihood of extreme weather events within that timeframe, and to account for the slower growth rate of the desired woody species. This plan will include plant species composition, distribution, density, and other parameters appropriate in evaluating the degree to which the desired plant communities have been successfully reestablished.

Failure to meet performance criteria, as determined jointly by EPA and NPS, will result in revegetation efforts appropriate to the desired plant community in a given polygon. Replanting of decadent or unhealthy vegetation in the same polygon will be limited to three replanting attempts, after which excavation and removal will be implemented. Excavation and removal under these circumstances will be performed in the same manner as for slickens areas. With the concurrence of EPA and NPS, excavation and removal may be triggered without attempting the maximum number of replanting attempts, but only after a thorough review of monitoring data.

Areas of relatively healthy, mature woody vegetation cover (willows, alder, water birch, and cottonwood) will be left undisturbed. These areas constitute approximately 53 acres of the fenced riparian area within the Grant-Kohrs Ranch National Historic Site. This determination to leave such undisturbed areas is based on the premise that such areas will have a greater benefit if left in place because of the geomorphic stability provided by extant root systems. This does not mean, however, that such areas are unimpaired or uninjured. On the contrary, these areas, too, deviate from the baseline plant communities native to the Grant-Kohrs Ranch National Historic Site. Nevertheless, EPA and NPS have determined that, on balance, RAOs will be best achieved if such areas are left undisturbed.

Streambank stabilization within the Grant-Kohrs Ranch National Historic Site will be required along a minimum of 9,450 feet of concave "cutbanks" using soft technologies, as described in Section 13.6.4, page 2-106. A possible exception to the use of such soft technologies is the river bridge where channel migration threatens both the road and bridge. In that area, EPA and NPS may determine that it is necessary to utilize more rigid bank protection measures. To the extent possible, however, stabilization of those banks will be achieved in a manner that appears natural and as well vegetated as is technically feasible. Existing bare rip-rap will be removed to the extent possible. Additional rip-rap or visible gabion baskets will not be utilized. In addition, irrigation ditch risk and possible remedial action shall be addressed in accordance with the criteria established in Section 13.8.3, page 2-119.

13.8 Additional Selected Remedy Considerations

Some additional considerations for the Selected Remedy, including caring for existing vegetation, steps in the revegetation process, and measures for wetlands, ponds, marshes, and irrigation ditches, are described in this section.

13.8.1 Existing Vegetation

On sites that will receive remedial treatment by removal of contaminated soil or of in-situ mixing and amendment of less contaminated soil, some woody plants will be affected. The desired option is to leave as many as possible of certain "preferred woody plant species" in place that are already growing on the floodplain within the Clark Fork River OU. This will be accomplished by working around them whenever practicable and whenever the overall goals of the project can still be achieved by doing so.

The set to be considered "preferred woody species" includes the following plants:

- All willow species (*Salix* spp.)
- Water birch (*Betula occidentalis*)
- Red-osier dogwood (*Cornus stolonifera*)
- Common chokecherry (*Prunus virginiana*)
- Western serviceberry (*Amelanchier alnifolia*)
- Mountain alder (*Alnus incana*)
- Cottonwood (*Populus trichocarpa)*

Because these plants occur on all kinds of sites and distribution patterns, a systematic protocol is needed for deciding when to remove and when to keep a particular plant. The key in Exhibit 2-25 provides a systematic procedure for deciding this issue on the basis of location and condition of plants.

There is a strong desire to leave existing woody vegetation undisturbed and to improve poorly vegetated streambank areas because of its importance in preventing erosion, channel migration, and floodplain destabilization. All construction activities will utilize construction BMPs to protect healthy vegetation and the river. All remediated lands will be protected to allow adequate establishment and growth of new vegetation. Once this regrowth time has occurred, the land will be brought back into the normal land use activities as outlined by each landowner. The land will be monitored to ensure adequate growth and establishment of the vegetation, especially the woody vegetation along the streambank.

Weed control will be a critical element of remediation. An aggressive integrated weed management program will be implemented during the construction cycle. Any time soil is disturbed, weeds will try to invade; therefore, an herbaceous mixture of grasses and forbs will be seeded into all treatment areas. All sites will be monitored and treated for 5 years for weed infestations as part of the post-construction monitoring process. Weed control is addressed in depth in Section 13.10, page 2-123.

EXHIBIT 2-25
Key for Deciding Whether to Remove or to Keep a Plant

Instructions: Read both parts of each couplet pair carefully before deciding which part is the better answer. Decide which side of the couplet pair is most nearly true (this will require best professional judgement in each case), and proceed to the next couplet indicated, until you arrive at an answer to remove or keep.

1. The plant is near the streambank (within 10 ft, approximately one mature shrub width) 2
    2. Contaminated soils contiguous to the plant are being removed, AND visibly contaminated soil extends into the main root mass of the plant, AND bank stabilization Treatment 2, Treatment 3, or Treatment 4 is being implemented at this point along the bank .... REMOVE
    2. Contaminated soils contiguous to the plant are not being removed, OR visibly contaminated soil does not extend into the main root mass of the plant, OR bank stabilization Treatment 2, Treatment 3, or Treatment 4 is not necessary at this point along the bank .... KEEP
1. The plant is not within 10 ft of the streambank 3
3. The plant is more than 10 ft from the streambank, but is within the Streambank Riparian Buffer Zone) 4
    4. The area that includes the plant is a slickens (Contaminated soil will be removed) 5
5. The plant is isolated (10 ft or farther from other plants of preferred woody species) 6
    6. The plant is of seedling/sapling age class OR is decadent (has more than 30 percent dead wood in its upper canopy) .... REMOVE
    6. The plant is of mature age class AND is not decadent (Does not have more than 30 percent dead wood in its upper canopy) .... KEEP
5. The plant is not isolated (It is closer than 10 ft to other plants of preferred woody species; i.e., a subpolygon can be drawn around a group of preferred woody plants, including this one, to keep undisturbed within the slickens area of contaminated soil being removed.) .... KEEP
    4. The area that includes the plant is to have impacted soils treated in-situ 7
7. The plant is isolated (10 ft or farther from other plants of preferred woody species) 8
    8. The plant is of seedling/sapling age class OR is decadent (has more than 30 percent dead wood in its upper canopy) .... REMOVE
    8. The plant is of mature age class AND is not decadent (does not have more than 30 percent dead wood in its upper canopy) .... KEEP
7. The plant is not isolated (it is closer than 10 ft to other plants of preferred woody species; i.e., a subpolygon can be drawn around a group of preferred woody plants, including this one, to keep undisturbed within the slickens area of contaminated soil being removed.) .... KEEP
3. The plant is outside the Streambank Riparian Buffer Zone 9
    9. The plant is isolated (is 10 ft or farther from other plants of preferred woody species) .. REMOVE
    9. The plant is not isolated (it is closer than 10 ft to other plants of preferred woody species; i.e., a subpolygon can be drawn around a group of preferred woody plants, including this one, to keep undisturbed within the slickens area of contaminated soil being removed.) .... KEEP

In general, slickens areas are nearly devoid of vegetation, and part of the CFR RipES definition of a slickens area or barren tailings is less than 25 percent vegetation cover of live plants. Another part of the CFR RipES characterization is that tufted hair grass is almost always present along the margins of the slickens and/or sometimes within the slickens (tufted hair grass is tolerant of lower pH and metals, and is therefore used as an indicator of such conditions). These plants will be removed along with the slickens as part of construction activities. Larger plant species such as willow clumps and water birch can be left in place, especially if they are adjacent to or surrounded by slickens, if they are robust, and if they provide deep binding root mass. They also provide browse for cattle and wildlife, structural diversity in the herbaceous vegetation community that will be established, and wildlife habitat. Appropriate care, through construction BMPs, will be exercised to identify existing vegetation that can be sacrificed and vegetation that is not to be disturbed. Existing vegetation in areas categorized with moderately dysfunctional plant communities may have significant vegetation that is to be retained during in-situ treatment. Landowner-specific remedial designs will address existing vegetation within and adjacent to barren slickens.

13.8.2 Revegetation Processes

Successful reclamation of land contaminated by mining activities within the Clark Fork River OU is defined as the establishment of plant communities capable of stabilizing contaminated soils against wind and water erosion, reducing COCs transport to groundwater, reducing the risk to human health and the environment, and compliance with Performance Standards, in perpetuity.

For the alternatives to meet the objectives, the physiochemical characteristics of soils media must meet minimal specifications to allow establishment of vegetation. Design criteria must be specifically linked to the physical characteristics of a particular area or polygon targeted for revegetation, along with its current and reasonably anticipated land use (which in most areas will be agriculture). Given the size of the potential remedial units, each parcel of land or polygon will be evaluated for a specific standard that is linked to land use, depth and level of soil contamination, and the physical conditions of the site. Furthermore, the physical conditions and landscape position of the site will influence the percent cover that can be maintained. Design criteria may include, but are not limited to, parameters set forth for depth of rooting media, texture, pH, metal concentration, organic matter, specific conductance, surface manipulation, and appropriate seed mixture.

13.8.2.1 Cover Soil for Excavated Areas

Cover soil design specifications for use as replacement soil after excavation of slickens and other areas are required to meet the following specifications:

- **Depth:** The entire depth of contamination is to be removed from slickens areas. In some areas, sufficient cover soil will be placed to bring area to pre-removal grade. In other areas, cover soil may not be used. When cover soil is used, the goal is to achieve a hospitable rootzone of at least 18 inches of non-toxic rooting media, except for residential yards. This is the absolute minimum for the long-term success of the vegetation. Enough cover soil needs to be applied to account for settling, sloughing, and erosion.

- **Coarse fragment contents:** Particles greater than 0.079 inches (2 millimeters) will constitute less than 45 percent (by volume) of the cover soil. Maximum rock size is 6 inches (15 centimeters) in diameter.

- **Texture:** Sandy loam or finer (to have the proper water holding capacity). Clay soils are not acceptable.

- **pH:** Between 6.5 and 8.5 for entire depth of cover soil.
- **Metal concentration:** Cover soil guidelines: arsenic < 30 ppm, cadmium < 4 ppm, copper < 100 ppm, lead < 100 ppm, and zinc < 250 ppm.
- **Organic matter:** Cover soil or engineered media having >1.5 percent (by weight) of composted organic matter in the upper 6 inches for upland areas. Cover soil imported into riparian areas must have organic matter levels of approximately 5 to 7 percent or similar to adjacent areas that are not contaminated and will not be remediated.
- **Specific conductance:** Cover soil or engineered rooting media must be less than 4.0 deciSiemens per meter for entire depth of cover soil.

13.8.2.2 Criteria for In-Place Treated Areas

Key components for successful implementation of in-situ reclamation are as follows:

- **Neutralizing amendments and pH control:** Only lime materials approved for use by the lead agency will be used for in-situ treatment. The field lime rate is based on acid base chemistry, the appropriate equation, and adjustments for calcium carbonate equivalence, particle size, and moisture. The pH of the growth media for treatment actions must be greater than 6.5 and less than 8.5, or equal to or greater than 7.0 and less than 8.5 if neutralizing amendments are used in the implementation of the action. The acid/base account of the treated growth media must be greater than zero.
- **Soil arsenic concentration:** For any remedial action taken at a specific location, the final growth media, either the cover soil or treated soil, is to meet the human risk based arsenic concentrations for the current land use and reasonably anticipated land uses.
- **Depth of amendment incorporation:** The general approach is to treat the entire depth of contamination at a specific location with neutralizing amendments. Tillage should be deep enough to incorporate beneficial materials (e.g., organics, clean soil) where practicable.
- **Organic matter:** The organic matter content within the treated rootzone in riparian areas must be equivalent to organic matter in adjacent, non-contaminated riparian soils. For upland areas, the organic matter in the top 6 inches of the treated growth media must be 1.5 percent.
- **Vegetation selection:** Native vegetation—including grasses, shrubs, and trees—will be specified for many areas that will receive remedial actions. For other areas, the vegetation community to be established will depend on current and future land uses and consideration of landowner preferences. Remediated areas that are to be used for intense agricultural production—for example, irrigated alfalfa—will be seeded with appropriate agronomic species. Vegetation performance will be integrated into specific remedial designs based primarily on end land use.

13.8.2.3 Best Reclamation Practices

Best reclamation practices are to be implemented during the implementation of the Selected Remedy. Some of these are identified below:

- **Site preparation:** Prior to implementation of the design for specific location or polygon, certain amounts of preparatory work will commonly be required. Preparatory work may include, but is not limited to, access roads, grading, clearing, grubbing, marking, development of staging areas, debris removal, amendment stockpiling, and stormwater control feature installation. The timing of site preparation tasks should be specified in design documents.

- **Temporary stormwater BMPs:** Control of sediment caused by remedial construction is required where surface water and wetlands are present adjacent to remediation areas, or where ditches and overland flow may convey stormwater from remediation areas to surface waters. BMPs for stormwater control are to be implemented.

- **Grading:** Regrading of rough surfaces should be considered in advance of tillage where erosional rills and gullies are sufficiently deep and pervasive that they limit amendment application, tillage, and related components of the remedial action. Site grading should be considered in concert with clearing and grubbing.

- **Clear and grub:** Removal of unwanted debris (refuse) and vegetation is to be part of the remedial design. Good judgment is imperative in selecting existing vegetation that should be preserved and vegetation that limits implementability and/or treatment effectiveness. Preference is given to preserving deep, binding woody vegetation, which consists of species that are important to the post-remedial land use and to large stems that could only be established over a great length of time.

- **Preservation of Existing Vegetation:** Preservation of desirable existing vegetation is an important consideration for areas to be excavated, treated in place, and within the riparian buffer zone. See Section 13.8.1, page 2-111, for additional detail.

- **Cover soil application:** After excavation of contaminated tailings/soils, cover soil is to be imported that meets specific chemical and physical specifications. For additional detail, see Section 13.8.2.1, page 2-113. Normal engineering practices are to be implemented to apply, grade, etc. These are to be specified in the remedial design(s).

- **Amendment selection, application and mixing:** Lime products include the family of neutralizing solids that may be applied to contaminated soils and include calcium carbonate ($CaCO_3$), calcium oxide (CaO) and calcium hydroxide ($Ca(OH)_2$). Reagent grade materials (99 percent purity or greater), ground to less than 200 mesh and with less than 1 percent water content, are preferred. Lime sources with lower levels of purity, coarser particle size, and elevated water content may be acceptable for use with EPA approval. Organic amendments include composted manure, manufactured compost, and other products. The use of organic materials that have not been composted, such as wood chips, sawdust, or fresh manure, are not considered sufficiently beneficial for plant growth in the short term and are not applicable for use in the Clark Fork River OU. Other amendments, such as phosphorus to minimize arsenic mobility, may be considered as part of the remedial design.

  Surficial application of amendments may be accomplished by a variety of equipment. Measurement of the amendment rate is required for calibration of the spreading equipment and for documentation of the rate of application for post-construction reporting. Seeding immediately following tillage will generally not be possible because of chemical and physical limitations. Lime addition and tillage tend to dry and loosen the soil making seeding physically difficult. The treated soil will typically require some period of "mellowing" to ensure that unacceptably high pH conditions (greater than pH 8.5) no longer persist following lime addition. The mellowing period may be as short as hours or as long as months depending on the geochemistry of the soil.

- **Seedbed preparation:** To facilitate seeding and improve the probability of seeding success, seedbed preparation is necessary. This includes leveling, breaking up of large clods, and reduction of soil seedbank and competitive plants. Appropriate equipment is employed to produce a good seedbed.
- **Fertilization:** Addition of nitrogen, phosphorous, and potassium fertilizer to treated and cover soils is required. Fertilization application should be performed prior to tillage such that phosphorous and potassium fertilizer are incorporated into the soil. Fertilizer should be tilled into the top 4 to 6 inches of the soil. Application of fertilizer can be accomplished by various approaches, including mechanized and hand powered spreaders. A standard fertilizer rate is not acceptable across the entire Clark Fork River OU. Research has shown (RRU 1993) that plant growth in highly contaminated soil is dependent on high phosphorus application rates, especially in soils with high levels of soluble arsenic.
- **Seeding:** Seeding of vegetation without supplemental irrigation should be performed either in the spring in advance of wet June weather, or in the fall after the growing season. Seeding may be performed by two principal methods: drill or broadcast seeding. Calibration and confirmation of seed application rates can be performed similarly to amendment application rate confirmation by placement of a tarp of known area on the ground and subsequently weighing or counting the number of seeds applied following seeding of the area. Weed free seed will be used with known germination rates. The seed source and quality should be reported in post construction documentation. Seed bag tags should be collected to provide documentation of the seeded species in parallel with the seed rate. Herbaceous communities are to be established that meet landowner management perspectives, which may include forage for cattle, agronomic crops, and others. Native plants that provide species and structural diversity will be emphasized for areas of wildlife use.
- **Planting:** In the riparian buffer zone, willow seedlings planted near the edge of the river and tipped-over willows are the first structures planted to stabilize banks. Bagged willows and mature willow transplants plus other woody species are also to be planted within the corridor. Remedial designs will specify numbers and species.
  - Disturbance of the streambank toe should be avoided or minimized. Care must be exercised to avoid destabilizing the outer streambank when removing or remediating in place. Removal of the toe of a streambank must be avoided. Unnecessary removal of a toe of the streambank will destabilize the entire streambank and result in accelerated erosion. Care should be taken during removal or in-situ treatment of phytotoxic soils to minimize any activity that may reduce the current streambank stability.

- To preserve geomorphic stability, the bank should be reconstructed to match its existing elevation, with as normal a streambank profile as possible. Removed materials will be replaced with suitable growth media-type soils meeting specific chemical and physical requirements.
- Once phytotoxic soils have been either removed and replaced with suitable soils or treated in-situ, appropriate revegetation of this streambank riparian buffer corridor or zone can be accomplished. All transplanting holes should be as small as possible to reduce fracturing of the streambank. This can be accomplished using an auger or other hole-producing equipment, instead of a backhoe, whenever possible.
- *Salix exigua* (sandbar willow) is to be the major plant used in the revegetation process. *Salix exigua* (sandbar willow) is a pioneer species that populates gravel bars and other riparian sites. The plant has adapted to high spring flows by flowering and setting its leaves on the falling limb of the hydrograph curve (i.e., immediately after high flow). This prevents the plant from having its leaves removed by high flow, and allows it to produce seed that can land on fresh, new sediment deposits. In addition, the plant has adapted to both ice flows and beaver activity. The plant is different from other native willows in the valley in that it is rhizomatous. Therefore, it does not form a clump of multiple stems from one set of roots, and it can rapidly invade a site from a single plant. *Salix exigua* (sandbar willow) also has a rapid growth rate of between 4 to 6 feet per year under optimal conditions. Currently, *Salix exigua* (sandbar willow) is the dominant willow along the Upper Clark Fork River, and is what one would expect to find along a river of this size in western North America. Therefore, the use of the plant in revegetation of the upper Clark Fork River would support the concept of developing a self-maintaining natural system.
- The key to any transplanting is to have the plant in contact with either the lowest water table encountered in a year or the capillary fringe at base flow. This can be accomplished by using an auger or other equipment attached to a tractor to drill a hole quickly and plant the material to the required depth. If this can not be done, then supplemental water is needed.
- Small containerized plants are generally more effective than willow stakes. Results from the use of willow stakes tend to show a success rate of around 20 to 30 percent after year 2. During the first year, a flush of new growth and a high rate of success seems possible (50 to 70 percent). However, after one winter season, only a small percentage of the plants grow the following year. Therefore, it is necessary to look at the success rate in the second growing season and not the initial growing season. This success rate has also been verified by Chris Hoag of the National Resources Conservation Service (NRCS) in Idaho, Eric Reiland of MFWP in the Clark Fork River watershed, and others throughout the West. On the other hand, the success rate for containerized plants (small plants of the 10T size) is typically around 80 to 90 percent in the second growing season. Even if one assumes the willow stakes are free, there is still a cost involved in collecting, preparation of the woody material, transporting, and planting of the stakes. In addition, three times the number of willow stakes would be needed to equal the survival rates of the containerized plants. When this is done, the costs are either the same or actually less for the

containerized plants. If there is a cost associated with obtaining the willow stakes, then the containerized material is substantially less costly. (For cost analysis, the entire process involved with collection, preparation, and planting of willow stakes versus growing and planting of containerized material was compared.) In addition, one does not have to deal with either a visual concern or a safety concern of having a series of "wooden stakes" sticking out of the ground and being a hazard for the public.

- Root-control bags are an excellent way to grow large plants in a short period of time. Some of the benefits of root-control bags include simple, cheap, and quick harvesting; retainage of 80 percent of the root system during harvesting, as opposed to up to 98 percent of the actively growing tree roots cut away during normal digging procedures; lower production costs; better quality plants mean better survivability; plant re-establishment is minimal; and smaller ball size means lower transportation and handling costs. Once planted, all holes need to be backfilled with soil and drenched with water to wash the soil around the roots to remove air pockets and to water the new transplants.

- Tipped-over *Salix exigua* (sandbar willow) can serve as drag control along the highly erosive streambanks and reduce the force of the river on the immediate streambank. The plants can be harvested with a backhoe, placed in a dump truck for transportation to the site, and off-loaded onto the ground. It is not necessary to be careful about keeping all of the soil with the roots. The plants can be placed using a backhoe. Root-control bag *Salix exigua* (sandbar willow) can be substituted for mature willows if there is a concern about finding enough plants for the treatment from the Clark Fork River floodplain. Immediately after placement, all holes need to be backfilled with soil and soaked with water to wash the soil around the root to reduce air pockets and to water the new transplants. The tipped-over *Salix exigua* (sandbar willow) will be placed, on average, approximately 15 feet apart. The actual distance will vary depending upon the amount of erosive forces being exerted on a particular streambank. During the planting process, techniques will be employed to avoid creating fracture lines along the streambank.

- Watering newly vegetated areas will enhance the vegetation's survival rate. Irrigation, combined with planting sprigs and transplants closer to the water table, should address the need for water. However, implementation must not compromise bank stability. *Salix exigua* (sandbar willow) represents 95 percent of the willow vegetation in this zone along the Clark Fork River.

- The *Salix exigua* (sandbar willow) will spread by rhizomes through time. It can be spaced far enough apart to allow approximately 5 years of growth to produce continuous cover.

- *Betula occidentalis* (water birch) will work in most areas and should be incorporated in the design. This species is a good anchor plant, but should not be expected to propagate like *Salix exigua* (sandbar willow) for spreading across the floodplain.

- Augering or other devices will be used as the primary method of creating a hole for transplants. An auger can be mounted on the back of a truck or trailer. This facilitates the use of smaller, more mobile rigs, which also translates into a smaller footprint and less damage.

- **Mulching:** Application of mulch should be used to stabilize reseeded areas prior to establishment of the seeded vegetation. Mulch serves to decrease water erosion, reduce wind velocity, reduce soil crusting, decrease rainfall impact, and decrease soil surface temperature and evaporation. Most typically, cereal grain mulch is spread at a rate of 2 tons per acre and subsequently crimped into the soil. The use of a green mulch can also be considered.

- **Irrigation:** Water will be applied as necessary to implement the remedy, and the water rights necessary to do so will be acquired.

- **Weed control:** Weed species represent one of the single greatest threats to long term success of soil based remedial actions taken in the Clark Fork River OU. Prevention of weed invasion at each site will require integrative management of many different factors, including preexisting weedy vegetation, proximity of weed seed source, density of vegetation established during reclamation, grazing practices following reclamation, competition among other species present, herbicide control programs, biological controls indigenous to the site, and other factors. A Weed Management Plan is described in Section 13.10, page 2-123.

- **Monitoring:** Monitoring of remediated areas is required to demonstrate that the Performance Standards described in this *Record of Decision* document have been met. Details of the Monitoring Program are described in Section 13.11.4, page 2-134.

13.8.3 Wetlands, Ponds, Marshes, and Irrigation Ditches

Wetlands, ponds, and marshes are common within the floodplain along the Clark Fork River and will be evaluated by CFR RipES. If vegetation is robust and tailings are not visible the area will not be remediated. If vegetation is impacted and tailings are visible, greater than 2 feet in thickness, or saturated, the contaminated material will be removed and replaced in a manner that re-establishes a productive and healthy wetland. If vegetation is impacted and the tailings and contaminated soils are less than 2 feet thick and not saturated, the area will be treated in-situ.

The Selected Remedy seeks to enhance areas near existing wetlands ponds and marshes, and to create new wetlands where there are willing landowners and where ideal opportunities for new wetlands present themselves during remedy implementation. Such areas must be sufficiently distant from the active channel so as not to contribute to the floodplain's susceptibility to destabilization during remedy implementation.

Historic and active irrigation/drainage ditches bisect the Deer Lodge Valley (Reach A) in a complex pattern of linear features. It is uncertain how many of these ditches may have conveyed contaminated water from the Clark Fork River. Ditches located within the historic 100 year floodplain (Clark Fork River OU boundaries) will be delineated on aerial photographs (showing existing property boundaries) with other topographic features. They will be incorporated into polygons established by the CFR RipES process and subject to the sampling and assessment procedures associated with that process (during remedial design). Remedial action will depend on the results of the CFR RipES assessment (particularly arsenic concentrations), but could include a variety of activities, such as the physical removal of visible tailings, in-situ treatment of impacted soils, complete abandonment of specific sections of ditches through grading and backfilling as part of the treatment process, construction of a new ditch as a replacement (if the ditch is active), or other measures. Historic ditches located outside of the historic floodplain will be evaluated case by case during remedial design.

13.9 The Role of ICs, BMPs, and Land Use Plans

As described in the Selected Remedy, BMP land use plans (defined as land management strategies) are proposed as important, supplementary parts of the Selected Remedy. General descriptions of BMPs that EPA sees as necessary to support a successful remedy are presented in the following text. Although the primary function of ICs and BMPs at the Clark Fork River OU is to support remedial objectives, attendant secondary benefits may be realized through their implementation, including improvements in wildlife habitat and livestock forage. Application of the remedy is not limited to implementation of BMPs.

13.9.1 Best Management Practice Plans (BMPs)

BMPs may be implemented by contractual agreements between private landowners, or by incentive based government programs such as the Federal Environmental Quality Incentives Program (EQIP) or the actions of local Conservation Districts. The main land use of the Clark Fork River floodplain is agricultural, thus the focus of BMPs is directed toward agricultural practices, particularly those associated with livestock grazing. Over the longterm, the objective of land use BMPs is to maintain the integrity of the remedial actions. A comprehensive monitoring plan will be developed as part of a ranch management plan. The construction phase of the remedy represents another arena for application of BMPs. Construction BMPs are discussed in more detail in Section 13.6.2, page 2-104. The following text discusses additional rationale and details for the implementation of grazing and other related BMPs.

The development of proper grazing strategies and BMPs is critical to the success of EPA's remedy for the Clark Fork River. These plans will be owner-specific, and ensure that revegetated areas—whether the subject of removal of contaminants, in-place treatment of contaminants, or contaminants left in place—are appropriately managed so that operation and maintenance (O&M) of these areas can occur and so that the important revegetation efforts are protective, comply with performance standards, and are sustained over time. The plans also ensure continued access, at appropriate times, by the agencies and their designees, as well as Atlantic Richfield Company personnel, to monitor and maintain the remedy. BMPs for removed areas would likely be less extensive and may discontinue once vegetation has achieved the desired performance standards. EPA believes it essential that these efforts are implemented on a wide scale within the Clark Fork River OU, and funded by the PRP in cooperation with the Department of Agriculture and local conservation boards. These efforts do not replace monitoring, O&M, or future work activities that remain the responsibility of the PRP.

In this section, EPA discusses grazing strategies, BMPs, and the process involved in developing grazing management plans for various landowners along the Clark Fork River.

All remediated lands will be protected to allow adequate establishment and growth of new vegetation. Once this time has occurred, the land will be brought back into the normal land use activities as outlined by each landowner. Extra caution will be needed if annual crops are grown on remediated land to ensure that farming techniques do not leave bare ground in sensitive areas exposed to erosion for significant periods of time. The land will be monitored to ensure adequate growth and establishment of the vegetation, especially the woody vegetation along the streambank.

On grazing lands, riparian pastures will be established in the Clark Fork River OU. A riparian pasture can allow for forage use by livestock while reducing any impacts to woody vegetation. Once the remediation and revegetation has taken place, the riparian zone is expected to produce a much greater amount of forage than it produces today. A riparian pasture with an appropriate level of use can provide the best of both worlds—herbaceous forage production for the landowner ***and*** maximum growth of woody vegetation to protect against erosion, soil loss, and floodplain instability. The appropriate livestock use levels will be determined and will follow those outlined in the documents by Hansen 1993, Hansen 1994, Ehrhart and Hansen 1997, and Ehrhart and Hansen 1998. Additional information on grazing in riparian zones can be found in articles by Hansen et al. 1995, Hansen et al. 2000, Adams and Fitch 1998, Fitch and Ambrose 2003, and by the Montana DNRC 1995, 1999, and 2001. In general, the key to success will be to monitor the use levels of the woody vegetation and not just the use levels on the herbaceous vegetation.

Invasive plant (weed) control will be a critical element of remediation (see Section 13.10, page 2-123). An aggressive integrated weed management program will be implemented during the construction cycle. Any time soil is disturbed, weeds will try to invade; therefore, an herbaceous mixture of grasses and forbs will be seeded into all treatment areas. All sites will be monitored and treated for 5 years for weed infestations, as part of the post-construction monitoring process.

Grazing is a complex issue that does not lend itself to a simple, "one size fits all" answer. The development of a comprehensive management plan that deals with the importance of woody vegetation and reduced streambank impacts is essential for the health and well-being of the Clark Fork River floodplain. The landowner will be consulted to understand the vision they have for their piece of land. Once this is done, reasonable and attainable goals and objectives will be developed for their land. In some cases, no fences will be needed because the piece of land is used for hay production or a crop. In other situations, the existing large pasture may be cross-fenced to allow for a rotational grazing system that provides for reduced impacts (reduced browsing of woody vegetation and reduced streambank trampling) in the riparian zone and periods of rest resulting in a healthy riparian zone. In other cases, a fence running a couple hundred feet back from the stream, but parallel to the stream, will allow for the development of a riparian pasture. Riparian pastures are one of the most successful options for the following reasons:

1. When land is fenced "like-with-like" (in homogeneous units), landowners can more easily control livestock distribution.
2. Animal distribution is improved in both uplands and riparian areas, which will often allow the landowner to increase sustainable carrying capacity.

3. Providing effective control over livestock grazing during high risk periods allows for the most rapid recovery of riparian area health and productivity.
4. As a component of a landowner's riparian area goal, a riparian pasture will help restore and maintain woody vegetation.

Finally, only as a last resort would fencing of a narrow riparian corridor (for example, the approximate 50-foot corridor) be attempted. These narrow corridors are too small to effectively manage except as an exclusion zone from livestock grazing. Corridor fencing may be done for those situations where the landscape and property ownership boundaries preclude one of the other options. In other words, corridor fencing will be considered for those riparian areas where all other management options would fail.

Livestock grazing and proper riparian management are not incompatible goals. There are examples of working ranches with healthy riparian systems throughout North America that did not eliminate grazing from the riparian zone. What was eliminated was improper grazing, not all grazing.

A set of BMPs does not mean a landowner will have a functioning and healthy riparian zone. Usually, the step that is missed is the development of a ranch management plan that takes the generalized ideas of a BMP and develops reasonable and attainable objectives specific to each piece of ground. The BMPs are really the overall goals for a piece of land, while the objectives are the specifics as to how those goals will be met. For example, a goal (BMP) may be to reduce browse levels on woody vegetation to allow for the growth and maintenance of a shrubby corridor near the river. Another goal (BMP) may be to reduce streambank trampling and shearing. These goals do not tell a landowner how to accomplish them. That is where a riparian management plan comes into play and the goals are made specific for a piece of land.

Appendix C contains a list of key ideas to keep in mind when developing BMPs (goals) and a riparian management plan (Ehrhart and Hansen 1997 and 1998). Appendix C also contains a discussion on the process involved in developing a riparian or wetland ranch management plan (Hansen 1993 and 1994). Ranch management plans along the Clark Fork River will be based on this process.

Grazing of the remediated sites will be allowed based upon the criteria defined in the vegetation and performance section (Section 13.11.1.2, page 2-128).

ICs necessary for the Selected Remedy are identified in the human health component of this *Record of Decision*. In addition, supplemental ICs, such as conservation easements or deed restrictions, may be useful for lands addressed by the remedy. EPA will continue to explore these types of ICs during the remedial design process.

13.9.2 Off-Site Livestock Watering

In cases where livestock access to drinking water from the river is prevented by the need to protect remedial treatment, off-site provision for livestock water will be made. Such provisions may be temporary (e.g., during the construction work) or permanent, depending on the individual situation and the overall ranch management plan.

13.9.3 Fencing

Fencing will be used to accomplish objectives only as a last resort, or in accordance with the larger management plan for a particular property. Two types of fencing will be employed: temporary electric fence, and permanent fence.

Those remediated sites outside the streambank and riparian corridor buffer zone will be temporarily fenced to allow establishment of the newly planted vegetation. This will take approximately 2 years.

The revegetated remediated lands and stabilized eroding streambanks must be protected from livestock for the first few critical years. The timeframe will be a minimum of 5 years. A more detailed set of criteria are identified in the vegetation performance standards section. The intent is to protect these investments long enough for the newly planted vegetation to become established. For each property, the problem will be treated individually to find a solution that best meets the needs of the remedial action, as well as the requirements outlined in the ranch management plan and the vegetation performance standards.

An array of potential tools will be available to accomplish this protection. Among these are temporary fencing, permanent fencing, off-site watering, and riparian pastures.

Fencing is to be maintained by the potentially responsible party or remedy implementor until the remedy is determined to be operational and functional and 5 years of monitoring has occurred. After that, fencing may be required under BMPs and will be the responsibility of the landowner. The timeframe associated with this determination will be different based on whether it is within or outside the streambank and riparian corridor buffer zone.

13.10 Weed Management Plan

13.10.1 Invasive Plant Species Management

Invasive plants specialize in colonizing disturbed ground. They possess a number of physical traits that allow them to arrive at disturbed sites sooner and grow faster than other plants. With these advantages, they are able to out-compete native species, at least for a time. To counter this, EPA plans to avoid disturbing existing vegetation whenever possible. Such disturbance exposes the soil surface and reduces desirable vegetation, creating ideal opportunities for weed colonization. If disturbance cannot be avoided, all disturbed areas would be re-seeded or re-planted immediately. Native species or carefully chosen non-invasive introduced species will be used so that "vacant" or bare ground is quickly occupied by desirable plants.

Weeds also invade plant communities that have been degraded by land management practices that expose the soil surface and stress the desirable vegetation. Healthy native plant communities resist weed invasion. One of the best ways to avoid damaging plant communities is to manage livestock grazing to maintain good vigor of native perennial vegetation, especially grasses. Recreationists can also damage vegetation by overusing popular camping areas and creating trails. Dense, vigorous stands of perennial grasses are highly resistant to weed invasion. However, certain very aggressive weeds such as leafy spurge (*Euphorbia esula*), spotted knapweed (*Centaurea maculosa*), and Canada thistle (*Cirsium arvense*) can invade even well managed lands that have dense, vigorous vegetation.

All remedial activities on a property will follow strict guidelines for preventing the spread or introduction of invasive species to the site. Specific practices designed to avoid transporting weed materials and introducing weeds will be strictly followed and monitored. These will include the following:

- Educating all project personnel in weed identification and prevention. Local Weed Boards, such as the Powell County Weed Board, can provide assistance in this process.
- Assuring that all equipment used in remediation (including all vehicles and digging tools) be thoroughly washed and inspected for plant matter before entering the OU, and before entering a new property or new site.
- Requiring adherence by all personnel on site to prescribed practices for prevention of weed dispersal.
- Minimizing movement of personnel and vehicles on the property, and limiting access to specifically identified necessary routes, parking, and staging points.
- Designing all work to minimize soil surface disturbance.
- Re-vegetating all disturbed soil surfaces with appropriate vegetation (e.g., native species, including agronomic varieties for rangelands, and appropriate species for croplands, such as alfalfa) to deny opportunity to invasive species.
- Identification and control of pre-existing weed populations on the site to remove nearby sources of invasive species.

13.10.2 Invasive Plant Species Management

Control of invasive plants will be an integral and critical component of remediation. An aggressive integrated weed management program will be implemented during the construction cycle. An integral part of the remedial plan for every site upon which remedial work is done will include a comprehensive plan for controlling weeds. The approach taken is that all weeds will be controlled on property within the Clark Fork River OU upon which remedial work is completed. This is the best way to minimize the possibility that weeds from nearby sites would invade remediated areas. An aggressive campaign to control weeds already on a site will be undertaken concurrently with any other remedial work being performed.

Upon entry onto a property for commencement of remedial site assessment (application of CFR RipES, etc.), a weed inventory will also be conducted to locate and identify existing weed populations. With this information, an invasive species control plan specific to the site will be written and implemented in a manner integral to other work. Planning and implementation of invasive species control efforts will be conducted in collaboration with local weed authorities, such as the Powell County Weed Board.

A list of invasive species known to occur within the Clark Fork River OU is compiled below in Section 13.10.2.1. Specific information for each species about ecology, dispersal mechanisms, prevention techniques, eradication techniques, and other factors is contained in Appendix D. The information for this list came from a variety of sources, including our previous work experience and field data on the Clark Fork River OU (RWRP 1996), the

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- Requiring adherence by all personnel on site to prescribed practices for prevention of weed dispersal.
- Minimizing movement of personnel and vehicles on the property, and limiting access to specifically identified necessary routes, parking, and staging points.
- Designing all work to minimize soil surface disturbance.
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Center for Invasive Plant Management (CIPM 2003), the Montana Weed Control Association (2003), and the Colorado Department of Agriculture (2000). The occurrence of additional weed species within the Clark Fork River OU is possible. Any such occurrence encountered during the Clark Fork River OU cleanup will be addressed in a similar, species-specific and site-specific manner to control the spread and eliminate the infestation.

Invasive species will be monitored and any re-infestations will be treated for 5 years after the remedial construction and re-vegetation phase of the work is completed on each site as part of the post-construction monitoring process. After 5 years, weed management becomes the responsibility of the landowners.

Invasive species management during and after the remedial implementation phase will require coordination between the landowners and various governmental and private entities. Weed management is continually researched throughout the world. Various methods of control have been shown to work in a variety of conditions, including biological control (insects and pathogens), herbicides, grazing, mowing, hand pulling, and cultural practices. In most cases, a combination of several of these methods in conjunction with persistent monitoring and prevention measures will result in effective weed management. This combination of several methods into a site-specific and species-specific approach is called Integrated Weed Management.

13.10.2.1 Invasive Species of the Clark Fork River OU

Several invasive plant species are already well established within the Clark Fork River OU, while several others have a limited occurrence in Reach A. Some species are among the most commonly encountered plants in some areas, while others are rare thus far. Included below is a list of twelve species of invasive plants. Brief individual fact sheets are provided for each weed species in Appendix D. The information for this list came from a variety of sources, including the Center for Invasive Plant Management at MSU (CIPM 2003), and the Colorado Department of Agriculture (2000). The species include the following:

- Canada thistle (*Cirsium arvense*)
- Common Tansy (*Tanacetum vulgare*)
- Dalmatian toadflax (*Linaria dalmatica*)
- Houndstongue (*Cynoglossum officinale*)
- Kochia (*Kochia scoparia*)
- Leafy spurge (*Euphorbia esula*)
- Perennial pepperweed (*Lepidium latifolium*)
- Russian olive (*Elaeagnus angustifolia*)
- Russian thistle (*Salsola iberica*)
- Spotted knapweed (*Centaurea maculosa*)
- Yellow toadflax (*Linaria vulgaris*)
- Whitetop (*Cardaria draba*)

13.10.3 Integrated Weed Management Options

On each remedial site, a plan for management and control of invasive species will be written to address those weeds already present, as well as the potential for further invasion. Taken into account will be the unique set of physical site and managerial factors identified for the property in consultation with the landowner and other involved parties. This plan will be designed as an Integrated Weed Management approach based on the invasive species identified. It will draw from individually prescribed practices for each weed species using such options as those described in Appendix D (CIPM 2003, Colorado Department of Agriculture 2000). The individual Weed Plans will be filed with the local Weed Boards.

When establishing an integrated weed management plan as part of the Selected Remedy, EPA's ultimate goal is to restore and maintain a healthy desired plant community. It may not be realistic to expect that the land will be completely weed-free, even after years of weed management. Instead, getting weeds under control, by not spreading and not choking out the desired plant community growth, is the overall goal. Therefore, it is necessary to choose accordingly and realistically when deciding which methods to implement on a site-specific basis.

13.10.4 Monitoring and Evaluation

Information on monitoring and evaluation used is from a variety of sources including CIPM at MSU (2003) and the Colorado Department of Agriculture (2000). Monitoring is an essential component of a weed control program. Monitoring is the repeated collection and analysis of information to evaluate progress in meeting resource management objectives. Periodic observation of weeds being managed is necessary to evaluate the effectiveness of a weed control program. Monitoring saves money by helping to determine what is working and what is not. If EPA management objectives are not being met, weed control actions would need to be modified. Appendix D lists factors involved in an integrated weed management monitoring and evaluation plan (CIPM 2003, Colorado Department of Agriculture 2000).

13.11 Performance Standards and Remedial Goals

This section of the *Record of Decision* describes performance standards and performance evaluations for vegetation, groundwater, and surface waters.

13.11.1 Performance Standards for Streambank Corridor and Dysfunctional Plant Communities

The RAOs for floodplain tailings and impacted soils are as follows:

- Prevent or inhibit ingestion of arsenic-contaminated soils/tailings where ingestion or contact would pose an unacceptable health risk.
- Prevent or reduce unacceptable risk to ecological (including agricultural, aquatic, and terrestrial) systems degraded by contaminated soils/tailings.

Implementation of the Selected Remedy will accomplish these objectives.

The Selected Remedy must be compliant with ARARs or appropriate waivers as established for the Clark Fork River OU, described in Appendix A to this *Record of Decision*. There are one set of performance standards for the cleanup.

Successful reclamation of land contaminated by mining activities within the Clark Fork River OU is defined as establishing plant communities capable of stabilizing soils against wind and water erosion, reducing transport of COCs to groundwater and surface water, and compliance with ARARs or replacement standards, in perpetuity. Goals of the plant community are to establish a permanent vegetative cover to accomplish the following:

- Minimize direct contact with arsenic, thus reducing the potential risk of human exposure to acceptable risk-based levels.
- Provide geomorphic stability to streambanks, thus minimizing release of COCs to the river.
- Improve agricultural production by reducing or eliminating phytotoxic conditions, thus providing for multiple land uses.
- Minimize surface water erosion and COC transport to surface water through methods described in the Selected Remedy.
- Minimize transport of COCs to groundwater.
- Minimize wind erosion and movement of contaminated soils onto adjacent lands, thus eliminating human, agricultural, and wildlife exposure.
- Remediate contaminated soils to be compatible with the existing and anticipated future land use with minimal future maintenance activities.

Woody vegetation is an important factor in channel roughness and the dissipation of the streams' energy. Woody vegetation filters out sediments and provides for floodplain stabilization. Sedges, rushes, grasses, and forbs capture and filter out finer materials while their root masses aid in stabilizing floodplains by capturing filtered sediments. On sites where the potential exists for both woody and herbaceous vegetation, the cumulative effect of plant diversity greatly enhances stream function. Woody and herbaceous vegetation performance standards will be developed during remedial design and will include the following:

- Specific browse levels on woody vegetation to allow for the growth and maintenance of a riparian corridor of deep, binding woody vegetation near the river.
- Specific levels of streambank stability to limit streambank erosion and shearing. Streambanks will be designed for the 10-year return flow.
- The development and/or maintenance of different age classes of the key woody plant species on the site in order to maintain a viable self-sustaining plant community (e.g., seedlings, saplings, poles, and mature age classes for trees; seedlings, saplings, and mature age classes for shrubs).
- Specific levels of herbaceous vegetation stubble height will be established. Herbaceous vegetation stubble is required to trap and hold sediment deposits during run-off events and to aid in rebuilding streambanks and restoring and/or recharging aquifers.

13.11.1.1 Rootzone Performance Standards

The performance standards for treated soils are the same as those specified as rootzone design criteria described earlier in the *Record of Decision*, and include specifications for pH, acid/base account, organic matter, and concentrations of soil arsenic that relate to human health action levels and land uses. Rootzone performance standards will be measured at approximately two sample pits per acre, depending on site specific conditions.

- Soil arsenic concentrations in the 0 to 2 inches soil interval must be less than the human health action level for the current or reasonably anticipated land use. Confirmation sampling of the treated soil or the imported soil (after final grading) is required. The upper confidence limit of the mean soil arsenic concentration is to be evaluated in relation to the exposure unit.
- The pH of the treated growth media must be greater than 6.5, or greater than 7.0 if neutralizing amendments are used in the implementation of the action. The maximum acceptable pH is 8.5. The pH of the treated soils within a polygon is to be determined in the same samples collected for acid base account.
- The acid/base account of the treated growth media must be greater than zero. The acid base account of the treated soils within a polygon is to be determined with a minimum of two sample pits per acre. Incremental samples, at 6-inch intervals, are to be collected from within the treated zone and acid base account of each sample is to be equal to or greater than zero. The goal is to achieve neutralization within the entire treated zone.
- The organic matter content within the treated rootzone in riparian areas must be equivalent to organic matter (approximately 5 to 7 percent) in adjacent, non-contaminated riparian soils. For upland areas, the organic matter in the top 6 inches of the treated growth media must be 1.5 percent. At least one confirmation sample is required per polygon of treated soil or imported soil, with large polygons requiring multiple confirmational samples.

13.11.1.2 Vegetation Performance Standards

Performance of vegetation is to be integrated into specific remedial designs based primarily on end land use; thus, each land unit may have site-specific vegetation performance standards. The use of native species for revegetation will be emphasized for some open space areas, while appropriate agronomic species may be used in other areas. Vegetation performance attributes may include, but will not be limited to, the following:

- Woody browse levels
- Completeness of the canopy within the streambank buffer
- Vegetation cover
- Production
- Species richness
- Structural diversity
- Maturation periods
- Plant reproduction
- Evidence of successional processes

The relative importance of a characteristic is driven by the land management objectives. Agricultural production objectives would favor high forage value and high production with limited emphasis placed on species and structural diversity. Wildlife values are the inverse, with better habitat value associated with structurally complex vegetation and species diversity. The degree to which the remedy is able to satisfy the objectives of the landowner is dependent on the management objectives for a specific land area. Native vegetation—such as grasses, shrubs, and trees—will be specified for many areas that will receive remedial actions. For other areas, the vegetation community to be established will depend on current and future land uses. Remediated areas that are to be used for intense agricultural production—for example, irrigated alfalfa—will be seeded with appropriate agronomic species. Recommended performance standards are provided in Exhibits 2-26 through 2-28 (pages 2-130 and 2-132) and are grouped by post-remedial land use and landscape position. The standards are chiefly based on historical data for areas within the Clark Fork River that have been remediated or those that have been assessed in research and demonstration projects conducted within the basin during the last 20 years. ***Note:*** In many riparian plant communities, greater diversity means earlier seral, disturbed conditions. Some healthy, natural communities are monocultures (such as common cattail or sedge stands).

Methods to evaluate soil and vegetation performance standards are to be provided in remedial action construction quality assurance plans and in remedial action monitoring and maintenance plans. Assessments or points of compliance are to be conducted on a remedial polygon by polygon basis. Timing of evaluations relates to the determination of when remedy becomes operational and functional, and other monitoring and maintenance requirements as described below.

The performance of remedial efforts to reach minimum standards in terms of survival of live plant installation, vegetation composition, and canopy cover on areas within the historic 100-year floodplain will be assessed on a CFR RipES polygon basis. There are separate standards or guidelines for areas within the approximate 50-ft streambank riparian buffer zone and for areas outside the streambank riparian buffer zone. These performance standards and guidelines are written to assure the achievement of ultimate targets at 10 years from initial remedial treatment. Interim targets at intervals of 1, 2, 4, and 7 years out from initial remedial treatment are designed as checkpoints to assess that progress is being made along a trajectory that will reach the ultimate performance standard after 10 years.

In general, remedial efforts are not intended to permanently exclude these areas from agricultural uses, such as livestock grazing. However, livestock will be excluded from these areas for varying amounts of time while the vegetation in the newly implemented treatments becomes established. After minimal standards are met as prescribed, and in accordance with a ranch management plan written to achieve maintenance of remedial objective functions, livestock may be grazed on these areas within the stated guidelines specific to each property.

Polygons Within the Streambank Riparian Buffer Zone. On polygons within the streambank riparian buffer zone, there are two main concerns:

1. Achieving at least 80 percent canopy cover of preferred species of woody plants as quickly as practicable to control streambank erosion.
2. Achieving and maintaining an essentially complete (98 percent) canopy cover of combined woody and herbaceous perennial vegetation to prevent invasion of weeds.

Exhibit 2-26 presents interim survival rate targets for planted woody plants, canopy cover of preferred woody species, and total canopy cover of non-weed perennial vegetation (woody and herbaceous together). Overall guidelines for livestock grazing use are also included.

Livestock may be grazed on streambank riparian buffer zone areas only when the CFR RipES polygon vegetation has obtained a minimum canopy cover of 50 percent for preferred woody species and 98 percent total canopy cover of perennial vegetation. With proper livestock management, the percent preferred woody species canopy cover of 80 percent will be met 10 years after implementation of remedy. Other, more site specific, guidelines may also apply, as written into the particular ranch management plan for the property.

EXHIBIT 2-26
Vegetation Minimum Performance Standards and Guidelines to be Met on Streambank Riparian Buffer Zone Polygons

After Year Number	Percent Planted Woody Species Survival	Percent Preferred Woody Species Canopy Cover	Percent Total Canopy Cover of Non Weed Perennial Vegetation	Livestock Grazing Allowed If Other Criteria Are Met
1	90	NA	90-98	No
2	90	NA	95-98	No
4	X[1]	NA	98	No
5	X[1]	50	98	Yes[2]
7	X[1]	60	98	Yes[2]
10	NA	80	98	Yes[2]

[1] Any area 10 ft by 10 ft, or larger, lacking live plants of preferred woody species must be replanted with bag plants (not seedlings) of the same species at the original spacing and augered down to the capillary fringe of the water table.

[2] Livestock grazing in the streambank riparian buffer zone may be allowed 5 years after implementation of remedial treatment, when the CFR RipES polygon has exceeded all minimum canopy cover vegetation standards, and in compliance with ranch management plan language specifically written for streambank riparian buffer zone sites.

Preferred Woody Vegetation. Periodic monitoring will be conducted to assure progress on a community development trajectory that will achieve the required final minimum performance standards at 10 years after remedial implementation. Following remedial implementation on a CFR RipES polygon, these interim and final performance standards are required:

- Year 1: There must be 90 percent survival of the original planted material by species. Replant to the original number of plants any species that has less than 90 percent survival.
- Year 2: Same as Year 1.
- Year 4: There can be no openings without live plants of preferred woody species larger than approximately 10 feet by 10 feet. Replant any openings greater than approximately 10 feet by 10 feet with bag plants (e.g., not seedlings) at the original spacing. These re-plantings must be done so that the plant roots reach the water table or the ground water capillary fringe (this can be done with a portable power auger).
- Year 5: There must be 50 percent or more canopy cover of preferred woody species within the streambank riparian buffer zone CFR RipES polygon. If there is less than 50 percent, then replant with bag plants at original spacing, in order to achieve 50 percent canopy cover. Grazing allowed if all criteria are met.

- Year 7: There must be 60 percent or more canopy cover of preferred woody species within the streambank riparian buffer zone CFR RipES polygon. If there is less than 60 percent, then replant with bag plants at original spacing, in order to achieve 60 percent canopy cover.
- Year 10: There must be 80 percent or more canopy cover of preferred woody species within the streambank riparian buffer zone CFR RipES polygon. If there is less than 80 percent, then replant with bag plants at original spacing, in order to achieve 80 percent canopy cover.

Herbaceous Vegetation. Performance standards for herbaceous riparian vegetation will also be applied within the streambank riparian buffer zone. Standards are in terms of percent canopy cover attained for all vegetation on the polygon. Periodic monitoring will be conducted after remedial implementation to assure that the minimum standard is met and maintained. Following remedial implementation on a CFR RipES polygon, these interim and final performance standards are to be met:

- Year 1: There must be 98 percent canopy cover of the CFR RipES polygon by live vegetation. If there is less than 98 percent, determine cause(s) for failure, remediate any determined cause(s) for failure, and reseed all unvegetated areas.
- Year 2: Same as Year 1.
- Year 4: Same as Year 1.
- Year 7: Same as Year 1.
- Year 10: Same as Year 1.

Polygons Outside the Streambank Riparian Buffer Zone, but Within the Historic 100 Year Floodplain. Vegetation performance standards on polygons that lie outside the streambank riparian buffer zone are primarily aimed at achieving ground cover and productivity. These objectives are driven by the dual purposes of stabilizing any residual low levels of contamination and of meeting landowner operational needs. Success of vegetation remedial efforts will also be assessed on a CFR RipES polygon basis, and will be in terms of completeness of the canopy cover of all non-weed perennial vegetation. As on streambank riparian buffer zone polygons, the status of the vegetation should progress toward the ultimate goal of at least 98 percent canopy cover. Exhibit 2-27 presents the performance standard checkpoint intervals and grazing criteria. The herbaceous vegetation performance standard is the same as in the streambank riparian buffer zone.

Livestock are excluded for 2 years on areas that have received remedial treatment involving vegetation seeding or planting. After the initial 2-year period, livestock may be grazed on these areas if canopy cover of non-weed perennial vegetation reaches at least 98 percent, and in compliance with the management plan written for the property.

EXHIBIT 2-27
Vegetation Minimum Performance Standards and Guidelines to be Met on Polygons Outside the Streambank Riparian Buffer Zone

After Year Number	Percent Total Canopy Cover of Non-Weed Perennial Vegetation	Livestock Grazing Allowed If Other Criteria are Met
1	90-98	No
2	95-98	No
3	98	Yes[1]
5	98	Yes[1]

[1] Livestock may be grazed in accordance with a ranch management plan, if the non-weed perennial vegetation canopy cover is at least 98 percent.

Exhibit 2-28 represents performance standards for the non-riparian vegetation areas.

EXHIBIT 2-28
Performance Standards for Non-Riparian Vegetation

Post-remedial Land Use	Noxious Weeds & Undesirable Weedy Species	Minimum[a] Vegetation Cover by species	Minimum Species Richness[b]
Open Space and Wildlife Habitat	Zero tolerance policy for noxious weeds.	-	-
Upland Areas	Undesirable weedy species count a maximum of 5 percent toward vegetative assessment measurements.	45 percent live cover	5 species/100 m^2
Agricultural	same as above		
Upland Grazing		45 percent live cover	5 species/100 m^2
Crop		No cover standard, but production is to be statistically equivalent to County average production for that crop.	N/A
Recreational	same as above	45 percent live cover in upland areas, 100 percent in riparian areas	5 species/100 m^2 for upland areas,
Residential/Parks[c]	same as above	45 percent live cover in upland areas, 100 percent in riparian areas	Appropriate for type of residence or park

[a] Canopy cover method, noxious weeds count zero and undesirable weed species count a maximum of 5 percent toward live cover percentage.
[b] Each species must account for greater than or equal to 1 percent of the live plant canopy cover. Invasive species and undesirable weedy species do not count.
[c] This does not apply to the Grant-Kohrs Ranch National Historic Site.

13.11.1.3 Performance Standards of Streambank Treatments

Performance standards for streambank treatment work (monitoring of streambank remedial work and material installed to correct erosion problems apply to streambank reaches receiving remedial Treatment 2, Treatment 3, and Treatment 4) should be conducted from a raft or boat. The streambanks with either No Treatment Necessary or Treatment 1 will not be evaluated for erosion problems, unless erosion is determined to be caused by any of the other treatments (Treatments 2, 3, and 4). For other areas, the performance standards are as follows:

- Year 1: Replace or repair any installed streambank material that has failed, such as:
  - Erosion along the toe of the material
  - Erosion at either the upper or lower ends of the treatments
  - Repair/patch any tear of the coir fabric greater than 1 foot in length
- Year 2: Same as Year 1.
- Year 3: Same as Year 1.
- Year 5: Repair any failures (as discussed in Year 1) greater than 5 linear feet along the streambank. The repairs may include the use of either pre-vegetated coir logs or pre-vegetated roll sods that can be carried to the site and installed by hand.
- Year 10: Same as Year 5.

13.11.2 Performance Standards for Groundwater

The groundwater RAOs are as follows:

- Return contaminated shallow groundwater to its beneficial use within a reasonable time frame.
- Comply with State groundwater standards, including nondegradation standards.
- Prevent groundwater discharge containing arsenic and metals that would degrade surface waters.

Implementation of the Selected Remedy will accomplish these objectives. The Selected Remedy must be compliant with groundwater ARARs or appropriate waivers as established for the Clark Fork River OU, described in Appendix A.

Standards for groundwater are as follows (dissolved concentrations):

- Arsenic 10 µg/L*
- Cadmium 5 µg/L
- Copper 1,300 µg/L
- Iron 300 µg/L
- Lead 15 µg/L
- Zinc 2,000 µg/L

* = For wells used for domestic purposes, analysis shall be total, rather than dissolved.

Methods to evaluate groundwater performance standards, points of compliance, monitoring well locations and numbers, frequency of sampling and analysis, and reporting requirements are to be specified in remedial action monitoring and maintenance plans. EPA recognizes that there is uncertainty whether the Selected Remedy will achieve full compliance with these Performance Standards in all groundwater at all times. If full compliance is not achieved, EPA will consider alternatives to meet this standard, or, if warranted, invoke appropriate waivers of these standards. Timing of evaluations relates to the determination of when the remedy becomes operational and functional, and other monitoring and maintenance requirements as described below.

13.11.3 Performance Standards for Surface Water

Standards for surface waters provided in Exhibit 2-29 are based on a hardness of 100 mg/L using a total recoverable method, except for the waived copper standards and the arsenic human health standard. The copper and the Federal human health arsenic standards are based on the dissolved component.

EXHIBIT 2-29
Surface Water Standards[a]

	Acute	Chronic	Human Health
Arsenic	340 μg/L	150 μg/L	10/18 μg/L[b]
Cadmium	2 μg/L	0.25 μg/L	5 μg/L
Copper[c]	13 μg/L	9 μg/L	1,300 μg/L
Lead	81 μg/L	3.2 μg/L	15 μg/L
Zinc	119 μg/L	119 μg/L	2,000 μg/L

[a] Based on 100 mg/L hardness, total recoverable, acute, and chronic

[b] The performance standard includes both the Federal MCL, 10 μg/L, dissolved and the State WQB-7 standard, 18 μg/L, based on total recoverable analysis. Final determination of whether these standards will be consistently attained will depend upon upstream source control as well as implementation of this remedy.

[c] Federal Ambient Water Quality Criteria (dissolved; Gold Book 1986)

Methods to evaluate surface water performance standards, points of compliance, sample locations, frequency of sampling and analysis, and reporting requirements are to be specified in the Remedial Design documents. Timing of evaluations relates to the determination of when the remedy becomes operational and functional, and other monitoring and maintenance requirements as described below.

13.11.4 Performance Evaluations of the Selected Remedy

Following completion of Remedial Action, a need exists to maintain the remedy and demonstrate that the remedy is operational and functional, and ultimately that the remedy is successful. A Monitoring and Maintenance Plan is to be developed and is to include the following assessments of the success of the Selected Remedy by evaluating the following:

- Reductions in streambank erosion attained by the development of the riparian buffer zone corridor.
- Improvements in groundwater quality compared to Performance Standards for multiple points of compliance over a reasonable time period.

- Reduction of acute and chronic risks to aquatics as measured by biological surveys of fish densities, and benthic macroinvertebrate taxa richness and species diversity counts.
- Reduction of phytotoxicity as measured by vegetation attributes of cover, production, species richness, and successional trend.
- Reduction of risks to human health as evaluated by assessing arsenic concentrations in surface soils and comparing them to the established RBCs for specified land uses.
- Assessments of meeting Performance Standards established in this *Record of Decision*, including ARARs.

13.11.4.1 Operational and Functional

Remedial actions are to be evaluated during the post-construction period, and during the first, second, and third growing season, to rapidly demonstrate that the remedy is operational and functional and to trigger corrective actions immediately as problems are encountered. As part of construction implementation, the rootzone performance standards specified above are to be attained. Vegetation targets (Exhibit 2-28, page 2-132) are established for different land uses and landscape positions, specifically for the following:

- Wildlife
- Open space and grazing for upland areas
- Agricultural areas seeded to agronomic species in both upland and riparian areas

It is reasonable to expect attainment of these targets during the third growing season, although recurrent drought cycles may extend this period. To ascertain landscape stability and determine whether vegetation is on a trajectory to attain the performance standards, the following assessments are to be made during the first growing season following implementation of remedial action:

- General landscape stability—Evidence of rills and gullies; soil movement or mass instability will trigger corrective actions.
- Streambank stability—Assessments of the banks are to be conducted from a raft or boat. Evidence of erosion along the toe or erosion at either the upper or lower ends of the treated banks will trigger corrective actions. Tears in coir fabric greater than 1 foot long will also trigger corrective actions.
- Year 1 goal for woody vegetation is 90 percent survival of the original planted materials by species. Corrective actions may include replanting to original number of plants for a particular species.
- Year 1 goal for herbaceous vegetation in the riparian zone is 98 percent canopy cover of the seeded area. Corrective actions may include determining cause(s) for failure, correcting them, and reseeding.
- Year 1 goal for herbaceous vegetation in upland areas is a density of 40 stems per square meter for seeded species. Corrective actions may include determining cause(s) for failure, correcting them, and reseeding.

- Noxious weeds and undesirable weedy species are to be controlled as specified in Section 13.10, page 2-123.

13.11.4.2 Short-Term Monitoring

Following demonstration that the remedy is operational and functional, the site will be monitored for a period of years. The short-term performance phase will demonstrate the immediate success of the remedy in terms of streambank stabilization and preferred vegetation establishment. In addition to the vegetation cover, species richness, weed control and landscape stability conditions required under operational and functional, the short term performance monitoring phase will include broader evaluations of ecological trend and land utility.

This level of monitoring is conducted after remedial action(s) are implemented, and results are used to determine whether the action remains operational and functional. This level includes baseline measurements, qualitative assessments of the remedial action, and failure assessments. Failure of the remedial actions completed for specific areas within the Clark Fork River OU includes failure to comply with Performance Standards as described in this *Record of Decision*.

13.11.4.3 Long-Term Monitoring

Specific areas will be subjected to long-term monitoring after short-term monitoring, which may include the assessment of temporal changes using qualitative and quantitative assessments. These data and information are used to assess whether the Remedy has been implemented and whether Performance Standards are met. This period of monitoring is generally 6 to 20 years depending on the time required to achieve operation and functional status, changes in land use, and any on-going maintenance activities.

All of the abiotic and biotic monitoring—including plant communities growth media, erosional stability, aquatic communities, evidence of sustainability, and wildlife—will play significant roles in the assessments of achievement of ecological and health risk reduction and assessment of meeting ARARs.

13.11.4.4 Maintenance Program

Maintenance programs may include diagnostic evaluations for areas that are deemed to require a corrective action during the monitoring phase. Diagnostic evaluation may include assessment of soil or growth media parameters, appraisal of the implementation of the land reclamation remedial action, effects of climatic conditions on the vegetation community, seedbanks, and streambank evaluations. Control and mitigation of weeds are part of the maintenance program. A comprehensive O&M plan will be developed for all work at the site. Until the remedy is determined to be operational and functional and for a maximum of 5 years if fencing is needed that long, fencing required to protect the remedy will be maintained by the PRP. After that, fencing may have to be maintained for a longer period under BMPs and will be the responsibility of the landowner.

This comprehensive O&M plan will address, among other things, areas that require maintenance because of localized or total failures of the remedial actions. These areas are to be identified and diagnostic evaluations are to be conducted to help ascertain the reason(s) for failure. Diagnostic tests may include, but are not limited to, assessments of the following:

- Growth media in terms of fertility, pH, and levels of metals and arsenic
- Implementation practices
- Climatic conditions during and following implementation
- Seedbank evaluations

Corrective action(s) will be required when failures are shown.

13.11.5 Safety Concerns

Conducting a cleanup in a safe manner is a primary concern. Safety will be stressed throughout all aspects of the project. Other sections of the *Record of Decision* elaborate on why it is necessary to remove some of the most toxic wastes. EPA's experience with other sites where large scale removal has been done indicates this project can be conducted safely with careful planning.

Comments on the *Proposed Plan* specifically discussed the potential for inhalation of contaminated dust from construction activities. A concern regarding this inhalation is contrary to the findings of the *Human Health Risk Assessment*, which did not find the inhalation pathway for contaminants associated with agricultural tillage or disturbance to be a problem. It is also contrary to experience at other sites (Warm Springs Ponds, LAO, Butte Hill, Silver Bow Creek) where dust control during removal of wastes has been appropriately implemented and no adverse health effects have been suggested or demonstrated.

The safety risks posed by removing and hauling away the worst wastes to a secure disposal area can be controlled and managed. Past cleanup actions in the Clark Fork Basin have generally demonstrated this. However, it does require a high level of safety consciousness, good planning, and a commitment to coordination and cooperation with local County and city officials and residents. In 17 years of cleanup construction valued at hundreds of millions of dollars and involving the removal of millions of cubic yards of wastes in the Clark Fork Basin, there has been one construction worker fatality and only a very few other injuries, but no injuries to the public.

A primary consideration at the Clark Fork River project is to manage haul trucks safely. This includes planning to safely optimize truck traffic flows on major State and Federal highways, primary local county roads, and secondary access roads onto private property. EPA has consulted with construction specialists at the U.S. Bureau of Reclamation and with EPA's contractor, and believes that the project can be designed and implemented in a safe manner. The removal aspect of this project may result in 6 to 7 trucks per hour hauling wastes and backfill during the actual time of construction for the estimated 10-year construction period. A fairly comparable EPA construction project (removal action) was implemented several years ago near Deer Lodge for the East Side Road TCRA. On average, 4 to 6 trucks per hour operated safely on local roads for a period from approximately May through October with careful safety considerations. Other large scale construction projects, such as road construction and logging operations, commonly pose traffic safety risks and yet are effectively planned and implemented.

EPA will emphasize project safety in implementation. This particular project will require possible road paving and widening, the use of constructed designated roads in some areas, timed hauling, and other techniques to minimize public contact with the trucks hauling wastes and heavy equipment, and to ensure wide and stable enough roads where that contact may occur. The remedy will retain responsibility for road upgrades and EPA will work closely with local representatives. EPA believes the remedy can be safely implemented through good planning and engineering practices.

13.12 Scheduling

A schedule for remedial action on the Clark Fork River will be prepared during remedial design. At this time, the anticipated duration is 10 field construction seasons. Within that period, it is assumed that multiple crews will be working on several properties concurrently. A 2-year implementation target, per property, remains the EPA's goal. The accuracy of the 2-year remedial cleanup prediction will be dependent on the size and complexity of the property. Thus, the first step of implementation involves a CFR RipES evaluation and discussions with the landowner. These activities form the cornerstone of the level of effort to be applied to the property. The level of effort (site specific design) then dictates the construction timetable for that portion of the project. As this process is repeated for all the properties and applied to a construction season calendar, a rough timetable for the project will be developed.

A formal construction sequencing plan will be prepared during the design phase of the remedial action. The sequence of properties to be remediated throughout Reach A and localized areas of Reach B will be carefully planned and prepared. While the general approach will be to work from the headwaters down, EPA believes remediation can be done more quickly and effectively and with less threat to river stability by working on discontinuous stretches of the river. Thus, properties will be engaged in a discontinuous manner to prevent jeopardizing the integrity of the floodplain, should a flood event greater than the annual flood occur during the 10-season remedial action period. Affected landowners will be involved in setting these schedules and clearly informed of the sequencing of the work.

EPA recognizes that timing of the remedial actions is an important implementation issue. Again, a primary cleanup objective is to minimize the inconvenience to individual landowners. As previously stated, the overall project timeline for the 43 miles of river in Reach A and portions of Reach B is estimated to be approximately 10 years. This estimate may change during the design and construction phase. Individual landowner operating needs, availability of irrigation water, and the end land use determinations may also impact project schedules and timing.

13.13 Cost Estimate for the Selected Remedy

A cost estimate was developed to reflect EPA's determination of a final remedy for the Clark Fork River (separate document from this *Record of Decision*). To accomplish this, variations and additions to key alternatives described in the *Feasibility Study* (Atlantic Richfield Company 2002) and that reflects the Selected Remedy were defined and developed in sufficient detail for costing purposes. Major considerations included 1) defining streambank classes and lengths, and 2) better defining quantities and unit costs consistent with the Selected Remedy.

The costing format presented in the *Feasibility Study* was followed to facilitate cost comparisons of EPA's Proposed Remedy with various alternatives in the *Feasibility Study* during the remedy selection process. Where appropriate, adjustments to either unit costs or quantities were made by EPA. The changes, where warranted, reflect consideration of the Atlantic Richfield Company's RDU6 demonstration (Forson Property) design, and other currently available information available to the EPA as described in the "Notes" referenced in the cost tables. Details regarding methods utilized can be found in *Cost Estimate for the U.S. Environmental Protection Agency's Cleanup Plan for the Clark Fork River OU* (EPA 2003).

The Selected Remedy required specific changes and additions to key components of various combined alternatives previously considered and described in the *Feasibility Study* (Atlantic Richfield Company 2002). These required changes have now been defined in sufficient detail.

Major tasks included:

A. Re-estimated streambank classes, lengths and types of treatments commensurate with bioengineering streambank practices.

B. More refined quantities and unit costs for other components consistent with the other modifications described in EPA's *Proposed Plan* and Selected Remedy.

Most significant is the work that was done to denote streambank classes, levels, and lengths of treatment, and other requirements noted in EPA's *Proposed Plan*. Details regarding methods utilized for the first task can be found in Appendices A through E of the cost estimate document. Costing details for other components noted for the second task can be found in the "Notes" section, which supports Cost Tables for Reaches A and B (noted as Tables D-1 and D-2, respectively) of the cost estimate document.

The entire length of the Clark Fork River streambank in Reach A is 455,136 feet (86.2 miles), which is determined by doubling the reach channel length to account for both streambanks. Streambanks are classified based on stability and phytotoxicity (Class 1, 2, and 3 as defined in the Selected Remedy). Historic RI/FS data that described physical characteristics, which included the presence of visible tailings, the presence and condition of streambank vegetation with deep binding root mass, and degree of perceived phytotoxicity were used to re-estimate and update the condition of various streambanks and tributaries streambanks, consistent with the latest methodology as described by CFR RipES. The following is a brief description of what percentage of Reach A the previously defined streambank classes represent.

- **Class 1 Streambanks**—It was estimated that 20.0 percent of Reach A streambank length (87,287 feet or 16.53 miles) is considered a Class 1 Streambank.
- **Class 2 Streambanks**—It was estimated that 65.5 percent of the Reach A streambanks length (285,866 feet or 54.14 miles) is considered a Class 2 Streambank.
- **Class 3 Streambanks**—It was estimated that 14.5 percent of Reach A streambank length (63,283 feet or 11.99 miles) is considered a Class 3 Streambank.

Class 3 streambanks are those that support some appropriate deep, binding woody vegetation. Class 3 streambanks will require little, if any remedial treatment to assure continued stability.

Of the 455,136 total feet of streambank in Reach A, there is 18,700 feet (3.54 miles) of streambank that is currently rip-rapped or otherwise protected. These locations include the reach through the town of Deer Lodge, and along the railroad and road bridge crossings.

Based on data presented in the *Remedial Investigation* and the *Feasibility Study*, no streambank removal and reconfiguration will be necessary in Reach B. The data show no exposed tailings or buried tailings greater than 12 inches thick in contact with the present streambank of the river. Of the 6.23 acres of visible surface tailings recorded on the 52.1 percent of area inventoried (Atlantic Richfield Company 1998) within Reach B, about 500 linear feet of streambank are within 10 feet of the surface tailings. This extrapolates to about 960 total feet of streambank that may be within close proximity to visible surface tailings in Reach B. The tailings and contaminated soils will require some form of remediation consistent with remedial actions in Reach A.

Remedial treatments will be applied to appropriate streambank conditions on a reach by reach basis as defined and described previously. Recommended treatments (1 through 4, described in Appendix B) were defined, matched to appropriate streambank lengths and costed as part of this document.

Summarized in Exhibits 2-30 and 2-31 are the main channel streambank lengths, treatment levels, and streambank riparian buffer zone acreage defined by the above analysis in Reaches A and B, respectively.

EXHIBIT 2-30
Clark Fork River Reach A Streambank Treatments, Lengths, Percent of Total Length, and Acreage

Streambank Treatment	Linear Streambank Length (ft)	Percent of Total Length	Acres
No Treatment Necessary	25,313	5.6 percent	29.1
Treatment 1 (Vegetation Augmentation)	95,144	20.9 percent	109.2
Treatment 2 (Low Shear Stresses/Flow Velocities)	131,803	29.0 percent	151.3
Treatment 3 (Moderate Shear Stresses/Flow Velocities)	128,923	28.3 percent	148.0
Treatment 4 (High Shear Stresses/Flow Velocities)	55,253	12.1 percent	63.5
Currently Rip-Rapped	18,700	4.1 percent	—
Total	**455,136**	**100.0 percent**	**501.1**

EXHIBIT 2-31
Clark Fork River Reach B Streambank Treatments, Lengths, Percent of Total Length, and Acreage

Streambank Treatment	Linear Streambank Length (ft)	Percent of Total Length	Acres
Treatment 2 (Low Shear Stresses/Flow Velocities)	192	20 percent	0.2
Treatment 3 (Moderate Shear Stresses/Flow Velocities)	461	48 percent	0.5
Treatment 4 (High Shear Stresses/Flow Velocities)	307	32 percent	0.4
Total	**960**	**100 percent**	**1.1**

Another component of the cost estimate development were the major and minor tributaries within the historic 100-year floodplain of the Clark Fork River requiring bank stabilization. Summarized in Exhibits 2-32 and 2-33 are the tributary channel lengths, treatment levels, and streambank riparian buffer zone acreage defined by the above analysis in Reach A. No secondary channels requiring upgrades were noted in Reach B.

EXHIBIT 2-32
Reach A Major Tributaries and Major Secondary Channels Streambank Treatments, Lengths, Percent of Total Length, and Acreage Assuming a 50-Foot Riparian Buffer Zone

Streambank Treatment	Linear Streambank Length (ft)	Percent of Total Length	Acres
No Treatment Necessary	6,020	29.8 percent	6.9
Treatment 1 (Vegetation Augmentation)	6,780	33.6 percent	7.8
Treatment 2 (Low Shear Stresses/Flow Velocities)	5,910	29.3 percent	6.8
Treatment 3 (Moderate Shear Stresses/Flow Velocities)	1,380	6.8 percent	1.6
Treatment 4 (High Shear Stresses/Flow Velocities)	110	0.5 percent	0.1
Total	**20,200**	**100.0 percent**	**23.2**

EXHIBIT 2-33
Reach A Minor Tributaries and Minor Secondary Channels Streambank Treatments, Lengths, Percent of Total Length, and Acreage Assuming a 25-Foot Riparian Buffer Zone

Streambank Treatment	Linear Streambank Length (ft)	Percent of Total Length	Acres
No Treatment Necessary	25,920	60.3 percent	14.9
Treatment 1			
(Vegetation Augmentation)	12,640	29.4 percent	7.2
Treatment 2			
(Low Shear Stresses/Flow Velocities)	3,730	8.7 percent	2.2
Treatment 3			
(Moderate Shear Stresses/Flow Velocities)	620	1.4 percent	0.4
Treatment 4			
(High Shear Stresses/Flow Velocities)	90	0.2 percent	0.1
Total	**43,000**	**100.0 percent**	**24.8**

Total Estimated Construction Costs for both Reaches A and B were developed after sufficient detail was developed for the key components of the cost structure. Total Construction Costs are defined as Capital Costs of various defined categories, plus Miscellaneous Costs, which includes such items as design engineering cost, contractor mobilization/demobilization costs, contractor profit, construction management costs, etc. In addition, a Maximum Estimated Construction Cost was also developed to establish an upper bound cost.

The Base Case Cost Estimate was composed of: "middle of the road" costs from the *Feasibility Study* (Atlantic Richfield Company, 2002), updates from the Atlantic Richfield Company's (Forson) RDU6 design, and costs and quantities as defined by EPA during this estimate preparation. The **Maximum Estimated Cost** was composed of the base case cost estimate plus an additional 20 percent, which was added either to the "quantity" or "unit cost" element. Capital costs are summarized in Exhibit 2-34.

EXHIBIT 2-34
Reaches A and B Total Construction Costs

Reach	Base Case Estimated Costs	Maximum Estimated Costs
Reach A		
Capital Costs	$67,960,237	$82,810,673
Misc. Costs	$23,786,083	$28,983,408
Subtotal—Reach A	$91,746,320	$111,794,081
Reach B		
Capital Costs	$3,483,703	$4,291,342
Misc. Costs	$1,219,296	$1,463,155
Subtotal—Reach B	$4,702,999	$5,754,497
Total Construction Costs-Reaches A & B	**$96,449,319**	**$117,548,423**

Annual Monitoring and Maintenance Costs were also determined for each Reach. Reach A Monitoring and Maintenance Estimated Costs are $1,826,514 and Reach B Monitoring and Maintenance Estimated Costs are $35,719.

Total Net Present Value (NPV) calculations were performed assuming three scenarios:

1. A 10-year construction period using the base case (middle of the road) estimated costs at a discount rate of 5 percent
2. A 15-year construction period using the maximum estimated (upper bound) costs at a discount rate of 5 percent
3. A 15-year construction period using the maximum estimated costs at a discount rate of 7 percent

The NPV for these three scenarios are shown in Exhibit 2-35. The NPV calculation assumes an annual inflation rate of 2 percent applied to construction cost.

EXHIBIT 2-35
Net Present Value for Costing Scenarios

Scenario	Construction Period	Costing Assumption	Discount Rate	Net Present Value
1	10 years	Base Case	5 percent	$122,017,549
2	15 years	Maximum Case	5 percent	$141,557,274
3	15 years	Maximum Case	7 percent	$117,338,024

The information in this cost estimate section is based on the best available information regarding the anticipated scope of the Selected Remedy. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the Selected Remedy. (For example, actual slickens may encompass between 167 and 250 acres; impacted soils may range from 700 to 1,760 acres.) Major changes may be documented in the form of a memorandum to the Administrative Record file, an Explanation of Significant Differences, or *Record of Decision* amendment.

13.14 Estimated Outcomes of Selected Remedy

Exhibit 2-36 presents a summary of the anticipated outcomes of the Selected Remedy by river reach with regards to land use, groundwater use, and human and ecological risk reduction as a result of the response action.

EXHIBIT 2-36
Expected Outcomes for the Selected Remedy

Site Scenario	Exposure controlled through treatment, off-site disposal of source material, and institutional controls
	Deer Lodge Valley
Land Use and Time Frame	The overall project timeline for the 43 miles of river in Reach A and portions of Reach B is projected to be up to 10 years. The Selected Remedy calls for managing land use for a flexible distance, which may be within 50 feet of the river. The Selected Remedy is designed to allow as much of the historical use as possible while still maintaining the effectiveness of the cleanup. An IC calls for County zoning requirements to limit residential use of floodplain areas where waste is left in place. It is not anticipated that the floodplain in Reach A and parts of Reach B will be suitable for residential human occupation, in spite of the proposed remedial efforts. With some limitations tied to the progress of the vegetative re-growth in remediated areas, most of the floodplain is anticipated to support agricultural uses (e.g. grazing, hay production, etc.). BMPs will be long-term actions, along with operation and maintenance and monitoring activities. The exact length of time for these activities will vary for each land unit.
Groundwater Use and Time Frame	Compliance with groundwater ARARs and standards is not expected immediately, but may occur within a reasonable time frame as a result of a combination of the Selected Remedy and natural attenuation. An IC calls for prevention of use of shallow groundwater for domestic consumption or other consumptions that may spread the groundwater contamination at the OU until groundwater cleanup is achieved. It is anticipated that this condition may persist for several decades after the remedial action has been implemented. Post-construction monitoring will provide a gauge for judging long-term conditions.
Anticipated socio-economic and community revitalization impacts	By remediating slickens areas on ranches, more land will be placed into production, which may help the ranching and farming economy. Also, Reach A is home to the Grant-Kohrs Ranch National Historic Site, as well as other historic areas (such as the old penitentiary at Deer Lodge). Improving water quality in the Clark Fork River through application of the Selected Remedy may improve conditions for fish and other aquatic receptors by reducing chronic and acute risks. This could make the Deer Lodge Valley a more attractive center for recreation, while also helping to preserve the existing agricultural economy.
Anticipated environmental and ecological benefits:	
Streambank Erosion	Reduction of streambank erosion through streambank stabilization and treatment of slickens areas is expected to reduce sedimentation and runoff to the river. It is also expected to help preserve the land base and reduce the land loss resulting from erosion to a level comparable with other Montana streams.
Geomorphic Stability	The USGS has indicated in their studies that the river is at risk of floodplain destabilization because of accelerated erosion rates above background levels. By stabilizing the streambanks and removing slickens areas along with backfilling and revegetation, this risk is expected to be reduced.

EXHIBIT 2-36
Expected Outcomes for the Selected Remedy

Site Scenario	Exposure controlled through treatment, off-site disposal of source material, and institutional controls
Water Quality	According to modeling projections, none of the alternatives considered are expected to fully comply with the State water quality standard for copper, and a waiver of the copper standard is justified. EPA believes the replacement copper standard can be achieved, and the improved water quality and eliminated pulse events will improve conditions for fish and other aquatic receptors. All other surface water quality ARARs are expected to be achieved. The Selected Remedy is expected to reduce the amount of fine-grained contaminated sediment in the river bed. The Selected Remedy is expected to provide a greater reduction in mobility and volume of contaminants by removal of wastes from the floodplain.
Phytotoxicity	The Selected Remedy is expected to reduce the phytotoxicity of contaminated soil and tailings through removal and in-situ treatment or combinations of these techniques. The final growth media will be capable of supporting vegetation compatible with current and anticipated future land uses.
Human Health	The Selected Remedy is expected to reduce contaminated soil and tailings arsenic concentrations to below the designated RBCs for reasonably anticipated land uses through treatment, removal, or combinations of these techniques. The performance standards for groundwater are based on human health risk standards. Educational measures are expected to help prevent ingestion of or direct contact with contaminated soils and further reduce risks to children, especially pica children, who are medically prone to eating dirt.

Cleanup levels or media-specific Performance Standards are described in detail throughout this *Record of Decision*.

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14 Statutory Determinations

The Selected Remedy described in this *Record of Decision* meets the statutory requirements of Section 121 of CERCLA, 42 U.S.C. § 9621 and NCP section 300.430(f)(5)(ii). These provisions require that CERCLA remedies be protective of human health and the environment, comply with ARARs or replacement standards for waived requirements, be cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

14.1 Protection of Human Health and the Environment

The Selected Remedy protects risks to human health identified in EPA's *Human Health Risk Assessment* (EPA 1998a) and *Human Health Risk Assessment Addendum* (EPA and ATSDR 2001) by establishing RBCs for arsenic contamination for areas within the Clark Fork River OU Reach A for reasonably anticipated land uses as Performance Standards. These levels will reduce the cancer risks for soils within Reach A to less than 1×10^{-4}, which is within EPA's acceptable level established by the NCP, and the hazard index for noncancer risks to below 1. Residential areas that exceed these levels were addressed, with limited exception, in the Deer Lodge Valley TCRA done prior to the issuance of the *Record of Decision*. The *Record of Decision* requires that the unaddressed areas be remediated to the established levels, and that follow-up operation and maintenance on areas addressed under the prior TCRA is done. The *Record of Decision* also requires the railroad trestle area to be addressed, which current data indicates exceeds recreational levels. It also requires an evaluation of historically irrigated areas outside of the TCRA area, other recreational areas, and agricultural areas remediated as described below to ensure that these areas are below the soil Performance Standards. Finally, it requires institutional controls and educational efforts to ensure that land use assumptions contained within the Selected Remedy are maintained and that shallow groundwater is not consumed for domestic purposes or spread until groundwater cleanup levels are obtained. The implementation of the environmental aspects of the remedy and natural attenuation will likely lead to the cleanup of contaminated shallow groundwater to the health-based groundwater Performance Standards established in this *Record of Decision*.

The Selected Remedy will address the terrestrial, erosional, floodplain stability, and aquatic risks described in this *Record of Decision* by eliminating slickens areas and treating impacted areas, and by addressing streambanks along Reach A and a limited portion of Reach B. Run-off during normal and high flows will be controlled and contribution of contaminant movement will be reduced, slickens pulse events will be eliminated, and terrestrial vegetation will be restored for productive land use and stream stability.

The Selected Remedy does not produce unacceptable short term risks. Such risks as worker safety, community safety from truck traffic and contaminant release, land use interference, and floodplain stability and run-off during construction can be readily controlled through careful planning. In addition, no adverse cross-media impacts are expected from the Selected Remedy.

14.2 Compliance with ARARs

The ARARs and replacement standards for this site that the Selected Remedy must comply with are identified in detail in Appendix A to the *Record of Decision*. Key ARAR requirements for this site are as follows:

- Water Quality Standards promulgated by the State of Montana
- Federal water quality criteria promulgated by EPA for copper only
- The Federal drinking water standard for arsenic as applied to both surface and groundwater
- State and Federal groundwater standards
- ESA requirements for animals and plants such as the bull trout—EPA will continue to consult with the FWS as described in the Biological Opinion for this project as remedial design goes forward
- Executive Order 11990—No net loss of wetlands: EPA will continue to consult with the FWS as described in the Biological Opinion for this project as remedial design goes forward
- State Solid Waste and Floodplain Management requirements addressing storage and management of wastes within the floodplain

Other criteria, advisories, or Guidance to be Considered during remedial design for this action are also identified in Appendix A.

EPA has invoked the ARAR waivers listed below for certain standards identified in the ARARs identification document used in the development of the final *Feasibility Study* and the *Proposed Plan* for the Clark Fork River OU.

A. The Copper Standard for Surface Water

The State of Montana established standards for surface water quality within the Clark Fork River OU under the State's Water Quality Act. EPA is waiving the copper standard ARARs and substituting Federal water quality criteria promulgated under the Federal Clean Water Act. The replacement standard is measured as a dissolved component. The replacement standard is reflected in the water quality performance standards noted in Section 8, page 2-48, and in Appendix A.

The basis for this waiver is the modeling information developed during the RI/FS for this site that demonstrated that none of the alternatives could achieve the State's copper standard. EPA is invoking the waivers described in Section 121(d)(4)(C) of CERCLA (the technical impracticability waiver) and Section 121(d)(4)(D) of CERCLA (the partial cleanup waiver) for the State's copper standard. As cleanup of upstream OUs such as those in Butte, Silver Bow Creek and the Warm Springs Ponds, and the Anaconda area creeks progress, some portions of the Clark Fork River OU may eventually meet the State standard.

B. Certain State Floodplain and Solid Waste Management Requirements/Federal Solid Waste Requirements

The State of Montana established requirements for the active management of wastes within a floodplain. Treatment of mining waste, as described in the portions of the Selected Remedy addressing in-situ treatment, is considered active management of waste. Some of the identified State standards basically prohibit the storage or disposal of wastes such as the mining waste found at the Clark Fork River OU within a 100-year floodplain. The Federal standards regulate how solid waste management is done. Some of the identified Federal standards prevent any contamination of groundwater beyond waste unit boundaries, and may be read to prevent in-situ treatment involving cadmium waste. The in-situ components of the Selected Remedy are not in compliance with these requirements.

EPA is waiving these standards for the in-situ components of the *Selected* Remedy. The specific requirements that are waived are noted in the ARARs Appendix A to this *Record of Decision*. The waiver does not apply to those areas, such as slickens or impacted areas, that meet the exceptions for in-situ treatment, designated in the Selected Remedy. EPA is invoking the waivers found at 121(d)(4)(C) (technical impracticability from an engineering perspective).

The waiver would apply to either exposed tailings areas or impacted soils and vegetation areas designated for in-situ treatment in the selected remedy description. EPA has determined that there exists sufficient uncertainty regarding the technical practicability from an engineering perspective for the very large-scale removal of all mining wastes and contaminated soils. The heterogeneity and distribution of the contamination would not provide for reliable removal of all the contamination and would not allow the remedy to be implemented within a reasonable time frame. The waiver does not apply to those contaminated areas designated for removal in the Selected Remedy.

14.3 Cost Effectiveness

In EPA's judgment, the Selected Remedy is cost-effective. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." (NCP § 300.430(f)(1)(ii)(D)). This was accomplished by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria (were both protective of human health and the environment and ARAR compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of the Selected Remedy was determined to be proportional to its costs. The chart shown on in Exhibit 2-37 shows the overall comparisons done for the alternatives that met the threshold criteria (Alternatives 4 through 8). The estimated present worth cost of the Selected Remedy is approximately $122,000,000. Alternative 4 is less expensive, but does not provide the long-term permanence of reduction in mobility for one of the principal threat wastes (the slickens) at the site that is necessary. It therefore is not cost effective. Alternatives 7 and 8 are significantly more expensive than the Selected Remedy costs, have significant short term effectiveness problems, and therefore are not cost effective. The Selected Remedy, which is a combination of alternatives 4B4, 5D, and 6C and most closely resembles Alternative 5D, provides an appropriate balance among the three effectiveness criteria and its overall effectiveness is proportional to its costs. Relevant considerations for the cost-effectiveness determination include the following:

A. Exposed tailings and contaminated soils extend throughout the floodplain in Reach A and portions of Reach B (greater than 43 miles). Remedy must be implementable over large area.

B. Lack of vegetation and accelerated erosion jeopardize the geomorphic stability of the floodplain. Remedy must not increase this risk.

C. Arsenic and metals (especially copper) associated with the tailings and soils comprise the risk to aquatic and terrestrial systems. Remedy must mitigate this condition.

D. Most of the affected land is privately held. Long term disruption of land use is a concern.

It is important to note that more than one cleanup alternative can be cost-effective, and the Superfund laws and regulations do not mandate the selection of the most cost-effective cleanup alternative. The most cost-effective remedy is not necessarily the least-costly alternative that is both protective of human health and the environment and is ARAR or ARAR waiver compliant.

EXHIBIT 2-37
Matrix of Cost Effectiveness Data for the Clark Fork River OU *Record of Decision*

Alternative	Present Worth Cost ($000s)	Cost effect (+ - * ✓)	Long Term Effectiveness and Permanence	Reduction of TMV through Treatment	Short Term Effectiveness
4A1. In-Place Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (222,367 feet), Criteria 1	$18,897	-	Does not remove principal threat waste (exposed tailings). Least effective at reducing COC movement via bank erosion.	Reduces toxicity and mobility of most COCs. Does not reduce volume of contamination. Does not actively remediate surface or groundwater.	Relies exclusively on in-situ treatment with minor removal of specifically targeted areas including riparian areas and streambanks. This alternative creates less traffic/construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.

EXHIBIT 2-37
Matrix of Cost Effectiveness Data for the Clark Fork River OU *Record of Decision*

Alternative	Present Worth Cost ($000s)	Cost effect (+ - * ✓)	Long Term Effectiveness and Permanence	Reduction of TMV through Treatment	Short Term Effectiveness
4A2. In-Place Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (72,777 feet), Criteria 2	$24,348	-	Does not remove principal threat waste (exposed tailings). More effective at reducing COC movement via bank erosion than 4A1.	Reduces toxicity and mobility of most COCs. Does not reduce volume of contamination. Does not actively remediate surface or groundwater.	Relies exclusively on in-situ treatment with minor removal of specifically targeted areas including riparian areas and streambanks. This alternative creates less traffic/construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.
4A3. In-Place Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization (160,450 feet), Criteria 3	$31,359	-	Does not remove principal threat waste (exposed tailings). More effective at reducing COC movement via bank erosion than 4A2.	Reduces toxicity and mobility of most COCs. Does not reduce volume of contamination. Does not actively remediate surface or groundwater.	Relies exclusively on in-situ treatment with minor removal of specifically targeted areas including riparian areas and streambanks. This alternative creates less traffic/construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.
4A4. In-Place Reclamation of Exposed Tailings and Other Impacted Soils (285 acres) with Streambank Stabilization and Riparian Corridor Buffer (264,000 feet), Criteria 4	$52,092	-	Does not remove principal threat waste (exposed tailings). More effective at reducing COC movement via bank erosion than 4A3. Riparian buffer zone provides greatest protection for bank stability.	Reduces toxicity and mobility of most COCs. Does not reduce volume of contamination. Does not actively remediate surface or groundwater.	Relies exclusively on in-situ treatment with minor removal of specifically targeted areas including riparian areas and streambanks. This alternative creates less traffic/construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.

EXHIBIT 2-37
Matrix of Cost Effectiveness Data for the Clark Fork River OU *Record of Decision*

Alternative	Present Worth Cost ($000s)	Cost effect (+ - * ✓)	Long Term Effectiveness and Permanence	Reduction of TMV through Treatment	Short Term Effectiveness
4B1. In-Place Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (22,367 feet), Criteria 1	$31,822	-	Does not remove principal threat waste (exposed tailings). Least effective at reducing COC movement via bank erosion.	Reduces toxicity and mobility of most COCs over a larger area/volume compared to 4A Alternatives. Does not reduce volume of contamination. Does not actively remediate surface or groundwater.	Relies exclusively on in-situ treatment with minor removal of specifically targeted areas including riparian areas and streambanks. This alternative creates less traffic/construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.
4B2. In-Place Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (72,777 feet), Criteria 2	$37,273	-	Does not remove principal threat waste (exposed tailings). More effective at reducing COC movement via bank erosion than 4B1.	Reduces toxicity and mobility of most COCs over a larger area/volume compared to 4A Alternatives. Does not reduce volume of contamination. Does not actively remediate surface or groundwater.	Relies exclusively on in-situ treatment with minor removal of specifically targeted areas including riparian areas and streambanks. This alternative creates less traffic/construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.
4B3. In-Place Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization (160,450 feet), Criteria 3	$44,284	-	Does not remove principal threat waste (exposed tailings). More effective at reducing COC movement via bank erosion than 4B2.	Reduces toxicity and mobility of most COCs over a larger area/volume compared to 4A Alternatives. Does not reduce volume of contamination. Does not actively remediate surface or groundwater.	Relies exclusively on in-situ treatment with minor removal of specifically targeted areas including riparian areas and streambanks. This alternative creates less traffic/construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.

EXHIBIT 2-37
Matrix of Cost Effectiveness Data for the Clark Fork River OU *Record of Decision*

Alternative	Present Worth Cost ($000s)	Cost effect (+ - * ✓)	Long Term Effectiveness and Permanence	Reduction of TMV through Treatment	Short Term Effectiveness
4B4. In-Place Reclamation of Exposed Tailings and Other Impacted Soils (867 acres) with Streambank Stabilization and Riparian Corridor Buffer (264,000 feet), Criteria 4	$64,504	+	Does not remove principal threat waste (exposed tailings). More effective at reducing COC movement via bank erosion than 4A3. Riparian buffer zone provides greatest protection for bank stability.	Reduces toxicity and mobility of most COCs over a larger area/volume compared to 4A Alternatives. Does not reduce volume of contamination. Does not actively remediate surface or groundwater.	Relies exclusively on in-situ treatment with minor removal of specifically targeted areas including riparian areas and streambanks. This alternative creates less traffic/construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.
5A. Removal of Exposed Tailings and In-Place Reclamation of Other Impacted Soils (118 acres In-Place, 167 acres Removal, 18,370 feet Streambank Removal), Opportunity Ponds Disposal Option	$36,310	-	Removes principal threat waste of exposed tailings. Least effective at reducing COC movement via bank erosion. Permanent disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings via removal. Reduces toxicity and mobility of most COCs through treatment over a larger area compared to 5A. Does not reduce volume through treatment. Does not actively remediate surface or groundwater.	Relies on removal of exposed tailings in concert w/in-situ treatment of impacted soils; amount of streambank remediation varies. This alternative creates less traffic/ construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.
5B. Removal of Exposed Tailings and In-Place Reclamation of Other Impacted Soils (700 acres In-Place, 167 acres Removal, 18,370 feet Streambank Removal), Opportunity Ponds Disposal Option	$50,717	-	Removes principal threat waste of exposed tailings. Least effective at reducing COC movement via bank erosion. Permanent disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings via removal. Reduces toxicity and mobility of most COCs through treatment over a larger area compared to 5A. Does not reduce volume through treatment. Does not actively remediate surface or groundwater.	Relies on removal of exposed tailings in concert w/in-situ treatment of impacted soils; amount of streambank remediation varies. This alternative creates less traffic/ construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.

EXHIBIT 2-37
Matrix of Cost Effectiveness Data for the Clark Fork River OU *Record of Decision*

Alternative	Present Worth Cost ($000s)	Cost effect (+ - * ✓)	Long Term Effectiveness and Permanence	Reduction of TMV through Treatment	Short Term Effectiveness
5C. Removal of Exposed Tailings and In-place Reclamation of Other Impacted Soils (700 acres In-Place,167 acres Removal, 18,370 feet Streambank Removal), DCCA Disposal Option	$54,943	-	Removes principal threat waste of exposed tailings. Least effective at reducing COC movement via bank erosion. Disposal in newly created waste management areas.	Eliminates toxicity, mobility, and volume of exposed tailings via removal. Reduces toxicity and mobility of most COCs through treatment over a larger area compared to 5A. Does not reduce volume through treatment. Does not actively remediate surface or groundwater.	Relies on removal of exposed tailings in concert w/in-situ treatment of impacted soils; amount of streambank remediation varies. This alternative creates less traffic/ construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.
5D. Removal of Exposed Tailings and In-Place Reclamation of Other Impacted Soils (700 acres In-Place, 167 acres Removal), Opportunity Ponds Disposal Option with Streambank Stabilization and Riparian Corridor Buffer (264,000 feet)	$84,327	+	Removes principal threat waste of exposed tailings. More effective in reducing COC movement via bank erosion than 5C. Riparian buffer zone provides greatest protection for bank stability. Permanent disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings via removal. Reduces toxicity and mobility of most COCs through treatment over a larger area compared to 5A. Does not reduce volume through treatment. Does not actively remediate surface or groundwater.	Relies on removal of exposed tailings in concert w/in-situ treatment of impacted soils; amount of streambank remediation varies. This alternative creates less traffic/ construction risks as a result. Moderate amount of time to implement (EPA estimates 10 years). Takes longer to achieve performance standards than more intrusive Alternatives 6, 7, and 8.
6A. Removal of Exposed Tailings and Other Impacted Soils (285 acres Removal, 43,845 feet Streambank), Opportunity Ponds Disposal Option	$48,225	-	Removes principal threat waste of exposed tailings, and limited volume of impacted soils. Least effective of the six alternatives in reducing COC movement via bank erosion. Disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings and impacted soils via removal. No reductions in toxicity, mobility, or volume of impacted soils that are not removed. Does not actively remediate surface or groundwater.	Removal volume increases—potential traffic and equipment related accidents, risks to the stability of the floodplain, and the duration of the remedial activity before full implementation are short term risks, less than Alternatives 7 or 8.

EXHIBIT 2-37
Matrix of Cost Effectiveness Data for the Clark Fork River OU *Record of Decision*

Alternative	Present Worth Cost ($000s)	Cost effect (+ - * ✓)	Long Term Effectiveness and Permanence	Reduction of TMV through Treatment	Short Term Effectiveness
6B. Removal of Exposed Tailings and Other Impacted Soils (867 acres Removal, 95,000 feet Streambank), Opportunity Ponds Disposal Option	$80,712	-	Removes principal threat waste of exposed tailings, and greater limited volume of impacted soils compared to 6A. Provides additional reductions of COCs movement via bank erosion compared to 6A. Disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings and impacted soils via removal. No reductions in toxicity, mobility, or volume of impacted soils that are not removed. Does not actively remediate surface or groundwater.	Removal volume increases—potential traffic and equipment related accidents, risks to the stability of the floodplain, and the duration of the remedial activity before full implementation are short term risks, less than Alternatives 7 or 8.
6C. Removal of Exposed Tailings and Other Impacted Soils, Opportunity Ponds Disposal option with Streambank Stabilization and Riparian Corridor Buffer (264,000 Streambank feet)	$110,478	+	Removes principal threat waste of exposed tailings, and greater limited volume of impacted soils compared to 6B. Riparian buffer zone provides greatest protection for bank stability. Disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings and impacted soils via removal. No reductions in toxicity, mobility, or volume of impacted soils that are not removed. Does not actively remediate surface or groundwater.	Removal volume increases—potential traffic and equipment related accidents, risks to the stability of the floodplain, and the duration of the remedial activity before full implementation are short term risks, less than Alternatives 7 or 8.
7A. Total Removal Unless Overlain by Woody Vegetation (2,600 acres Removal, 131,583 feet Streambank Reconstruction), Opportunity Ponds Disposal Option	$161,614	-	Removes principal threat waste of exposed tailings, and removal of all estimated impacted soils unless they support woody vegetation. Reduction of COC movement via bank erosion. Disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings and impacted soils via removal. No reductions in toxicity, mobility, or volume of impacted soils that are not removed. Does not actively remediate surface or groundwater.	Large soil removal effort—greater short-term risk based on potential for traffic and equipment related accidents, risks to the stability of the floodplain, and the duration of the remedial activity before full implementation occurs.
7B. Total Removal Unless Overlain by Woody Vegetation (2,600 acres Removal), Opportunity Ponds Disposal Option with Streambank Stabilization and Riparian Corridor Buffer (264,000 feet Streambank)	$179,381	-	Removes principal threat waste of exposed tailings, and removal of all estimated impacted soils. riparian buffer zone provides greatest protection for waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings and impacted soils via removal. Eliminates source of COCs to surface and groundwater within the OU.	Large soil removal effort—greater short-term risk based on potential for traffic and equipment related accidents, risks to the stability of the floodplain, and the duration of the remedial activity before full implementation occurs.

EXHIBIT 2-37
Matrix of Cost Effectiveness Data for the Clark Fork River OU *Record of Decision*

Alternative	Present Worth Cost ($000s)	Cost effect (+ - * ✓)	Long Term Effectiveness and Permanence	Reduction of TMV through Treatment	Short Term Effectiveness
8A. Total Removal (3,500 acres Removed and 345,000 feet Streambank Reconstruction), Opportunity Ponds Disposal Option	$355,370	-	Removes principal threat waste of exposed tailings, and removal of all estimated impacted soils. Reduction of COC movement via bank erosion. Disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings and impacted soils via removal. Eliminates source of COCs to surface and groundwater within the OU.	Largest soil removal activities—greatest short-term risk based on potential for traffic and equipment related accidents, risks to the stability of the floodplain, and the duration of the remedial activity before full implementation occurs.
8B. Total Removal, Opportunity Ponds Disposal Option, with Streambank Stabilization and Riparian Corridor Buffer (264,000 feet Streambank)	$368,438	-	Removes principal threat waste of exposed tailings, and removal of all estimated impacted soils. Riparian buffer zone provides greatest protection for bank stability. Disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings and impacted soils via removal. Eliminates source of COCs to surface and groundwater within the OU.	Largest soil removal activities—greatest short-term risk based on potential for traffic and equipment related accidents, risks to the stability of the floodplain, and the duration of the remedial activity before full implementation occurs.
Selected Remedy: Combination of Alternatives 4B4, 5D, and 6, Removal of Exposed Tailings and In-Place Reclamation of Other Impacted Soils (700 acres In-Place, 167 acres Removal), Opportunity Ponds Disposal Option with Streambank Stabilization and Riparian Corridor Buffer (455,136 feet)	$122,000	✓	Removes principal threat waste of exposed tailings. Maximizes reduction of COC movement via bank erosion. Riparian buffer zone provides greatest protection for bank stability. Permanent disposal in designated waste management area.	Eliminates toxicity, mobility, and volume of exposed tailings via removal. Reduces toxicity and mobility of most COCs through treatment. Does not reduce volume through treatment. Does not actively remediate surface or groundwater.	Variations of Alternatives 4 and 5 tend to rank high by limiting the volume of materials for removal, reducing the impacts of treatment on the floodplain, and promoting a relatively short healing process for recovery.

Cost Effective Summary:

The Selected Remedy reflects a fair balance between the long-term and short-term effectiveness and permanence, reduction of mobility, toxicity, and volume, and implementability issues associated with these alternatives. Using the criteria found in NCP section 400.300(f)(ii)(D), EPA believes that Alternatives 7 and 8 would not be cost effective, and that the overall effectiveness of Alternative 5d best meets the cost effectiveness criteria. EPA believes the Selected Remedy is cost effective and will achieve benefits and effectiveness proportional to the expected costs.

Key

"+" more effective than previous Alternative

"-" less effective than previous or other Alternatives

* no change compared to previous Alternative

✓ most effective compared to other Alternatives

14.4 Utilization of Permanent Solution and Alternative Treatment Technologies (or Resource Recovery Technologies) to the Maximum Extent Practicable

This finding looks at whether the remedy provides the best balance of trade-offs among the alternatives with respect to the Balancing Criteria set in NCP § 300.430(f)(1)(ii)(B), with an emphasis on long term effectiveness and permanence and reduction in toxicity, mobility, and volume (see NCP § 300.430(f)(1)(ii)(E)). Modifying criteria were also examined in making this finding. In other words, the finding of practicability for use of permanent solution and alternative treatments to the maximum extent practicable is determined by looking at the remedy selection criteria.

EPA has determined that the Selected Remedy represents the maximum extent to which permanent solution and treatment technologies can be utilized in a practicable manner at the site. Of those alternatives that are protective of human health and the environment and comply with ARARs, EPA has determined that the Selected Remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site treatment and disposal and considering State and community acceptance. EPA's balancing is explained in Section 10.2.10, page 2-71.

The Selected Remedy reduces mobility of the principal threat wastes through removal of the waste outside of the Clark Fork River floodplain and aggressive treatment of Class I streambanks. This provides for more certain long term effectiveness and permanence by reducing the uncertainty that would be associated with the application of in-situ treatment in these areas. The Selected Remedy also provides for long term effectiveness and permanence in the in-situ treated areas and Class II streambanks by employing careful in-situ treatment requirements to land where it is most likely to succeed (soils with existing vegetation and organic content and relatively lesser amounts of contamination. The Selected Remedy presents some short term effectiveness and implementability challenges, but these can be managed successfully. It avoids the more pronounced short term effectiveness, protectiveness, and implementability problems of Alternatives 6, 7, and 8. Cost effectiveness is discussed above in Section 14.3. The State has accepted the Selected Remedy as described in its concurrence letter, Appendix F. General community acceptance can be achieved through the modifications to the proposed remedy described in Section 15, page 2-159, and continued consultation and coordination with local officials and landowners.

14.4 Preference for Treatment as a Principal Element

The Selected Remedy addresses principal threat wastes (slickens material and Class I streambank areas) through removal of most of these wastes from the floodplain and appropriate disposal at Opportunity Ponds near Anaconda, Montana. There, these wastes may be partially treated or contained through use of capping and in-situ treatment technologies per ARWWOU's remedial requirements. If the waste is left in place, it will be treated using the in-situ technology described in the *Record of Decision*. Other waste in impacted areas or Class II streambanks will be treated using the in-situ treatment technology. This satisfies the CERCLA statutory obligations for preference of treatment as a Principal Element.

14.6 Five Year Reviews

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action at the Milltown/Clark Fork River Superfund Site, to ensure that the remedy is, or will be, protective of human health and the environment.

15 Documentation Of Significant Differences

The *Proposed Plan* for the Clark Fork River OU was released for public comment in August 2002. The plan identified a combination of Alternatives 4, 5, and 6 that most closely resembled Alternative 5D (streambank treatment, in-situ treatment of impacted areas with one exception, excavation of slickens with one exception, the human health component and ICs, construction BMPs, and land use BMPs for removal and in-situ treated areas aimed at creating a riparian buffer zone).

During the public comment period, significant public comment was received. All comments are addressed in the *Responsiveness Summary*, Part 3 of this *Record of Decision*. Comments and information submitted during the public comment period that led to significant changes to the *Proposed Plan* are explained below.

The State of Montana Natural Resource Damage Litigation Program (NRDP) submitted a study describing research that demonstrates the potential chronic risks presented to fish from arsenic. EPA has noted this research in its description of chronic risk in Section 7, page 2-39, and other locations in this *Record of Decision*. This information is important and further bolsters the need for an aggressive streambank component of the Selected Remedy for this site that will control streambank sloughing and contaminant release from banks. Additional detail about the streambank component is contained in Section 13.6.4, page 2-106, and Appendix B of this *Record of Decision* to ensure that this aspect of the Selected Remedy is implemented in a robust and permanent fashion.

The ATSDR noted that areas at which in-situ treatment was used should be checked through post-construction sampling for compliance with the health-based arsenic soil performance standards. It also noted that a prior recommendation to EPA will be addressed; namely, the trestle recreational area in Deer Lodge, since the area soil samples exceed soil arsenic Performance Standards for recreational use. Both concerns of ATSDR are addressed in the Selected Remedy.

Landowners and Powell County Commissioners expressed concerns about weed control, flexibility in application of removal and in-situ treatments on their land, traffic and safety issues, and the proposed width of the riparian buffer zone discussed in the *Proposed Plan*. These concerns have been addressed as follows:

- Weed control is emphasized in the Selected Remedy, as described in detail Section 13.10, page 2-123 of the *Record of Decision*.
- The Selected Remedy states clearly that the riparian buffer zone is flexible in width, and should be coordinated with a landowner's land use plans.
- The *Selected Remedy* describes EPA policy regarding PRP payment for access to land for remedy implementation, and emphasizes the need to coordinate BMP planning and payment considerations with existing programs when possible.

DOI and more than one hundred commenters emphasized the need to ensure that the remedy, as implemented at the Grant-Kohrs Ranch National Historic Site, be implemented in such a way as to ensure compliance with the ARARs which are unique to that site—the

NPS Organic Act and associated implementation statutes for the Grant-Kohrs Ranch National Historic Site. EPA has worked closely with NPS in developing the description of how the Selected Remedy must be implemented at the ranch to meet these concerns. The NPS also produced a *Human Health Risk Assessment* directed specifically at the Grant-Kohrs Ranch National Historic Site. That risk assessment is generally consistent with EPA's *Human Health Risk Assessment* and its addendum when values are adjusted for site-specific bioavailability information, and does not generally change EPA's conclusions about its risk assessments or its soils arsenic Performance Standards. The NPS assessment did identify an exposure scenario on the Grant-Kohrs Ranch National Historic Site for irrigation workers who spend time working directly in contaminated sediments in irrigation ditches. EPA has addressed this new information by including irrigation ditch evaluation in the ranch and in the human health component of the Selected Remedy.

Some public interest groups, particularly the National Wildlife Federation, discussed the need to ensure that the streambank stabilization component be a secure and permanent part of the final remedy designed to hold during high flow events. The Selected Remedy contains a detailed description of how the streambank stabilization component should be designed and emphasizes measures to ensure adequate protection against shear stresses on unstable streambanks, such as use of pre-vegetated coir inserts and submerged fiber mats.

16 Coordination With Natural Resource Damage Restoration Actions

The Clark Fork River OU has received considerable attention from Natural Resource Trustees, as described in section 107(f) of CERCLA. These trustees include the State of Montana, DOI, and the Confederated Salish and Kootenai Tribes. The trustees have individually undertaken efforts to develop restoration plans and/or secure restoration money from potentially responsible parties to restore the Clark Fork River OU to baseline conditions, or the condition that would exist absent the release of hazardous substances. The State developed a restoration plan which, if implemented, would provide for certain actions to restore the injured resources. The State's existing restoration plan is likely to be revised following issuance of this *Record of Decision*. The DOI is assessing injuries to Federally owned land along the Clark Fork River and, following issuance of this *Record of Decision*, will pursue appropriate restoration activities.

The Selected Remedy is not intended to and will not restore natural resources in and along the Clark Fork River to baseline conditions.

Each of these entities, separately or as a group, may select restoration actions applicable to the Clark Fork River OU. If this occurs, EPA will work with the trustees to coordinate implementation of the Selected Remedy with these actions to avoid duplication of effort and unnecessary costs and to maximize benefits to the area.

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Part 3
Responsiveness Summary

Clark Fork River Operable Unit
of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Part 3: Responsiveness Summary

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

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Exhibits **Page**

1 Overview of Process, Responders, and Stakeholder Comments

This *Responsiveness Summary* is Part 3 of the *Record of Decision* for the Clark Fork River Operable Unit (OU). The purpose of the *Responsiveness Summary* is to present the U.S. Environmental Protection Agency's (EPA's) response to significant stakeholder and potentially responsible party (PRP) comments on the *Proposed Plan* in accordance with 40 CFR 300.430(f)(3)(F) and Section 117(a) and (b) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The public outreach process used to encourage comment and participation on this decision is presented in this *Record of Decision* at Part 2, *Decision Summary*, Section 3.

This *Responsiveness Summary*, which is Part 3 of the *Record of Decision* for the Clark Fork River OU, consists of four sections. First, this section (Section 1) provides an overview of the comments received from various stakeholder groups. Section 2, *Stakeholder Issues and Lead Agency Responses*, summarizes with more detail the specific, significant comments received from all stakeholders (page 3-11). Responses to those comments are provided by the lead agency: Region 8 of the EPA, after consultation with the Montana Department of Environmental Quality (DEQ). Section 3, *PRP Comments and Lead Agency Responses*, summarizes significant *Proposed Plan* comments from the PRP—the Atlantic Richfield Company—and lead agency responses to those comments (page 3-81). Section 4, *Stakeholder and PRP Categorized Comments* (page 3-137), provides the original text of the comments from the stakeholders and the PRP as Adobe Acrobat Reader (PDF) files on an enclosed CD-ROM.

1.1 Number of Comments Received and Types of Stakeholders Submitting Comments

A total of **1,978 people submitted comments**, excluding the Atlantic Richfield Company (their comments and responses are summarized in Section 3, *PRP Issues and Lead Agency Responses*). Many people submitted more than one comment document. Therefore, the total number of comment documents submitted was higher, at 2,109, excluding Atlantic Richfield Company.

The statistics in this summary **are based on comment documents**—not people. Two basic types of comment documents are recognized:

- **Personal Comment Documents**, such as letters, e-mails, telephone messages, or postcards with additional comments written on them. EPA received a total of **330 unique comment documents.**
- **Form Letters/Public Meeting Testimony**, which include such documents as postcards, form e-mails, and testimony (comments) presented at public meetings. EPA received a total of **1,779 form letters and made transcripts of two public meetings.**

To identify the range of the public represented by the comment documents, this section contains a description of the kinds of form letters and public testimony received. Later, this section contains a description of the comment documents by commenter type.

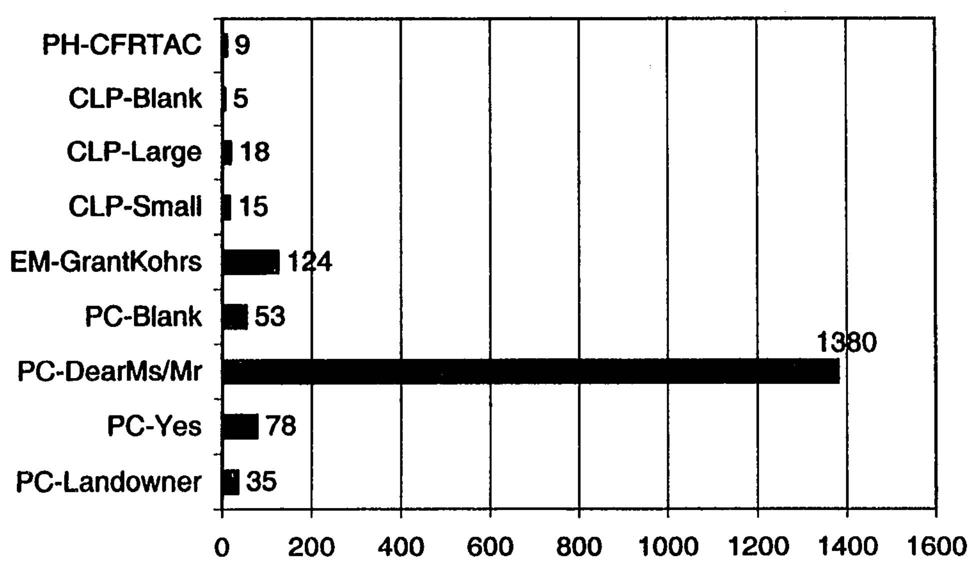
1.1.1 Form Letters and Public Testimony (Comments) Received

The form letters were grouped by the content of the postcard or e-mail, as shown below:

- CLP-Blank: Blank, lined newspaper clipping that contains handwriting
- CLP-Large: Large newspaper clipping from (Clark Fork River Technical Advisory Committee (CFRTAC) advertisement
- CLP-Small: Small newspaper clipping from CFRTAC advertisement
- EM-GrantKohrs: Form e-mail that focuses on the Grant-Kohrs Ranch
- PC-Blank: Blank, lined postcards with handwritten comments
- PC-DearMs/Mr: Postcards beginning with an address to "Dear Ms. Thomi and Mr. Brown"
- PC-Landowner: Postcards sent by landowners
- PC-Yes: Postcards beginning with "YES" and a checkbox
- PH-CFRTAC: Phone message left on the CFRTAC public recording

If someone submitted two different kinds of form letters, for example, a Landowner postcard and a "DearMs/Mr" postcard, each postcard was counted. That is, each postcard is counted in its group as two separate comment documents, rather than just one for the person. Exhibit 3-1 shows the number of comment documents received for each of these types.

Exhibit 3-1: Number of Form Letters Submitted (1,717) by Type



Public testimony was heard at two meetings: one in Deer Lodge on September 17, 2002, and one in Missoula on September 19, 2002. At the Deer Lodge meeting, 29 people provided comments. At the Missoula meeting, 33 people provided comments.

1.1.2 Comment Documents by Commenter Type

The authors of comment letters were organized into the following commenter types:

- **ATSDR:** Agency for Toxic Substances and Disease Registry
- **CFB Residents:** Clark Fork Basin Residents—anyone in Butte, Anaconda, Deer Lodge, Garrison, Missoula, Drummond, Clinton, Milltown, and smaller communities
- **Group:** Citizen groups and organizations
- **Local Government:** City and County officials, Conservation District Board
- **Meeting:** Oral comments provided to EPA at meeting or hearing
- **Natural Resources Trustees:** Federal, Tribal, and State Trustees
- **No Address:** People who did not supply an address
- **Others:** All other individuals

Each comment document was tagged with a commenter type, and form letters were counted in the total. Therefore, the total count for each type of document received includes form letters. Exhibit 3-2 presents the numbers of each commenter type by "unique comment document" and by "form letter."

EXHIBIT 3-2
Number of Comment Documents Received by Commenter Type

Commenter Type	Unique Comment Documents	Form Letters	Total Comment Documents
CFB Residents	183	1,317	1,500
Others	81	388	469
No Address	33	64	97
Group	17	4	21
Local Government	9	6	15
Meeting	3	0	3
Natural Resources Trustees	3	0	3
ATSDR	1	0	1
TOTAL	330	1,779	2,109
Percent of Total	15.6%	84.4%	100%

Exhibits 3-3 through 3-5 display the table information graphically.

Exhibit 3-3: Unique Comment Documents (330) by Commentor Type

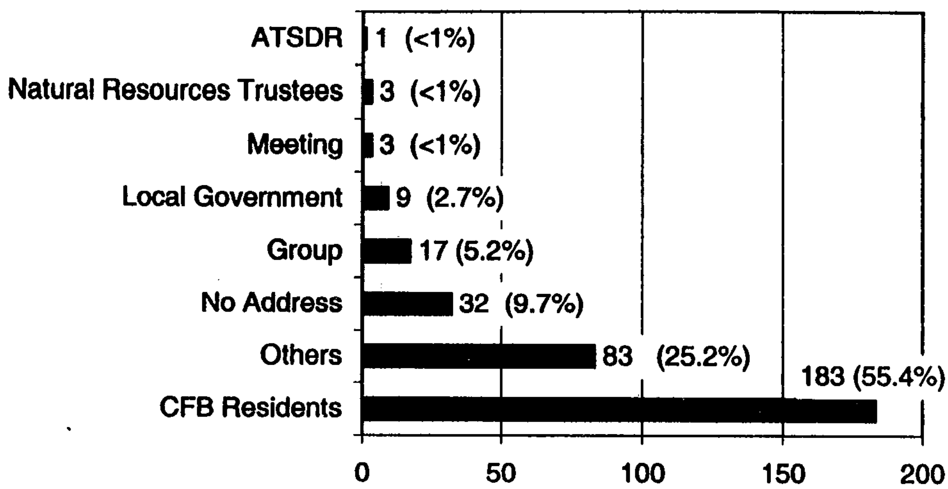


Exhibit 3-4: Number of Form Letters and Public Meeting Participants (1,779) by Commentor Type

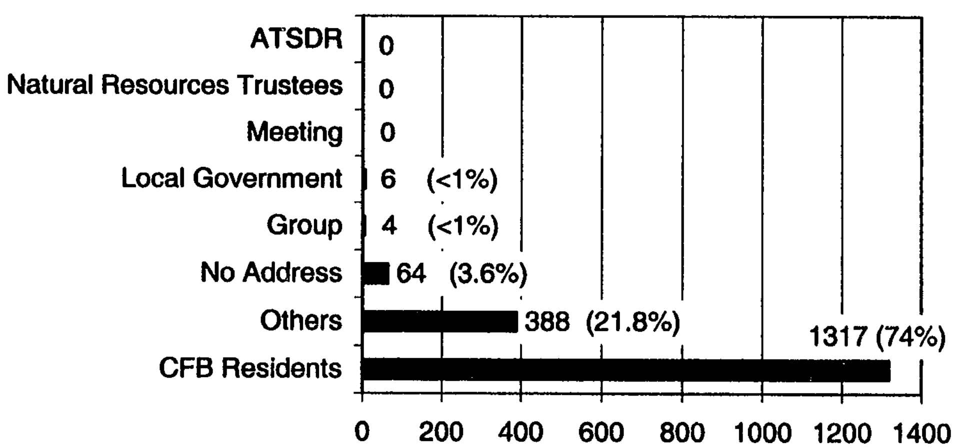
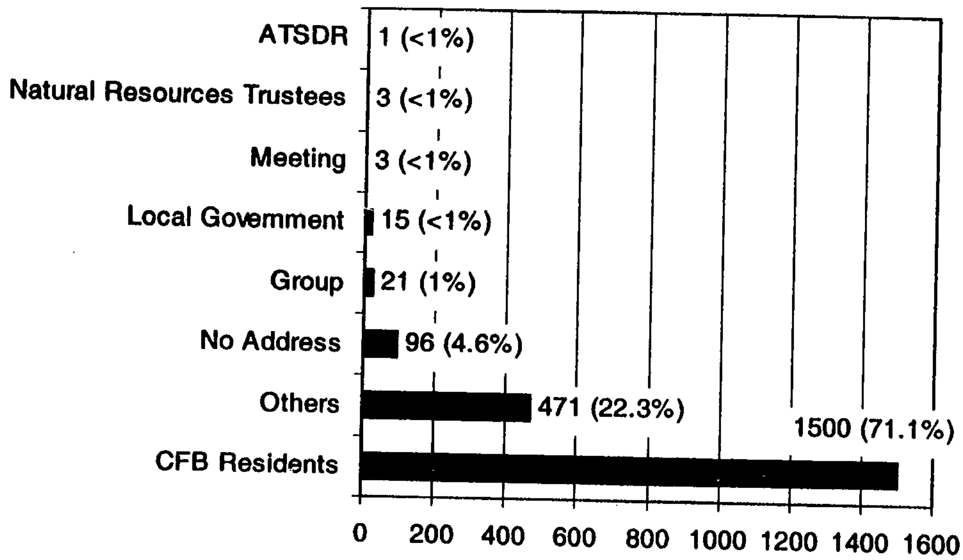


Exhibit 3-5: Total Comment Documents (2,109) by Commentor Type

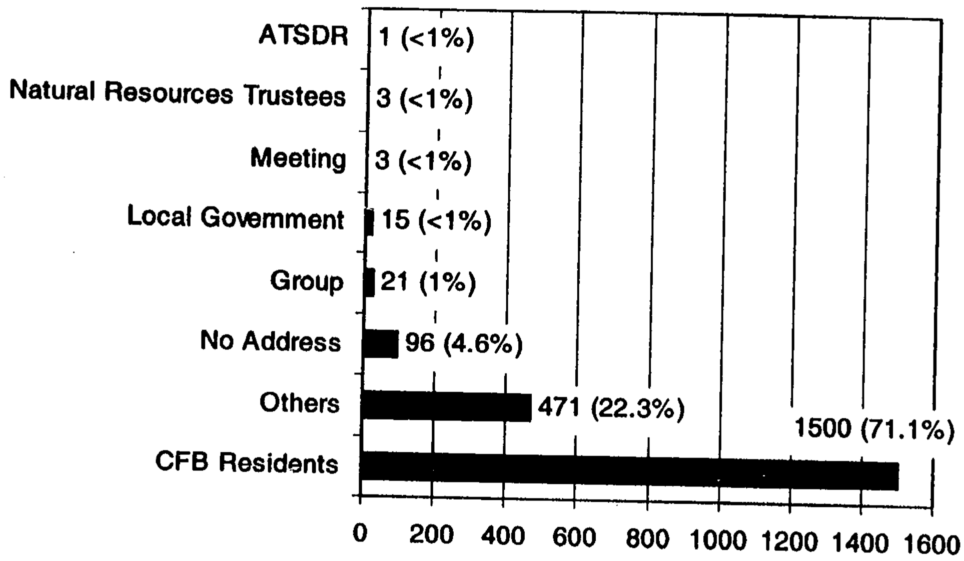


1.2 Types of Comments Received

All non-PRP comments received during the comment period were categorized as shown in Exhibit 3-6, *Categories and Subcategories Applied to Stakeholder Comments*. Comments within each comment document were numbered and marked for placement with an appropriate category and subcategory, whether it was an e-mail, letter, fax, phone message, or public meeting transcript. These comment documents, with comment number and categorization indicated, are available for viewing in Section 4, *Stakeholder and PRP Categorized Comments*. The table also indicates the number of comments received for each category.

Notable in this analysis of the comments are the 1,629 comments that support the *Proposed Plan* as well balanced and sufficiently protective. Another 161 comments conditionally supported the plan. Thirty-four commenters directly opposed the plan.

Exhibit 3-5: Total Comment Documents (2,109) by Commentor Type



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Notable in this analysis of the comments are the 1,629 comments that support the *Proposed Plan* as well balanced and sufficiently protective. Another 161 comments conditionally supported the plan. Thirty-four commenters directly opposed the plan.

EXHIBIT 3-6
Categories and Subcategories Applied to Stakeholder Comments (Excluding the PRP)

Categories	Subcategories	Description	Number of Comments
Technical Categories			
Air Quality	Air quality	Comments about air quality	2
Bank Stabilization/Buffer Zone	General comments	General comments on streambank stabilization and riparian buffer	206
	Remedies	What would happen at banks and in near-channel corridor	133
	Protection of vegetation	Limit use in areas of riparian woody vegetation for protection	4
	Buffer zone too narrow	Width of the buffer zone is too narrow	1,556
	Buffer zone too wide	Width of the buffer zone is too wide	6
	Concern about erosion	Comments about erosion	11
Best Management Practice (BMPs)	Grazing	BMPs for grazing	29
	Other land use management issues	Other BMPs	155
Costs	Cost of remedy	Cost of remedy	8
Ecological Health Risks	Terrestrial vegetation	Risks to terrestrial vegetation	2
	Livestock and wildlife	Risks to livestock and wildlife	3
	Soil organisms	Risks to soil organisms	1
	Fish/aquatic life	Risks to fish and other aquatic life	13
	Threatened and endangered species	Risks to threatened and endangered species	1
Floodplain Stability	Fluvial geomorphology issues	Floodplain stability and fluvial geomorphology issues	2
Groundwater Quality	Copper and other metals	Impact of copper and other metals on groundwater quality	3
	Arsenic	Impact of arsenic on groundwater quality	2
	Other constituents	Other constituents that affect groundwater quality	1
Human Health Risks	Residential	Residential risks	13
	Rancher and farmer	Agricultural rancher/farmer risks	1
	Recreational and Tribal	Recreational risks and risks to Tribal members in traditional cultural practices	5
Impacts During and After Remedy	Human safety and health	Traffic and dust affecting residents and construction workers	143
	Roads	Impact of roads on the environment	7

EXHIBIT 3-6
Categories and Subcategories Applied to Stakeholder Comments (Excluding the PRP)

Categories	Subcategories	Description	Number of Comments
	Ecological health	Impacts of implementation on ecological health	4
	Sequencing of construction activity	How construction will proceed	3
	Time required for construction	Length of construction period	16
	Construction monitoring	How construction will be monitored	3
	Post-construction monitoring	Post-construction monitoring and maturation of vegetation	151
	Operations and maintenance (O&M)	Ongoing O&M of remedy	1
In-situ Treatment/Phytostabilization	Extent	Extent of application of in-situ treatment and phytostabilization	3
	Vegetation success	Willows and other vegetation	18
	Re-entrainment	Re-entrainment of treated contaminants	1
	Arsenic mobilization	What happens to arsenic if in-situ treatment is applied	1
	Effectiveness	Effectiveness of in-situ treatment	29
Institutional Controls (ICs)	ICs for land use management	Comments about ICs	14
Natural Recovery/Natural Healing	Natural recovery effectiveness	Comments about natural recovery and healing	11
Non-Floodplain Lands	Historically irrigated fields	Irrigated fields outside of the floodplain	3
Noxious Weeds	Noxious weeds/invasive plant species	Concerns about these plants	186
Permanence	Long-term permanence	Permanence of remedy	15
Reaches B and C and Tributaries	Reaches B and C and Tributaries	Comments about reaches B and C and tributaries	25
Removal/Excavation	Effectiveness	Effectiveness of Removal	11
	Extent	Extent of removal	175
	With backfill	How much backfill is used	3
	Without backfill	No backfill used	1
Riparian Evaluation System (RipES)	Further development	How CFR RipES is developed	1,556
	Application in the field	How CFR RipES is implemented	3

EXHIBIT 3-6
Categories and Subcategories Applied to Stakeholder Comments (Excluding the PRP)

Categories	Subcategories	Description	Number of Comments
Surface Water Quality	Copper and other metals	Impact of copper and heavy metals on water quality	3
	Arsenic	Impact of arsenic on surface water quality	1
	Other constituents	Other constituents that affect surface water quality	2
Non-Technical Categories			
Access	Access to land by landowners	Access during and after remedy implementation for owners	3
	Recreation access and use river	Access during and after remedy implementation for recreation	3
ARARs	Compliance	ARARs compliance	4
	Waivers	ARARs waivers	10
	Park Service Organic Act	Relationship of ARARs to Park Service Organic Act	126
General Comments	General comments	No technical response needed because comment is an opinion	141
Consistency with Guidance	Consistency w/ NCP guidance	Consistency with NCP guidance	38
Economic Development	Effects on local economy	How remedy will affect economic development of area	19
Enforcement of BMPs	BMP enforcement on private land	How enforcement of BMPs will work	3
Landowner Compensation	Compensation for lost use of land	Landowner compensation for lost use of land	306
Landowner Involvement	Mandatory cleanup	Cleanup should be mandatory regardless of landowner desires	18
	Optional cleanup	Cleanup should be optional, allowing landowner choice	1
	Property rights	What rights landowners have	17
	Design/Land Use	Landowner/EPA negotiations	1,649
Opinion of Plan	Fully support plan	Commenter fully supports plan	1,629
	Conditionally support plan	Commenter conditionally supports plan	161
	Needs more information	Commenter needs more information to support/oppose plan	17
	Oppose plan	Commenter opposes plan	34

EXHIBIT 3-6
Categories and Subcategories Applied to Stakeholder Comments (Excluding the PRP)

Categories	Subcategories	Description	Number of Comments
Proposed Plan Remedy	Differences RRB vs. Plan	Differences between the Remedy Review Board (RRB) and Proposed Plan Remedies	1
	Additional study requests and Feasibility Study issues	Why the preferred remedy was selected	5
	Needs more investigation	Remedy needs further study or evaluation	3
Restoration	Restoration vs. remediation	Remediation is under Superfund; restoration is State and Federal Natural Resource Damages Program	6
State and Local Acceptance	Degree of State and local acceptance	Comments about State and local acceptance	3
Unrelated Comment	Out of scope; no response required	Comment was on an unrelated topic – no response needed	18
Water Rights	Transfer/use	Obtaining water rights for project	3

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2 Stakeholder Issues and Lead Agency Responses

The analysis method used by EPA provided a means of categorizing (and thereby separating) comments into common topics, then grouping similar comments together so that stakeholder's comments could be thoroughly and efficiently examined. To accomplish this, EPA analyzed and responded to comments using a four-step process:

- First, EPA identified technical and non-technical comment categories and subcategories after reviewing comment documents.
- Second, EPA assigned individual comments within each piece of correspondence a comment number, category, and subcategory (see Exhibit 3-6, page 3-6, for a list of categories and subcategories). A total of 8,764 separate comments were identified in the 2,109 pieces of correspondence received (not including the PRP).
- Third, EPA viewed the comments for each subcategory as a group and summarized the range of issues represented by the comments.
- Finally, EPA, in consultation with DEQ, wrote a response for each subcategory of comments.

This section is organized alphabetically by category. The subcategories are listed under each category. Within each subcategory, a summary of the comments is provided, along with the lead agency's response. The original comment documents, with comments marked and category indicated, are provided in Section 4, *Stakeholder and PRP Categorized Comments* (page 3-137).

2.1 Technical Categories

2.1.1 Air Quality

2.1.1.1 Air Quality

Summary of Comments

Of the comments received in this category, one individual felt that air quality risks from construction and implementation were negligible and could easily be mitigated by water trucks, and that the overall goal of restoring water quality is more important. Another commenter believed that construction would create huge dust clouds, contaminated with metals and arsenic, and would pose significant human health risks that should be analyzed more thoroughly before proceeding.

Response

The Selected Remedy for the Clark Fork River will be applied in a progressive manner throughout the Deer Lodge Valley. As with any construction project, it is anticipated that localized dust will be generated, particularly during the drier periods of the year. Most of the excavation work will be near the river, within the 100-year floodplain, and away from local structures and residents. Precautions to reduce dust levels, such as keeping roads moist, will be implemented as part of the site activities. The likelihood of fugitive dust and air impacts is unlikely. Construction Best Management Practices (BMPs) will be used throughout the remedial work to assure that the generation of contaminated dust and inhalation exposure is minimized.

Additionally, EPA believes the risks posed by construction dust are not significant. The *Baseline Human Health Risk Assessment* (EPA 1998) performed an evaluation of farming and ranching field activities (such as plowing and tilling) that generate substantial levels of soil and dust and could lead to inhalation exposure. It was concluded that the inhalation risk (for arsenic) was small when compared to the risk posed by ingestion, and that the exposure pathway did not warrant quantification.

2.1.2 Bank Stabilization/Buffer Zone

2.1.2.1 General Comments

Summary of Comments

Comments within the bank stabilization/buffer zone general comments category were quite diverse. Most commenters in this subcategory assumed that a buffer zone of some sort will be a remedy component. One person asked if EPA could provide an example of another river system with similar problems that were solved in the same way as proposed through a 50-foot buffer zone. Many commenters felt that implementation of the zone would be key to success of the remedy.

Several commenters questioned the size of the zone. Specific comments about the width of the zone are addressed in later sub-categories within this category. In the general comments, some commenters questioned how EPA determined the proposed width. Two people said that the 50-foot width is arbitrary and should be flexible for site-specific conditions. These commenters believe that a one-size-fits-all approach would be inappropriate. One commenter asked that the final buffer zone selected be based on science and account for stream hydrology and avoidance of contaminated areas in the future.

Many commenters want to make sure the remedy results in a healthy riparian plant community that can be protected for long-term stability. Most of these commenters indicated that using plants to stabilize the bank and reduce erosion would be the preferred approach, and asked that EPA use as little rock rip-rap as possible. One commenter agreed that mature willows, planted 3 feet deep, would be a good strategy for streambank stabilization, but wanted assurance that funding would be available if the first planting failed and additional plantings were needed. In addition, the commenter requested a contingency plan for the possibility of large flood events during the implementation of the remedy, and for some specified period of time after planting—at least 10 years.

Some commenters questioned the need for a riparian buffer zone and bank stabilization and asked for a detailed description and rationale for this component.

A few commenters were concerned about the use of willow plantings for a number of reasons. Such reasons included concerns that willow plantings would change the course of the river, willows would not be compatible with current land use practices, willows would not survive far from the river, or willows would use too much water from the Clark Fork River and contribute to dewatering the river.

One commenter specifically mentioned the work of Dr. Jim Smith of the U.S. Geological Survey (USGS). This commenter asked that EPA's plan be combined with Dr. Smith's research and consultation, which differs from the approach at the Atlantic Richfield Company's demonstration areas.

Another specific request was that for areas where meander bends are close to natural avulsions, bank stabilization techniques should be used to reduce the chance of streambank erosion and re-entrainment of contaminated soils from the floodplain. The commenter also asked EPA to consider establishing woody vegetation strips perpendicular to the slope of the meander belt in order to trap sediment and limit avulsion. The commenter suggested that these could potentially be associated with off-channel sediment detention ponds.

Individuals who commented on land use in the buffer zone ranged from asking that all grazing be excluded and no development allowed, to asking that no land uses be excluded and landowners should use the land in the riparian zone as they choose. Some commenters suggested riparian exclosure fencing. Others felt that a landowner compensation component would be needed if land uses are excluded. A few commenters suggested that conservation easements or outright purchase of the riparian buffer zone would be the best approach.

Response

During the *Remedial Investigation/Feasibility Study* (RI/FS), the USGS and the Fluvial Geomorphology Committee prepared several reports for EPA stating that there is clear evidence of floodplain instability on the Clark Fork River because of the release of hazardous material on the floodplain from mining activities. This is demonstrated primarily by available data that shows high erosion rates and frequent meander and tab changes and washouts. The primary cause of this excessive erosion is the lack of vegetation along the streambank, which in turn is caused, primarily, by the phytotoxic effects of mine contamination on vegetation (Atlantic Richfield Company 1998, *Final Draft Remedial Investigation Report;* EPA 1999, *Ecological Risk Assessment for the Clark Fork River;* Atlantic Richfield Company 2002, *Feasibility Study Report;* EPA 2002, *Proposed Plan*). Therefore, accelerated erosion of streambanks poses a threat to the environment, and this condition is primarily the result of a lack of adequate vegetation.

Excessive streambank erosion releases substantial quantities of copper and other metals and arsenic into the river, which causes violations of the State of Montana water quality standards. During normal hydrologic events, approximately 60 percent of the copper loading to the river is from streambank erosion (see Exhibit 3-7, *Sources of Copper in Surface Water [at Turah, 1998]*). The erosion also causes the loss of productive land to private and public landowners along the river.

These high levels cause exceedances of State of Montana water quality standards and are a significant concern. The proposed remedy must address this issue according to the CERCLA law, which requires Applicable or Relevant and Appropriate Requirements (ARARs) to be met by remedy implementation. Streambank erosion is also a major source of copper in the river that causes an unacceptable chronic risk to the aquatic environment and fish as described in the *Proposed Plan* (EPA 2002) and *Ecological Risk Assessment* (EPA 1999).

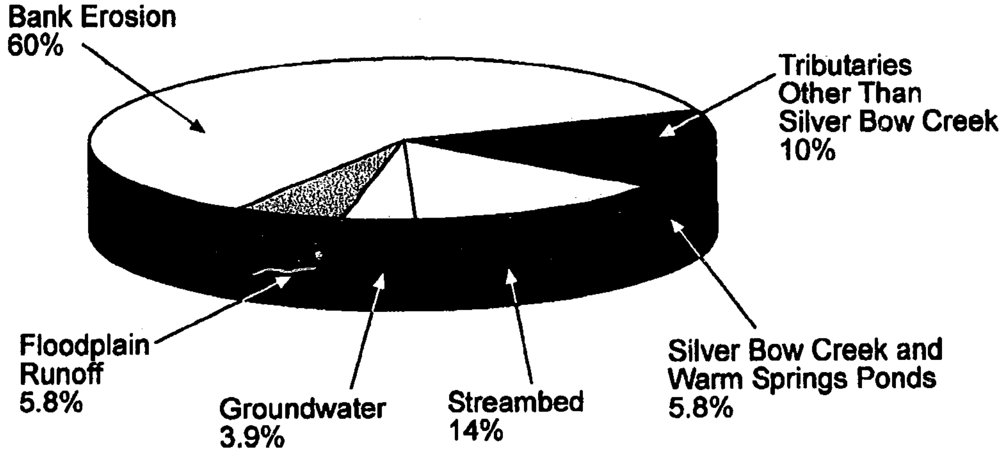

EXHIBIT 3-7
Sources of Copper in Surface Water (at Turah, 1998)

EPA's remedy includes an approximate 50-foot streambank stabilization component designed to develop a properly functioning, healthy riparian zone in response to this concern. The approximate 50-foot streambank stabilization component developed for the Clark Fork River by EPA is judged to be crucial for addressing overall protection of the environment. It addresses sediment copper loading, erosion risks, and exposure pathways. The approximate 50-foot width of the buffer zone is an ecologically based compromise. See further discussion of this issue in Section 2.1.2.4, page 3-20.

In general, healthy riparian areas provide for at least eight key ecological functions (Hansen et al. 1995, Hansen et al. 2000, Adams and Fitch 1998, Fitch and Ambrose 2003):

1. Trap and store sediments
    a) Sediment adds to and builds soil in riparian areas.
    b) Sediment aids in the ability of soils to hold and store moisture.
    c) Sediment can carry contaminants and nutrients—trapping it improves water quality.
    d) Excess sediment can harm aquatic animals like fish and insects.
2. Build and maintain streambanks
    a) Erosion is balanced with streambank building—the effects of erosion are reduced by adding streambanks elsewhere.
    b) Increase stability, resilience, and recovery.
    c) Maintain or restore profile of channel—extends width of riparian area through higher water tables.
3. Store water and energy
    a) Watershed safety valve—storage of high water on the floodplain during floods.
    b) Reduce flood damage by slowing water and reducing erosion.
    c) Slow floodwater allowing absorption and storage in underground aquifer.

4. Recharge aquifers
   a) Store, hold, and slowly release water.
   b) Maintain surface flows in rivers, streams, and wetlands through storage and slow release.
   c) Maintain high water table and extend width of productive riparian area.
5. Filter and buffer water
   a) Reduce amount of contaminants, nutrients, and pathogens reaching the water.
   b) Uptake and absorption of nutrients by riparian plants.
   c) Trap sediment, reduce water quality issues, and enhance amount of vegetation to perform filtering and buffering function.
6. Reduce and dissipate energy
   a) Reduce water velocity, which slows erosion and sediment transport.
   b) Resist erosion and slow channel movement.
   c) Aid in sediment capture.
7. Maintain biodiversity
   a) Create and maintain habitats for fish, wildlife, invertebrates, and plants.
   b) Connect other habitats to allow corridors for movement and dispersal.
   c) Maintain a high number of individuals and species.
8. Create primary productivity
   a) Vegetation diversity and age-class structure creates links to other riparian functions.
   b) Provide shelter and forage values.
   c) Enhance soil development.
   d) Capture and recycle nutrients.

Geomorphic stability is characterized by a dynamically stable floodplain that allows for lateral adjustment through normal streambank erosion and bar building. A necessary component of an equilibrium channel and floodplain are mobile channel boundaries that reflect a balance between the basin hydrology, geology, and climate. Typically, in alluvial geomorphic equilibrium systems, the streambank stability is provided by well-vegetated streambanks that are characterized by the presence of a deep, binding rootmass. Therefore, the long-term goal of the streambank stabilization component is to achieve well-vegetated streambanks with deep, binding rootmass that allow for gradual streambank change over time.

Peak flow data from the gage at Deer Lodge indicate that geomorphic and hydrologic conditions in the Upper Clark Fork Basin are now such that a bankfull flow recurs approximately every 7 years in the Deer Lodge Valley. This is the stage of flow that is most formative in establishing channel size and shape; that is, this stage has the greatest power to erode the streambanks. Broad, non-entrenched valleys such as this greatly dissipate the fluvial energy of flood flows that surpass the bankfull stage because the volume and energy of overbank flooding spreads out over a wide area, instead of increasing depth and velocity.

Most, but not all, riparian areas support woody vegetation (trees and shrubs). Trees and shrubs have an important and key role in riparian health. Their root systems generally are excellent streambank stabilizers and play a key role in the uptake of nutrients that could otherwise degrade water quality. The canopies formed by trees and shrubs protect soil from erosion, provide shelter to livestock and wildlife, and modify the riparian environment. Even when dead, the trunks of woody vegetation provide erosion protection and structural complexity, which plays a role in stabilizing floodplains. A good indicator of the ecological stability of a riparian reach is the presence of woody vegetation in all age classes, especially young age classes. Without signs of regeneration of preferred woody vegetation (those species that contribute most to riparian condition and stability), the long-term stability of the stream reach is compromised.

Currently, Reach A of the Upper Clark Fork River is characterized as a shrub-dominated system with trees playing a limited role. During the *Remedial Investigation* (Atlantic Richfield Company 1998) and the *Feasibility Study* (Atlantic Richfield Company 2002), it was determined that prior to European settlers, the Upper Clark Fork River Valley was a beaver-influenced system dominated by numerous beaver ponds and dams. The river corridor was dominated by shrubs such as willows (*Salix* species), water birch (*Betula occidentalis*), mountain alder (*Alnus incana*), red-osier dogwood (*Cornus stolonifera*), common chokecherry (*Prunus virginiana*), and western serviceberry (*Amelanchier alnifolia*). Trees, such as black cottonwood (*Populus trichocarpa*) and quaking aspen (*Populus tremuloides*) were limited in extent, mostly associated with the higher gradient tributaries of the Upper Clark Fork River. These species will be replanted in the streambank stabilization zone.

EPA's approximate 50-foot streambank stability component relies on extensive use of shrub planting to stabilize streambanks, which will slow the rate of erosion to more natural levels. It is important to remember that the woody vegetation is the glue that holds the streambanks together. With this in mind, all streambanks will need to have deep, binding, woody vegetation along them. One must think of the upper Clark Fork River floodplain as one unit. The river and its floodplain are inseparable. The natural movement of a river is to move back and forth across its floodplain over time. This means that through time, meanders are naturally cut off. However, the wide-spread presence of mine contaminants has accelerated this rate of movement above the natural background levels for the upper Clark Fork River and its floodplain. Therefore, it is critical to both establish and maintain woody vegetation throughout much of the meander tabs and not just along the outside of current meander bends. The woody vegetation on meander tabs will also reduce overland erosion and help stabilize the tabs so that meander cutoffs do not occur at an accelerated rate. This is critical for establishing both short- and long-term geomorphic stability along the upper Clark Fork River.

Temporary irrigation water to ensure survival of the revegetation efforts will be obtained. Plantings of willows and other species will be to a depth that reaches groundwater during sufficient periods during the growing season. EPA believes additional water demand placed on the river system by enhanced vegetation, such as willows, can be achieved with no harmful effects on existing water users.

Phytotoxic soils within the streambank stabilization component will be either removed and replaced with appropriate soil or treated in-place. (The Selected Remedy is described in Part 2, *Decision Summary*, Sections 13.2 and 13.3.) There is a strong desire to leave existing woody vegetation undisturbed and to improve poorly vegetated streambank areas because of the importance of vegetation in preventing erosion, channel migration, and floodplain destabilization. All construction activities will apply construction BMPs to protect healthy vegetation and the river.

The use of rock toes or rip-rap (large rock) will be minimized. In a stable natural system, the rate of lateral migration is typically low. A rip-rapped bank is static and cannot move with the river as it migrates naturally across its floodplain. Using rip-rap extensively would forever change the upper Clark Fork River Valley. The goal is to develop a self-maintaining, self-regulating floodplain by establishing a riparian buffer zone of woody vegetation. During the remedial design phase, certain areas may be identified by the design professional that require a more rigorous defense than vegetation alone is capable of providing. Examples would include protection of public infrastructure or streambanks subject to high stress where little or no riparian vegetation exists. In these areas, limited, targeted use of rock in conjunction with vegetation elements of the riparian buffer zone may be appropriate.

All remediated lands will be protected in such a fashion to allow adequate establishment and growth of new vegetation. Once the required amount and type of vegetation has become established, the land will be brought back into normal land use activities as described by a management plan written with landowner participation for each property. The land will be monitored to ensure adequate growth and establishment of the vegetation, especially the woody vegetation along the streambank. The use of grazing BMPs is discussed in Part 2, *Decision Summary*, Section 13.9. Performance standards must be met 10 years after remedial treatment and at interim intervals before that to ensure the site is on a revegetation trajectory to reach compliance (see Part 2, *Decision Summary*, Section 13.11.1).

Riparian pastures will be established throughout the floodplain. A riparian pasture can allow for forage use by livestock while reducing impacts to woody vegetation. Once the remediation and revegetation has been implemented, the riparian zone is expected to produce a much greater amount of forage than it currently produces. A riparian pasture with an appropriate level of use can provide the best of both worlds—herbaceous forage production for the landowner and maximum growth of woody vegetation to protect against erosion, soil loss, and floodplain instability. The appropriate livestock use levels will be determined and will follow those outlined in the documents by Hansen 1993, Hansen 1994, Ehrhart and Hansen 1997, and Ehrhart and Hansen 1998. Additional information on grazing in riparian zones can be found in articles by Hansen et al. 1995, Hansen et al. 2000, Adams and Fitch 1998, Fitch and Ambrose 2003, and by the Montana Department of Natural Resources Conservation (DNRC) 1995, 1999, and 2001. For bank stabilization, the key to success will be to base management responses on monitored levels of woody vegetation use, not on use levels of herbaceous vegetation.

During the design phase of the remedial action, a construction sequencing plan will be prepared. The priority of activities that will be enacted within a specific parcel of property as described in Part 2, *Decision Summary*, Section 12.2. The sequence of properties to be remediated throughout the Deer Lodge reach will be carefully planned and prepared. Properties will be engaged in a discontinuous manner to prevent jeopardizing the integrity of the floodplain, should a flood event greater than the annual flood occur during the 10-season remedial action period. Regarding high water events, the construction activities will be planned and conducted to the extent practical in concert with continuing awareness and evaluation of anticipated hydrologic changes (particularly high runoff that could cause overbank flows).

The approximate 50-foot streambank stabilization component developed by EPA is judged to be crucial for addressing overall protection of the environment. EPA believes the streambank revegetation component of the remedy will reduce erosional rates to levels that will address the potential for environmental risk in the river from flood events and mine contaminants that may be left in place in the remedy, and lessen the loss of land to normal erosional ranges experienced by other Montana landowners. It will also reduce the impact of very large flood events such that these events will not produce widespread floodplain destabilization. EPA also believes that a greatly expanded woody riparian corridor would be less implementable, as it would cause more disruption with landowners current operations. For a discussion of the issues regarding the proposed width of the buffer zone, please see Section 2.1.2.4, page 3-20.

Streamside buffers are widely used to reduce sedimentation and erosion problems along streams. Therefore, EPA believes the approximate 50-foot streambank stabilization component of the proposed remedy is implementable, protective, and practical. EPA's normal CERCLA authorities allow EPA to direct additional remediation if events occur, such as flooding, that exacerbate the release of hazardous substances. Because of these authorities, EPA does not see a need to include contingency components for bank stabilization if flooding occurs.

2.1.2.2 Remedies

Summary of Comments

While a few commenters advocated the use of large rock rip-rap to stabilize the streambank, many felt that a more natural remedy involving native vegetation would be more appropriate. One commenter felt that any revegetation approach to streambank stabilization needs to be accompanied by removal of tailings, significant re-shaping of banks, and heavy use of erosion control matting. Another was concerned about how the bank stabilization material would be transported along both banks of the river for up to 50 miles. A common theme in the comments was the desire for all landowners to participate to stabilize streambanks to ensure that future contamination would not be a problem.

Response

See previous response in Section 2.1.2.1, page 3-12, for a more detailed discussion. In general, most, but not all, riparian areas support woody vegetation (trees and shrubs). Trees and shrubs have an important and key role in riparian health. Their root systems generally are excellent streambank stabilizers and play a key role in the uptake of nutrients that could otherwise degrade water quality. The canopies formed by trees and shrubs protect soil from erosion, provide shelter to livestock and wildlife, and modify the riparian environment. Even when dead, the trunks of woody vegetation provide erosion protection and structural complexity, which plays a role in stabilizing floodplains.

EPA's approximate 50-foot streambank stability component relies on extensive use of shrub planting to stabilize streambanks that will slow the rate of erosion to more natural levels. It is important to remember that the woody vegetation is the glue that holds the streambanks together. With this in mind, all streambanks will need to have deep, binding, woody vegetation along them. It is critical to both establish and maintain woody vegetation throughout much of the meander tabs and not just along the outside of current meander bends. The woody vegetation on meander tabs will also reduce overland erosion and help stabilize the tabs so that meander cutoffs do not occur at an accelerated rate. This is critical for establishing both short- and long-term geomorphic stability along the upper Clark Fork River. Phytotoxic soils within the streambank stabilization component will be either removed and replaced with appropriate soil or treated in-place. There is a strong desire to leave existing woody vegetation undisturbed and to improve poorly vegetated streambank areas because of the importance of such vegetation in preventing erosion, channel migration, and floodplain destabilization. All construction activities will use construction BMPs to protect healthy vegetation and the river. BMPs will be done in close consultation with landowners. They will specifically be carefully applied in designing, constructing, and reclaiming roads on private lands that are needed to access areas of contaminated land and streambanks.

The use of rock toes or rip-rap (large rock) will be minimized. The goal is to develop a self-maintaining, self-regulating floodplain by establishing a riparian buffer zone of woody vegetation (see Response in Section 2.1.2.1, page 3-12).

2.1.2.3 Protection of Vegetation

Summary of Comments

Commenters had varied opinions about how the buffer zone should be used to protect riparian vegetation. While one commenter supported the idea that the riparian buffer zone still allows for grazing and weed control, another wanted all grazing uses removed and a fund established to maintain riparian fences in perpetuity. Another simply asked EPA for more detail about how grazing would be controlled until the vegetation is established. Another commenter asked that the remedy focus on restoring soil health so that vegetation could be supported.

Response

See response in Section 2.1.2.1, page 3-12, for a more detailed discussion. All remediated lands will be protected in such a fashion to allow adequate establishment and growth of new vegetation. The land will be monitored to ensure adequate growth and establishment of the vegetation, especially the woody vegetation along the streambank. Once this re-vegetation has met all applicable performance standards, the land will be brought back into the normal land use activities in accordance with management plans written for each property. Part 2, *Decision Summary*, Section 13.11, describes specific requirements and limitations for vegetation and grazing. Section 13.9.3, also in Part 2, *Decision Summary*, describes fencing maintenance and fencing requirements.

Once the remediation and revegetation has taken place, the riparian zone is expected to produce a much greater amount of forage than it currently produces. A properly managed riparian pasture can provide both herbaceous forage production for the landowner and maximum growth of woody vegetation to protect against erosion, soil loss, and floodplain instability. Appropriate livestock use levels will be determined and will follow those outlined in the documents by Hansen 1993, Hansen 1994, Ehrhart and Hansen 1997, and Ehrhart and Hansen 1998. Additional information on grazing in riparian zones can be found in articles by Hansen et al. 1995, Hansen et al. 2000, Adams and Fitch 1998, Fitch and

Ambrose 2003, and in DNRC 1995, 1999, and 2001. For bank stabilization, the key to success will be to monitor the use levels of the woody vegetation and not the use levels on the herbaceous vegetation. See Section 2.1.3.1, page 3-23, for more discussion about grazing issues. For a more detailed discussion, see Part 2, *Decision Summary*, Section 13.9.1.

Control of invasive plants will be an integral and critical component of remediation. An aggressive campaign to control weeds already on a site will be undertaken concurrently with any other remedial work being performed. For a more detailed discussion, see Part 2, *Decision Summary*, Section 13.10.

Native species or carefully chosen non-invasive introduced species will be used so that "vacant" or bare ground is quickly occupied by desirable plants. All sites will be monitored and treated for 5 years for weed infestations, as part of the post-construction monitoring process.

2.1.2.4 Buffer Zone Too Narrow

Summary of Comments

The approximate 50-foot buffer zone was considered either barely adequate or too narrow by most commenters. Many suggested expanding the zone to adequately stabilize the river, and their suggestions ranged widely, from 75 feet, 80 feet, 100 feet, 150 feet, 300 feet, 400 feet, and up to 600 feet. Other specific suggestions included increasing the riparian buffer zone to 400 feet upstream of Deer Lodge and to 300 feet downstream of Deer Lodge. Some suggested that the buffer should include as much of the floodplain as possible.

Some commenters argued that the riparian buffer zone width should be flexible. According to these commenters, the width should be determined by stream channel characteristics such as sinuosity, floodplain width, and channel slope that follows the natural contours of the landscape as it relates to the shape and natural meander of the river.

Response

The width of the streambank stabilization component (that is, the streambank and riparian corridor buffer) was based upon both the ecology of riparian plant species and the work of Dr. Jim Smith of the USGS. According to Griffin and Smith (2001), the Clark Fork River is vulnerable to high rates of streambank erosion as a result of extreme thinning of woody vegetation. They also stated that the presence of dense, woody vegetation on streambanks can decrease erosion substantially both by reducing the shear stress along the bases of the streambanks and by reinforcing the cohesion of the soil that forms the streambanks.

In a streambank stabilization demonstration project, Dr. Smith suggested that a series of rows of woody vegetation are needed to protect the streambank from excessive erosion rates. If the buffer zone is too small (for example, one or two rows of woody vegetation), the streambank is vulnerable to excessive erosion rates and is not protected by multiple rows of woody vegetation. Dr. Smith suggests that a minimum of four to five rows of woody vegetation will provide sufficient protection to effectively reduce the susceptibility of the streambank to excessive erosion rates.

Griffin and Smith (2001 and 2002), and Smith and Griffin (2002) stress the need for overlapping canopies of woody vegetation to have a density of plants great enough to effectively reduce excessive erosion rates. With this in mind, EPA developed the streambank stabilization component based on a buffer zone of approximately 50 feet that would have at least 10 to 12 rows of various woody vegetation (for example, clonal and multiple-stemmed shrubs) providing streambank stabilization.

Dr. Smith, in his November 2001 letter, criticized EPA's streambank stabilization component as insufficient to address the postulated unraveling event. Dr. Smith's concern was that the zone only addressed streambanks and not the floodplain, therefore, he proposes additional woody vegetation and land use restriction over a broader area than is contained in EPA's remedy.

EPA acknowledges this concern and acknowledges that the remedy does not fully address Dr. Smith's postulated unraveling event. However, EPA strongly disagrees that the remedy will not address the demonstrated erosional problems along the Clark Fork River. (See response under Section 2.1.2.1, page 3-12, for a more detailed discussion.) The approximate 50-foot streambank stabilization component developed by EPA is judged to be crucial for addressing overall protection of the environment. EPA believes the streambank revegetation component of the remedy will reduce erosional rates to levels that will address the potential for environmental risk in the river from flood events and mine contaminants that may be left in place in the remedy, and lessen the loss of land to landowners to normal erosional ranges experienced by other Montana landowners. It will also positively influence the very large flood events such that these events will not produce widespread floodplain destabilization (that is, floodplain unraveling). EPA also believes that an expanded woody riparian corridor would be less implementable, as it would cause greater disruption of some landowners' current operations.

Finally, many landowners stated that the riparian buffer zone should be flexible to address site specific conditions. EPA agrees with the commenters that specific landowner needs or land conditions may require flexibility in the approach. Accordingly, the *Record of Decision* notes that the approximate 50-foot streambank stabilization buffer zone component is approximate, and can be varied on a property-by-property basis. Therefore, EPA believes the approximate 50-foot streambank stabilization component of the proposed remedy is implementable, protective, and practical, given the requirement by EPA to select implementable remedies under the Superfund program.

2.1.2.5 Buffer Zone Too Wide

Summary of Comments

Comparatively few commenters indicated that the approximate 50-foot riparian buffer zone was too wide, as compared to those who felt it was too narrow. Those commenters favoring a more narrow zone felt that a 50-foot buffer would adversely affect normal ranching operations. One commenter stated that there are many places where the river has recovered on its own without a 50-foot wide buffer of willows.

Response

See previous responses in Section 2.1.2.1, page 3-12, and Section 2.1.2.4, page 3-20, for additional related discussion.

As noted in the previous response, EPA agrees that some flexibility is appropriate for the buffer zone, and will work with landowners on a site-by-site basis to determine the exact width of the buffer zone. Therefore, EPA believes the approximate 50-foot streambank stabilization component of the proposed remedy is implementable, protective, and practical.

2.1.2.6 Concern About Erosion

Summary of Comments

Most commenters in this subcategory were concerned about the erosion of contaminated materials into the river, especially during remediation work on the streambanks. They wanted measures taken to reduce the possibility of erosion during the streambank work and for up to 10 years after the streambank work or until the vegetation is well established. One commenter did not feel that the use of willows will stop the river from meandering. Another commenter did not want a lot of willows along the river, as it will reduce the ability to see the river.

Response

See response in Section 2.1.2.1, page 3-12, for additional related discussion.

Geomorphic stability is characterized by a dynamically stable floodplain that allows for lateral adjustment through normal streambank erosion and bar building. Typically, in alluvial geomorphic equilibrium systems, the streambank stability is provided by well-vegetated streambanks that are characterized by the presence of a deep, binding rootmass. Therefore, the long-term goal of the streambank stabilization component is to achieve well-vegetated streambanks with deep, binding rootmass that allow for gradual streambank change over time.

EPA's approximate 50-foot streambank stability component relies on extensive use of shrub planting to stabilize streambanks that will slow the rate of erosion to more natural levels. It is important to remember that the woody vegetation is the glue that holds the streambanks together. With this in mind, all streambanks will need to have deep, binding, woody vegetation along them.

EPA is acutely aware of the need to prevent the re-introduction of sediment from streambanks during remedial activities and the streambank stabilization process. Construction practices that incorporate safeguards and BMPs (such as the use of silt curtains, sediment barriers, etc.) will be implemented. EPA will coordinate these activities with the U.S. Fish and Wildlife Service (FWS). Construction activities will be closely monitored by EPA as will downstream water quality.

During remedial design, a construction sequencing plan will be prepared. The priority of activities that will be enacted within a specific parcel of property is described in Part 2, *Decision Summary*, Section 12.2. The sequence of properties to be remediated throughout the Deer Lodge reach will be carefully planned and prepared. Properties will be engaged in a discontinuous manner to prevent jeopardizing the integrity of the floodplain, should a flood event greater than the annual flood occur during the 10-season remedial action period.

A willow-lined river corridor that provides a stable floodplain will unavoidably impair the view of the river in some locations. However, the structural diversity provided by a combination of pastures and shrubs favors species diversity and increases wildlife values, further adding to the attractiveness of the landscape.

2.1.3 Best Management Practice (BMPs)

2.1.3.1 Grazing

Summary of Comments

Most commenters in this subcategory favored allowing some limited, careful livestock usage of the remediated areas under BMP guidelines with monitoring and enforcement provisions made. Some preferred that all livestock use be excluded from the streamside riparian buffer zone, but agreed reluctantly that BMPs are necessary if the streamside riparian buffer zone must be grazed. Some who favor BMP employment spelled out more specific suggestions and concerns. A common suggestion was that all grazing be excluded from the riparian buffer zone until woody vegetation is well established.

Some commenters did not favor employment of BMPs, favoring instead total exclusion of all grazing from the streamside riparian buffer zone. A few expressed doubt that BMPs can work because typical Montana riparian grazing practices are far too intense for this project.

Two commenters preferred that their grazing access to the floodplain not be limited. Without referring specifically to BMPs one way or the other, they took issue with fencing, fence maintenance, and the long time period required for woody vegetation to reach an effective growth stage.

Other specific comments and suggestions from those in favor of BMP employment included creating land use restrictions based on conditions at certain streambank areas, excluding livestock permanently from some areas, and including Reaches B and C (in addition to Reach A) in these considerations. One commenter was concerned that unrealistic expectations are being created by overstating the ability of the treated areas to tolerate grazing use, and that grazing levels will need to be much lower than they have been historically on many properties. A couple of commenters asked that landowners be compensated for lost uses and for fencing maintenance, while another said that conservation easements from willing landowners would be a good long-term solution. One commenter asked what kind of fence might be installed that would exclude livestock, but allow passage of wildlife.

Response

The development of proper grazing strategies and BMPs is critical to the success of EPA's remedy for the Clark Fork River. These management plans will be landowner-specific, and ensure that revegetated areas—whether the subject of removal of contaminants, in-situ treatment of contaminants, or contaminants left in place—are appropriately managed so that operation and maintenance (O&M) of these areas can occur. This approach will protect important revegetation efforts, minimize risks to the environment, achieve compliance with ARARs, and sustain remedial actions over time. The plans also ensure continued access, at appropriate times, by agency and Atlantic Richfield Company personnel to monitor and maintain the remedy. BMPs for removed areas would likely be less extensive and continue for a lesser period of time. EPA believes it essential that these efforts are implemented on a wide scale within the Clark Fork River OU, and funded by Atlantic Richfield Company in cooperation with the Department of Agriculture and local conservation boards. These efforts do not replace O&M or future work activities that remain the responsibility of the PRP.

In Section 13.9 of Part 2, *Decision Summary*, EPA discusses grazing strategies, BMPs, and the process involved in developing grazing management plans for various landowners along the Clark Fork River. Some things to consider in designing BMPs and in writing a riparian grazing management plan are presented in more detail in Appendix C of the *Record of Decision*. Plans for individual ranch management of grazing in the Clark Fork River riparian zone will be written based on the process described in Appendix C.

All remediated lands will be protected in such a fashion to allow adequate establishment and growth of new vegetation. Within the approximate 50-foot streambank riparian buffer zone, grazing will be excluded for 5 years following remedial treatment. After that period, grazing may be re-introduced as interim performance standards are met (see Part 2, *Decision Summary*, Section 13.11.1). Once this time has occurred, the land will be brought back into the normal land use activities as outlined in land use management plans written for each property in cooperation with the landowners. The land will be monitored to ensure adequate growth and establishment of the vegetation, especially the woody vegetation along the streambank.

On grazing lands, riparian pastures will be established in the Clark Fork River OU. A riparian pasture can allow for forage use by livestock while reducing any impacts to woody vegetation. Once the remediation and revegetation has taken place, the riparian zone is expected to produce a much greater amount of forage than it produces today.

Grazing is a complex issue that does not lend itself to a simple, "one size fits all" answer. The development for each property of BMPs and a comprehensive management plan that promotes woody vegetation and minimizes streambank impacts is essential for the success of these remedial actions on the Clark Fork River floodplain (see Part 2, *Decision Summary*, Section 13.9.1). Each landowner will be consulted to learn their vision for their piece of land. Once this is done, reasonable and attainable goals and objectives will be developed for their land. In some cases, no fences will be needed because the piece of land is being used for hay production or a crop. In other situations, an existing large pasture may be cross-fenced to allow for a rotational grazing system to reduce browsing of woody vegetation and reduced streambank trampling in the riparian zone and to provide periods of rest that will promote a healthy riparian zone. In still other cases, a fence running a couple hundred feet back from the stream, but parallel to the stream, will allow for the development of a riparian pasture. Riparian pastures are one of the most successful options for the following reasons:

1. When land is fenced "like-with-like" (in homogeneous units), land managers can more easily control livestock distribution.
2. Animal distribution is improved in both uplands and riparian areas when these areas are managed as separate units, which will often allow the land managers to increase sustainable carrying capacity.
3. Providing effective control over livestock grazing during the high risk periods immediately following construction allows for the most rapid recovery of riparian area health and productivity.
4. As a component of a land manager's riparian area management options, a riparian pasture will provide the flexibility to help restore and maintain woody vegetation.

Finally, and only as a last resort, would fencing of a narrow riparian corridor (for example, the approximate 50-foot riparian buffer corridor) be attempted. These narrow corridors are too small to effectively manage except as an exclusion zone from livestock grazing. Corridor fencing may be done for those situations where the landscape and property ownership boundaries preclude the other options. In other words, corridor fencing will be considered for those riparian areas where all other management options would fail. Fencing is to be maintained by the PRP as part of the remedy as provided in the *Record of Decision* (see Part 2, *Decision Summary*, Section 13.9.3).

Livestock grazing and proper riparian management are not incompatible goals. There are examples of working ranches with healthy riparian systems throughout North America that did not eliminate grazing from the riparian zone. Improper grazing was eliminated, not grazing altogether.

Having written a set of BMPs does not mean a landowner will have a functioning and healthy riparian zone. Usually, the step that is missed is the development of a ranch management plan that takes the generalized ideas of a BMP and develops reasonable and attainable objectives specific to each piece of ground. The BMPs are really the overall goals for a piece of land, while the objectives contain the specifics of how those goals are going to be met. For example, a goal (BMP) may be to reduce browse levels on woody vegetation to allow for the growth and maintenance of a shrubby corridor near the river. Another goal (BMP) may be to reduce streambank trampling and shearing. These goals do not tell a land manager how to accomplish them. That is where a riparian management plan comes into play. This is where the goals are made specific for a piece of land.

To assure compliance and performance, a comprehensive monitoring plan will be written for implementation along with each ranch management plan. Funding for the monitoring and enforcement will be provided.

Institutional controls (ICs) necessary for the Selected Remedy are identified in Part 2, *Decision Summary*, Section 13.4. In addition, conservation easements or deed restrictions may be useful for lands addressed by the remedy. EPA will continue to explore these types of ICs during the remedial design process.

Compensation to landowners is an issue that the agencies will continue to explore. See Part 2, *Decision Summary*, Section 13.6.5, for further discussion of this issue.

Appendix C, *Clark Fork River OU BMPs and Riparian Management Plan Considerations*, contains a list of key ideas to keep in mind when developing BMPs (goals) and a riparian management plan.

2.1.3.2 Other Land Use Management Issues

Summary of Comments

Of the many commenters in this category of general land use BMPs, several expressed outright preference for application of BMPs, while none expressed opposition to them. The most frequent comment was a request for definition of the BMPs. One stipulated that the Atlantic Richfield Company not be allowed to write them. Two asked that they be based in "good science." Commenters asked for clarification on such matters as where and how BMPs would be applied.

Some concern was expressed about enforcement of the BMPs and ICs. One person stated that the ICs and BMPs are not enforceable and not credible as written. A few asked who would enforce BMPs, who would pay for enforcement, and whether independent staff would be hired and funded for the purpose. A few others disliked the suggestion in the *Proposed Plan* that the Natural Resources Conservation Service (NRCS) or the local counties be charged with the task, because these agencies are already overworked and their staff members are vulnerable to local pressures. A few other commenters pointed out that success of BMPs depends on close monitoring, with two stating that water quality, as well as vegetation, should be monitored.

Some commenters suggested purchasing floodplain properties from willing sellers, with one suggesting that title to such lands could be placed with Montana Fish, Wildlife, and Parks (MFWP). A couple of commenters suggested that the use of conservation easements with willing sellers as a good way to gain better control of management within the critical riparian buffer.

Other comments included a request that the Atlantic Richfield Company pay for fencing maintenance, unless the landowner wishes to assume maintenance; that agricultural uses be given consideration to minimize disruption as much as possible; that some term other than ICs be used; and that cleanup should not depend on BMPs in locations where contaminants are left in place. Finally, the Deer Lodge Valley Conservation District requested continued, long-term involvement with the BMP program.

Response

EPA has responded to these comments by providing detail about BMPs and BMP enforcement in this *Record of Decision*. See response above in Section 2.1.3.1, page 3-23, for a more detailed discussion on grazing BMPs.

The role of ICs, BMPs, and land use plans are described in detail in Part 2, *Decision Summary*, Section 13.9, and BMP enforcement is addressed in Part 2, *Decision Summary*, Section 13.6.5. Additional detail is also found in Appendix C of this *Record of Decision*.

2.1.4 Costs

2.1.4.1 Cost of Remedy

Summary of Comments

Of the commenters in this subcategory, most indicated that the Atlantic Richfield Company should pay, one indicated the need for adequate funding, and one asked how the balancing criteria of cost was used in defining the remedy called for in the *Proposed Plan*.

Response

EPA, as mandated by CERCLA, has the authority to require the PRP, in this case the Atlantic Richfield Company, to perform or be financially responsible for the costs of remedial actions and associated monitoring costs as defined in Part 2, *Decision Summary*, Section 13.3. As was the case with previously completed records of decision such as for the Warm Springs Ponds and Rocker OUs, the Atlantic Richfield Company was deemed financially responsible for all remedial actions and funded and completed remedial actions as mandated in those respective records of decision.

As a balancing criteria, Capital and Operating and Maintenance Costs, in a present worth form, were compared for each alternative as proposed. Cost effectiveness was then considered, as described in NCP section 300.430(f)(ii)(D). Of the alternatives considered, EPA believes that the overall effectiveness of Alternative 5 best meets the cost effectiveness criteria. EPA believes the Selected Remedy is cost effective and will achieve benefits and effectiveness proportional to the expected costs (see Part 2, *Decision Summary*, Section 14.3).

2.1.5 Ecological Health Risks

2.1.5.1 Terrestrial Vegetation

Summary of Comments

The commenter stated that there are no numeric goals for terrestrial vegetation.

Response

Performance of vegetation will be integrated into specific remedial designs based primarily on end land use; thus, each land unit may have site-specific vegetation performance standards. The use of native species for revegetation will be stressed for some open space areas, while appropriate agronomic species may be used in other areas. Detailed numerical performance standards for vegetation based on post-remedial land use are presented in Part 2, *Decision Summary*, Section 13.11.1. For streambank riparian buffer zone polygons, numerical values for survival of planted woody species and for canopy cover of perennial vegetation are provided (see Exhibit 2-26 in Section 13.11.1), and relate to the length of time after remedation is completed. Numerical performance standards are also provided in Section 13.11.1, Exhibit 2-27 for canopy cover of perennial vegetation outside the riparian buffer zone, and for cover and species richness for non-riparian vegetation (Exhibit 2-28).

2.1.5.2 Livestock and Wildlife

Summary of Comments

The commenter stated that good water quality would be a plus for livestock and wildlife.

Response

EPA agrees. *The Ecological Risk Assessment* (EPA 2001) predicted that the overall hazard to range cattle to be moderate, with the primary source of the risk from ingestion of copper from soil, not from normal drinking water sources.

Surface water runoff from barren slickens or ponded water on barren slickens can contain very high concentrations of contaminants. Maximum concentrations in runoff water from barren slickens were reported to be 7,380 mg/L copper, 2,350 mg/L zinc, and 23 mg/L arsenic (Atlantic Richfield Company 1997). Because of the high level of contaminants in runoff from bare slickens, EPA made screening level calculations of acute risk to wildlife (birds and mammals, including cattle) from ingestion of surface runoff water. Results presented in the *Ecological Risk Assessment* (EPA 2001) indicated that under these maximum concentration conditions of contaminants in surface runoff waters, ingested doses might be of acute concern to birds and even large mammals. Removal of barren slickens areas as part of the Selected Remedy will eliminate this potential acute risk.

2.1.5.3 Soil Organisms

Summary of Comments

Commenter indicated that levels of contaminants of concern (COCs) were negatively correlated with microbial respiration in the contaminated soils. Microbial community structure was also negatively impacted by COCs.

Response

EPA agrees with the comment that soil organisms are impacted by contamination. The *Ecological Risk Assessment* reported that available data and information on the effect of soil contamination with elevated metals and/or low pH to soil organisms are limited, but the weight of evidence is strong that hazard does exist to soil organisms (worms, microbes), at least in slickens areas and in soils adjacent to slickens areas. It is also likely that metals in non-slickens soils within the riparian and upland areas may also be toxic to some soil organisms.

2.1.5.4 Fish and Aquatic Life

Summary of Comments

Of the comments in this category, most commenters were generally supportive of the proposed cleanup plan, but expressed some concern that EPA may have underestimated ecological risks. A few commenters questioned the need for cleanup, saying that fishing was already great near the Warm Springs Ponds, and that there was insufficient risk to justify the proposed cleanup plan.

Response

EPA recognizes that both acute and chronic aquatic risks must be considered in selecting a final remedy. EPA's Selected Remedy identified removal of slickens and in-situ treatment of less impacted contaminated areas, along with significant bank stabilization, as an appropriate and balanced means to address all risks identified in the administrative record for this site.

Acute Risks

The Ecological Risk Assessment (EPA 2001) reported that acute toxicity studies done using Clark Fork River water indicate acute lethality does not occur at dissolved copper concentrations lower than about 30 to 40 µg/L (depending on hardness). This finding is generally supported by laboratory studies that use water similar to that from the Clark Fork River (hardness = 100 to 300 mg/L). Between 1991 and 1997, concentrations of dissolved copper in the Clark Fork River measured under "typical" (non-storm event) conditions have mainly ranged from 2 to 20 µg/L, with 2 out of 232 samples falling above a concentration where some lethality might be expected. This low frequency of concentrations above the lethal effect level indicates that typical concentrations of copper in the river pose low risk of acute mortality to trout, even to the most sensitive life stage (which occurs at a body weight of about 0.4 grams).

Historically, there has been a clear association between storm events and the occurrence of fish kills in the Clark Fork River. This is thought to be due to surface water run-off from exposed tailings areas, since these surface flows generally contain high concentrations of copper and other metals, and are also acidic. Maximum concentrations in runoff water from barren slickens were reported to be 7,380 mg/L copper, 2,350 mg/L zinc, and 23 mg/L arsenic (Atlantic Richfield Company 1997). In this regard, it is important to note that not all storms cause acute lethality. Rather, a key factor appears to be the formation of a salt crust on the tailings, which in turn requires an appropriate set of meteorological conditions to form initially. In a review of a major fish kill in 1989, EPA postulated that concentrations of metals in these salts, in readily soluble form, were responsible for rapid increases in river water metal levels, and subsequently the lethal concentrations of metals, especially copper, in fish tissues (Munshower et al. 1997). In recent years (1992 to 1997), no storm-related fish kill events have been reported within the OU; however, berms were constructed in 1989 and 1990 to limit runoff from slickens areas and no data have been obtained to document the occurrence of acutely lethal concentrations of metals in the Clark Fork River, either during routine sampling or during detailed monitoring of storm events. However, absence of observed fish kills is not proof that fish kills are no longer occurring, and available monitoring data are not adequate to establish that short-term pulse events are not occurring. Because the basic source material remains in place (barren slickens and reoccurring metal salts), and because run-off waters from exposed tailings are known to contain very high levels of metals and are acidic, it is concluded that the risk of acutely lethal pulses remains.

Removal of barren slickens areas, which produce these soluble metal salts that can then be washed into the river during storm events, as part of the Selected Remedy described in this *Record of Decision* document will eliminate this potential acute risk to aquatic receptors.

Chronic Risks

In the *Ecological Risk Assessment* (EPA 2001) several factors and investigation results relating to chronic risks to Clark Fork River fish were evaluated. These included chronic exposure to contaminated surface waters, site-specific fish survival tests, avoidance studies, exposure to contaminants from diet and from sediments, and comparative fish density studies. In a recent fish feeding study (Stratus 2002), juvenile rainbow trout were fed live diets exclusively of *Lumbriculus variegatus* (common names include California blackworm, blackworm, mudworm). The *Lumbriculus* were cultured in metal- and arsenic-contaminated sediments collected from Silver Bow Creek and the Clark Fork River. Significant growth inhibition was reported for fish fed the contaminated diets during the 67 day trial period. Growth inhibition was statistically related to metals and arsenic in the diets and to levels found in fish tissues. The best statistical correlations were reported for arsenic. The study suggests that *Lumbriculus variegatus* grown in metal- and arsenic-contaminated sediments can pose a risk to juvenile rainbow trout through an exclusive dietary exposure pathway.

Taken together, the data from these studies are consistent with the hypothesis that copper (and possibly arsenic and other metals) in the aquatic environment (surface water and diet, which presumes intake from contaminated sediments) impose low-level chronic stress on aquatic macroinvertebrates, trout, and other fish. The *Ecological Risk Assessment* and EPA's unacceptable risk findings are carefully and accurately stated in this *Record of Decision* and the *Proposed Plan*, and are well supported by the record.

EPA's broad unacceptable risk finding also accounts for the State's concern about chronic risks to aquatic organisms. The State also maintains as its ARAR for the Clark Fork River a total recoverable standard for metals and arsenic, and this chronic standard is routinely violated in the upper reaches of the Clark Fork River by releases of metals from sources such as bank erosion and runoff. The State emphasizes the chronic risks presented at the site.

EPA's proposed remedy is an appropriate response to these unacceptable acute and chronic risks to Clark Fork River fish as well as to other risks identified in the Clark Fork River OU administrative record (see Part 2, *Decision Summary*, Section 7, for a thorough discussion of site risks and the relationship of risks to the Response Action). The removal of barren slickens areas addresses the principal waste and acute risk in a permanent manner without residual risk. The in-situ treatment component addresses other impacted soils and vegetation and related terrestrial risk found at the site. The bank stabilization component addresses the erosion, stream stability, and chronic aquatic risks found at the site.

2.1.5.5 Threatened and Endangered Species

Summary of Comments
One commenter stated that bull trout recovery required removal of toxic metals.

Response
Bull trout are listed as a threatened species under the Endangered Species Act (ESA), and EPA has a responsibility under the National Contingency Plan (NCP) to ensure that such species are sufficiently protected through remedy selection and implementation. The remedy will remove the most toxic metal located in barren slickens areas, treat other impacted areas, and stabilize the streambanks. These actions will all help in recovery of bull trout. EPA has performed consultation under the ESA with the FWS and produced a Biological Assessment as part of the RI/FS process for the Clark Fork River OU. EPA will continue to consult with the FWS as described in the Biological Opinion for this project as remedial design goes forward.

2.1.6 Floodplain Stability

2.1.6.1 Fluvial Geomorphology Issues

Summary of Comments
One commenter was not convinced that the *Proposed Plan* contains the proper strategy to address the next 100-year flood. This individual predicted the unraveling of the floodplain, conversion to a braided system, and subsequent release of the same toxic contaminants downriver over the floodplain that this *Proposed Plan* is attempting to contain and control. Another commenter was concerned that the removal of 167 acres of tailings will cause the channel to unravel.

Response
The USGS and the Fluvial Geomorphology Committee prepared several reports for EPA as part of the RI/FS and site study process. Those reports stated two essential points about floodplain stability on the Clark Fork River.

There is clear evidence of floodplain instability on the Clark Fork River because of the release of mine contaminants upon the floodplain. This is demonstrated primarily by available data that shows high erosion rates and frequent meander and tab changes and washouts. This erosion is caused by impacts to the terrestrial environment (vegetation) resulting primarily from mine wastes at the site. This, in turn, causes the Clark Fork River to have less streambank stability than it should. The erosion releases substantial quantities of copper and other metals into the river, which causes violations of the State of Montana water quality standards. The erosion also causes the loss of productive land to private and public landowners along the river.

Dr. Jim Smith, a USGS scientist, has postulated that the present floodplain instability is so great as to present a risk of further severe floodplain instability and land loss (the unraveling theory) in very high flood events because of the lack of vegetation.

EPA acknowledges uncertainty associated with the modeling of Dr. Smith and with the developing science used for modeling and predicting these effects. (See the following reports prepared by Atlantic Richfield Consultants Parker, Gary—St. Anthony Falls Laboratory, University of Minnesota—*Draft Technical Review of Smith, J. Dungan on Quantifying the Effects of Riparian Vegetation on Stabilizing Single Threaded Streams*, 7th Federal Interagency Sedimentation Conference, Reno, Nevada, April 26, 2001; R2 Consultants Inc.—*Technical Review of Smith, J. Dungan on Quantifying the Effects of Riparian Vegetation on Stabilizing Single Threaded Streams*, 7th Federal Interagency Sedimentation Conference, Reno, Nevada, September, 2001; and R2 Consultants Inc.—*Assessment of Geomorphic Stability During Historical Floods of Silver Bow Creek, Little Blackfoot River and Big Hole River, Montana*, September 2001).

EPA notes that Dr. Smith's work was peer reviewed by other USGS scientists prior to publication. EPA must address this possibility and risk despite its uncertainty. EPA also notes that Dr. Parker's comments as well as other Atlantic Richfield Company citations have not been peer reviewed. In fact, Dr. Parker states, "The reach of the Clark Fork in question is **moderately affected** by tailings from the Anaconda copper mine, which were deposited in a major flood in 1908." He further states, "It does not suggest that the basis for the analysis by Smith is fundamentally wrong." Thus, Atlantic Richfield Company's own retained expert finds some validity in Dr. Smith's modeling work.

In partial response to this geomorphic stability concern, EPA's remedy includes a streambank stabilization component. It is not a component supported by Dr. Smith and, in his view, does not fully address the problem. Dr. Smith, in his November 2001 letter to EPA, proposes additional woody vegetation and land use restrictions over a broader area than is contained in EPA's proposed remedy.

EPA believes that the streambank stabilization component is a protective measure given the uncertainty associated with the modeling effort, and will continue to monitor the remedy after implementation to see if sufficient vegetation is present to prevent the risk of unraveling.

The Selected Remedy's streambank stabilization component is not based solely on the risk of catastrophic unraveling. The streambank component also addresses two other elements of risk presented by mine contaminants deposited along Reach A of the Clark Fork River:

- Excessive erosion of valuable agricultural, recreational, and important habitat land is documented by other USGS studies in which Atlantic Richfield Company experts participated. The primary cause of this excessive erosion is the lack of vegetation along the streambank, which in turn is caused, primarily, by the phytotoxic effects of mine contaminants on vegetation (see the *Remedial Investigation, Ecological Risk Assessment for the Clark Fork River, Feasibility Study*, and *Proposed Plan*). The streambank stabilization component will slow the rate of erosion to more natural levels.

- The streambanks release large quantities of copper and other metals during erosion into the Clark Fork River (See Exhibit 3-7, page 3-14). During normal hydrologic events, approximately 60 percent of the copper loading to the river is by streambank erosion. These levels cause exceedances of State of Montana water quality standards and are a significant concern. The proposed remedy must address this issue according to the CERCLA law, which requires ARARs to be met by remedy implementation. Streambank erosion is also a major source of copper in the river that causes an unacceptable chronic risk to the aquatic environment and fish as described in the *Proposed Plan* and the *Ecological Risk Assessment*. During high bank flows, invertebrate levels may become significantly reduced.

EPA acknowledges that the remedy does not fully address Dr. Smith's postulated unraveling event. However, EPA strongly disagrees that the proposed remedy will not address the demonstrated erosional problems for the Clark Fork River. EPA believes the streambank revegetation component of the remedy will reduce erosional rates to acceptable levels. This reduction will address the potential for environmental risk in the river from flood events and contaminants that may be left in place in the remedy, and will lessen the loss of land to landowners to normal erosional ranges experienced by other Montana landowners. It will also reduce the impact of the very large flood events so that these events will not produce widespread floodplain destabilization. EPA also believes the woody riparian corridor plan advocated by Dr. Smith may not be implementable, as it would disrupt the use of riparian pastures by certain landowners.

Therefore, EPA believes the streambank stabilization component of the proposed remedy is implementable, protective, and practical.

2.1.7 Groundwater Quality

2.1.7.1 Copper and Other Metals

Summary of Comments

All commenters in this subcategory believed that contamination would leach into the groundwater, and/or that contaminated groundwater would leach into the Clark Fork River.

Response

In a 1998 report, the USGS conducted a study to determine sources of contaminants to the Clark Fork River. They found that the mass load contribution of contaminants, using copper as an indicator, was as follows (see Exhibit 3-7, page 3-14):

- From the shallow groundwater system into the Clark Fork River: 3.9 percent
- From floodplain runoff into the Clark Fork River: 5.8 percent
- From upstream sources (Silver Bow Creek and Warm Springs Ponds) into the Clark Fork River: 5.8 percent
- From tributaries into the Clark Fork River: 10 percent
- From the streambed into the Clark Fork River: 14 percent

- From the streambanks into the Clark Fork River: 60 percent

The *Remedial Investigation* (Atlantic Richfield Company 1998) found groundwater is contaminated only to shallow depths of approximately 10 feet or less and the plumes are associated with overbank tailings locations. The migration pathway of contaminants from this shallow system into the Clark Fork River is the pathway of least concern in terms of loading to the river. Concentrations of copper in groundwater ranged from the detection limit of 0.5 µg/L to 413 µg/L, while zinc levels ranged from the detection limit of 0.5 µg/L to 60,000 µg/L. Of the 381 samples tested, none were found to exceed the State of Montana water quality standard for copper of 1,000 µg/L, while two of the samples exceeded the standard for zinc of 5,000 µg/L. Arsenic concentrations in 385 samples ranged from below the detection limit (0.1 µg/L) to 170 µg/L. Thirty-four samples from 18 wells had levels above the Montana standard of 18 µg/L. All of these concentrations, except one, were found in samples within 8 feet of the ground surface. Five percent of the groundwater samples exceeded Montana standards for cadmium and for lead. Potable wells were found to be generally uncontaminated. Data from the Clark Fork River Site Screening Study (CH2M HILL et al. 1991) indicate one domestic well, of the 77 tested, had an exceedance of existing Montana standards for cadmium. Arsenic levels in all but four domestic wells are below the State and Federal drinking water standards of 10 µg/L. The wells were completed in the shallow water table, and were sampled in June 1987. The wells were located in Deer Lodge, Montana, and are to be re-sampled as part of the Selected Remedy.

The removal of slickens and in-situ remediation of impacted soils and vegetation as described in the *Record of Decision* will reduce the rate of future groundwater contamination for copper, cadmium and other metals and shallow groundwater quality is expected to improve over time. In addition, a domestic well sampling program will be instituted to ensure groundwater wells are safe for human consumption. For a discussion of arsenic, see Section 2.1.7.2, *Arsenic*, below.

2.1.7.2 Arsenic

Summary of Comments

The sole commenter in this subcategory said that there are no groundwater protection measures in the *Proposed Plan*, and such measures should be added.

Response

The Selected Remedy described in this *Record of Decision*, when implemented, will improve groundwater quality over time. The removal of slickens and in-situ remediation of impacted soils and vegetation as described in the *Record of Decision* will reduce the rate of future groundwater contamination for copper, cadmium, and other metals. In the case of arsenic, removal of slickens will eliminate this arsenic from the system. For in-situ treatment, the addition of lime to impacted soils will raise the pH of the soils into the neutral or basic range (approximately pH range of 7.5 to 8.5). Such a pH change can theoretically mobilize arsenic ions from the soils and/or substrate and allow them to move to shallow groundwater and into the Clark Fork River. Additional amendments to fix arsenic and inhibit its mobility are suggested for impacted soils and vegetation areas slated for in-situ treatment when the arsenic concentration exceeds 1,000 mg/kg (refer to Part 2, *Decision Summary*, Section 13.5.4). Arsenic is also bound to soils and substrate by other mechanisms that may not be sensitive to the aforementioned pH changes, thus not releasing arsenic ions. Additionally, increased vegetation may reduce arsenic mobilization and input to groundwater. In any case, the arsenic concentrations are relatively low in the soils and substrate and, if released, the arsenic would have no detectable measurable concentration changes in the river. This conclusion is also supported by the fact that only 3.9 percent of the total contamination is estimated to come from the groundwater, as mentioned earlier. This *Record of Decision* also specifies performance standards to minimize the transport of COCs into groundwater. These are presented in Part 2, *Decision Summary*, Section 13.11.2. Public health issues with groundwater can be managed through the use of monitoring and well surveys as described in Part 2, *Decision Summary*.

2.1.7.3 Other Constituents

Summary of Comments

The only commenter in this category said that there is a risk of radionuclides in groundwater that is not addressed.

Response

During the initial investigations conducted during the *Remedial Investigation* for this site, numerous water and contaminated soils samples were tested for various radionuclides. Based upon those initial analytical results, it was concluded that radioactivity from radionuclides and radionuclide concentrations were not above screening levels at this OU. Therefore, these contaminants were not identified as COCs.

2.1.8 Human Health Risks

2.1.8.1 Residential

Summary of Comments

Most commenters in this category asked for continued evaluation and assessment of health risks from all COCs, including arsenic, copper, zinc, lead, cadmium, and mercury. One commenter asked that these assessments focus on risks to children and other high-risk populations. Along with this, some commenters noted that recreational areas, which attract children, are being constructed on what they believed to be contaminated ground. A couple of commenters cited Arrowstone Park as an example, and requested that these types of areas be cleaned up along with the rest of the floodplain, and that complete removal would be the only way to assure a safe environment.

Some commenters felt that the *Human Health Risk Assessment* was inadequate and left many questions unanswered. One commenter said that additional questions have been raised about exposure levels for arsenic and COCs since the publication of the *Human Health Risk Assessment*, so additional review of acceptable levels is warranted. Another commenter asked whether tributaries were included in the remedy because of human health risks.

Other commenters asked if cancer rates in Deer Lodge are abnormal, and if there is a connection between an apparent increase in Wegener's disease in the Deer Lodge Valley and the contamination in the river. A few other commenters asked if the 10^{-4} excess cancer risk level would be applied in the Clark Fork River OU, and why the EPA did not use a 10^{-5} or 10^{-6} standard for residential, recreational, or agricultural uses.

In contrast to these comments, a few commenters felt that the minimal human health risks described in the *Human Health Risk Assessment* and the *Proposed Plan* would not warrant a cleanup on the scale proposed. Because the *Proposed Plan* stated that human health risks are within the normally acceptable range, the *Record of Decision* should simply address other risks (such as living in a historically irrigated field, using a shallow well, ingesting contaminated soil, or engaging in Tribal traditional cultural activities) through educational programs. Another commenter felt that implementation of the remedy would cause more human health risk problems that it would solve by disturbing the area.

Finally, the ATSDR provided some specific recommendations for addressing human health risks. While they acknowledged that EPA has already analyzed risks for specific exposure scenarios, they felt that future development of recreational or residential areas may require further risk evaluation. Although they believed land use restrictions in the *Proposed Plan* would protect human health in most situations, ATSDR stated that they would be available to assist in evaluating special situations that may arise. ATSDR also recommended that exposed tailings be addressed at the area of the old trestle site in Deer Lodge.

Response

A summary of human health risks is provided in Part 2, *Decision Summary*, Section 7.1. How the Selected Remedy will mitigate these human health risks is explained in Part 2, *Decision Summary*, Section 13.4. In the recent past under its removal authority, EPA has actively addressed human health risks resulting from arsenic exposure in residential areas near Deer Lodge, including playgrounds and parks, and some residential areas along the East Side Road. This *Record of Decision* specifies that any similar exposures would also have to be addressed to ensure that human health is protected. This *Record of Decision* also specifically identifies that ICs, such as limiting residential use of the floodplain and potable water wells in the floodplain, will be implemented to ensure public health protection. Groundwater well surveys and monitoring are also required. Seven specific actions to reduce risks to human health are presented in Part 2, *Decision Summary*, Section 13.4.

EPA's *Human Health Risk Assessment* (EPA 1998) and its Addendum (EPA 2001) evaluated the most likely scenarios for human exposure to COCs in the Clark Fork River OU. Risk managers have made decisions establishing specific action levels for cleanup of wastes containing arsenic, which is the contaminant associated with unacceptable risk. These levels vary depending on the reasonably anticipated land use for a given area. Human health risk based concentrations (RBCs) of antimony, arsenic, beryllium, cadmium, copper, iron, manganese, mercury, and zinc for soils/tailings, river water, pooled water, groundwater, and for foods were established in the *Human Health Risk Assessment* (EPA 1998). In addition, risks were calculated for humans exposed by multiple pathways.

EPA has used the 10^{-4} risk level as a basis to require remediation to protect human health at the Clark Fork River OU. This is consistent with other EPA superfund cleanups in the basin where risks less than 10^{-4} (such as 10^{-5} or 10^{-6}) have not been addressed by remedial action and are considered acceptable. The 10^{-4} risk level is within EPA's acceptable risk range as provided for in the NCP at 40 CFR 300.430(e)(2)(i)(A)(2).

The *Human Health Risk Assessment* provided text to help interpret the RBC and states, "RBC values should be interpreted by comparison to concentration values which represent the arithmetic mean and/or UCL (upper confidence level) of the mean of a chemical averaged over an appropriate exposure unit and should not be interpreted as a 'not-to-be-exceeded' value on a sample-by-sample basis." The document also states, "noncancer and cancer risks from exposure to soil and tailings are dominated by arsenic, and no other chemical poses risks in a range of concern."

The *Record of Decision* document specifies actions required to address human health considerations. The Selected Remedy sets action levels for arsenic in soils within the Clark Fork River OU as follows:

- Residential – 150 ppm
- Rancher/Farmer – 620 ppm
- Recreational – 680 ppm for children at Arrowstone Park and other recreational scenarios
- Fishermen, swimmers, and tubers along the river only – 1,600 ppm

The trestle area in Deer Lodge was identified by ATSDR as an area where current data indicates an exceedance of the recreational level established above. Early sampling of this area shall be undertaken as needed to supplement existing data. If levels are exceeded, contaminated soils will be removed and replaced with appropriate backfill, and revegetation shall be implemented. Disposal of excavated materials will be in Opportunity Ponds. Other known recreational areas will be evaluated, using existing data where possible, to determine if they exceed the recreational level. If exceedances are found, they will be dealt with in a similar manner.

Some residences are identified under the Deer Lodge Valley Historically Irrigated Lands time-critical removal action (TCRA) as exceeding the action level for arsenic in residential areas and were not addressed under the TCRA. These areas will be revisited and remediated consistent with that action. Other follow-up operation and maintenance activities from this action will be implemented.

EPA does not believe that other historically irrigated lands within the Clark Fork River OU exceed EPA's action level for reasonably anticipated land use for those lands. This shall be confirmed via sampling of these lands if necessary and confirmation that residential development is not planned for these areas. As noted in later portions of this section, confirmation sampling for in-situ treated areas is also required to ensure that these areas are below action levels for current and reasonably anticipated uses (which is likely to be agricultural for most lands) after treatment.

The Clark Fork River *Human Health Risk Assessment* (EPA 1998) and the *Human Health Risk Assessment Addendum for Recreational Visitors at Arrowstone Park* (EPA and ATSDR 2001) evaluated the human health risks arising from exposures to heavy metals and arsenic within tailings deposits, soils, and groundwater along the river. The studies concluded that, based upon the understanding that no residential development exists within the floodplain, and that exposures are limited to ranch (or farm) workers and recreators (fishermen, tubers, and children at parks), the human health risks are generally acceptable. On historically irrigated lands, however, where residential development has occurred or where it may occur in the future, the risk assessment concludes that risks may be unacceptable. National Park Service (NPS) conducted a human health risk assessment for the Grant-Kohrs Ranch National Historic Site (NPS 2003) and found potential risks to workers from contaminated sediments in irrigation ditches that may be unacceptable.

EPA is unaware if cancer rates in Deer Lodge are abnormal. As previously stated, EPA considers acceptable exposure levels to be concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} (1 in 10,000 probability) to 10^{-6} (1 in 1,000,000 probability), with 10^{-6} as the point of departure. EPA is also unaware if there is a connection between exposure to metals and Wegener's disease. Health experts do not know what causes Wegener's granulomatosis. Wegener's granulomatosis is an uncommon disease, in which the blood vessels are inflamed (vasculitis). This inflammation damages important organs of the body by limiting blood flow to those organs and destroying normal tissue. Although the disease can involve any organ system, Wegener's granulomatosis mainly affects the respiratory tract (sinus s, nose, trachea [windpipe], and lungs) and the kidneys. This disorder can affect people at any age and strikes men and women equally. It is rare in African Americans compared to Caucasians.

EPA will respond to any new information it may become aware of during remedy implementation to be sure that public health protection is achieved.

Three ICs will be implemented (refer to Part 2, *Decision Summary*, Section 13.4, for detailed description of these ICs) to further protect human health. The ICs are summarized below:

- Continued implementation, including funding, will be provided for Powell County's and Deer Lodge County's zoning ordinances, which prohibit building a permanent residence within the floodplain of the Clark Fork River in those counties.
- Permanent deed restrictions and use funding are required for Arrowstone Park near Deer Lodge, to ensure that this area is maintained and dedicated to use as a recreational area.
- All previously sampled domestic wells that exceeded MCLs will be resampled, as well as any new private domestic well located in or near the floodplain. Appropriate ICs to address groundwater use in the shallow aquifer shall be implemented and funded. A survey of well use in the floodplain of Reach A is necessary. Domestic wells that are near contamination sources will be sampled, and appropriate action to ensure safe water supplies for domestic users will be taken if exceedances of groundwater performance standards are found. Additional ICs beyond existing State statutory protections can range from groundwater control areas to ordinances or deed restrictions.

Educational efforts for recreational users within the river corridor area concerning the need to prevent soil intake by children and maintain other health practices to prevent unnecessary exposure to soils shall be undertaken, in cooperation with local and State health authorities. These also must be funded.

2.1.8.2 Rancher and Farmer

Summary of Comments

The Department of the Interior expressed concerns relative to workers exposed to soils historically irrigated with Clark Fork River water on the Grant-Kohrs Ranch National Historic Site.

Response
The NPS provided data indicating potential risks to workers from arsenic contaminated irrigation ditches at the Grant-Kohrs National Historic Site. A baseline human health risk assessment for the Grant-Kohrs Ranch National Historic Site (Foster Wheeler 2003) indicated that a full time seasonal irrigator working at the ranch had a cancer risk estimate greater than 1×10^{-4}, (arsenic and cadmium) and a hazard quotient greater than 1.0 (arsenic). Additional sampling will be performed in coordination with the NPS to determine if unacceptable risks are present for the Grant-Kohrs Ranch National Historic Site and other similar irrigators, and, if so, contamination will be remediated.

2.1.8.3 Recreational and Tribal

Summary of Comments
Commenters in this category felt that recreational human health risks had not been adequately assessed. In particular, the commenters felt that children involved in recreational activities would be especially vulnerable to contamination along the river. One commenter asked EPA to explicitly prohibit, or at least limit, recreational access to known contaminated areas.

Another commenter was concerned about risks to Tribal members in their traditional cultural practices. The key concerns expressed include the following:

- The Clark Fork River OU is contained wholly within the aboriginal territory in which Tribes retain Treaty rights. The *Proposed Plan* points out that the exercise of those rights and participation in traditional cultural practices may result in additional exposures to Tribal members above and beyond those expected from general recreational and agricultural activities.
- The risks to Tribal members from these activities has not been assessed.
- The *Proposed Plan* would reduce soil arsenic concentrations based on land use criteria (for example, different levels based on agricultural, recreational, or residential uses and sites). It is not clear if these reductions would reduce additional exposures for traditional cultural practitioners. The *Record of Decision* should recognize this.

Response
Since the *Human Health Risk Assessment* was released, a local public park (Arrowstone Park) was developed in Deer Lodge. This park has different use patterns than those evaluated in the *Human Health Risk Assessment*. As a consequence, EPA prepared an addendum to the *Human Health Risk Assessment* that focused on characterizing chronic arsenic exposure to children aged 1 to 10 years old visiting Arrowstone Park no more than 48 times per year (Syracuse 2001). The chronic risk-based concentration of 680 mg/kg (ppm) for children recreational users was determined. Concurrently, the ATSDR concluded that the existing data for the park did not adequately characterize park conditions and recommended further sampling and analysis of soils for arsenic concentrations. A team from ATSDR collected soil samples from several areas within the park that represented different exposure units in 2001. Conclusions of this work (ATSDR 2001) are provided in Part 2, *Decision Summary*, Section 7.1. In summary, EPA and ATSDR both believe that the 680 ppm level is appropriate, and that unacceptable risks are not present at Arrowstone Park.

Although human RBCs for arsenic did not specifically address Tribal traditional cultural practitioners, the *Baseline Human Health Risk Assessment* quantitatively considered risks to humans from subsistence hunting, subsistence fishing, and ingestion of native plants. Evaluations of these specific exposure routes cover some of the pathways that may be of concern to Native Americans. Other cultural practices, not known by EPA, which may lead to exposure of Native Americans by other pathways, were not considered. However, EPA expects that these unidentified cultural activities may not differ greatly from the recreational use scenario considered in the *Human Health Risk Assessment Addendum*. One scenario assumed 48 days of use each year for a combined age of 40 years (10 years child and 30 years adult). The most stringent RBC for such chronic exposure to arsenic is 745 ppm. EPA believes the remedy of removal of slickens and treatment of impacted areas will reduce the arsenic exposures in the floodplain to values that would not pose unacceptable risk to traditional Tribal practitioners.

2.1.9 Impacts During and After Remedy

2.1.9.1 Human Safety and Health

Summary of Comments

Many commenters expressed concern about the human safety risks associated with the large volume of truck traffic that would accompany implementation of the *Proposed Plan*. Stated concerns about risks included accidents with other vehicles, bicycles, horse riders, and pedestrians. The second most frequent concern was directed at human health issues that could be generated by the creation and exposure to dust and noise. Impacts on local roads and the disruption of culture and serenity of the small town of Deer Lodge were also voiced as concerns. Suggestions for limiting human health risks included the use of ICs where applicable and sampling and maintenance activities.

Response

As previously stated, the proposed remedy for the Clark Fork River will be applied in a progressive manner throughout the Deer Lodge Valley, that is, not all at one time. The *Record of Decision* requires the removal and backfill of approximately 430,000 cubic yards of tailings from slickens areas and treatment of approximately 700 acres of contaminated soils. This work will be staged at different times and locations and will create an increase in truck traffic within the valley. The safety risk posed to the public is directly related to many things, including the route driven, condition of the existing road infrastructure, and the volume of traffic using it. As with other large construction projects, preparing truck and equipment travel routes, times, and frequency are essential to an efficient and safe plan of operations. EPA anticipates that truck and local traffic planning will be coordinated through local County and City officials before being implemented to help minimize impacts to local residents. Travel routes will be publicized ahead of time to notify the community of travel corridors that will be affected. Through this careful planning process, construction risks can be managed to avoid injury. EPA has overseen other large construction projects like this, with satisfactory health and safety results.

Precautions to reduce dust levels, such as keeping roads moist and covering haul loads, will be implemented as part of the site activities. As explained in Part 2, *Decision Summary*, Section 13.11.5, and Section 2.1.1 of this *Responsiveness Summary* (page 3-11), the likelihood of fugitive dust and air impacts is unlikely. Construction BMPs will be used throughout the remedial work to assure that the generation of contaminated dust and inhalation exposure is minimized. The *Baseline Human Health Risk Assessment* (EPA 1998) concluded after examining dust generating activities (such as soil tilling) that the inhalation risk (of arsenic) was small when compared to the risk posed by ingestion, and that this exposure pathway did not warrant quantification.

Prior to implementation of the remedy, road and bridge designs along proposed corridors of travel for trucks and equipment will be evaluated for structural integrity. Results of these assessments will dictate the required changes to the infrastructure to promote a safe and efficient travel plan for the remedial activities.

2.1.9.2 Roads

Summary of Comments

A handful of comments were specific to the impacts on local roads caused by heavy truck traffic from the proposed cleanup. Commenters' concerns ranged from wanting East Side Road paved, to making sure all roads and bridges used for the cleanup were properly upgraded and maintained, to asking that all new access roads would be reclaimed at no cost to the County. Two commenters indicated they had no problem with the likely increased traffic.

Response

Implementation of the Selected Remedy, as described in this *Record of Decision*, will result in an increase of truck and equipment traffic on many local roads and a portion of the interstate corridor during the planned 10-year construction phase. The remedial design phase will be performed on a landowner-by-landowner basis. During design, slickens areas designated for removal and disposal at the Opportunity Ponds will be delineated, and the actual volume of these materials to be excavated will be calculated. The excavation volumes will determine the number of truck cycles that will be required. The design will also define transportation corridors across the property that will subsequently connect with County, City, State, and the interstate road systems to transport the wastes to the Opportunity Ponds repository. It is likely the same route will accommodate a return trip with the required backfill soils and other remedy defined supplies and amendments to the same property. Traffic safety plans for those corridors will be prepared and coordinated with appropriate City, County, and State agencies as described in Part 2, *Decision Summary*, Section 13.11.5. The existing connecting roads will then be evaluated based upon the additional haul traffic and will be upgraded as necessary to safely handle the additional traffic. All other roads and bridges will be evaluated and upgraded on an as-needed basis. The cost of the upgrades and maintenance are the responsibility of the PRP. It is anticipated that temporary haul roads on private property will be constructed in consultation with landowners, as will the reclamation of those roads.

2.1.9.3 Ecological Health

Summary of Comments

A few comments specifically stated concerns for the resident wildlife and disruption of their habitat by the remedial action. Other commenters suggested that the final water quality and health of the wildlife populations be used to help gage the success of the cleanup.

Response

Implementation of the remedy will be conducted in a manner that minimizes impacts to areas not specifically targeted for remedial action. BMPs will be employed to avoid contributing additional sediment to the river or increasing the risks to aquatic life. Sensitive wildlife habitat will be noted during design and pre-construction reconnaissance of areas. Remedial designs will reflect the sensitive nature of these areas. However, it is anticipated that some habitat will be impacted because of the scale of the remedial action being proposed. The agencies will strive to minimize impacts as the remedy progresses through the Deer Lodge Valley. Water quality monitoring in the Clark Fork River will be implemented during the construction activities to assess impacts to the aquatic environment.

2.1.9.4 Sequencing of Construction Activity

Summary of Comments

A few commenters recommended that cleanup begin on the most contaminated areas first. Another suggested that, before work begins, a logical plan for sequencing the work throughout the Deer Lodge Valley be prepared and implemented.

Response

During the design phase of the remedial action, a construction sequencing plan will be prepared. Since the majority of Clark Fork River to be remedied is on private property (71 percent), it is important that the remedy be implemented on a property owner by property owner basis. It will be appropriate to first schedule and coordinate design and construction work with willing landowners who control large sections of the river since necessary construction impacts will affect these people the most. Willing property owners with lesser amounts of property may be scheduled if sequencing a number of properties in a row will be advantageous. Until such contacts are made with all property owners, a final sequencing plan cannot be completed.

The final sequencing of properties to be remediated throughout the Deer Lodge reach will be planned as carefully as possible. Progress is heavily dependent upon the cooperation of willing landowners.

2.1.9.5 Time Required for Construction

Summary of Comments

Several commenters spoke to the necessity of starting the cleanup as soon as possible. Other commenters focused on the duration of the cleanup. Many commenters asserted that the cleanup should and would take more than the 10 years projected in the *Proposed Plan.* Limiting cleanup operations to 18 months on any one property was suggested, as was remaining flexible with the duration of the property operation and the importance of working with the landowner. One comment suggested that a realistic schedule should be presented in the *Record of Decision.*

Response

A general schedule for remedial action on the Clark Fork River is described in the *Record of Decision*. The anticipated duration, as discussed in the *Record of Decision*, is ten field construction seasons. EPA believes this is a reasonable period of time for implementation of the remedy, if the work is well planned and organized. Within that period, it is assumed that several construction crews will be working on several properties concurrently. At this time, a 2-year implementation target per property appears reasonable. However, the first step of implementation involves a detailed reconnaissance of the subject property, which includes a Clark Fork River Riparian Evaluation System (CFR RipES) assessment and discussions with the landowner. These activities form the cornerstone of the level of effort to be applied to the property. The site specific design then dictates the construction timetable for that portion of the project. As the remedy progresses and knowledge is gained, there may need to be adjustments in this anticipated schedule.

2.1.9.6 Construction Monitoring

Summary of Comments

Commenters in this subcategory emphasized the importance of oversight during cleanup, hiring competent contractors, conducting adequate planning and monitoring of increased truck traffic, and monitoring of the duration of operations on each property with emphasis on successful re-vegetation.

Response

The remedy will be implemented with agency (EPA/DEQ) oversight over the length of the planned 10-year remedial construction period. It is currently assumed that the Atlantic Richfield Company will implement the remedy as they have done on the majority of other Clark Fork Basin OUs. If that is the case, the agencies performing oversight will review and approve all final designs. In addition, they will review and approve all contractors selected for work on each property.

During construction, EPA/State representatives will provide field oversight to assure that all work is being conducted appropriately and in conformance with the design developed for that property. They will verify removal depths, backfill quality and placement, and in-situ methods and depths to determine that adequate mixing is achieved and that health based criteria for arsenic at the surface are met when mixing is complete. They will verify that streambank remediation is conducted per the design. All revegetation efforts will be monitored to assess their conformance with performance standards and the design specifications.

2.1.9.7 Post-Construction Monitoring

Summary of Comments

Post-construction monitoring of the proposed cleanup activities was suggested by many commenters. Performance standards for cleanup that could be readily monitored in a post-construction activity were suggested. Providing adequate funds to promote the long-term monitoring and re-planting, if necessary, was important to commenters. It was also suggested that remedies not requiring monitoring in perpetuity be considered. In several comments, the question was posed about a comparison between long-term impacts of the proposed remedy versus that of no action. The final suggestion raised the concern of high water events and whether that possibility had been considered.

Response

Post-construction monitoring of the remedial action is an integral part of the remedy. Adequate funding will be provided for monitoring activities. The *Record of Decision* discusses various post-construction monitoring programs that will be implemented, such as operational and functional monitoring, and short term and long term monitoring. Five-year reviews will assess the progress of the remedial action, allow comparison of specific remedial attributes with performance standards outlined in the *Record of Decision*, and dictate follow-up action, if warranted. Refer to Part 2, *Decision Summary*, Section 13.9, Section 13.10, and Section 13.11, for detailed discussions. The application of nutrients and water to the re-vegetation effort should promote a quicker, more robust, growth response. EPA and DEQ will coordinate with local land management agencies (such as the NRCS) regarding the monitoring and assessment of post-construction response. Sufficient funding will be provided to ensure that the necessary monitoring will be conducted by a qualified party. Post-construction monitoring will continue until EPA and DEQ determine that the remedy is functioning properly and performing as designed, as directed by regulations in 40 CFR 300.435(f)(1). Regarding high water events, the construction activities will be planned and conducted to the extent practical in concert with continuing awareness and evaluation of anticipated hydrologic changes (particularly high runoff that could cause overbank flows).

2.1.9.8 Operations and Maintenance (O&M)

Summary of Comments

The commenter requested a better definition for the term O&M, and also asked what organization or agency would be responsible for O&M.

Response

O&M activities will be employed as part of the remedy to protect the integrity of the Selected Remedy for the Clark Fork River. The O&M measures are initiated after the remedy has become functional after the completion of construction as outlined in the *Record of Decision*, and the constructed remedy is determined to be complete based on State and Federal acceptance. Once the O&M period begins after the completion of construction for a specific property, the PRP has continuing responsibility for maintaining the effectiveness of the remedy. Monitoring and maintenance activities are specified in Part 2, *Decision Summary*, Section 13.11.4.

2.1.10 In-situ Treatment/Phytostabilization

2.1.10.1 Extent

Summary of Comments

The comments received in this subcategory are polarized. While some individuals desire more extensive use of in-situ treatment—even of slickens areas—others said that impacted areas should be removed rather than treated. One commenter asked that conditions for removal and in-situ treatment be stated in the *Record of Decision*.

Response

Decision criteria and definition for removal areas, in-situ treatment areas, and no treatment are fully presented in this *Record of Decision* (see Part 2, *Decision Summary*, Section 13.6). CFR RipES is a remedial design tool that allows the *Record of Decision* requirements to be implemented on a site-specific, refined, and definitive basis. The purpose is to provide a data predicated decision tool to identify and categorize polygons based on landscape stability, plant community attributes, and contamination severity within the OU.

EPA carefully considered the comments advocating more treatment and those advocating more removal. EPA believes that the combination of these techniques—removal of most slickens and in-situ treatment of most impacted areas—reflects the best balance among trade-offs when considering the NCP required balancing criteria and modifying criteria. Further explanation regarding EPA's decision making is contained in Part 2, *Decision Summary*, Sections 10 through 13, and in the August 2003 EPA memorandum (regarding: Preparation of the *Record of Decision* for the Clark Fork River OU), which responded to concerns from four employees, and is incorporated herein by reference.

2.1.10.2 Vegetation Success

Summary of Comments

Commenters had a range of opinions about how to achieve vegetative success. Some asked that willows and other woody species only be planted in areas that provide the highest vegetation success rate, and that native species (local origin) of grasses, trees, and shrubs be established in the riparian corridor. Some commenters identified the individual species to be used. A few asserted that the remedy, whether it involves removal and replacement or in-situ treatment, should focus on restoring soil conditions that support grasses and woody species to ensure streambank stability. Some commenters were concerned about the effects of metals and arsenic on the vegetation community after in-situ treatment, and wondered if willows could only be established in limited areas in tailing-impacted sites. One commenter stated that slickens areas could be developed into a good alfalfa field, as demonstrated by Lampert's field.

Response

As discussed in this *Record of Decision*, removal with replacement and in-situ treatment represent the primary tools for addressing exposed tailings and impacted soils and vegetation areas, respectively. These remedial tools will be used to create a remedial environment that will promote and sustain a robust vegetative community within the floodplain.

In a recent investigation, the effect of depth of incorporation of soil amendments (lime and organic matter) on growth of Geyer willow planted in fluvial mine tailings was reported by scientists at Colorado State University (Fisher et al. 2000). Willows grown in tailings treated to a depth of 60 cm produced eight times more biomass than willows planted in non-amended (pH 4.0) tailing materials, and 36 percent more than willow planted in tailings amended to a depth of 20 cm. Chemical analyses of the growth media indicated the lime amendment increased pH of the mine tailings (pH near 7.3) such that metals were made less bioavailable and therefore, not phytotoxic. This study suggests that increased depth of incorporation of soil amendments into mine tailings can significantly enhance production of willow cuttings. Depth of incorporation of amendments for phytostabilized areas and depth of excavation for removal areas are major remedial design issues for the application of the remedy for the Clark Fork River. Treatment of the entire contaminated zone for phytostabilization and excavation of all contaminated materials during removal are key design criteria. In practice, willows will be planted in or near the static water table, ensuring the best possible potential for successful establishment and growth. Appendix B of this *Record of Decision* document provides streambank stabilization design considerations and examples.

Objectives for the reclaimed plant community cross many disciplines, including geomorphology, agriculture, wildlife, fisheries, hydrology, risk assessment, and others. The plant community within the OU is expected to serve as a biological soil anchor during flood events, as forage and habitat for wildlife and cattle, as an evapotranspiration system to prevent the recharge of COCs into groundwater, as a deterrent to surface water runoff, and as an aesthetic component of the agricultural landscape. Characteristics of the plant community that are important in the remedy include plant production, forage quality, species diversity, and structural diversity. The relative importance of a characteristic is driven by the land management objectives. Agricultural production objectives would favor high forage value and high production with limited emphasis placed on species and structural diversity. By contrast, wildlife and habitat values increase with structurally complex vegetation and species diversity. The degree to which remedy is able to satisfy the objectives of the landowner is dependent on the management objectives for a specific land area. Native vegetation—such as grasses, shrubs, and trees—will be stressed for many areas that will receive remedial actions. For other areas, the vegetation community to be established will depend on current and future land uses. Remediated areas that are to be used for intense agricultural production—for example, irrigated alfalfa—will be seeded with appropriate agronomic species. In areas that may be subject to flooding during high spring runoff, extra caution will be needed to ensure that farming techniques do not leave bare ground in sensitive areas exposed for significant periods of time.

2.1.10.3 Re-Entrainment

Summary of Comments

This commenter desired removal of toxins as protection of human health. The commenter felt that in-situ treatment is doomed to failure because of the relentless power of the river over time.

Response

Human health RBCs for antimony, arsenic, beryllium, cadmium, copper, iron, manganese, mercury, and zinc for soils/tailings, river water, pooled water, groundwater, and for foods were established in the *Human Health Risk Assessment* (EPA 1998) and its addendum. In addition, risks were calculated for humans exposed by multiple pathways. Arsenic was determined to be the primary COC for human health. Refer to Part 2, *Decision Summary*, Section 13.4, for a discussion of how the Selected Remedy will reduce the risk (from arsenic) to humans.

The Clark Fork River will meander within its existing channel, and re-entrain treated or phytostabilized tailing materials as well as untreated materials and soils that are imported after removal actions. No remedy, including removal or in-place treatment of mine tailings, will stop stream processes such as erosion. The extensive streambank stabilization planned as part of the remedial action, including the 50-foot buffer zone, is intended to slow the rate of meandering and erosion to normal levels, thereby reducing the release of contaminants to concentrations that achieve State of Montana water quality standards or replacement standards when combined with the other remedial action components.

2.1.10.4 Arsenic Mobilization

Summary of Comments

Commenter believed that in-situ treatment of contaminated soils will likely make arsenic more soluble. The commenter added that even if it were granted that STARS (in-situ treatment) approach does result in overall decrease in solubility of arsenic, low mobility does not mean that arsenic present in contaminated soils is not a significant risk as it will continue to enter the environment slowly and that risk will continue over a long time period. EPA should not downplay the public's concern over arsenic mobility and in-situ treatment, but should take a reasonably precautionary approach.

Response

The mobility of arsenic, differentiated from its solubility, in a phytostabilized environment is dependent on several interrelated chemical, physical, biological, and climatic factors. In laboratory column experiments (Jones et al. 1997), arsenic concentrations in the effluent were increased by a factor of 400 when the pH of smelter tailings was raised from 4.5 to very high pH levels between 9 and 10. Adding lime to reprocessed smelter tailings raised the pH from 3.5 to about 8. Under these pH conditions, the arsenic concentrations in the laboratory column effluent increased from about 0.74 to about 7.4 µg/L (Jones et al 1997). Speciation of arsenic was not attempted in these laboratory tests. Extensive site-specific field data from the Governor's Project and from other sites within the Clark Fork River basin were well summarized in the phytostabilization document (CH2M HILL 2001). At the Anaconda Revegation Treatibility Studies (ARTS) phytostabilization experimental field sites near Anaconda (RRU 1997), concentrations of water soluble arsenic within the rootzone of the amended wastes varied among the sites and by oxidation state of arsenic. Little difference exists between the soluble arsenic (V) levels as a result of increasing the pH of the materials. Levels of water soluble arsenic (III) were increased by a factor of two upon liming of the heavily contaminated soils on Anaconda's Smelter Hill. Adding lime to the smelter wastes in the Opportunity Ponds reduced the soluble arsenic (III) by a factor of 250.

In *Arsenic in the Environment*, Mok and Wai (1994) state the following: "The observation of enhanced arsenic solubilization at low and high pH as well as under reducing conditions is significant… Therefore, when planning disposal of arsenic-containing wastes or when dealing with long-term stability of mine wastes with respect to arsenic, consideration should be given to maintaining high-redox and near-neutral [pH] conditions for minimum arsenic solubility and mobilization." Mobility of arsenic can be controlled by careful liming practices, by increasing the arsenic oxidation state, by adding amendments that precipitate arsenic (ferrous sulfate), and by adding phosphorus to decrease arsenic bioavailability. The bottom line is that between a pH of 6.5 to 8.0, arsenic solubility appears to be well controlled. This is the long-term target pH range for phytostabilization techniques that are to be applied to impacted soil and vegetation areas as part of the Selected Remedy.

2.1.10.5 Effectiveness

Summary of Comments

Comments received regarding the effectiveness of phytostabilization or in-situ treatment were variable, ranging from "in-situ treatment within the floodplain is not acceptable," to "in-situ is a proven remedial technology being used for 15 years throughout the U.S. and should be used here." In general, however, most of the comments questioned the effectiveness and permanence of in-situ treatment, and the potential effects of not being able to establish appropriate plant communities, bioaccumulation, re-entrainment, and increases in contamination volume. A much smaller number of comments suggested that there is no scientific evidence that removal is preferable to in-situ treatment and that in-situ treatment is a sound scientific approach. A third set of comments suggested that results of in-situ treatment were variable: some phytostabilized areas have improved substantially while others have not responded. Some suggested that in-situ treated sites could be used in areas that are contaminated, but only where vegetation is present. Others said that long-term monitoring and maintenance and ICs on land use would be required for treated areas in which contaminated materials are to be left in place.

A series of comments were received that questioned all aspects of in-situ treatment. People were concerned about creating an inappropriate pH for native plants, grazing their animals in metals-contaminated soils, accumulating contaminants in the food chain, increasing the mobility of metals, and creating solidification and encapsulation problems. People questioned whether the mixing would be effective, if this treatment is only effective for a shallow depth of contamination, and what would happen if drought or floods destroyed plants. This series of comments concluded that phytoremediation is too new to be approved by regulatory agencies, does not meet goals of Superfund, and that it is not an effective long-term remedy for hazardous waste problems.

Another set of comments stated that metals and arsenic remaining in the treated soils after phytostabilization continue to be phytotoxic, reducing productivity and altering the plant community composition from its potential natural community. There is uncertainty concerning the effectiveness and permanence of establishing woody vegetation, as contaminants will continue to impact riparian plant communities. People are also concerned that treated soils might re-acidify.

One commenter suggested that EPA should proceed cautiously in applying in-situ treatment to large areas, and questioned how EPA would react if phytostabilization caused more problems than cures.

Only one commenter mentioned human health in relation to phytostabilization, and stated that if in-situ treatment could reduce soil arsenic levels below applicable human RBCs, as proven by post-treatment sampling, the proposed cleanup would be protective of human health.

Response

There is some risk that any vegetation-based technology, phytostabilization or others, will fail to achieve objectives in the future. Many possible circumstances could lead to a partial or complete failure. Possible problems include weed infestation, excessive metal accumulation impacting wildlife or livestock, changes in the plant community, over-grazing, phytotoxicity, excessive channel migration, contaminant leaching to groundwater, soil erosion by wind or water, failure to achieve agricultural productivity goals, failure to provide adequate fish habitat, and failure to allow reestablishment of wetlands. Some of these potential failures are relevant only to phytostabilization and can be related directly to the continued presence of contaminants in the soil. Risks not related to COCs can be attributed equally to any vegetation based remedial action. Central issues for phytostabilization technologies are toxicity to plants, livestock exposure from forage, incidental ingestion by livestock, vegetation response to grazing phytostabilized land, COC caused phytotoxicity, plant communities and phytostabilization, and long-term permanence of phytostabilization. Each of these issues is addressed below. In conclusion, EPA believes that the lengthy development and examination of in-situ treatment done for the Clark Fork River OU makes it an appropriate technology for use at this site in combination with the streambank stabilization and removal components.

Toxicity to Plants

Based on a review of the scientific literature, ranges of elemental levels for mature leaf tissue have been presented by Kabata-Pendias and Pendias (1992). The authors provide elemental levels for generalized plant species into ranges representing deficient, sufficient or normal, excessive or toxic, and tolerable in agronomic crops.

Vegetation samples collected from the Governor's Demonstration area in 1996 revealed that most plant loadings were within the normal or sufficient range, with a few arsenic concentrations in the excessive range. It is believed that the plant species growing in phytostabilized areas of the Governor's Demonstration are tolerant of metal and acid. For example, redtop (*Agrostis* spp.) is known to be able to evolve metal-resistance (Shaw 1990), and basin wildrye has invaded the upper portions of Smelter Hill in Anaconda, which has soils with extremely elevated metal and arsenic concentration (RRU 1993). EPA believes that restricting the in-situ treatment to non-slicken areas where metals are generally lower, pH is higher, and there is more organic material will help reduce potential toxicity to plants.

Contaminant Exposure from Forage

Cattle grazing is a major agricultural land use in the Clark Fork River Basin. The protection and enhancement of this resource is a significant consideration in remedial design for land near the river. One of the principles of phytostabilization is to select plant species that are poor translocators of contaminants (metals and arsenic) into the above ground portions of the plant. In 1999, a summary of metal and arsenic concentrations in and on plants growing in reclaimed areas in the vicinity of Silver Bow Creek, Anaconda, and along the Clark Fork River was prepared (CDM and RRU 1999). These metal loads (concentration on (as topical dusts) and in the plant tissue) were compared to maximum tolerable levels of dietary minerals for domestic animals (NRC 1980). The maximum tolerable dietary levels for cattle and horses are as follows:

- arsenic = 50 mg/kg
- cadmium = 0.5 mg/kg
- lead = 30 mg/kg
- zinc = 500 mg/kg
- copper = 100 mg/kg (cattle) or 800 mg/kg (horses)

Most of the plant species growing in the Governor's Demonstration revealed metal and arsenic concentration below the maximum dietary tolerance levels for cattle and horses. It is expected that by removing slickens and treating less impacted areas, the overall less-metal tolerant vegetation that will be established and may be grazed would not be a concern for excessive metal ingestion.

Incidental Ingestion by Livestock

Because in-situ treatment does not remove contaminants from the soil, there is a residual risk of exposure to cattle from the incidental ingestion of soil during grazing. Ingestion of soil along with forage can be a source of additional elements for grazing cattle. Mayland et al. (1975), Healy (1974), and Thornton (1974) reported similar soil ingestion rates. Lead levels in blood from cattle residing near the East Helena Smelter (Neuman and Dollhopf 1992) were significantly correlated with soil concentrations of lead, as well as vegetation concentrations, and distance (negative correlation) from the lead smelter. It was postulated that soil concentrations may be more important than forage as a source of lead to the cattle in the East Helena investigation.

Edible muscle, kidney, and liver tissues from six selected cattle from the Grant-Kohrs Ranch National Historic Site were analyzed for concentrations of arsenic, cadmium, copper, lead, and zinc (DOI 1996 and revised 1997). Ninety days prior to slaughter, three of the animals were allowed to graze within contaminated riparian areas, and three others were held in less-contaminated pastures. It was reported that riparian cows had metal tissue concentration very similar to pasture cows. Elevated diagnostic levels were reported for cadmium in kidney tissue from pasture cows, copper levels in muscle tissues were elevated in four animals, and copper in liver tissue of one animal was reported at a toxic level. There are no site-specific data for metal levels in cattle grazing on in-situ treated lands within the Clark Fork River Basin. White-tailed deer and cattle were selected for quantitative evaluation in the Clark Fork River *Ecological Risk Assessment* (EPA 1999). Predictive analysis indicated little or no hazard of toxic effects to deer from metals or arsenic in the terrestrial environment. A moderate hazard to range cattle was predicted from arsenic and copper in soils. The authors stated that results should be interpreted with caution because there is little site-specific information to support the predictions.

Vegetation Response to Grazing Phytostabilized Land

As part of the Governor's Demonstration, landowners were restricted from grazing the phytostabilized land for a 3-year period after implementation of the treatment. When grazing resumed, the cattle were to be removed by the landowners when the stand of vegetation was reduced to a predetermined height of approximately 4 inches (Atlantic Richfield Company 2000a). Production and vegetation cover were measured on grazed and non-grazed pastures. During the monitoring period, forage production varied from year to year, but averaged 3,004 kilograms per hectare (kg/ha) on the ungrazed areas as compared to 2,453 kg/ha on grazed areas. Statistically, these mean production values were not different. Vegetation cover values of grazed and ungrazed were nearly identical with mean percentages of 70.1 and 70.8 percent, respectively (Atlantic Richfield Company 2000a).

The number and source of plant species on treated areas within the Governor's Demonstration Project was also summarized in the Atlantic Richfield Company's report. The study included grasses, forbs, shrubs, and rushes, and noted whether each species was seeded or if it invaded from nearby areas. This information was analyzed with respect to the initial tailings thickness (deep, moderate, shallow, or riparian), and as a function of whether the area was grazed or ungrazed by cattle. Species richness, or the number of species, was identical between areas that were grazed and those not grazed. For example, 10 species were found growing in areas with deep treated tailings that were not grazed, while 12 species were found growing in areas with deep treated tailings that were subjected to grazing pressure. There are some, but limited, differences in the presence or absence of specific plant species when observations from grazed and ungrazed areas are compared. It should be noted that this was a short-term study. EPA believes that well-managed grazing can be compatible with a healthy riparian system that results from removal of phytotoxic conditions. This *Record of Decision* provides guidelines for allowance of grazing after appropriate vegetation levels are achieved.

COC Caused Phytotoxicity

The initial plant community, established on phytostabilized lands of the Governor's Demonstration, provided production (6-year average of 3,100 kg/ha), adequate cover (6-year average of 83.7 percent), and species richness (average of 9 species with greater than 1 percent cover) over a 10-year period (Atlantic Richfield Company 2000a and 2001). The community consisted of species obviously tolerant of the climatic and chemical environment (including metal levels measured in pore waters). A privately owned portion of the Governor's Demonstration area was subjected to multiple land uses during this time, including a hay pasture, cattle grazing, an alfalfa field, and a bull pasture. These practices resulted in different plant communities in this area. In 2000, the rancher seeded this area with barley, and in 2001 he seeded it with a mix of barley and alfalfa. The response of the barley in the first growing season was quite variable. An investigation (Neuman et al. 2002) was conducted to determine the causative factor(s) for this variable barley response. Statistical analyses of amended soils and barley plants data indicated that reduction in barley biomass, grown in materials with near neutral pH, was significantly correlated with metal levels (as a "standardized metal index") in the remediated soil. When the barley data were superimposed on EPA's Phytotoxicity Model (as was done for the *Ecological Risk Assessment* for the Clark Fork River), the results indicated that barley may be a sensitive plant species, or that the model itself becomes less accurate as it appears to flatten out at pH above about 7.5. The investigators concluded the in-situ treated areas with elevated metals may have limitations on the vegetation communities that can be established, but that healthy communities can be established. This conclusion is consistent with field observations, the theoretical phytotoxicity models, and data presented in the *Ecological Risk Assessment* for the Clark Fork River. EPA believes that in-situ treatment, carefully done in impacted areas, will produce successful plant communities.

Plant Communities and Phytostabilization

In general, diversity on reclaimed lands is less than that of undisturbed, adjacent areas. This has been observed even on areas that are not impacted by harsh chemical environments (metals and pH). It is unlikely that replacement of available soils after total removal of tailings or contaminated soils would result in communities that are exactly equivalent to the baseline or reference area. It is important to distinguish remedy—in this case, in-situ treatment, removal, or a combination of techniques—from restoration. For additional information, please see Section 3.2, items number 18 (page 3-19) and 28 (page 3-99).

Long-term Permanence of Phytostabilization

A recent paper (Munshower et al. 2003) investigated the permanence of phytostabilization, primarily in upland areas, within the upper Clark Fork Basin. The purpose of the investigation was to generate sufficient data and information from areas receiving phytostabilization treatments, varying in age from 6 to 19 years, so that the permanence and self-sufficiency of the established and reconstructed ecosystem(s) can be generally assessed.

Major conclusions of this investigation were that phytostabilization of acid mine waste is a valuable reclamation technique, calcium carbonate amendment applied as ground limestone or certain industrial wastes can be calculated and applied to produce a non-acid root zone (particularly if underlain by organic soil) that will last indefinitely, and that successional changes in vegetation are occurring over time. To ensure that phytostabilized vegetation in the floodplain is permanent, a comprehensive monitoring and operation and maintenance program must also be employed. In all, EPA finds that the in-situ treatment at impacted areas designated in this *Record of Decision* can be done with long-term effectiveness and permanence because residual risks can be effectively managed. Again, EPA believes the Selected Remedy appropriately weighs trade-offs from the balancing criteria, including long-term effectiveness and permanence, as reflected elsewhere in this *Responsiveness Summary*.

2.1.11 Institutional Controls (ICs)

2.1.11.1 ICs for Land Use Management

Summary of Comments

Most commenters were in favor of ICs, but had specific issues and questions about implementation. Five key issues were cited in the comments:

- Compensate landowners for ICs that impact their land use.
- Fund local agencies for enforcement of ICs.
- Develop a plan to ensure long-term effectiveness of ICs.
- Do not rely heavily on ICs because they are not effective.
- Use conservation easements or outright purchase to ensure long-term protection instead of ICs.

Many commenters believed that a commitment of dollars for the long term would be key to the success of ICs. One commenter said that ICs are considered "takings" of private property because some land uses could be eliminated. Many commenters who called for landowner compensation also asked that agencies be funded for enforcement. Commenters felt that agencies do not have the staff to enforce the ICs. One commenter cited an example from Butte-Silver Bow, in which there are no guarantees to manage the site in perpetuity because the agency was not funded in perpetuity.

Some commenters described specific processes and features that should be included in a long-term, comprehensive plan for ICs. The process suggested by one commenter included gathering input from the public, landowners, and local and State agencies. Others requested specific features, such as riparian zone controls and a human health and safety component.

Some commenters felt that ICs are inadequate and that the *Proposed Plan* relies too heavily on this tool. One commenter cited cases where enforcement of ICs had declined over time, and education programs were not adequately implemented. Also, the commenter felt that ICs incur high costs to landowners while providing little benefit. Future land use cannot always be anticipated, which makes ICs more difficult to implement. Some commenters suggested using conservation easements or outright purchase to assure a long-term remedy instead of ICs.

Response

ICs are non-engineered instruments such as administrative or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use. They are typically used in conjunction with engineering measures such as waste treatment or containment. They can be used during all stages of cleanup. The fact that the most heavily contaminated areas will be removed helps to reduce the potential need for long-term ICs in these areas.

ICs will be implemented as part of the proposed remedy; refer to Part 2, *Decision Summary*, Section 13.9, for a full description of the role of ICs, BMPs, and land use plans. Appendices C and D also contain pertinent information on this topic. ICs necessary for the Selected Remedy to protect human health and ecological health are provided in Part 2, *Decision Summary*, Section 13.4, and Section 13.5, respectively. Access and BMP enforcement are discussed in Part 2, *Decision Summary*, Section 13.6.5. See Sections 2.2.6 and 2.2.7 of this *Responsiveness Summary* (pages 3-70 and 3-71, respectively) for additional details on IC issues and compensation issues. Orders and decrees require PRPs to pay reasonable compensation to landowners or tenants for access. The loss of production from the land affected by implementation of the remedial actions, including remedial components such as road building and staging areas, will be an important issue that must be addressed in any access agreement. Clearly defined BMPs and the ability to ensure that BMPs are implemented is very important to the success of the remedy. As noted in Part 2, *Decision Summary*, Section 13.9.1, EPA will work with the PRP, other stakeholders, and the U.S. Department of Agriculture to develop an effective, funded, and enforceable BMP program. EPA believes that the carefully crafted ICs described in various sections of Part 2, *Decision Summary*, are appropriate for this type of a site and can be successful over the long run to protect the remedy. EPA will work with stakeholders on the exact nature of the specific ICs during remedial design.

2.1.12 Natural Recovery/Natural Healing

2.1.12.1 Natural Recovery Effectiveness

Summary of Comments

Several commenters indicated that a lot of healing has occurred naturally in the Clark Fork River floodplain. A couple of these commenters cautioned against disrupting the gains already made by the natural system and of causing even more harm. Based on long histories of living along the river, a couple other people indicated that both the vegetation and wildlife, including fish, are much more abundant and healthy than before. Other commenters said that the *Proposed Plan* failed to recognize the extent of natural healing that has occurred in the system without human intervention. Another commenter asked for a way to predict effects of remediation on levels of sediment and metals in the river. While one commenter suggested that tailings should be left alone where good vegetation is naturally establishing, another advocated a more active approach and said nature needs help to repair the damage that humans caused. Finally, one commenter said that the river downstream from Deer Lodge already looks great with lots of fish, wildlife, and beautiful vegetation.

Response
Some natural recovery has occurred along the Clark Fork River, but EPA found widespread unacceptable risk and surface water quality problems, especially in Reach A. Barren slickens still exist along the upper 43 miles of river after nearly 100 years, with little observable healing. This *Record of Decision*, through the CFR RipES process, appropriately distinguishes between impacted soils and vegetation areas where in-situ treatment will be implemented, and areas that are only slightly impacted and require no active remediation. These areas may be said to be naturally healing. Many areas with elevated concentrations of metals in the soil profile do have pH near the neutral range and robust vegetation. The application of CFR RipES to these areas will discern between areas to remove, areas to remediate in-situ, and areas where no action will be taken (see Part 2, *Decision Summary*, Section 13.6.1). The desired option is to leave as many as possible of certain "preferred woody plant species" in place that are already growing on the floodplain within the Clark Fork River OU. This will be accomplished by working around them whenever practicable and whenever the overall goals of the project can still be achieved by doing so. Additional discussion is provided in Part 2, *Decision Summary*, Section 13.8.1.

It is not possible at this time to accurately predict the effects of remediation on specific levels of sediment and metals in the river. However, it is expected that significant reduction in erosion will occur, resulting in improved water quality. Measurement of the improvement of water quality will be ascertained through a rigorous monitoring program to be developed during remedial design.

2.1.13 Non-Floodplain Lands

2.1.13.1 Historically Irrigated Fields

Summary of Comments
Those who commented in this category feel that historically irrigated fields represent a large potential for contamination. The commenters suggested that these areas be included in the proposed remedy.

Response
Historically irrigated field are addressed in several sections of this *Record of Decision* in Part 2, *Decision Summary*. In Section 13.4 of Part 2, the following text describes how the remedy will be implemented for irrigated fields:

> Some residences are identified under the Deer Lodge Valley Historically Irrigated Lands TCRA as exceeding the action level for arsenic in residential areas and were not addressed under the TCRA. These areas will be revisited and remediated consistent with that action. Other follow-up operation and maintenance activities from this action will be implemented.

EPA does not believe that other historically irrigated lands within the Clark Fork River OU exceed EPA's action level for current and reasonably anticipated land use for those lands. This shall be confirmed via sampling of these lands if necessary and confirmation that residential development is not planned for these areas. As noted in later portions of this section, confirmation sampling for in-situ treated areas is also required to ensure that these areas are below action levels for current and reasonably anticipated uses (which is likely to be agricultural for most lands) after treatment.

2.1.14 Noxious Weeds

2.1.14.1 Noxious Weeds/Invasive Plant Species

Summary of Comments

Many commenters stated the need for effective weed control measures to be incorporated into the cleanup work on the upper Clark Fork Basin, while most of them, as well as others, expressed a variety of concerns about details or the lack of detail in the *Proposed Plan* on this topic. A variety of adjectives were applied to the term weed control, including well-funded, comprehensive, and long term.

Stakeholder comments on this topic included issues of landowner assistance and compensation for weed control measures, minimization or avoidance of chemical herbicides—particularly near the river, and inclusion of county and local weed boards in formulating weed education, prevention, and control plans. A few commenters expressed fear that remediation work would actually spread weeds to more sites. A couple of commenters emphasized the importance of employing education and prevention methods as the primary thrust of the plan, with control of existing weeds secondary. Other commenters felt that controlling weeds at the river's edge seems minimal compared to what needs to be done, and that weed management should cover the entire 100-year floodplain. One commenter suggested that EPA adopt Roger Sheley's (MSU Extension) recommendations on how to accomplish weed control:

- Include weed reports when working with landowners.
- Plan for prevention, rather than relying on control after invasion.
- Identify and address causes of invasion in remediation areas.
- Include strategies for early detection of weed invasion.
- Rely on multiple control strategies working in tandem.
- Plant multiple species, all having ability to resist weed competition.

One commenter felt that the Atlantic Richfield Company should be responsible for weed control during the project and for 5 years after completion of the work. Another felt that the *Proposed Plan* was misleading, because burning weeds is not a control measure and bringing in new soil will introduce more weeds. Other opinions about weed control included the use of grazing as a long-term weed management tool, incorporation of weed control contracts in the remedial design, and guarantee of monitoring and weeds control throughout the Upper Clark Fork River Valley. Finally, a commenter indicated that if the agencies sincerely and substantively address landowner concerns about weeds, then landowners would be more likely to participate in the cleanup.

Response

Control of invasive plants will be an integral and critical component of remediation (see Part 2, *Decision Summary*, Section 13.10). An aggressive integrated weed management program will be implemented during the construction cycle. An integral part of the remedial plan for every site upon which remedial work is done will include a section, confirmation sampling for in-situ treated areas is also required to ensure that these areas are below action levels for current and reasonably anticipated uses (which is likely to be agricultural for most lands) after treatment.

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Response

Control of invasive plants will be an integral and critical component of remediation (see Part 2, *Decision Summary*, Section 13.10). An aggressive integrated weed management program will be implemented during the construction cycle. An integral part of the remedial plan for every site upon which remedial work is done will include a comprehensive plan for controlling weeds. The approach taken is that all weeds on property within the Clark Fork River OU upon which remedial work is done will be controlled. This is the best way to minimize the possibility that weeds from nearby sites would invade treated areas. An aggressive campaign to control weeds already on a site will be undertaken concurrently with any other remedial work being performed.

An integrated weed management approach will be taken, and an integrated weed management program will be established as a vital component of all ranch management BMPs and ranch management plans. This program will be developed with the cooperation of the State, local weed management experts, and landowners. The program, as described in this *Record of Decision*, will emphasize up front planning, resource identification, monitoring, and corrective actions. Appendix D of this *Record of Decision* presents a detailed series of weed management options and measures specific to weed species likely to occur within the OU. Coupled with the implementation of the integrated weed management plan on each property will be a program of comprehensive monitoring and evaluation to assess which components are working and which are not, so that adjustments can be made. Invasive species will be monitored and any re-infestations will be treated for 5 years after the remedial construction and re-vegetation phase of the work is completed on each site as part of the post-construction monitoring process. Monitoring will be conducted in a timely manner, so as to promptly inform managers of the need for any adjustments of control efforts. EPA consulted with the Powell County weed board as it developed the weed control requirements and explanations found in this *Record of Decision*.

The Center for Invasive Plant Management (CIPM) at Montana State University was heavily utilized to obtain information on invasive plant control and management, as well as sources from surrounding states and Canada, including the Powell County Weed Board.

2.1.15 Permanence

2.1.15.1 Long-Term Permanence

Summary of Comments

All commenters in this subcategory desired "permanence" or a "permanent remedy," but differ widely on the definition of permanence and how that definition applies to the Selected Remedy. One individual said that "permanence," as used in Superfund law, means that the ecological or human health risks are controlled long term, which could be accomplished with in-situ treatment and ICs. Another commenter felt that nothing less than a "permanent, total cleanup" was acceptable, and advocated removal to the greatest extent possible. One commenter cited the "non-impairment clause" for the Grant-Kohrs Ranch National Historic Site to argue for a permanent solution. Many of the commenters in this subcategory felt that leaving any contaminated soil in place would not equate to a permanent solution and does not consider impacts on future generations. Others felt that if contaminated soil remained, conservation easements and restricted land use would be the only way to then assure a permanent remedy. Another commenter felt that regardless of which remedy is selected, landowners should not be held liable if the remediation fails.

Response

In the CERCLA *Feasibility Study* process, remedial alternatives are evaluated against nine criteria. Long-term effectiveness and permanence is one of the criteria and is a balancing, not a threshold, criteria. According to EPA Guidance, a remedy is to be assessed for "magnitude of residual risks" and "adequacy and reliability of controls." Long-term effectiveness and permanence are also addressed in Part 2, *Decision Summary*, Section 10.2.3. The remedy described in this *Record of Decision* physically removes and disposes of concentrated deposits of exposed tailings or "slickens" from the floodplain and addresses other contaminated areas with vegetation impacts through blending and dilution with underlying clean soil, amendments of lime, and planting of vegetation. Although the exposed slickens represent approximately 5 percent of the mining waste contamination in the Reach A floodplain, sampling has shown that these deposits often have the lowest pH, the highest metal and arsenic concentrations, and the most potential for re-mobilization of metals through thunderstorm and flood events. They also represent phytotoxic conditions that do not support healthy vegetative cover with robust, soil-binding root structures. Their removal and replacement with clean borrow material reduces the risk of human and ecological exposure associated with this contaminated material, and does not implement in-situ treatment where there is less chance of success, and thus less chance for successful management of residual risks. In-situ treatment of the balance of contaminated soils areas immobilizes contaminants within the soil and plant complex, reduces contaminant movement to groundwater and receiving streams, and helps stabilize the landscape from wind erosion. Once implemented, EPA considers the "magnitude of residual risks" from these materials to be acceptable where done with long-term operation, maintenance, and monitoring. From the standpoint of "adequacy and reliability of controls," EPA is confident that these technologies work when properly implemented and coupled with an appropriate land use management strategy that promotes healthy vegetative cover.

O&M activities will be implemented as part of the remedy to protect the integrity of the Selected Remedy for the Clark Fork River. Performance evaluations of the Selected Remedy is discussed in Part 2, *Decision Summary*, Section 13.11, and includes methods for determining when and if the remedy is operational and functional, and provides a mandate for short-term and long-term monitoring of the remedy, as well as a maintenance program. Numerical performance standards are also specified in Section 13.11 for the rootzone, for vegetation, surface and groundwater. Finally, a review of the entire remedy is required at 5-year intervals.

2.1.16 Reaches B and C and Tributaries

2.1.16.1 Reaches B and C and Tributaries

Summary of Comments

Many commenters wanted the cleanup extended in some degree to include more of Reach B and at least some of Reach C. Of the commenters, most used the terms "cleanup," "treatment," or "remedy" in their preference for Reaches B and C. Some suggested application of BMPs, streambank stabilization and revegetation techniques, or use of rip-rap to protect the remedy if ice jams occur. A few expressed a desire for no contamination to be left in place along the entire upper Clark Fork River, and believe that more contamination will be found in Reaches B and C in the future. A few commenters asked for further investigation of possible contamination in these reaches, stating that contaminated sediments have accumulated in these reaches incrementally over time, and the *Record of Decision* should provide for future remediation if critical concentrations are ever found there. One commenter feared that the "No Action" decision for Reaches B and C sends a message that these areas are free of contamination. At a minimum, this commenter believed that landowners should be informed of possible contamination and land use restrictions should be in place.

Response

The remedy, as described in this *Record of Decision*, will be applied at limited, localized areas within Reach B of the OU. The difficulty of applying any remedial technique in Reach C and most areas of Reach B—where waste has been thoroughly mixed with soils and where higher flows occur—lead EPA to find that a remedy is not required for lands within many areas of Reaches B and C of the OU.

Studies performed for the *Remedial Investigation* and the *Feasibility Study* have shown that a focused cleanup effort in Reach A results in the greatest reduction in contamination. Efforts in Reach B would be expected to provide limited additional benefit. Reach C has more limited risks and no clear practical clean-up alternatives because of the widespread contamination, mixing of the contamination with fluvial soils, and the lack of feasible remedial alternatives.

Based on data presented in the *Remedial Investigation* and the *Feasibility Study*, no streambank removal and reconfiguration will be necessary in Reach B. The data do not show exposed tailings or buried tailings greater than 12 inches thick in contact with the present streambank of the river. Of the 6.23 acres of visible contamination recorded on the 52.1 percent of area inventoried within Reach B (Atlantic Richfield Company 1996), about 500 linear feet of streambank are very near the surface tailings (within 10 feet). This extrapolates to about 960 total feet of streambank that may be near visible surface contamination in Reach B. No secondary channels of the Clark Fork River or its tributaries requiring remediation work were noted in Reaches B or C.

2.1.17 Removal/Excavation

2.1.17.1 Effectiveness

Summary of Comments

The removal portion of the *Proposed Plan* generated a wide variety of comments. While overall many commenters favor removal, others expressed concern about removal. Some felt that it would be best not to disturb anything through removal, because such disturbance could create a bigger risk of contaminant release to the environment. People were also concerned that importing soils from other locations would extend the disturbance issue to off-site locations and heighten the risk of importing a seed bank of invasive weed species.

Many commenters wanted to know why EPA selected removal (including off-site contaminated soil disposal and replacement with clean soils) instead of in-situ treatment. These people indicated that removal results in greater disturbance, higher cost, and equal effectiveness. They asked why EPA feels that in-place treatment is less permanent and effective, and what the measurable benefits would be of removing slickens rather than treating them in place. Many landowners who are not in favor of removal and replacement have been informed that EPA has the authority to compel access on their property to implement the remedy, which was not favored.

Finally, commenters were concerned about the ultimate fate of the removed soils. Some asked for disclosure of where removed soils will be deposited, while others suggested that nutrients within removed floodplain soils may actually benefit Opportunity Ponds as a repository site. Contrary to this, other commenters suggested that another repository site be selected because Opportunity Ponds already contains plenty of waste and has existing groundwater problems.

Response

The Selected Remedy requires removal of the most phytotoxic exposed tailings, while the lesser impacted soils and vegetated areas will be remediated using in-situ treatment with appropriate BMPs. The removal of exposed tailings is discussed in Part 2, *Decision Summary*, Section 13.6.2. Necessary temporary haul roads to provide an access corridor across a landowners' property can be designed and constructed to avoid or minimize impacts on healthy vegetation and all such roads will be reclaimed after cleanup. Excavated materials will be transported to the Opportunity Ponds Waste Management Repository, as specified in Part 2, *Decision Summary*, Section 13.6.2.

The Selected Remedy balances the desire for permanent source control with the reality that not all wastes can or need to be removed but that some must be managed in place. Removal will be done only in the most phytotoxic areas as defined in Part 2, *Decision Summary*, Section 13.6.2. The removal of approximately 430,000 cubic yards of tailings in slickens in Reach A will reduce the arsenic by approximately 750 tons and the copper by 1,900 tons.

EPA believes this approach will result in greater vegetative success than if slickens were remediated by in-situ means. This belief is supported by BRI (2002), which showed that "Lower Area One (LAO) has a significantly higher riparian functional health than the Governor's Demonstration Project as determined by the methods of this study." At LAO, tailings were removed, while at the Governor's Demonstration Project, tailings/impacted soils were treated in-situ.

As described in the CERCLA statute, EPA has the authority to compel the landowner to implement the Selected Remedy. However, EPA intends to work closely with each landowner before, during, and after implementation of the Selected Remedy on each property. Part 2, *Decision Summary*, Section 13.6.1, presents information about how landowners and the agencies will interact through the CFR RipES process in determining the level of implementation of the remedy required. Initial consultation with each landowner regarding access and implementation, as well as management plans, ICs, and BMPs, will all be part of a remedial plan specific to each landowner. Refer to Part 2, *Decision Summary*, Section 13.6.5 for a discussion of access and BMPs, to Section 13.9 for a description of BMPs, to Section 13.10 for a description of weed management, and to Section 13.12 for anticipated scheduling of the remedy.

2.1.17.2 Extent

Summary of Comments

Again, commenters expressed a variety of views relative to this issue. While some commenters asked that only the slickens be removed and the buried tailings left alone, others asked that all contamination and phytotoxic areas be removed from the floodplain and transported to Opportunity Ponds. Some said that that slickens removal was essential to the success of this cleanup project, while others said that soils should also be tested and removed if they exhibit high concentrations of metals, arsenic, or phytotoxicity. Most commenters asked that removal be done carefully to prevent additional contamination, protect bank stability, enhance woody vegetation, and reduce the risk to the floodplain if a flood occurs during construction. One commenter suggested excavating replacement soils from elsewhere in the floodplain and making the excavations into ponds for stock watering.

Several commenters felt that no removal was necessary, the removal of 167 acres was unwarranted, and in-situ treatment should be maximized because the risks were not great enough to justify the removal strategy. Some commenters expressed concern about the uncertainty of the volume of material to be removed and the impacts on landowners. EPA was strongly encouraged to work with landowners to develop plans for their properties.

One commenter said that the *Record of Decision* should specify exactly how removal areas would be selected, and suggested that EPA treat everything in-situ except for those slickens areas that exceeded 2 feet in depth. Another commenter also wanted an exact removal specification, but suggested that all exposed tailings except those 400 square feet in size located contiguous to impacted soils with impacted vegetation be removed.

Response

Clear definitions of areas that must be removed are provided in Part 2, *Decision Summary*, Section 13.6.2. For each landowner-specific design, locations and aerial extent of exposed tailings, impacted soils and vegetation, and streambank classifications (lengths and locations of Class 1, 2, and 3 streambanks) will be clearly delineated using CFR RipES (refer to Part 2, *Decision Summary*, Section 13.6.1). This step defines what and where various types of work must be done. Following this initial step, transportation corridors can be determined to enable removal of wastes and replacement with backfill soils. Chemical amendments, plants, other supplies, and appropriate types of construction equipment will also need to get to the work. After the required remedial actions are completed for the slickens, impacted soils, and the streambanks, revegetation of the riparian corridor and other lands—suitable to previous use—can be completed. Finally, fences, gates, haul road reclamation, and other construction activities can be completed for each landowner.

EPA disagrees with comments to expand the removal. It is estimated that there are more than 9 million cubic yards of tailings and contaminated soils in the floodplain of Reach A. In the *Feasibility Study*, Alternative 8b, total removal, was evaluated and was found to cost in excess of $355 million. This alternative would take many decades to implement. EPA believes the Selected Remedy strikes a sensible balance between the use of in-situ remediation on impacted soils and vegetated areas and the use of removal and replacement techniques on the slickens areas. Also, this approach significantly reduces environmental risk, can be implemented in one decade, and is cost effective.

EPA disagrees that there should be less removal of slickens. The *Ecological Risk Assessment* established clear risks to the aquatic and terrestrial environment along Reach A of the river. Slickens generally lack vegetation, and impacted soils and vegetation areas sustain reduced terrestrial plant species and diversity. Based on the USGS copper loading model, more than 60 percent of the copper load to the river comes from eroding banks lacking deep binding root mass (see Exhibit 3-7, page 3-14). This lack of deep binding woody vegetation primarily results from the phytotoxicity typically associated with slickens. The additional copper load to the river, and results of other studies described in Section 2.1.5.4 of this *Responsiveness Summary* (page 3-28), has led EPA to the conclusion that copper (and possibly arsenic and other metals) in the aquatic environment (surface water and diet, which presumes intake from contaminated sediments) impose low-level chronic stress on aquatic macroinvertebrates, trout, and other fish. In addition, EPA considers it likely that acute exposures to pulses of metals also contribute to reduced fish and aquatic invertebrate populations. The Clark Fork River frequently exceeds State WQB-7 water standards at certain monitoring locations. Because of the aforementioned risk issues and their causes, EPA believes that removal of the slickens, in conjunction with the implementation of the additional streambank improvements to significantly reduce erosion and improve bank stability, will provide important remedial components to the reduce the copper load to the river.

EPA believes that the Selected Remedy approach to removal will result in the best level of remediation success. This approach involves the removal of approximately 167 acres of slickens and disposal in the Opportunity Ponds. The removed areas would be backfilled with high quality, clean, amended soils and revegetated. Use of the CFR RipES tool will define the areal boundaries and thickness of slickens and impacted soils and vegetation to be addressed.

In general, slickens that are removed will be replaced with clean backfill soils to the approximate original elevation(s) so as not to change the overall floodplain characteristics and geomorphology, so that the general channel alignment will remain the same. In certain specific locations, with the concurrence of the landowner, it may be prudent to develop wetland areas, including watering ponds, in conjunction with removal efforts to establish a healthier riparian ecosystem or provide greater land use and to minimize backfill requirements for a given section of the floodplain.

In the detailed design stage for a given landowner parcel to be remediated, CFR RipES will be used to specifically designate the areal boundaries of slickens to be removed and those areas to be remediated by in-situ techniques. Maintaining existing bank stability and not impacting existing woody vegetation are important components considered in the design, particularly in the riparian buffer zone, regardless of which method is used.

2.1.17.3 With Backfill

Summary of Comments

Commenters in this subcategory focused on the quality of the soils that would replace the removed slickens. Commenters were also concerned about the source of the borrow material.

Response

After removal, and as appropriate depending on the land use (to be determined during design), an equivalent volume of clean soil backfill (considering in-situ compacted density and that has been tested and determined to be suitable as growth media for both riparian and herbaceous vegetation), will be brought to the site and placed in the excavations, leveled, and compacted for revegetation. Consideration will be given to reducing backfill needs, where possible. Borrow material source areas must be carefully planned to minimize the amount of disturbed land, and must be adequately reclaimed. Specific backfill source areas have not yet been identified. The backfill soils must meet the following criteria:

- Match strict chemical and physical specifications (e.g. soil type, grain size, metal and arsenic concentrations, percent organic, etc.).
- Be free of weeds and weed seeds.
- Contain the required quantity of organic materials and other nutrients necessary for growth media.

Specific chemical and physical properties of the borrow soils are presented in Part 2, *Decision Summary*, Section 13.8.2.

2.1.17.4 Without Backfill

Summary of Comments
One commenter felt that removal without replacement soils is a better approach.

Response
In general, exposed tailings that are removed will be replaced with clean backfill soils to the original elevation so that the overall floodplain characteristics and geomorphology will not be changed. This will allow the general channel alignment to remain the same. In certain specific locations, it may be appropriate to develop wetland areas (including watering ponds) in conjunction with removal efforts to minimize backfill requirements for a given section of the floodplain. Site-specific remedial designs will be required for these areas.

2.1.18 Riparian Evaluation System (RipES)

2.1.18.1 Further Development

Summary of Comments
Many comments were received asking that EPA describe the decision criteria that would be used to determine where removals would be implemented and where in-situ treatment would be selected. In a related comment, it was suggested that EPA needs to clarify an apparent contradiction between pre-determined remedial actions in the *Proposed Plan* (removal of 167 acres of slickens and treatment of 700 acres using in-situ methods) and those actions determined by CFR RipES. A second set of comments recommended that CFR RipES should use river health as the ultimate measure of evaluating the recovery effort. A third set of comments suggested that "best science" be used to determine which materials should be removed and which materials should stay.

Many comments requested that CFR RipES should be described in detail in the *Record of Decision* document, that CFR RipES should be subjected to public comment, and that a field demonstration of the system should be conducted. Some individuals volunteered to help develop the system.

A few comments suggested that phytotoxicity thresholds should be considered, and additional related comments suggested that copper levels in slickens and soils (and impacts to water levels) should be part of CFR RipES. A third related comment asked if there is a water component to the system. A couple of comments were received regarding the lack of clarity regarding streambank classification, with one suggesting that EPA err on the conservative side in classifying banks.

One comment suggested that site-specific results of CFR RipES be subject to public comment prior to design, and another objected to details of CFR RipES being negotiated with landowners at a later time. It was stated that CFR RipES was not robust enough to determine site-specific remediation. Lastly, one commenter was "insulted" that site-specific treatment is to be determined by an unspecified and underdeveloped evaluation scheme.

Response

The CFR RipES remedial design tool is described in Part 2, *Decision Summary*, Section 13.6.1. Decision criteria for selection of areas at which removals are to be implemented, areas that will be treated in place, and areas that do not require remedial action are also fully presented in Part 2, *Decision Summary*, Section 13.6.1. CFR RipES will be released by EPA at the same time as this *Record of Decision* is released and will be subject to further discussion and refinement.

Metals in soils and tailings are present at concentrations that range from benign, to slightly phytotoxic, to severely phytotoxic. In addition, metals released from tailings via overland flow of surface water runoff and from bank erosion are major contributors to loads found in the river. The concentration of copper (used as a surrogate for all the COCs) in the soil and tailings is one of the metrics scored in the CFR RipES system. Low concentrations of soil and tailings copper receive several points (maximum of 10), while elevated concentrations receive few or no points. The *Remedial Investigation* found a geometric mean value for copper in unimpacted soils of 303 mg/kg (ppm). Polygons with soils or tailings having greater than or equal to 300 mg/kg copper receive full points. A sliding scale is then used that relates copper concentration and CFR RipES points. Copper levels above 1,500 mg/kg receive zero points. The basis of the upper concentration is the *Baseline Ecological Risk Assessment for Anaconda Regional Water, Wastes, and Soils OU* (EPA 1997), which reported phytotoxic values for copper in soils ranging from 750 mg/kg (for soils with pH less than 6.5) to 1636 mg/kg (for soils with pH greater than 6.5).

A CFR RipES Data Summary Report (RRU and BRI 2003) was prepared based on data collected in the summer of 2003. This Data Summary Report describes the results of analysis of polygon vegetation data, physical attribute data, and laboratory analysis data on soils/tailings samples collected on the polygons within Reach A of the Clark Fork River OU. The purpose of this analysis was to calibrate and validate the CFR RipES remedial design tool. A field demonstration describing the development and application of the CFR RipES process was conducted in summer 2003. In short, good and thorough science has been applied in developing CFR RipES. CFR RipES, however, does not substitute for remedial decision making based on the nine criteria. That is the function of this *Record of Decision*. CFR RipES is a design tool and will be used to implement the remedy consistent with the requirements of this *Record of Decision*.

2.1.18.2 Application in the Field

Summary of Comments

A field demonstration of the application of CFR RipES to a representative area along the Clark Fork River was requested. Another commenter suggested that the human health RBCs be used to determine where contaminants should be removed (that is, soils with levels of contamination greater than the human health RBC should be removed). It was further recommended that the *Record of Decision* document specify other action levels for aquatic and human health based on each contaminant and on other soil attributes. Finally, a commenter asked whether the plan would be altered if additional contaminated lands are found during the CFR RipES assessment so that those areas would be included in remediation.

Response

A field demonstration of CFR RipES was conducted during the summer of 2003. Several locations within Reach A of the Clark Fork River OU were visited by agency representatives, Atlantic Richfield Company representatives and contractors, citizen's groups, and other interested individuals including landowners. Polygons representing different classes of streambanks and lands with varying levels of contamination impact were identified by the CFR RipES developers. Each polygon was scored using appropriate field forms and the CFR RipES decision matrix was then used to select potential remedial actions. Modifying factors were also identified for each polygon. The CFR RipES evaluation tool is ecologically based, and does not contain a human health or an aquatic health component. The CFR RipES tool assesses the vegetation status and the contamination severity of the landscape within a defined polygon. However, for in-situ treated areas, the surface soil arsenic concentration after remediation is completed must be less than the human RBC for the current and reasonably anticipated land use. If this risk level is not achieved after one re-treatment, the contaminated soils will then be removed. According to the *Human Health Risk Assessment*, only arsenic presents a potentially unacceptable risk to the human population in some locations. Other Clark Fork River COCs (refer to Part 2, *Decision Summary*, Section 7.1) pose no unacceptable human health hazard or risk at the concentrations found within the Clark Fork River OU. If additional contaminated lands are found during the CFR RipES assessment that meet criteria for remediation, they will be included in remediation.

2.1.19 Surface Water Quality

2.1.19.1 Copper and Other Metals

Summary of Comments

Commenters in this subcategory stated that ongoing water quality monitoring should indicate reduced metals loading and serve to see if standards were met or improved.

Response

During normal flow conditions, more than 60 percent of the copper load is estimated to come from streambanks, and 6 percent of the copper load comes from overland flow (see Exhibit 3-7, page 3-14). Therefore, removal of exposed tailings (the principal source of copper from overland flow) and streambank stabilization should significantly reduce copper loads (hence total recoverable copper concentrations) in the river, particularly during ice scour events. However, even with these remedial measures, WQB-7 standards for copper would likely not be met all of the time. Extensive monitoring of surface waters of the Clark Fork River has been in place for over a decade and will continue during and after remediation. Long term water quality, as monitored throughout the years, will clearly improve as a result of these remedial actions. Points of compliance will be established as part of a formal Monitoring and Maintenance Program. Ongoing monitoring of the remedy is discussed in Part 2, *Decision Summary,* Section 13.11.4.

2.1.19.2 Arsenic

Summary of Comments

The commenter in this category asserted that the maximum contaminant levels (MCLs) as measured in potable tap water for arsenic would not represent an appropriate standard for instream water quality. The commenter asked whether EPA agrees that post-water-treatment-based MCLs are not an appropriate standard for instream water quality.

Response

EPA agrees with this assertion, but only if the instream water quality (as a dissolved measurement) is evaluated appropriately. At Superfund sites, EPA is generally measuring and attempting to control ambient levels of contaminants, like arsenic and other inorganic metals, in surface water and groundwater. MCLs are relevant and appropriate requirements, and EPA must determine the appropriate manner in which to apply them as ambient standards. If a surface water source (such as the Clark Fork River) is used for public water supply purposes, it is required to be filtered with conventional filtration to remove particulate matter. This would reduce or eliminate particulate matter, including total metals. Therefore, EPA interprets the use of MCLs for inorganic metals for Superfund sites as appropriately measured using the dissolved method. This method filters surface water (to mimic conventional treatment) and measures metals content in the filtered sample. Thus it is appropriate for EPA to use the MCL for a human health RBC standard for this project, but with modification for application to the ambient environment. Performance standards for arsenic in surface water are discussed in Part 2, *Decision Summary,* Section 13.11.3. This human health RBC is based on the Federal drinking water MCL for dissolved arsenic. The State's WQB-7 human health standard for arsenic in surface water, 18 μg/L, is also a performance standard, and under WQB-7, is measured as total recoverable. According to the *Human Health Risk Assessment,* arsenic levels in the surface water of the Clark Fork River do not pose unacceptable health risks for people who wade or swim in the river.

2.1.19.3 Other Constituents

Summary of Comments

This commenter asked why the *Human Health Risk Assessment* did not consider the Clark Fork River to be a drinking water source. Also, the commenter asked whether the use of a mass load model was appropriate.

Response

The Clark Fork River in Reach A is not currently used as a source of drinking water. All known potable water is currently obtained from wells.

The mass load model was used during the RI to determine the relative contribution of total copper from various sources and pathways to the Clark Fork River as part of the necessary determination of nature and extent of contamination. The model was used to distinguish contamination coming from on-site sources versus that coming via upstream pathways.

2.2 Non-Technical Categories

2.2.1 Access

2.2.1.1 Access to Land by Landowners

Summary of Comments

Comments received in this category were primarily in regards to steps that would be taken in accessing landowner property, impacts on landowners' quality of life, and effects on property values. Specifically, commenters were concerned about procedures and responsibilities for opening and closing property gates, covering haul trucks to minimize emissions, accessing currently "inaccessible" sections of the riparian zone, providing liability protection for landowners, and impacts of riparian easements on property use, value, and taxes (specifically, could land with easement restrictions still be used by landowner, how would values be impacted, and who would pay property taxes).

Response

If the agencies perform the cleanup, they will strive to obtain access from landowners to conduct cleanup activities by creating a simple, understandable access agreement that clearly describes the purpose and extent of the access. If the PRP, the Atlantic Richfield Company, performs the remedy, they will be asked to obtain access. EPA's direction to Atlantic Richfield Company will be to act reasonably and responsibly to obtain this, including payment of reasonable compensation if needed. The access agreement may have two separate sections to deal with two separate purposes for needing access. The first section would be only for accessing the property to obtain soil/tailings and other samples so that a cleanup plan specific to the property could be designed. The design would be done with landowner input to attempt to address any landowner concerns. A second section of the access agreement would be signed when a specific design has been completed and the landowner understands exactly what cleanup activities will occur on the property. It is expected that this two-phase approach to obtaining access agreements will provide much more information to landowners, which will improve opportunities for access agreements to be reached. EPA can require access from landowners under the Superfund law.

2.2.1.2 Recreation Access and Use of the River

Summary of Comments

Comments received requested that more information be provided on the expected impacts of the riparian easement and remediation work on recreational uses of the river. In addition, one commenter suggested that additional public access points be constructed in coordination with the remediation work.

Response

It is not expected that the implementation of the remedy will change any new or present recreational access opportunities. Access for recreation will be controlled by the current landowner.

2.2.2 ARARs

2.2.2.1 Compliance

Summary of Comments

The comments received represented two diverse concerns. The first questioned the impacts of upstream remediation projects (for example, Silver Bow Creek) on Clark Fork River OU water quality compliance, such as eliminating the need for waivers. The second view stated concerns that the remedy should comply with the ARARs, preferably without the use of regulatory waivers.

Response

In response to the commenter who asked questions about the meaning of statements regarding upstream contamination, the *Proposed Plan* was meant to convey that upstream cleanup, when combined with the Clark Fork River OU cleanup, is expected to result in ARAR compliance (except for the waived copper standard). The same standards are used, generally, for upstream and Clark Fork River cleanups.

To the second commenter, EPA agrees that compliance with ARARs is an important requirement of section 121 of CERCLA. That same statutory section allows EPA to invoke ARAR waivers, when those waivers are justified under the criteria given there. After re-examination, EPA continues to find that the ARAR waivers discussed in the *Proposed Plan* and found in this *Record of Decision* are justified under the criteria. Further responses on ARAR waivers are provided in subsequent comment responses. EPA continues to believe that the Selected Remedy meets the entire set of criteria given in section 121 and the NCP, including the ARAR compliance or waiver requirement. EPA's waiver explanations are contained in this *Record of Decision*.

2.2.2.2 Waivers

Summary of Comments

Comments received generally opposed the use of waivers. Several comments stated that the remedy should be in compliance with ARARs without the use of waivers. Several more commenters suggested water treatment systems be installed or more extensive removal of contaminated materials should be performed to meet the ARARs.

Several commenters also requested that the waivers be temporary and subject to periodic review. Finally, a few comments questioned the need for arsenic waivers. One contends the Safe Water Drinking Act standards do not apply to surface water and the other questions the constitutionality of the waivers under the State constitution.

Response

Some ARAR waiver comments focused on the application and waiver of the arsenic standard, and the *Proposed Plan's* notation that a waiver of this standard may be required. One commenter correctly notes that the arsenic MCL is an "at the tap" standard under normal applications of the Safe Drinking Water Act and questions whether its use as an instream standard is appropriate. The Federal Drinking Water Act standard of 10 μg/L is a relevant and appropriate requirement for surface water designated for use as drinking water under CERCLA's ARAR provisions and EPA guidance, even if the standard would not be applied as an in stream standard directly under the Safe Water Drinking Act. The remedy must either meet this standard or invoke an ARAR waiver. EPA carefully examined Atlantic Richfield Company's modeling information on arsenic, and concluded that the 10 µg/L standard for arsenic measured as a dissolved constituent is potentially achievable at the Clark Fork River OU. This is based on an examination of the current instream data from USGS, which shows that some areas of Reach A are at or near compliance with this standard during a significant part of the year. It is difficult to model or predict what will occur at the site once upstream cleanup occurs in source areas, and Clark Fork River banks are stabilized, slickens areas are removed, and impacted areas are treated and vegetation is re-established. There are too many factors involved to model resulting arsenic levels accurately. EPA believes it is more prudent to retain the instream arsenic standard of 10 µg/L dissolved as an ARAR and performance standard, as well as the State WQB-7 ambient water quality standard, 18 µg/L, measured as total recoverable. EPA recognizes the uncertainty associated with the remedy's ability to achieve these standards, and may waive one or both of these standards after remedy implementation and monitoring.

EPA agrees with the commenters who suggest that the waived copper standard for in-stream water quality should be reviewed periodically. EPA's 5-year review process is required at this site and will assess this issue. If remedy performance, and upstream cleanups, lead to compliance with the State standard, or if the waived standard does not prove to be protective of human health and the environment, the waiver can be revisited at that time. EPA will measure the copper, as well as other in-stream standards within the Clark Fork River, at appropriate monitoring locations—it does not intend to measure compliance in all tributaries or intermittent water bodies.

EPA disagrees with commenters who believe that the copper standard should not be waived. Achievement of the copper standard is unlikely for any of the examined potential remedies at the Clark Fork River OU, and the *Feasibility Study* and the *Proposed Plan* provide adequate justification for this waiver. The waivers are described in this *Record of Decision*. The State of Montana's general preference for removal does not provide a sufficient basis to alter the remedy or to require full ARAR compliance without waivers, and the State DEQ supported the *Proposed Plan* at public meetings on the *Proposed Plan*, and has now concurred in the *Record of Decision*.

With respect to the State constitutional provision requiring the State to maintain a clean and healthful environment, the State has identified as ARARs the substantive provisions of the State statutes and regulations that have been promulgated by the legislature and authorized administrative agencies. These substantive requirements establish, for example, cleanup levels that must be met by the remedial action and represent at least one available criteria for determining what is "clean and healthful." The cleanup is expected to attain these standards except to the extent that certain ARARs are waived under the Federal CERCLA law. The State believes that the remedy is a necessary step in attaining a clean and healthful environment and DEQ concurs in the remedy for that purpose. When combined with possible natural resource damage restoration actions that the State hopes to implement, the State believes that it will attain a clean and healthful environment in the Clark Fork River OU to the fullest extent possible.

2.2.2.3 Park Service Organic Act

Summary of Comments

Several comments received stated that the proposed remedy would fail to meet site-specific ARARs set for the Grant-Kohrs Ranch National Historic Site by EPA in a letter from Scott Brown dated May 2000 (Brown 2000a and 2000b).

Response

Commenters on this issue included more than 120 comments from citizens and a specific comment from the U.S. Department of the Interior, which is responsible for implementation and enforcement of the Organic Act ARAR requirements in most situations. EPA agrees that the NPS Organic Act and accompanying provisions, as defined in the May 2000 letter from EPA to the Department of the Interior, and their emphasis on non-impairment, are important ARARs applied to the site cleanup at the Grant-Kohr's Ranch National Historic Site, which is within the Clark Fork River OU. The *Proposed Plan* did not clearly identify the specific requirements and modifications from the general *Proposed Plan* that would be needed to ensure compliance with this ARAR. In developing the *Record of Decision*, EPA worked closely with the NPS to clearly define these additional requirements, and they are reflected in Part 2, *Decision Summary*, Section 13.7. Some commenters wanted action taken on the streamside property owned by the Bureau of Land Management (BLM), located in Reach C of the Clark Fork River. EPA disagrees that the Organic Act requires additional remediation at areas downstream from the Grant-Kohr's Ranch National Historic Site on BLM land in Reach C, as explained elsewhere. EPA notes that BLM has found injury to natural resources at its land in Reach C, which is a different issue addressed under a different provisions of CERCLA—the natural resource damage provisions. EPA also notes that the NPS has found that residual injury to its land will continue to exist even after implementation of the remedial activities, and again notes the applicability of CERCLA's natural resource damage provisions to these findings. Further explanation of the NPS ARARs is provided in the response to PRP comments in Section 3.3, issue number 51, page 3-111.

2.2.3 General Comments

2.2.3.1 General Comments

Summary of Comments

These comments were general in nature or expressed general opinions of the respondents. Many expressed support or non-support for the decision as a whole. For example, comments such as, "Montanans deserve a good cleanup," do not bring up a specific issue for response. In some cases, substantive issues were described in the context of the general comments. Responses to those specific issues are presented below.

Response

EPA does value public input and has incorporated public input where possible and consistent with statutory and regulatory mandates and EPA guidance. This *Record of Decision* has been modified in response to comments on the *Proposed Plan*. Landowner rights are important to EPA, and EPA will try to work with landowners before seeking ordered access. The use of local work forces is something EPA has encouraged Atlantic Richfield Company itself and the State to use in past remedial implementations, and EPA will continue to seek that if Atlantic Richfield Company or the State perform the work. Educational opportunities during design and implementation are also important side benefits from remedy implementation, which EPA encourages.

2.2.4 Consistency with Guidance

2.2.4.1 Consistency with NCP Guidance—Funding and NRD Coordination

Summary of Comments

The majority of the comments emphasized the need to secure adequate funding for the long term remedy. Several of these commenters were specific in adding that this funding needs to be provided by the Atlantic Richfield Company.

Additional comments suggested that a trust fund be established for land leases or purchases, BMP expenses, compensation, groundwater losses, contracts, and other issues. One comment stated that funding should be provided for local governments to repair and maintain roads, as well as provide for additional police services. Some commenters specifically added that this fund needs to be sufficient for a 100-year period.

Several commenters recommended that the *Record of Decision* should specify the management plans for land use restrictions, liabilities, long-term O&M, and other ongoing project features. These comments were phrased in the context of allowing better evaluation of funding issues.

A couple of commenters stated that the *Proposed Plan* appears cost effective, but that the plans should be kept flexible. One additional commenter stated that the plan would not meet the NRDP's requirements and that complete remediation must occur.

On the opposing side, one commenter stated there was no need to establish a fund for land leases or purchases, BMP expenses, or other project needs. Furthermore, this commenter asserted that remediation must take place and that the remediation should take precedence over private property rights.

Response

EPA agrees that the obligations to implement the remedy need to be clearly delineated and enforced, and that adequate funding for remedy implementation and ICs and BMP activities beyond the normal landowner responsibilities needs to be provided. The *Record of Decision* describes the necessary ICs and BMP guidelines in more detail than the *Proposed Plan*. The current cost estimate includes costs for these activities. EPA will ensure, through its enforcement mechanisms, adequate funding and/or commitments to make the requirements of this *Record of Decision* become reality.

EPA agrees that the Atlantic Richfield Company, as the primary potentially responsible party, should bear the costs for implementation of the remedy, including ICs and additional BMP activities.

Some specific comments addressed the enforceability of land use BMPs and other ICs. EPA will work with the county, the Department of Agriculture, and other interested agencies and entities during remedial design to ensure that these plans and controls are indeed implemented. These mechanisms may include easements or other government programs, and funding for these programs also needs further definition. These issues will be further explored during remedial design.

Some specific comments focused on the need for adequate financial assurance associated with enforcement mechanisms to implement the remedy. EPA is given considerable flexibility in establishing these requirements, and EPA will pursue adequate protection for financial assurance at these sites. EPA's cost estimates for the remedial action, including long term operation and maintenance, have been calculated conservatively and will form the basis for these assurances.

Coordination with restoration activities is important to EPA. EPA believes the remedy can fit with restoration plans and will continue to work with natural resource damage trustees to ensure coordination and efficient implementation of cleanup activities at the site.

EPA notes that one commenter has concerns about the role of landowners in the cleanup decisions. EPA believes that cooperative and constructive relations with landowners during implementation is very important, and plans to implement the remedy with that in mind. EPA also recognizes the need for an adequate and protective remedy at the site, and the need for consistency and clarity during remedy implementation. EPA and the other parties involved in the implementation of the remedy will work along those lines to balance these needs.

2.2.5 Economic Development

2.2.5.1 Effects on Local Economy

Summary of Comments

The strong majority of the comments stated that the plan was a good investment in the area and expected the remediation to positively impact area jobs, recreationists, and businesses, as well as increase land values. A few commenters suggested that local residents should be hired preferentially. One commenter stated that the remediation plans should not be based solely on the potential economic boost to the area.

Response

The remedy for the Clark Fork River may have an overall cost in excess of $100 million. Previous experience with other cleanup projects in the basin indicate that much of that money will go to local contractors and businesses. As an example, approximately 95 percent of the $15 million spent on cleanup of Silver Bow Creek has been paid to Montana contractors. This will have an overall positive impact on the local economy for the project duration, which is expected to be at least 10 years.

2.2.6 Enforcement of BMPs

2.2.6.1 BMP Enforcement on Private Land

Summary of Comments

A few comments were received supporting the monitoring and enforcement of land use restrictions.

Response

It is expected that BMPs employed by the remedy would be similar to BMPs that are currently employed throughout the West where progressive riparian and range management occurs. This type of management is only successful when it is tied into a comprehensive ranch management plan. This is typically done with assistance by the local conservation district and the NRCS. The agencies expect to work closely with these agencies and landowners to provide additional resources to enable development of site specific ranch management plans that describe any necessary BMPs. Experience to date has shown that this type of up-front planning, supported by necessary resources and monitoring, can improve production from the land. As awareness of this positive impact becomes more prevalent, it is expected that voluntary compliance with management plans will become the norm (because it benefits the landowner financially). However, the agencies plan to ensure appropriate monitoring of the use and effectiveness of these BMPs so that compliance problems can be detected and corrected.

This *Record of Decision* defines what BMPs are meant to accomplish in terms of this project and provides additional detail and definition. However, BMPs need to be site specific and include flexibility to meet landowner needs. Implementation of BMPs is left for further development under this *Record of Decision*—EPA will work with other agencies and the State NRDP concerning easements and/or regulatory programs to ensure the best fit for each landowner.

2.2.7 Landowner Compensation

2.2.7.1 Compensation for Lost Use of Land

Summary of Comments

EPA received a large number of comments supporting compensation to landowners during remedy implementation. One commenter opposed compensation. Comments in favor of compensation were received from those who generally supported the proposed remedy and those who opposed it. Granite County Commissioner comments emphasized this issue and requested specific language in the *Record of Decision* to address the issue.

Most commenters focused on compensation for lost or reduced use of land during remedy implementation. Some commenters wanted clarification about fencing and responsibility for that fencing. Other commenters suggested the use of conservation easements as a means of compensation for landowners.

Response

EPA has added language to this *Record of Decision* that addresses both access and landowner compensation, and fencing responsibility. Part 2, *Decision Summary*, Section 13.6.5, addresses access and BMP plans. It notes that when PRPs perform EPA remedial action, EPA requires those parties to pay reasonable compensation to landowners for access. The section emphasizes the need to look at lost use compensation when addressing these issues.

EPA also added Section 13.9.3 to Part 2, *Decision Summary*, which addresses fencing needs and fence maintenance. It requires the remedy implementer to maintain fences as needed to protect the remedy until fences are no longer required, or if they are, they become the responsibility of the landowner or tenant.

The use of conservation easements is a possibility. Many of the commenters who discussed this issue pointed out that they are voluntary measures between willing buyers and sellers. EPA believes that conservation easements for landowners who agree to them could be a useful tool to address compensation and land use management as part of the remedy. During remedial design, EPA will explore the potential use of conservation easements, as well as funding sources for such easements, with the State of Montana and the PRP.

2.2.8 Landowner Involvement

2.2.8.1 Mandatory Cleanup

Summary of Comments

Most commenters supported requiring the landowners to cooperate with the plan. Some comments supported encouraging the landowners to cooperate. One commenter asked whether landowner participation would be required, and a few commenters stated that cleanup should be optional for landowners. One commenter suggested that those landowners who do not participate should be held liable for future impacts.

Response

The remedy will be implemented with close landowner involvement. Close interaction will occur with landowners throughout the cleanup duration but particularly during several specific activities noted below:

- Arranging access agreements.
- Developing sampling plans.
- Developing site-specific designs for improving or eliminating contaminated areas while minimizing impacts on ranch operations.
- Preparing ranch management plans.
- Defining actual construction methods, procedures, and schedules.
- Correcting any problems during construction.
- Defining future monitoring and maintenance activities.
- Implementing ranch management plans that will complement the remedy and ensure improved productivity of the resource.

Further discussion of ways to obtain cooperative involvement in the cleanup plan is provided in this *Responsiveness Summary* in Section 2.2.1, page 3-65, and Section 2.2.6, page 3-70. The CFR RipES process is described in Part 2, *Decision Summary*, Section 13.6.1. Several steps within the CFR RipES process detail landowner feedback and input into cleanup plans. These steps will provide the opportunity to achieve landowner cooperation.

EPA does have authority, given to it by Congress in the CERCLA law, to require access to land if voluntary access is not granted. See section 104(e) of CERCLA as amended, 42 U.S.C. § 9604(e). EPA intends to see the entire cleanup described in this *Record of Decision* implemented, again in accordance with the CERCLA law.

2.2.8.2 Optional Cleanup

Summary of Comments

One comment was submitted stating that landowner cooperation should be optional.

Response

See the response in Section 2.2.8.1, *Mandatory Cleanup*, above.

2.2.8.3 Property Rights

Summary of Comments

Comments varied widely in this area of interest. Several landowners stated they intend to limit access to their property unless need is clearly shown. Several landowners asked for more specific details about the cleanup plans and processes. One commenter specifically intended to use legal means to limit access. One commenter questioned the legal basis for accessing private property and restricting land use. One commenter expressed concern that land ownership will be taken away. Another landowner expressed concern that property values would decrease.

Several commenters stated that the plan be developed to meet landowner needs, with two stating that landowners should have the decision on what actions would be taken on their land. Some landowner comments stated a specific preference for in-place treatment versus removal of contaminated soils.

Response

The comments that address EPA's selection of some limited removal along with treatment are addressed in other parts of this *Responsiveness Summary*, including Section 2.1.10, page 3-43, and Section 2.1.17, page 3-57. EPA also provided a detailed explanation of its decision to use a mixture of removal and in-situ treatment in the August 2002 *Proposed Plan*, the EPA memorandum dated July 28, 2003, which was published in the Silver State Post, and in the *Record of Decision*. EPA incorporates the July 28 memorandum and its Attachment 3 into this *Responsiveness Summary* by reference. EPA has also added specific details on what areas will be removed, what areas will be treated in-situ, BMPs and long term O&M needs, and how the remedial design and CFR RipES process will work at any given property.

Property rights are important to EPA as well. That is why we are emphasizing cooperation and communication between the implementing party and the landowner as property specific cleanup plans are developed. We also have emphasized the need to consider compensation for lost use when cleanup activities are implemented. We think this, along with the direct benefits of cleanup, will lead to voluntary access for the cleanup plans. As noted above in Section 2.2.8.1, EPA does have other means available to it to legally obtain access if voluntary access is not obtained.

2.2.8.4 Design/Land Use

Summary of Comments

Many of the comments specifically stated that the plan should be developed to meet landowner needs. Several commenters said that landowners should be treated fairly, with one specifically adding that landowners should be treated equally. Many comments were received stating that landowner cooperation is critical to the success of the plan. Several landowner commenters pointed out that landowners' expertise and knowledge about their own land needs to be carefully considered in any cleanup plan.

Several comments stated that the individual landowners should have a say on specific actions to be taken on their land. Conversely, one commenter stated that individual landowners should not have a say on the actions to be taken on their land and that EPA should do what is required to remediate the Clark Fork River. A few commenters requested that specific plan information (such as what, where, and when) be conveyed to individual landowners. In addition, several commenters suggested there be a mechanism for retaining landowner acceptance of the remediation plan.

Similarly, there were several commenters who stated agreement with the *Proposed Plan*, but that success of the plan will be dependent upon getting the majority of landowners involved. One commenter suggested that the landowners should be provided with a neutral group of technical and legal advisors to evaluate the plan. A couple of other commenters supported the use of fee titles and conservation easement purchases in negotiations with the landowners.

One comment was received stating that the river looked great as is.

Response

EPA intends to work closely with landowners, and agrees with the commenter who urged careful and respectful dialogue with landowners throughout the cleanup process. This point is emphasized in several places in this *Record of Decision*, as the specifics of weed control, BMP plans, access, and the process for land evaluation and cleanup design are described.

Prior to the release of the *Record of Decision*, EPA held a field demonstration of the CFR RipES process and evaluation issues for landowners. EPA representatives have spoken at length with landowners as the *Record of Decision* has been developed. EPA also agrees with the commenters who noted that landowners expertise and knowledge of their own land has to be a major part of the planning for cleanup at a specific site.

EPA cannot give landowners a neutral group of advisors regarding this plan. EPA does fund a Technical Assistance Grant to the CFRTAC, and one of its main jobs is to provide neutral evaluation of technical issues and to distribute that information to the affected public. We will continue to work with CFRTAC to ensure that their efforts are aimed at a broad range of affected parties.

Conservation easements are discussed in Section 2.2.7.1 in this *Responsiveness Summary* (page 3-71).

2.2.9 Opinion of Plan

2.2.9.1 Fully Support Plan

Summary of Comments

Many commenters support proceeding with the *Proposed Plan*. Several commenters specifically support the 50-foot riparian zone. Two commenters stated specific support for a remedy that combines elements of the Alternatives 5d and 6c.

Response

EPA acknowledges the support of more than 1,600 commenters for the *Proposed Plan's* recommended remedy.

2.2.9.2 Conditionally Support Plan

Summary of Comments

All comments received in this category generally support the *Proposed Plan*, and stated that it would be reasonable and workable. However, numerous commenters proposed specific actions that should be taken, including the following:

- Adding stabilization, bank cleanup, or other actions for Reaches B and C.
- Going further in protecting river and corridor, including emphasis on removal of all contaminated soils.
- Continuing evaluation of human health risks.
- Implementing an ongoing, long-term monitoring and maintenance program to evaluate remediation results and to identify contamination that may become exposed in the future.
- Specifying plan details on revegetation, livestock use, fencing, and owner compensation.
- Providing more technical data on remediation and revegetation processes.
- Adding more technical input from specialists, specifically geomorphologists.
- Requesting more details on proposed weed control plans.
- Recommending expanding the riparian buffer to accommodate flood conditions and include old river channels.
- Providing an example of CFR RipES evaluation based on an actual area.
- Modifying the plan significantly:
  - Use Alternative 7b instead.
  - Evaluate if the CFR RipES process is sufficient to determine long-term remediation needs.
  - Allow evaluation and comments on CFR RipES results before beginning remedation.
  - Develop a permanent remedy, because the commenter does not believe the *Proposed Plan* is protective of human health and the environment.

Response

EPA examined these comments and added additional detail to the *Record of Decision* to address many of these issues. Human health risks are addressed with more detail, and additional requirements for the measurement of arsenic in soils to ensure the protection of human health at irrigated soils, irrigation ditches, and in-situ treated areas are emphasized. Weed control elements of the *Record of Decision* are addressed in much greater detail. Additional specification on vegetation, grazing, fencing, old river channels, and access and landowner compensation is now included in the *Record of Decision*. Long term monitoring is also described in more detail in the *Record of Decision*. EPA did a demonstration of the application of the CFR RipES process in August 2003.

EPA does not agree that additional work in Reaches B and C is required to meet remediation requirements, both because of the nature of the contamination in those areas and the lack of demonstrated remedial risk. The removal of all contaminated soils is not practical or cost effective under EPA's remedy selection criteria, and we believe the remedy described in this *Record of Decision* best meets the remedy selection criteria. EPA had a wide variety of technical specialists involved throughout the RI/FS process, and used those people's views and input extensively in the remedy selection process. EPA did not see a need for additional involvement of specialists beyond its contractors and in house experts during the remedy selection process.

EPA believes that the remedy does reflect the appropriate balancing of the long-term effectiveness and permanence balancing criteria with the other balancing and modifying criteria, as noted in Part 2, *Decision Summary*, Section 10. EPA believes that the detailed monitoring requirements and performance standard definitions, along with ICs, will result in the reliable management of residual risk at the site, and that additional removal is not necessary to meet remediation requirements at this site.

2.2.9.3 Needs More Information

Summary of Comments

Commenters in this category generally stated that the *Proposed Plan* was vague and that specific details were needed. Several comments stated that the *Proposed Plan* did not adequately describe land cleanup and long-term management issues. Several other commenters recommended that each landowner be informed of the specific actions planned for their land. Some of the specific information needs of these commenters include details about BMPs, land use restrictions, plan funding, and impacts of other restoration activities in the Clark Fork River Basin.

Response

Proposed plans are normally general in nature. EPA supplemented the *Proposed Plan* with specific answers to specific questions, to ensure that the public had adequate information during the public comment period. The *Record of Decision* contains detail on the issues that commenters identified as too vague in the *Proposed Plan*—definitions of slickens and impacted soils, vegetation standards, information on grazing, weed control, and BMPs.

EPA cannot provide information regarding how the remediation may affect restoration issues. Restoration issues are the responsibility of natural resource damage trustees. Those trustees may individually or collectively produce restoration plans for the Clark Fork River OU after EPA issues its remedial *Record of Decision*. EPA will continue to coordinate with the natural resource damage trustees in the post-*Record of Decision* processes.

2.2.9.4 Oppose Plan

Summary of Comments

Comments received for this category generally take two positions: either the *Proposed Plan* does not go far enough, or the *Proposed Plan* goes too far.

Approximately half of the commenters who oppose the *Proposed Plan* prefer more extensive removal and treatment, as described under Alternatives 7 and 8.

The other half of the commenters oppose the proposed extent of the cleanup plan, generally believing it is better to leave the river alone. Some of these commenters specifically requested that more in-situ treatment is preferred over removal of contaminated soils.

A couple of the other commenters generally oppose the *Proposed Plan*, believing it to be inadequate in addressing human health issues during remedial activities.

Response

EPA notes opposition on both ends of the remedy spectrum (from no action to extensive removal without in-situ treatment). EPA believes that the remedial action described in the *Record of Decision* meets the threshold criteria for remedy selection, and provides the best balance among the remaining balancing and modifying criteria. This remedy selection analysis is described in greater detail in Part 2, *Decision Summary*, Sections 10, 13.1, and 14.

2.2.10 Proposed Plan Remedy

2.2.10.1 Differences in Remedy Review Board Presentation vs. the Proposed Plan

Summary of Comments

One comment was received questioning the basis for the changes noted in the *Proposed Plan*, with the overall concern being the extent of the proposed removal activities.

Response

EPA's Clark Fork River *Proposed Plan* did differ from EPA Region 8's recommendation to the National Remedy Review Board (NRRB), primarily by including additional removal requirements for most slickens areas. EPA made this change based on additional consideration of community and State acceptance criteria—particularly State acceptance. The State of Montana has invested considerable time and effort into the study of the Clark Fork River OU and has consistently recommended that removal of slickens areas be done. These concerns emerged even more strongly in the time period following the NRRB proceedings and the issuance of the *Proposed Plan*. EPA is required under CERCLA and the NCP to give the State substantial and meaningful involvement in the remedy selection process. EPA also notes that some affected landowners and all Trustees for natural resources also strongly supported additional removal requirements.

EPA also re-examined the technical basis for use of in-situ treatment at slickens areas. This re-examination is explained in detail in the publicly distributed EPA memorandum of July 2003 (prepared by EPA in response to a memorandum by four staff level personnel who wanted EPA to use in-situ treatment in slickens areas), which is incorporated herein by reference. That analysis found that slickens areas generally presented conditions of low pH and high metals content that would make the success of in-situ treatment less certain in these areas, and also noted that the removal of slickens would help the remedy possibly achieve groundwater performance standards. The analysis also looked closely at the safety and implementability issues surrounding removal and found that careful implementation of a limited removal program could be achieved safely and in a timely manner. All of these factors led EPA to change its position in the *Proposed Plan*.

2.2.10.2 Additional Study Requests and Feasibility Study Issue

Summary of Comments

The comments in this subcategory raised specific issues regarding past investigations, feasibility study analysis, and weighting of alternatives, or suggested broad future study needs. Specific issues raised include a quantitative evaluation of long-term benefits from the recommended action, evaluation of potential impacts of flooding on pond sediments, reexamination of weighting methodology used in *Feasibility Study* comparative analysis, and inclusion of a discussion of preliminary investigation findings in the analysis.

Response

The NCP does not require EPA to do a detailed comparison study of the quantified benefits of a proposed remedial action versus the no action alternative, as one commenter suggested. This *Record of Decision* does contain a more general description of expected benefits in Part 2, *Decision Summary*, Section 13.14. The Opportunity Ponds area is not within the 100-year floodplain and will not wash out during flooding, so additional study of that area is not needed. The *Remedial Investigation* process did look closely at prior investigations and data results, and summaries of these efforts are included in the administrative record for the Clark Fork River OU and in the *Remedial Investigation*. The equal weighting given to the seven criteria in the *Feasibility Study* report is recommended in EPA guidance—the remedy selection process then appropriately weighs the different criteria according to the threshold, balancing, and modifying categories described in the NCP. The numeric scores given for the *Feasibility Study* alternatives is generally explained in the *Feasibility Study*—cost effectiveness scoring was determined by looking at past Clark Fork Basin actions and applying a general ranking for costs.

2.2.10.3 Needs More Investigation

Summary of Comments

A few comments were received proposing additional areas of investigation needed to address the *Selected Remedy*. These areas included development of a long-term monitoring and maintenance program to address new areas of contamination, additional monitoring and experimentation on plant and COC interaction, and additional studies on impact of removal and treatment processes on vegetation.

Response

The *Record of Decision* now requires detailed and systematic monitoring to ensure that impacted areas and slickens are identified and addressed within Reach A and limited areas of Reach B. If more technical studies are determined to be necessary during remedial design regarding vegetation response, EPA can require this during that process.

2.2.11 Restoration

2.2.11.1 Restoration vs. Remediation

Summary of Comments

Some commenters in this subcategory requested additional information on the proposed restoration actions, while others proposed a more extensive removal followed by or in conjunction with restoration actions. One commenter stated a desire for long-term restoration of the river versus short term fixes.

Other commenters specifically stated that the Atlantic Richfield Company should fund the restoration program in addition to the remedial action. One expressed concern that incomplete remediation actions will, in turn, deplete restoration funding.

Response
EPA cannot give additional information on what specific restoration actions will be implemented in addition to the remedial actions, as those decisions are reserved for other agencies that act as natural resource damage trustees. EPA understands that the State of Montana and the Department of Interior will present revised or initial restoration plans after EPA has issued its *Record of Decision*. EPA believes that the remedial action is a significant action that will achieve EPA's mandate to protect human health and the environment. EPA cannot consider the effects of its remedy decision making on the State's existing restoration funds in choosing a remedy, as urged by one commenter. Finally and most importantly, EPA will continue to coordinate with natural resource damage trustees at this site as required by CERCLA and the NCP.

2.2.12 State and Local Acceptance

2.2.12.1 Degree of State and Local Acceptance

Summary of Comments
Few comments were received in this category, and one stated the opinion that EPA has failed to encourage community consent and that new and better project management to bring in the State and landowners is needed. Another commenter specifically asked if the DEQ has accepted the plan, asserting that State acceptance will be needed to garner public support. One commenter questioned whether the decision on volume of material to be removed was a politically based decision designed to appease the State, versus being based on technical or cost considerations.

Response
State acceptance is shown in the concurrence letter from the State in Appendix F of this *Record of Decision*. EPA considered State acceptance as an important modifying criteria in accordance with the NCP and noted the State's clear interest in this site as reflected in the time and effort the State has put into the study of the Clark Fork River. However, EPA based its final remedial decision on the full remedy selection criteria, and did not make "political" decisions in an effort to satisfy the State. EPA agrees that bringing all stakeholders together during remedial design will be important at this site because of the high level of interest in the environmental conditions at the site. EPA will continue to pursue efforts in that regard.

2.2.13 Unrelated Comment

2.2.13.1 Out of Scope, No Response Required

Summary of Comments
These comments were deemed to be outside the scope of the plan and, therefore, no specific response is required. Virtually all the comments stated support for removal of the Milltown Dam and sediments, which does not apply to this OU.

2.2.14 Water Rights

2.2.14.1 Transfer/Use

Summary of Comments

Of the comments received, most specifically stated that the Atlantic Richfield Company's water rights in the upper basin should be used as needed for the remedy. One commenter specifically mentioned that Atlantic Richfield Company's water rights from the Silver Lake and Ueland Ranch sources should be dedicated to maintain in-stream flows versus use for agriculture. One commenter recommended calculation of the anticipated water usage by vegetation in the 50-foot riparian zone.

Response

EPA understands the importance of water rights and irrigation needs, and will work closely with State water rights authorities to ensure that existing water rights are respected and irrigation water is made available as necessary for this action. EPA notes that the Atlantic Richfield Company has obtained water rights in the nearby basin. Finally, use of water rights for in-stream flow is outside the scope of EPA's remedial requirements at this site, but may be an issue of interest to the natural resource damage trustees.

3 PRP Comments and EPA Responses

3.1 Introduction

The Atlantic Richfield Company, the PRP for the Clark Fork River OU, submitted two documents with comments on the *Proposed Plan*. The first document was a letter containing a request to extend the comment period. EPA did extend the comment period by 30 days. The second document was a cover letter and two-volume binder containing comments and supporting data. After the conclusion of the comment period, the Atlantic Richfield Company submitted a letter requesting that the comment period be reopened. EPA did not reopen the comment period.

EPA's August 2002 *Proposed Plan* invited comments on EPA's August 2002 *Proposed Plan* and the other remedial alternatives described in the Clark Fork River OU *Feasibility Study* and summarized in the *Proposed Plan*. Section 117(2) of CERCLA requires the agency to publish the *Proposed Plan* and accept comments on the *Proposed Plan* and other alternatives examined by EPA, and on proposed cleanup standards for the site. Section 400.300(f)(2) of the NCP (40 CFR § 300.430(f)(2)) states that the "purpose of the *Proposed Plan* is to supplement the RI/FS and provide the public with a reasonable opportunity to comment on the preferred alternative for remedial action, as well as alternative plans under consideration, and to participate in the selection of the remedial action at a site." After the conclusion of the public comment period, EPA must respond to "significant comments, criticisms, and new relevant information submitted during the public comment period."

Atlantic Richfield Company's two-volume, 2,000-page comment letter goes well beyond the boundaries established by law and regulation for the remedy selection and *Proposed Plan* comment period. In its comments, Atlantic Richfield Company actually develops and submits remedial design for a new alternative of its own making, and submits this information as comments. This has made response to Atlantic Richfield Company's submission difficult, as Atlantic Richfield Company's remedial design information relates primarily to a remedy that is not selected by EPA and is not consistent with the NCP. The NCP requires the lead agency, in this case EPA, to select the remedy after review of all community and State comments—see section 430(f)(4) of the NCP (40 CFR § 300.430(f)(4). According to CERCLA and the NCP, remedial design then occurs after selection of the remedy, and must be "in conformance with the remedy selected and set forth in the *Record of Decision* or other decision document for that site." Section 435(b)(1) of the NCP (40 CFR § 300.435(b)(1)).

Accordingly, much of Atlantic Richfield Company's comment package, especially the remedial design information for an alternative that was not selected as the appropriate remedy under CERCLA and the NCP, is outside the scope of the laws and regulations that govern the comment period and is not in accordance with the NCP. Atlantic Richfield Company does not provide a rationale or basis for this unusual submittal. Additionally, much of the Atlantic Richfield Company two volume package is repetitive and rhetorical. Much of the package explains what Atlantic Richfield Company calls the Atlantic Richfield

Preferred Remedy, which is not the remedy selected under CERCLA and described in the *Record of Decision.*

Despite the problems presented by the Atlantic Richfield Company package, EPA did examine the Atlantic Richfield Company comment package carefully and methodically, and extracted significant comments, criticism, and relevant new information from the Atlantic Richfield Company package that fit within the appropriate scope of the comment period as defined above. In accordance with the NCP, EPA responds to those comments here.

The comments that were most readily identifiable as appropriate comments were those contained in Appendix B to the Atlantic Richfield Company comment package. These comments specifically addressed the August 2002 *Proposed Plan* and EPA's rationale for selection of the Proposed Remedy. Issues 1 through 32 of Section 3.2, *Summary of Comments and Responses,* respond to those comments. Section 3.3, *Additional Comments and Responses,* contains responses to other comments beyond those in Appendix B of Atlantic Richfield Company's submission.

3.2 Summary of Comments and Responses

The text of each issue number (1 through 32) refers to the page and section of the August 2003 *Proposed Plan* that Atlantic Richfield Company targets in their comments.

1) Proposed Plan, page 4, second paragraph under "Site Characteristics"

Summary of Comments

The statement in the *Proposed Plan,* "The potential flood unraveling risk could change the Clark Fork River from a cobble-bed, single thread meandering system to a braided system with dispersed contaminants, incapable of supporting trout" is unsupported. Atlantic Richfield Company has identified flaws in the analysis: see AERL 2001, R2 Resource Consultants 2001, and G. Parker 2001. To the extent that such geomorphic instability exists, EPA has not correlated such potential instability with the presence of hazardous substances.

Response

Following the above statement quoted from the *Proposed Plan,* EPA also stated, "There is uncertainty associated with the probability and severity of this event."

EPA acknowledges uncertainty associated with the modeling of Dr. Smith of USGS. EPA notes that Dr. Smith's work was peer reviewed by other USGS scientists prior to publication. EPA must address this possibility and risk despite its uncertainty. EPA also notes that Dr. Parker's comments as well as other Atlantic Richfield Company citations have not been peer reviewed. In fact, Dr. Parker states, "The reach of the Clark Fork in question is moderately affected by tailings from the Anaconda copper mine, which were deposited in a major flood in 1908." He further states, "It does not suggest that the basis for the analysis by Smith is fundamentally wrong." Thus, Atlantic Richfield Company's own retained expert finds some validity in Dr. Smith's modeling work.

EPA's Selected Remedy contains a streambank stabilization component, which is not based solely on the risk of catastrophic unraveling. The streambank component also addresses two other elements of risk presented by the mine contamination deposited along the Clark Fork River:

- Excessive erosion of valuable agricultural, recreational, and important habitat land documented by USGS studies in which Atlantic Richfield Company experts participated. The estimated annual channel meander rates for Reach A ranges from 0 to 5.8 feet per year with an average rate of 0.6 feet per year over the 43-mile reach. On unaffected streams, erosion rates are estimated to be 0.1 to 0.25 feet per year. The primary cause of this excessive erosion is the lack of vegetation along the streambank caused by the phytotoxic effects of the mine contaminants on plant growth. Implementation of EPA's streambank stabilization component will slow the rate of erosion to more acceptable levels.

- The streambanks release large quantities of copper and other metals through erosion into the river over a wide range of flow conditions. Under current conditions, the source of about 60 percent of all copper input into the river upstream of Turah Bridge originates from streambank erosion. These erosional copper loads contribute to the frequency of exceedances of State water quality standards. This is a concern to the State, and any remedy must address this issue according to the CERCLA law that requires ARARs to be met by remedy implementation. Streambank erosion is a major contributor to copper concentrations, which cause low level but still unacceptable chronic risk to the aquatic environment, as described in the *Proposed Plan* and *Ecological Risk Assessment*, and during high bank flows may cause invertebrate levels to drop considerably.

Further explanation of the need for the streambank stabilization and buffer zone component of the remedy is found in this *Responsiveness Summary* in Section 2.1.2.1, page 3-12, and in Section 2.1.6, page 3-30. In short, the statements in the *Proposed Plan* are supported and appropriately qualified, and the component of the remedy associated with the unravelling risk is necessary and appropriate.

2) Page 5, Third paragraph of "Nature and Extent of Contamination"

Summary of Comments

Atlantic Richfield Company disagrees with the statement in the *Proposed Plan* that the "entire Deer Lodge valley floodplain—some 43 miles long and generally 300 to 500 feet wide—consists today of tailings, soils and sediments that are impacted by metals, arsenic and acid-generating sulfides." Atlantic Richfield Company has suggested alternate language.

Response

EPA disagrees with Atlantic Richfield Company's suggested language. During the years that mining wastes were discharged into various Clark Fork River headwaters, they were redistributed and mixed with river sediments and were deposited over the entire historic 100-year floodplain, particularly during the 1908 flood. Every sample taken and analyzed on the floodplain contains metals concentrations that were higher than anticipated natural background levels (refer to Table 3-6 of the Clark Fork River *Remedial Investigation* [Atlantic Richfield Company 1998]). Over the years, weathering of primary minerals contained in the tailings has occurred. This has resulted in some areas that still produce acid, creating phytotoxic conditions resulting in a total lack of vegetation or moderately impacted vegetation. Other areas have a lower pH, but no acid generating capability, and show severely to moderately impacted vegetation. Still other areas have a high concentration of residual metals but near neutral pH, and produce moderately to minimally impacted vegetation. Overall, vegetative communities range from severely affected to minimally impaired.

3) Page 6, First paragraph of "What are Primary Sources of Copper"

Summary of Comments

EPA stated that, "During non-flood conditions, the largest source of copper to surface water in Reach A of the Clark Fork River is bank erosion (see Exhibit 2)." This implies that the loading evaluation results presented in Exhibit 2 showing bank erosion contributing 60 percent of the loading was limited to non-flood conditions only. In actuality, the data collected and model developed for the copper loadings to the Clark Fork River evaluation included a range of flow conditions including high flows. The statement in this same paragraph that, "Streambed sediments make up 14 percent of the copper loading" should be qualified to note that this will not always be the case. The copper loading evaluation concluded that over time, the streambed sediments would be expected to equilibrate with surface water concentrations naturally, eliminating them as a net loading source.

Response

EPA concurs with the Atlantic Richfield Company comment that the modeling considered a range of flow conditions, including high flows. EPA has adjusted the language relating to the mass balance loading and associated charts to reflect a more accurate description of the mass balance. EPA also concurs that streambed sediments will equilibrate over time. However, EPA and USGS believe that "over time" means decades or even centuries, based on the hydrology of the basin over the last 100 years. Given this, EPA does not see a need to change any language in the *Record of Decision*.

4) Proposed Plan page 6 and Fact Sheet

Summary of Comments

Atlantic Richfield Company contends that lack of floodplain vegetation also results from historic land use/management practices including cattle grazing, rancher vegetation clearing, and other induced human actions.

Response

EPA recognizes and has concurred in the *Remedial Investigation* and in the *Feasibility Study* that historic land use/management practices have had an effect on the current conditions of the historic floodplain. However, EPA believes the main cause of vegetative impacts to the historic floodplain is the fluvially deposited mine contaminants and the resulting elevated metals and phytotoxicity in the soils of the floodplain.

5) Proposed Plan, page 10

Summary of Comments

Atlantic Richfield Company disagrees with EPA's concern regarding the Clark Fork River channel geomorphic instability. The *Ecological Risk Assessment* did not note "risks" from COCs documented to cause excessive erosion and loss of land and the hypothesized unraveling during a flood event. Nowhere in the geomorphic studies are such risks from

CERCLA COCs documented. To the extent that the *Proposed Plan* Preferred Remedy is intended to prevent undocumented geomorphologic risks, no documented unacceptable CERCLA risk from the alleged release of hazardous substances has been identified to support such a remedy. In addition, the documentation of vegetative screening risks in the *Ecological Risk Assessment* did not use specific endpoints related to key woody plant species that stabilize banks such as willows.

Response

See *Role of Geomorphic Fluvial Stability in the Clark Fork River Remedy Selection Process*, EPA, August 14, 2002. USGS and the Fluvial Geomorphology Committee prepared several reports for EPA as part of the RI/FS and site study process. Those reports stated two essential points about floodplain stability at the Clark Fork River. The text below is excerpted from that document:

A. There is clear evidence of floodplain instability at the Clark Fork River due to the release of mining waste hazardous substances upon the floodplain. This is demonstrated primarily by available data that shows high erosion rates and frequent meander and tab changes and washouts. This erosion is caused by impacts to the terrestrial environment (vegetation) present at the site, which causes the Clark Fork River to have less streambank stability than it should. The erosion process releases substantial quantities of copper and other metals into the river, which causes violations of the State of Montana water quality standards. The erosion also causes the loss of productive land to private and public landowners along the river.

B. Dr. Smith has postulated that the present floodplain instability is so great as to present a risk of further floodplain instability and land loss (the unraveling theory) in very high flood events because of the lack of vegetation. Dr. Smith's modeling efforts are not complete in this area at this time, as EPA understands it, and there is substantial uncertainty associated with the developing science used for modeling and predicting these effects (see Parker, Gary—St. Anthony Falls Laboratory, University of Minnesota—"Draft Technical Review of Smith, J. Dungan on Quantifying the Effect of Riparian Vegetation on Stabilizing Single Threaded Streams: 7th Federal Interagency Sedimentation Conference, Reno, Nevada—September, 2001", R2 Consultants Inc.—"Technical Review of Smith, J. Dungan on Quantifying the Effects of Riparian Vegetation on Stabilizing Single Threaded Streams, 7th Federal Interagency Sedimentation Conference, Reno, Nevada, September, 2001," and R2 Resource Consultants—"Assessment of Geomorphic Stability During Historical Floods of Silver Bow Creek, Little Blackfoot River and Big Hole River, Montana—September 2001."

In the same document, EPA further states:

> EPA acknowledges this concern and acknowledges that the remedy does not fully address Dr. Smith's postulated unraveling event. However, EPA strongly disagrees that the proposed remedy will not address the demonstrated erosional problems for the Clark Fork River. It has been developed by EPA advisors other than Dr. Smith who are familiar with Montana growing seasons, rainfall expectations, plants, and other land use practices. EPA believes the proposed streambank revegetation component of the remedy will reduce erosion rates to levels which will address the potential for environmental

risk in the river from flood events and waste which may be left in place in the remedy, and lessen the loss of land to landowners to normal erosion ranges experienced by other Montana landowners. It will also positively influence the very large flood events, such that these events will not produce widespread floodplain destabilization.

In short, EPA believes that the streambank component of the proposed remedy released in the *Proposed Plan* is necessary, implementable, protective, and practical. EPA also believes that the erosional and unravelling risks were sufficiently documented and quantified in the RI/FS process, such that risk managers had to recognize and address these risks. The fact that these risks were not in the *Ecological Risk Assessment* does not imply they should not be addressed. They are clearly a result of the impact of COCs in the floodplain.

6) Page 10, last paragraph of "What are the Human Health Risks?"

Summary of Comments

The *Proposed Plan* fails to note that State regulations prevent the construction of shallow wells less than 25 feet deep in the floodplain so unacceptable risks to human health resulting from arsenic do not exist.

Response

The State has classified all groundwater within and near the OU as a potential drinking water source. An examination of the RI data indicates that a total of four existing domestic wells within the OU exceed the most recent Federal drinking water standard for arsenic for human consumption (10 μg/L). These wells were completed in the shallow water table (no exceedances were found below a depth of 22 feet), and were sampled in June 1987.

State laws referred to by Atlantic Richfield Company can be changed, and are not routinely enforced. Thus, the findings of the *Proposed Plan* regarding the potential for groundwater risk are well founded. All previously sampled domestic wells that exceeded MCLs will be resampled, as well as any new private domestic well located in or near the floodplain. Appropriate ICs to address groundwater use in the shallow aquifer shall be implemented and funded. This will help ensure that State regulations preventing the construction of shallow wells less than 25 feet deep are enforced. This will also eliminate the potential that shallow groundwater contamination could be drawn deeper if groundwater development occurred and the shallow contamination was unaddressed.

7) Page 10, "What are the Ecological Risks," first paragraph

Summary of Comments

The geomorphological studies did not conclude that the Clark Fork River suffers from excessive loss of land. Atlantic Richfield Company disagrees that excessive bank erosion is due solely to the presence of historic mine wastes but rather past land management practices.

Response

EPA disagrees. See EPA response to Atlantic Richfield Company issues 4 and 5 from above.

8) Page 11, second paragraph of "What are the Ecological Risks?"

Summary of Comments

EPA's partial reference to statements made in the *Ecological Risk Assessment* is extremely misleading. Atlantic Richfield Company also disagrees with EPA's conclusion in the *Ecological Risk Assessment* that copper in diet (and other metals) impose an intermittent low level chronic stress on fish as evidenced by numerous papers cited by Atlantic Richfield Company.

Response

EPA stands by its conclusion in the *Ecological Risk Assessment* that metals are likely to contribute to the reduction in standing trout populations, to the reduction in some types of benthic macroinvertebrates, to decreased diversity and abundance of terrestrial plants in some locations, as well as potentially posing risks to several terrestrial receptors. EPA evaluated several factors and investigation results relating to chronic risks to Clark Fork River fish. These included chronic exposure to contaminated surface waters, site-specific fish survival tests, avoidance studies, exposure to contaminants from diet and from sediments, and comparative fish density studies. In a recent laboratory fish feeding study (Stratus 2002), juvenile rainbow trout were fed live diets exclusively of *Lumbriculus variegatus* (common names include California blackworm, blackworm, mudworm). The *Lumbriculus* were cultured in metal-contaminated sediments collected from Silver Bow Creek and the Clark Fork River. Significant growth inhibition was reported for fish fed the contaminated diets over the 67 day trial period. Growth inhibition was statistically related to metals and arsenic in the diets and to levels found in fish tissues. The best statistical correlations were reported for arsenic. The study suggests that *Lumbriculus variegatus* grown in metal-contaminated sediments can pose a risk to juvenile rainbow trout through an exclusive dietary exposure pathway. Taken together, EPA concluded the data from these studies are consistent with the hypothesis that copper (and possibly arsenic and other metals) in the aquatic environment (surface water, diet) impose a low-level chronic stress on aquatic macroinvertebrates, trout, and other fish. The *Ecological Risk Assessment* and EPA's unacceptable risk findings are carefully and accurately stated in *Proposed Plan* and are well supported by the record.

Atlantic Richfield Company's extensive comments on EPA's *Ecological Risk Assessment* were responded to by EPA in a lengthy written document, which is part of the administrative record and is incorporated herein by reference (May 2001, *EPA Response to Comments from AERL on the Clark Fork River Ecological Risk Assessment*).

9) Page 10, second paragraph

Summary of Comments

Atlantic Richfield Company strongly disagrees with EPA's conclusion that acute exposure during pulse events and other mining-related causes has led to decreased trout populations as evidenced by numerous papers cited by Atlantic Richfield Company.

Response

Historically, there has been a clear association between storm events and the occurrence of fish kills in the Clark Fork River. This is thought to be due to surface water run-off from contaminated soils, since these surface flows generally contain high concentrations of copper and other metals, and are also acidic. Maximum concentrations in runoff water from barren slickens were reported to be 7,380 mg/L copper, 2,350 mg/L zinc, and 23 mg/L arsenic (Atlantic Richfield Company 1997). In this regard, it is important to note that not all storms cause acute lethality. Rather, a key factor appears to be the formation of metal salt crusts on the tailings, which in turn requires an appropriate set of meteorological conditions to form initially. In a review of a major fish kill in 1989, EPA postulated that concentrations of metals in these salts, in readily soluble form, were responsible for rapid increases in river water metal levels, and subsequently the lethal concentrations of metals, especially copper, in fish tissues (Munshower et al. 1997). EPA considers it likely that acute exposures to pulses of metals or other high-concentration events are more important than chronic stresses to both fish and other important aquatic invertebrates, since even intermittent fish kills from pulse events could lead to reductions in fish population. Such pulse events are also responsible for the intermittent fish kills that have occurred since fish populations began to re-establish in the 1950s. It is also considered likely that decreases in fish populations in the Clark Fork River may also be due in part to other (non-metal) factors, such as sedimentation caused by excessive erosion resulting from contaminated soils. Considering all the available information, EPA has concluded that the risks to the aquatic system are unacceptable, including acute risks from pulse events.

Atlantic Richfield Company's extensive comments on EPA's *Ecological Risk Assessment* were responded to by EPA in a lengthy written document, which is part of the administrative record and is incorporated herein by reference (May 2001, *EPA Response to Comments from AERL on the Clark Fork River Ecological Risk Assessment*).

10) Page 11, second paragraph of "Remedial Action Objectives"

Summary of Comments

EPA provided no explanation in the *Proposed Plan* for a change in Preliminary Remedial Action Objective (PRAO) regarding groundwater waivers. The change is inconsistent with that stated in the *Feasibility Study* which indicated no *Feasibility Study* alternatives would fully achieve groundwater standards. By eliminating the reference to the potential for waiver of groundwater standards, EPA appears to insist on achieving what is technically impractical to achieve, as acknowledged by EPA.

Response

The remedial action objective for groundwater is to return contaminated shallow groundwater to its beneficial use within a reasonable timeframe. EPA believes that the removal of slicken areas, increased vegetative cover, and decreased percolation rates, in combination with natural attenuation, will lead to groundwater compliance within a reasonable time (perhaps several decades). Therefore, EPA is not proposing a waiver of groundwater standards. EPA reached this conclusion subsequent to the completion of the *Feasibility Study*, based on a closer examination of the expected effects of robust vegetation and careful in-situ treatment. EPA also has worked with scientists from Montana State University on possible amendment additions during in-situ treatment, which may further reduce arsenic mobilization. That work also supports the *Proposed Plan* and *Record of Decision* findings in this regard.

11) Page 11, second paragraph of "Remedial Action Objectives", No. 3

Summary of Comments

Groundwater discharge to surface waters is not a significant source of metals in surface water. Under existing conditions, groundwater discharge does not cause exceedances of surface water RAOs and would not be expected to under any of the alternatives considered.

Response

EPA believes the RAOs as stated are correct. The remedial actions in the *Record of Decision*, when implemented, will collectively reduce contaminated groundwater loading to the surface waters over time. Even though the loading model indicated only 3.9 percent of total copper loading to the river came from the groundwater compared to floodplain runoff of 5.8 percent and streambank erosion of 60 percent, the remedial actions will have an effect on all three and result in the ability to meet State of Montana surface water ARARs or the copper replacement standard.

12) Page 12, middle of first column

Summary of Comments

In the *Proposed Plan*, EPA stated that the *Human Health Risk Assessment*, the *Human Health Risk Assessment Addendum* and the *Ecological Risk Assessment* provide numeric goals for the protection of human health and the environment. Atlantic Richfield Company believes the reference should be clarified to state whether EPA is referring to site-specific numeric goals, such as trout Toxicity Reference Values (TRVs) that were developed for the *Ecological Risk Assessment*, or screening values, which are not themselves indicators of risk.

Response

The Selected Remedy specifies performance standards for protection of human health and the environment. These include calculated RBCs for contaminated soil and numeric concentrations (ARARs) for surface and groundwater. In addition, performance standards for vegetation and streambank treatments are specified.

13) Page 16, first paragraph of "ARARs Waivers for Certain Metals, Surface Water Standards"

Summary of Comments

EPA's Preferred Remedy proposes a waiver of the State's WQB-7 standard for copper in surface water but states that no waiver of the arsenic standard is proposed at this time. Atlantic Richfield Company previously submitted an analysis of predicted arsenic loads to EPA, which showed that none of the *Feasibility Study* alternatives would achieve the recently promulgated Federal standard of 10 ppb for arsenic, because the majority of current arsenic loading comes from upstream. Upstream and tributary sources of arsenic by themselves are predicted to result in exceedance of the 10 ppb standard so the need for a surface water arsenic standard waiver is clear.

Response

EPA believes the *Selected Remedy* for the Clark Fork River will ultimately reduce arsenic loading to the river from adjacent floodplain surface and groundwater sources. EPA acknowledges there are other upstream sources that contribute to elevated levels of arsenic in the river at this time. However, it is anticipated that future Superfund cleanup activities at these sources will ultimately reduce loads to the river. The overall effect from these basin-wide cleanup activities is expected to result in a positive trend toward compliance with the arsenic standard. EPA notes that some areas of Reach A are at or near compliance with the 10 µg/L dissolved arsenic standard during significant parts of the year. Therefore, EPA has elected not to waive the arsenic standard. See also Section 2.2.2.2 of this *Responsiveness Summary* (page 3-66) for further information regarding EPA's decision on the arsenic standard waiver.

14) Page 18, last paragraph

Summary of Comments

Atlantic Richfield Company believes EPA's conclusion stated in the *Proposed Plan* that "Alternative 1... does not address the unacceptable risks and pathway and is not considered further," is too general. They feel the *Ecological Risk Assessment* fails to document risks to aquatic species resulting from historic mine wastes and that in the *Feasibility Study*, through the evaluation of compliance with TRVs, the no further action alternative achieves remedial objectives for aquatic species.

Response

EPA disagrees with this comment. Based on the entire administrative record, including the *Ecological Risk Assessment* and the *Human Health Risk Assessment* and *Addendum*, and geomorphology reports and other USGS work, EPA's conclusion is that widespread unacceptable terrestrial and aquatic risk exists in Reach A and portions of Reach B of the Clark Fork River OU. Alternative 1, no further action, would fail to achieve ARARs and replacement standards, would fail to address terrestrial risks at exposed tailings areas (as well as human health risks), and would allow excessive erosion and stream instability to continue.

15) Page 19, first paragraph

Summary of Comments

Atlantic Richfield Company disagrees with EPA and believes that Alternatives 2 and 3, as demonstrated in the *Feasibility Study* and NRRB comments, are reliable and permanent. Furthermore, implementation of remedial actions such as Alternatives 2 and 3 has drawn the support of many landowners and local government, based particularly on the success of the Governor's Demonstration Project, and the ability to execute the actions with minimal disruptions to the landowners' property and operations.

Response

EPA strongly disagrees with Atlantic Richfield Company, particularly because the two alternatives do not include a streambank stabilization component, which is absolutely necessary to reduce copper loading from the eroding streambanks and to provide the necessary geomorphic stability. Reduced copper loading from eroding streambanks is necessary to move much closer to achieving State of Montana surface water standards. In addition, as noted in Exhibit 2-19 of Part 2, *Decision Summary*, Alternatives 2 and 3 scored lower in overall protectiveness, compliance with ARARs, and long-term effectiveness and permanence, compared to Alternatives 4, 5, and 6, the combination upon which the Preferred Remedy is based. EPA also notes that some landowners and the Anaconda/Deer Lodge County commissioners adamantly opposed these alternatives.

16) Page 19, last paragraph

Summary of Comments

Atlantic Richfield Company believes that Alternatives 5D and 6C will not significantly "move closer to State water quality standards" based upon *Feasibility Study* prediction comparisons to Alternative 4B4 because the model does not allow for conclusions to be made to this level of precision.

Response

EPA believes that the Selected Remedy, which removes the principal threat wastes, slickens and phytotoxic streambanks, will be a more permanent remedy. It will move closer to water quality standards because there will be less metals in the floodplain (an estimated 1,900 tons of copper and 750 tons of arsenic) to potentially be eroded back into the river as it moves across the floodplain over time. EPA did not indicate that a specific precise change in metals would occur, and EPA recognizes the model is unable to predict such changes in future metal concentrations.

17) Page 19, third paragraph

Summary of Comments

Atlantic Richfield Company believes Alternatives 5D and 6C do not "provide a greater reduction in mobility and volume" of the contaminants because the contaminants are not treated, the intent of the EPA criterion. Alternatives that include treatment (phytostabilization) actually provide greater achievement with this criterion since mobility is reduced.

Response

EPA disagrees. Alternatives 5 and 6 provide some reduction in mobility and volume by removal of the worst of the contaminants from the floodplain. Contaminants left in a floodplain are mobile. Alternative 5D addresses principal soil contaminants—slickens and phytotoxic streambanks—in a more reliable manner by removing these materials from the floodplain and thereby decreasing mobility. It also decreases toxicity of the remaining contaminants by using in-situ treatment on impacted areas. Alternative 6C, removal of exposed contaminated soils and impacted soils and vegetation, better addresses reduction of toxicity and mobility than Alternatives 4 and 5 because it reduces mobility for a large volume of contamination. Alternative 5 also relies on in-situ treatment, but in areas where organic content is present and some vegetation has established over time. EPA considers in-situ treatment in these areas to be effective in reducing toxicity in the long term, as long as it is designed, carefully implemented, and monitored over time.

18) Page 19, fourth paragraph

Summary of Comments

Atlantic Richfield Company notes that EPA, during the technical evaluation included in the *Feasibility Study*, identified, "uncertainties for implementation of in-situ in areas with low pH such as slickens." They disagree, noting that EPA's own contractors have produced numerous documents showing phytostabilization as being implementable and effective on low pH tailing areas such as slickens (see responses to issues to NRRB).

Response

At the request of the EPA NRRB, EPA conducted a review of the in-situ treatment technology, which is documented in *Responses to Issues Posed by the EPA National Remedy Review Board Regarding Phytostabilization of the Clark Fork River Operable Unit, Milltown Sediments Superfund Site* (CH2M HILL 2001). The record shows that some experts did not participate and disagree with some of the findings. However, the record also shows that the Governor's Demonstration Project and other areas treated in-situ have generally produced a return of vegetated conditions in contaminated soils when that soil is amended with appropriate chemicals (lime, organic matter, fertilizer, and other amendments) throughout the zone of contamination, and is monitored and maintained. The data and evaluations also demonstrate some problems with in-situ treated areas—less diverse vegetation, soluble arsenic in the vadoze zone of the treated area, concern about the ability to sustain woody vegetation, and a concern regarding the permanence of in-situ treatment. These issues and others were addressed in detail, using site-specific data in the responses to the EPA NRRB document. For the large acreages of impacted areas without slickens in the Clark Fork River OU, but where some vegetation and organic material exists, the in-situ technology should be implemented with a goal of returning mostly private agricultural land to productive use. For areas of exposed tailings without organic content, and with low pH and high metals content, particularly at the surface, the residual risk is greater and the removal technology is more appropriate. The slickens areas are the principal waste within the OU—remediation of these areas requires a higher level of certainty and permanence according to EPA guidance and the NCP (refer to Part 2, *Decision Summary*, Sections 11 and 13). The slickens areas have low pH and virtually no organic content. They have existed for many decades and natural healing has not led to revegetation in those areas. They generally have higher levels of arsenic and metals, and represent the principal threat waste. They produce runoff that is a clear threat to aquatic receptors (refer to Part 2, *Decision Summary*, Sections 7.2, 13.5.1, and 13.5.2). The higher metal content could also lead to more extensive re-treatment and more monitoring and land use controls on these areas, which is not beneficial to the landowners. Finally, it appears that deep rooted woody vegetation growth, which is so important to the bank and river stability, is less certain with in-situ treatment in these areas. EPA believes that the Selected Remedy is correct in addressing slickens areas with the more aggressive cleanup; that is, removal of slickens. See also the August 2003 EPA memorandum (regarding: Preparation of the *Record of Decision* for the Clark Fork River OU) for a detailed discussion of this point. That document is incorporated herein by reference.

19) Page 19, fifth paragraph

Summary of Comments

EPA proposed a combination of Alternatives 4B4, 5D, and 6C as the Preferred Remedy. Atlantic Richfield Company notes that EPA's own evaluation of alternative performance (Table 7-1 of *Feasibility Study*) scored Alternative 6C lower than 4B4 and 5D. Therefore Atlantic Richfield Company questions including any components from 6C in the preferred alternative.

Response

The *Feasibility Study* ranked alternatives by weighing each of the seven criteria equally, in accordance with EPA guidance. The remedy selection process weighs different criteria differently—threshold criteria are the most important and long-term effectiveness and permanence, implementability, and reduction of mobility, toxicity, and volume receive added emphasis, according to the preamble to the NCP. EPA believes that this *Record of Decision* appropriately weighs and discusses these criteria (see Part 2, *Decision Summary*, Section 10), and that the Selected Remedy, including portions of Alternative 6C, is the appropriate remedy for this site.

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20) Page 20, first paragraph of "General Cleanup Strategies"

Summary of Comments

EPA identified small, localized areas of Reach B that will require streambank stabilization. Atlantic Richfield Company notes that these areas were dropped from the *Feasibility Study*, and no basis was provided as to why they are now included in the Preferred Remedy.

Response

There are locations in Reach B with eroding banks containing tailings that need bank stabilization to minimize further bank erosion and land loss and to reduce copper loading to the river. These areas are partially documented in the *Remedial Investigation*. Their inclusion in the *Proposed Plan* and *Record of Decision* is appropriate.

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21) Page 20, fourth paragraph of "General Cleanup Strategies"

Summary of Comments

EPA identifies the costs of the preferred remedy to be in the range of $90 to $100 million. Atlantic Richfield Company believes this cost range significantly overestimates actual costs, considering flexibility in design and implementation.

Response

The comment represents Atlantic Richfield Company's opinion. EPA has conducted further review of the estimated remedy costs, including a careful review of the cost issues presented by Atlantic Richfield Company in its comments, and believes the cost estimate presented in the *Record of Decision* is reasonable. EPA's cost estimate document, which will be available at the same time as this *Record of Decision* is released, contains specific responses to Atlantic Richfield Company's cost information.

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22) Page 20, "General Cleanup Strategy," first bullet

Summary of Comments

The term "channel reconstruction" should be removed from the *Proposed Plan*.

Response

EPA agrees. Its use was in error.

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23) Page 20, "General Cleanup Strategy," second bullet

Summary of Comments

EPA states that exposed tailings would be removed with limited exceptions (small areas [less that 400 square feet], less than 2 feet deep, and contiguous with impacted soils and vegetation that would be treated in place). Atlantic Richfield Company believes these exceptions are unclear as to whether the exception applies to areas with all of the described properties or to any of them. Atlantic Richfield Company believes there is no technical basis for the exceptions given the equipment and techniques that have been demonstrated to effectively phytostabilize all of the identified areas slated for removal.

Response

EPA requires that all of the described properties be present in order to apply the exception for removal and has added language to the *Record of Decision* to ensure this clarity. EPA included this exception to provide certain flexibility and practicality not to adversely impact productive land with haul roads simply to access relatively small areas of tailings. This is part of the "additional design considerations" being integrated with the CFR RipES process to be used as a part of site-specific design to help meet important landowner concerns about disruption of their operations.

With regards to the last portion of the comment, see Section 2.1.10 (page 3-43), and Section 2.1.17 (page 3-57), of this *Responsiveness Summary*.

24) Page 21, "General Cleanup Strategy," first bullet

Summary of Comments

The Preferred Remedy identified that impacted soils and vegetation areas will be treated in-place unless the tailings and impacted soils extend to depths more than 2 feet or is limited to depths of 2 feet below the surface or are too wet to permit the use of in-place treatment techniques. Atlantic Richfield Company disputes the 2-foot limit and believes it has been demonstrated that methods of in-place treatment to mix soils and lime effectively to depths greater than 2 feet. In addition, existing vegetation conditions overlying buried tailings extending greater than 2 feet below ground surface may already achieve RAOs and may not warrant treatment or removal.

Response

See response to issue 18 (page 3-91). EPA has established the 2-foot depth limit for in-situ treatment based upon proven technologies capable of treating to those depths. A detailed description of the treatment of impacted soils and vegetation is provided in Part 2, *Decision Summary*, Sections 13.3 and 13.6.3. The presently accepted in-situ treatment technology, the Baker plow, has proven to be effective in mixing the soil and lime to depths of up to 30 inches based upon use of three right angle or acute angle passes. Extremely wet ground can limit the use of this technique.

With regards to the possibility of finding existing vegetation that achieves RAOs and exists over soils with tailings greater than 2 feet in depth, the use of CFR RipES to delineate impacted soils and vegetation areas versus slightly impacted soils requiring no additional treatment will be able to identify areas with sufficient vegetation such that in-situ treatment will not be required.

25) Page 21, "Preferred Remedy," second bullet

Summary of Comments

Some larger removed areas may actually require more BMPs, due to the likelihood of weed infestation, not less as indicated by EPA.

Response
Weed growth exacerbation is a historical phenomenon associated with any ground surface disturbance, whether by removal or by the use of in-place treatment. EPA believes that fewer BMPs may be associated with the removal portions of the Selected Remedy, because the replacement soils should have a much lower weed seedbank because of prior weed treatment, in contrast to the existing soils being treated by in-situ means, and because there will be less need for long-term monitoring and maintenance of these areas.

26) Page 21, "Preferred Remedy," fourth bullet

Summary of Comments
The Human Health Risk Assessment documented that there are no risks to human health outside the normally accepted range, based upon data collected during the *Remedial Investigation*. Atlantic Richfield Company believes the sole potential exception to this are certain residential areas historically irrigated with water from the Eastside Ditch, most of which have been remediated under a TRCA. Other data, such as from Arrowstone Park, have been collected since completion of the *Remedial Investigation* and confirmed there are no risks outside the normally acceptable range. Atlantic Richfield Company feels it is unnecessary to evaluate recreation and residential health risks further.

Response
A summary of human health risks is provided in Part 2, *Decision Summary*, Section 7.1. How the Selected Remedy will mitigate these human health risks is explained in Part 2, *Decision Summary*, Section 13.4. In the recent past under its removal authority, EPA has actively addressed human health risks resulting from arsenic exposure in residential areas near Deer Lodge, including playgrounds and parks, and residential areas along the East Side Road. This *Record of Decision* specifies that any similar exposures would also have to be addressed to ensure that human health is protected. The *Record of Decision* also specifically identifies that ICs, such as limiting residential use of the floodplain and potable water wells in the floodplain, will be implemented to ensure public health protection. Seven specific actions to reduce risks to human health are presented in Part 2, *Decision Summary*, Section 13.4.

EPA's *Human Health Risk Assessment* (EPA 1998) and its addendum evaluated the most likely scenarios for human exposure to the COCs for the Clark Fork River OU. Risk managers have made decisions establishing specific action levels for cleanup of arsenic contaminated soils throughout Reach A.

The *Human Health Risk Assessment* provided text to help interpret the RBC and states, "RBC values should be interpreted by comparison to concentration values which represent the arithmetic mean and/or UCL (upper confidence level) of the mean of a chemical averaged over an appropriate exposure unit and should not be interpreted as a 'not-to-be-exceeded' value on a sample-by-sample basis." The document also states, "noncancer and cancer risks from exposure to soil and tailings are dominated by arsenic, and no other chemical poses risks in a range of concern." EPA has incorporated these concepts into the *Record of Decision*.

The *Record of Decision* document specifies actions required to address human health considerations. The Selected Remedy sets action levels for arsenic in soils within the Clark Fork River OU as follows:

- Residential—150 ppm

- Rancher/Farmer—620 ppm
- Recreational—680 ppm for children at Arrowstone Park and other recreational scenarios
- Fishermen, swimmers, and tubers along the river only—1,600 ppm

ATSDR, an agency devoted to human health protection, commented on the *Proposed Plan* and stated a basis for ensuring human health risks are carefully and methodically protected as part of this remedy. The trestle area in Deer Lodge will be sampled and if risk based levels are exceeded, contamination will be removed and disposed in the Opportunity Ponds. Other known recreational areas will be evaluated and if exceedances are found, they will be dealt with in a similar manner. Some residences, identified under the Deer Lodge Valley Historically Irrigated Lands as exceeding the action level for arsenic in residential areas, were not addressed under the TCRA. These areas will be revisited and remediated consistent with that action. Other follow-up operation and maintenance activities from this action will be implemented.

EPA does not believe that other historically irrigated lands within the Clark Fork River OU do not exceed EPA's action level for reasonably anticipated land use for those lands. This will be confirmed via sampling of these lands if necessary and confirmation that residential development is not planned for these areas. As noted in Part 2, *Decision Summary*, Section 13, confirmation sampling for in-situ treated areas is also required to ensure that these areas are below action levels for the current and reasonably anticipated land use.

Additional sampling will be performed in coordination with the NPS at the Grant-Kohrs Ranch National Historic Site irrigation areas and other similar areas to determine if unacceptable risks are present, and if so, contamination will be removed.

Three ICs will be implemented (refer to Part 2, *Decision Summary*, Section 13.4 for detailed description of these ICs) to further protect human health. The ICs are summarized below:

- Continued implementation, including funding, will be provided for Powell County's and Deer Lodge County's zoning ordinances, which prohibit building a permanent residence within the floodplain of the Clark Fork River in those counties.

- Permanent deed restrictions and use funding are required for Arrowstone Park near Deer Lodge, to ensure that this area is maintained and dedicated to use as a recreational area.

- All previously sampled domestic wells that exceeded MCLs will be resampled, as well as any new private domestic well located in or near the floodplain. Appropriate ICs to address groundwater use in the shallow aquifer shall be implemented and funded. A survey of well use in the floodplain of Reach A is necessary. Additional ICs beyond existing State statutory protections can range from groundwater control areas to ordinances or deed restrictions.

Educational efforts for recreational users within the river corridor area concerning the need to prevent soil intake by children and maintain other health practices to prevent unnecessary exposure to soils shall be undertaken or funded, in cooperation with local and State health authorities.

EPA believes all of these measures are necessary and appropriate for protection of human health.

27) Page 21, second column, first full paragraph

Summary of Comments

EPA provided no basis for the "approximately 56 miles of streambank stabilization" mentioned. Atlantic Richfield Company believes that this amount of streambank stabilization is not required based upon design of RDU6 and earlier work and also believes the criteria selected by EPA, less than a 0.25 feet per year of bank erosion, may not be attainable.

Response

The approximately 56 miles of streambank stabilization referred to in the *Proposed Plan* should have been approximately 50 miles in order to correspond with the 264,000 feet of streambank stabilization included as part of the Preferred Remedy in the *Proposed Plan*. Additional information about the required amount of streambank stabilization identified in the Selected Remedy is provided below:

- **Information on the Clark Fork River in Reach A:**
  - Total streambank length in Reach A = 455,136 feet (86.2 miles of streambanks; 43.1 river miles), include:
    1. Length of streambank in Reach A considered = 436,436 feet
    2. Length of streambank in Reach A not considered = 18,700 feet, which includes:
       a. City of Deer Lodge = approximately 11,600 feet
       b. Streambank with public infrastructure currently protected by rip-rap = 5,500 feet, which include:
          i. Highway = 2,500 feet
          ii. Railroad = 1,800 feet
          iii. County roads/bridges = 300 feet
          iv. Irrigation structures = 200 feet
          v. Sewer lagoon = 700 feet
       c. Other lengths of rip-rapped streambanks of unknown origin = 1,600 feet
- **Comparison of the Feasibility Study, Atlantic Richfield Company's Evaluation of the *Proposed Plan*, and EPA's Cost Estimation of the *Proposed Plan***—Exhibit 3-8 represents a comparison of lengths of treatments and acres for the *Feasibility Study* (Atlantic Richfield Company 2002), Atlantic Richfield Company's evaluation of the *Proposed Plan* Preferred Remedy on 2.5 miles of floodplain immediately upstream of Deer Lodge, Montana (Booth and Johnson 2003), and EPA's cost estimation of the *Proposed Plan* (2003). (The values in Exhibit 3-8 represent Atlantic Richfield Company's extrapolations to the entire Reach A.)

EXHIBIT 3-8
Comparison of Estimates of Streambank Lengths, Percent of Total Length, and Acres for the Clark Fork River in Reach A
Percent of total length is based upon a total length of Reach A = 455,136 ft.

Cost Estimate Evaluation	Linear Streambank Treatment Length (feet)	Percent of Total Length (%)	Acres
April 5, 2001, EPA Memo to Atlantic Richfield Company; EPA original streambank request (Atlantic Richfield Company 2002)[a]	385,968	85.0	443.1
April 5, 2001, EPA Memo to Atlantic Richfield Company; EPA agreed to the following streambank length (Atlantic Richfield Company 2002)[b]	298,848	65.7	343.1
Feasibility Study streambank lengths (Atlantic Richfield Company 2002)	264,000	58.0	303.0
Atlantic Richfield Company's Evaluation of the *Proposed Plan* on Forson's property (EPA 2002)	313,287	68.8	308.0
EPA's Cost Estimation of the CFR Cleanup Plan (CH2M HILL 2004)[c] (Excludes No Treatment and Currently Rip-Rapped)	411,123	90.3	501.1
EPA's Cost Estimation of the CFR Cleanup Plan (CH2M HILL 2004)[c] (Excluding No Treatment, Currently Rip-Rapped, and Treatment 1)	315,979[d]	69.4	362.8[e]

[a] This information is added to the original Table D3 based upon April 5, 2001, memo from EPA to Atlantic Richfield Company. It is found in Appendix D5-2 (page 1068 of the *Feasibility Study* CD).

[b] This information is added to the original Table D3 based upon April 5, 2001, memo from EPA to Atlantic Richfield Company. It is found in Appendix D5-2 (page 1068 of the *Feasibility Study* CD).

[c] The Cost Estimate document is to be released at the same time as the *Record of Decision.*

[d] The value is based upon the exclusion of No Treatment Necessary, Currently Rip-Rapped, and Treatment 1 (vegetation augmentation) due to the limited amount of work that needs to be done and the limited costs per linear foot of streambank vegetation augmentation treatment ($2.78 per linear foot; linear streambank length = 95,144; total cost = $264,500).

[e] The value is based upon the exclusion of No Treatment Necessary (29.1 acres) and Treatment 1 acres (109.2 acres).

In the memo dated April 5, 2001, to Scott Brown of the EPA, which included in Appendix D5-2 (page 1068 of the *Feasibility Study* CD) of the *Feasibility Study*, the technical team estimated the streambank work in Reach A to be 385,968 feet. On page 1068 of the *Feasibility Study* CD, the memo states:

> The new subalternative has been crafted in such a manner as to be consistent with the framework of the existing Alternatives and the structure of the cost estimates.

On page 1075 of the *Feasibility Study* CD, the memo states:

> EPA desires to add the streambank component described above to the range of existing alternatives. This addition facilitates a better comparison and contrast with alternatives containing different types of streambank stabilization methods. EPA's original intent was to apply the new streambank riparian buffer zone model design to both sides of the river channel and in all areas where deep binding root mass does not currently exist. It is assumed this would encompass approximately 85 percent of 43 river miles in Reach A or 385,968 feet of riverbank. However, to do so would require more extensive work, make this subalternative incompatible with streambank stabiiization lengths of other alternatives, and require re-running the CAST Model and other Feasibility Study variables.

The memo goes on to state:

> Instead, EPA has chosen to apply it to a more limited length of streambanks (assumed to be 298,848 feet, double Atlantic Richfield Company's estimate for streambank stabilization along one bank under Alternative 4a&b Criteria 3) that is compatible with existing Alternatives. The erosion rates of the new subalternative are assumed to be comparable to Atlantic Richfield Company's most effective streambank alternatives, which achieve an erosion rate of 0.25 feet per year. This permits EPA to add this additional streambank component to Alternatives 4 (4a and 4b), 5 (5c), 6 (6c), 7 (7b), and 8 (8b) for comparative analysis.

However, the streambank length actually used in both the *Feasibility Study* and the *Proposed Plan* was changed to 264,000 feet.

In the memo from Don Booth of EMC2 (Booth and Johnson 2003), Don discusses the differences between the extrapolated streambank lengths from Forson's property (313,287 feet) and the *Feasibility Study* (264,000 feet). Booth and Johnson (2003) state:

> SRBZ bank treatment lengths based on GIS queries completed for the Feasibility Study and incorporated into the Preferred Remedy (i.e. 264,000 feet in Reach A) are considered to be the most representative, as they make the most use of available site-specific information.

In other words, even though the preliminary design work done on Richard Forson's property came up with a higher number than their numbers from the *Feasibility Study* (313,287 feet vs. 264,000 feet), they recommend using the lower number as they feel it is more representative of the entire Reach A than Forson's property by itself.

EPA did not select the criterion of 0.25 feet per year of bank erosion. It is not mentioned in the *Proposed Plan*. This was a value determined by the geomorphology subcommittee that represented an average erosion rate of a well vegetated bank. Dr. Smith, in a later USGS publication, indicated that an average erosion rate could possibly be reduced to as little as 0.1 feet per year with banks and riparian corridor stabilized with deep binding root mass that was assumed by EPA to be the ultimate minimum erosion rate achievable by the use of the riparian buffer zone concept when fully mature. Both rates were used in the *Feasibility Study* in modeling runs to see the effect of copper loading differences based upon different bank treatment methods.

28) Page 21, second column, second full paragraph

Summary of Comments

EPA states that removal focuses on specific areas where severe contamination complicates or prevents re-establishment of vegetation while treatment in-place focuses on other less contaminated areas. Atlantic Richfield Company believes that the Governor's and other demonstration areas have shown that areas of relatively greater contamination (slickens) can be effectively treated in-place and should not require differentiation for removal.

Response

EPA disagrees. Slickens areas are highly contaminated, phytotoxic, and the principal threat wastes to the environment; therefore, they must be removed (refer to Part 2, *Decision Summary*, Section 11). Leaving contaminated wastes in-place leaves the landowner with property management issues that removal of these wastes does not. There is evidence that treated wastes left in place can restrict the types of vegetation a landowner may want to grow (DOI 2002; MSU 2002). If the wastes are removed, the landowner is free to manage the property without restriction, after vegetation has been established. Moreover, removal ensures that these wastes will not be re-entrained into the river. A full description of phytostabilization methods as implemented in the Clark Fork River basin is presented in EPA's responses to issues posed by the NRRB (CH2M HILL 2001).

The results of three more recent investigations are summarized below:

- Hansen (2002) states that LAO (where tailings were removed) has a statistically-significant higher riparian functional health that the Governor's Demonstration Project (where tailings were treated in-situ). Twenty-five percent of the plant community at the Governors Demonstration Project is composed of redtop, a metal tolerant species, while it was not present at all at LAO. This contributes to the finding that the functional health rating average scores for vegetation at the Governor's Demonstration Project is 74, (Functional at Risk—Healthy, but with problems), while at LAO it is 88, (Proper Functioning Condition—Healthy). It should be noted that several variables between the two sites, such as grazing practices, weed control, and bank stabilization work, make it difficult to accurately compare the two sites, which also have different re-growth periods. Nevertheless, within the objective methodology of this study, an analysis shows statistically significant differences in vegetation functional health and overall functional health.
- An investigation by Neuman et al. (2002), at privately owned portions of the Governor's Demonstration, concluded the phytostabilized areas with elevated metals may have

limitations on the vegetation communities that can be established. This conclusion is consistent with field observations, the theoretical phytotoxicity models, and data presented in the *Ecological Risk Assessment* for the Clark Fork River. It is noted that the private landowner's field produced very good alfalfa crops in 2002 and 2003. This species is thought to be tolerant, relative to barley, of the chemical, physical, and biological attributes in the rootzone.

- A recent paper (Munshower et al. 2003) investigated the permanence of phytostabilization, primarily in upland areas, within the upper Clark Fork basin. The purpose of the investigation was to generate sufficient data and information from areas receiving phytostabilization treatments, varying in age from 6 to 19 years, so that the permanence and self-sufficiency of the established and reconstructed ecosystem(s) can be assessed. Major conclusions of this investigation were that phytostabilization of acid waste is a valuable reclamation technique, calcium carbonate amendment applied as ground limestone or certain industrial waste can be calculated to produce a non-acid root zone that will last indefinitely, and that successional changes in vegetation are occurring over time. See also EPA's August 2003 memorandum, which is incorporated herein by reference.

29) Page 21, last paragraph

Summary of Comments

The implication that some impacted soils may be too deep or too wet for in-situ treatment is not correct. Techniques can be developed for treating these soils in-place.

Response

The general clean-up strategy in Part 2, *Decision Summary*, Section 13.3, states that impacted soils and vegetation areas will be generally treated in-situ, unless certain exceptions apply. Areas of impacted soils and vegetation that have tailings and impacted soils extending deeper than 2 feet will be removed rather than treated in-situ. Such areas will also be removed if they are too wet to efficiently treat in-situ. Additional detail for treatment of impacted soils and vegetation is provided in Part 2, *Decision Summary*, Section 13.6.3, as follows: Agricultural tillage up to depths approaching 12 inches can be completed with a disc, chisel, or moldboard plow. For deeper tilling, incorporation and mixing of lime and soil has been successfully completed to depths up to 30 inches with the use of a Baker disc type plow being pulled by a large tractor or bulldozer, again using several right or acute angle passes. Other large or small rotary-type mixers have also been used to very effectively mix and incorporate amendments in dry conditions. These application techniques can be applied in areas with shallow groundwater, if the area is not too wet to permit equipment access, and if the mixer blends amendments without the formation of unmixed "balled-up" materials.

30) Page 23, first paragraph (continuation of No. 2 from page 22)

Summary of Comments

The *Human Health Risk Assessment* documented that there are no risks outside the normally accepted range in the Clark Fork River, based on data from the *Remedial Investigation*, with the exception of the Eastside Ditch historically irrigated lands. It is not necessary to continue evaluation of other recreational and residential areas to determine if action levels are exceeded.

Response
EPA disagrees. See response to issue 26, page 3-95.

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31) Page 23, No. 4

Summary of Comments
Atlantic Richfield Company agrees that ICs will prevent groundwater use of the shallow aquifer, should be enforced by government, and should not be funded by Atlantic Richfield Company as the *Proposed Plan* implied.

Response
When costs are incurred to implement necessary institutional controls in order to protect public health from contamination, it is appropriate that those costs be borne by the responsible party, as they are response and remedial costs, as defined by CERCLA and the NCP.

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32) Page 23, Box "Impacted Soils Areas"

Summary of Comments
EPA should have qualified their assumption regarding the use of 700 acres of impacted soils and vegetation areas for some alternatives described in the *Feasibility Study*, which was based on the phytotoxicity formula included in the *Ecological Risk Assessment*. Based on the use of the buried tailings method, impacted soils could be a low as 185 acres.

Response
Comment noted. EPA has noted in the *Record of Decision* that all estimates of slickens areas and impacted areas are estimates with ranges. However, whether a site is categorized as an impacted soils and vegetation area will depend on its CFR RipES score, which is based on actual vegetation and contamination conditions on the polygon. Estimates of the area of impacted soils and vegetation areas, as reported in the *Feasibility Study*, ranged as high as 1,760 acres in Reach A. Remedial design will determine the actual areas of slickens and impacted areas.

3.3 Additional Comments and Responses

As noted previously, Atlantic Richfield Company's remaining comment package cannot be as easily examined to find comments on significant issues, criticisms, and new relevant information regarding the *Proposed Plan* or the other alternatives examined in the *Feasibility Study* and summarized in the *Proposed Plan*. The remaining text of the comment package was read and significant comments, criticism, or new relevant information were summarized and responded to as shown below. The text of each issue number (33 through 103) refers to the page number and paragraph from the Atlantic Richfield Company December 2003 comment package where the comment was found.

33) Page 1, second paragraph, and page 4, second paragraph

Summary of Comments

Include this document and the other Atlantic Richfield Company authored documents referred to in the text and listed in Appendix A of the comment package, in the Administrative Record.

Response

EPA has included the December 2003 Atlantic Richfield Company comment package in the Clark Fork River OU Administrative Record. Not all documents listed in Appendix A of the Atlantic Richfield Company package are referred to in the text of the Atlantic Richfield Company package, as asserted by Atlantic Richfield Company in this comment. Please see the response to Appendix A (issue 99, page 3-134) for a listing of which of these documents are included in the Administrative Record.

34) Page 2, paragraph 2, and page 4 second paragraph

Summary of Comments

There is no viable explanation as to why EPA's Preferred Remedy is necessary or appropriate to address ecological risks at the Clark Fork River OU.

Response

EPA's August 2002 *Proposed Plan* contains a detailed explanation of the human health and ecological risks found at the Clark Fork River OU, and the rationale for the approach contained in the *Proposed Plan*. The *Record of Decision* contains more detailed findings about the risks presented at the site and the rationale for the remedial action selected in the *Record of Decision*—see especially Part 1, *Declaration*, Sections 1.2 and 1.5; and Part 2, *Decision Summary*, Sections 5, 7, 10, 11, 13.1, and 14.

Atlantic Richfield Company is incorrect in asserting that only ecological risks exist at this site—human health risks were identified in the *Human Health Risk Assessment* and its *Addendum*, the ATSDR human health evaluations for the site, and the NPS Human Health Risk Assessment, and EPA risk managers considered these findings in describing the human health risks that exist and must be addressed in the final remedy for the site. Action levels for arsenic in soils, appropriate for the reasonably anticipated land uses, and groundwater are established in the *Proposed Plan* and *Record of Decision*. The *Record of Decision* also describes appropriate actions to ensure that the areas addressed by the Selected Remedy meet those levels to ensure protection of human health.

Prior responses to comments have further explained EPA's reasons for selection of the remedial action, and the connection of the remedy components with the ecological risks and ARAR exceedance problems presented at the site. EPA refers Atlantic Richfield Company to Section 2 of this *Responsiveness Summary* and to EPA's August 2003 Memorandum for additional explanation of EPA's remedy selection reasons.

Given the significant detail contained in the *Proposed Plan* and supporting documents, it strains credibility to state that EPA has provided no explanation why it proposed the actions it did in the August 2002 *Proposed Plan*.

33) Page 1, second paragraph, and page 4, second paragraph

Summary of Comments

Include this document and the other Atlantic Richfield Company authored documents referred to in the text and listed in Appendix A of the comment package, in the Administrative Record.

Response

EPA has included the December 2003 Atlantic Richfield Company comment package in the Clark Fork River OU Administrative Record. Not all documents listed in Appendix A of the Atlantic Richfield Company package are referred to in the text of the Atlantic Richfield Company package, as asserted by Atlantic Richfield Company in this comment. Please see the response to Appendix A (issue 99, page 3-134) for a listing of which of these documents are included in the Administrative Record.

34) Page 2, paragraph 2, and page 4 second paragraph

Summary of Comments

There is no viable explanation as to why EPA's Preferred Remedy is necessary or appropriate to address ecological risks at the Clark Fork River OU.

Response

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Given the significant detail contained in the *Proposed Plan* and supporting documents, it strains credibility to state that EPA has provided no explanation why it proposed the actions it did in the August 2002 *Proposed Plan*.

35) Page 2, paragraph 2

Summary of Comments

Slickens present the only unacceptable risk at the site.

Response

EPA's August 2002 *Proposed Plan* contained a detailed explanation of the various pathways and receptors for hazardous substances at the site, and the unacceptable risks found at the site—see pages 2 through 11 of the *Proposed Plan*. EPA's *Record of Decision* contains a more detailed description of the unacceptable risks and the basis of those assessments—see Part 2, *Decision Summary*, Sections 5, 6, and 7. Atlantic Richfield Company provides no rationale for its comment beyond this statement, and no further response can be given to this general statement.

36) Page 2, paragraph 2

Summary of Comments

EPA's proposed action is arbitrary and capricious, inconsistent with the NCP, unauthorized by CERCLA, and contrary to law.

Response

Again, Atlantic Richfield Company has provided no basis for this conclusory statement, nor does it cite specific NCP provisions or CERCLA provisions that it believes have not been followed for the site or the remedy selection process or content. EPA believes the detailed Administrative Record, *Proposed Plan*, and *Record of Decision* more than adequately demonstrates that EPA's Selected Remedy is not arbitrary and capricious, and is consistent with the NCP and CERCLA. More detailed and specific Atlantic Richfield Company comments concerning the remedy selection process and content are responded to in issues 34 and 35 above and issue 37 below.

37) Page 2, paragraphs 3 and 4

Summary of Comments

Atlantic Richfield Company has developed a proposed remedy called the Atlantic Richfield Preferred Remedy that is consistent with CERCLA and the NCP and protective of human health and the environment, and costs considerably less than the EPA *Proposed Plan* remedy.

Response

EPA acknowledges that Atlantic Richfield Company's Preferred remedy costs less than EPA's selected remedy, but cost is not the only consideration in EPA's remedy selection process. EPA disagrees that Atlantic Richfield Company's Preferred Remedy is protective of human health and the environment or in compliance with ARARs for the site, and its selection would not be consistent with the NCP or CERCLA. EPA's disagreements with these assertions are more fully explained below.

38) Page 3, paragraph 5 and page 4 paragraph 1

Summary of Comments

EPA's cost estimates for its *Proposed Plan* are flawed and excessive and should be reduced substantially.

Response

EPA examined Atlantic Richfield Company's detailed cost estimates and its own cost estimates carefully, and has presented a more detailed cost estimate in a separate document titled *Cost Estimate for the U.S. Environmental Protection Agency's Cleanup plan for the Clark Fork River Operable Unit*, which will be released at the same time as this *Record of Decision*. EPA responds to Atlantic Richfield Company's cost estimate criticisms in detail in that document, which is incorporated herein by reference. The basis for EPA's cost estimate is described in detail in that document, and was prepared by experienced engineers in accordance with EPA's Superfund cost estimation guidance. That effort largely confirmed and refined EPA's initial cost estimates presented in the *Proposed Plan*. EPA disagrees with Atlantic Richfield Company's assertion that the *Proposed Plan* cost estimate was flawed, and believes the cost estimate that appears in this *Record of Decision* at Part 2, *Decision Summary*, Section 13.13, is well founded and accurate.

39) Section I, pages 1 through 3

Summary of Comments

Atlantic Richfield Company's Preferred Remedy is one in which slickens and surrounding areas where cover soils are thin and/or buried tailings are thick—areas that Atlantic Richfield Company describes as disturbed areas—would be addressed through in-situ treatment or soil cover. Atlantic Richfield Company estimates that only 420 acres would meet Atlantic Richfield Company's criteria for slickens and disturbed areas. Atlantic Richfield Company does not describe when it would apply in-situ treatment and when it would apply soil cover. Areas would be revegetated after cover or in-situ treatment. Atlantic Richfield Company would apply three types of bank stabilization—revegetation, bio-technical, and rip rap—to banks that are actively eroding and have exposed tailings. Atlantic Richfield Company estimates the streambank length covered by this part of its proposed action to be 22,400 feet within Reach A. The bio-technical bank stabilization would be done only at banks such as outer meander bends or other high shear stress areas. Atlantic Richfield Company would also implement BMPs to floodplain areas and streambanks in Reach A that contain metals-elevated soils or groundwater, which would temporarily prohibit cattle grazing in revegetated areas until vegetation was fully established and would also include fencing, off-site water provision, or grazing rotation. Atlantic Richfield Company's preferred remedy would also implement ICs that would consist of the continued land use restrictions on residential development within the Clark Fork River floodplain. Atlantic Richfield Company believes that its preferred remedy meets the threshold criteria for selection of a remedy and should be selected by EPA under CERCLA remedy decision criteria.

Response

Atlantic Richfield Company states that this remedy is similar to Alternative 4A1, which was presented in the *Feasibility Study*. EPA's rationale for not selecting Alternative 4 is explained on pages 18 through 20 of the *Proposed Plan* and in this *Record of Decision* at Part 2, *Decision Summary*, Section 10. This rationale notes that Alternative 4A does not address the copper loading found at the approximately 242,000 feet of streambanks outside of the approximately 22,000 feet of streambank addressed in Atlantic Richfield Company's Preferred Remedy—all of which are contaminated with metals and all of which erode and contribute to aquatic risks and other pathways at the site. The Atlantic Richfield Company stabilization technique would also not address comprehensively the high erosional rates and loss of land or the unraveling risks presented at the site. EPA notes that Atlantic Richfield Company's preferred remedy would implement in-situ treatment in areas where it is not reliable and is not likely to be effective in the long term—namely in phytotoxic streambanks without vegetation and in slickens areas. It also would not address at least 582 acres of impacted soils and vegetation which, because they do not exhibit vegetation that is sufficient and have elevated metals and pH content, are impacted and exhibit environmental terrestrial risk. Atlantic Richfield Company's remedy does not address groundwater at all, and Atlantic Richfield Company admits that groundwater would not likely achieve required, protective standards under its proposal. Atlantic Richfield Company also does not propose ICs of any kind to address groundwater contamination, despite the fact that four domestic wells sampled during the RI exceeded the arsenic standard for drinking water. The Atlantic Richfield Company preferred remedy also does not address those known residential areas above risk based levels that were not addressed under the previous Deer Lodge Valley TCRA, nor does it propose anything towards surveying other areas within Reach A of the OU to ensure that they meet risk based standards for protection of health from arsenic. Thus the Atlantic Richfield Company preferred remedy would not be protective of human health or the environment, one of the main, threshold criteria for selection of a remedy under CERCLA. It would also not do enough to comply with surface water ARARs and would do nothing to attempt to comply with groundwater ARARs—another threshold criteria for remedy selection under CERCLA. More detailed evaluation of Atlantic Richfield Company's issues on these threshold criteria are addressed below in response to more specific comments from Atlantic Richfield Company. Those responses are incorporated into this response by reference.

EPA's evaluation and balancing of the other seven criteria, in relation to Alternative 4 and in relation to EPA's Selected Remedy, are further explained below and in this *Record of Decision*. Those responses and sections of the *Record of Decision* are incorporated by reference into this response.

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40) Page I.3, paragraph 3

Summary of Comments

EPA's 1998 *Human Health Risk Assessment* found that current risks to humans from constituents of concern tailings deposits was within the normally acceptable range.

Response

Atlantic Richfield Company does not accurately summarize EPA's *Human Health Risk Assessment* and ignores ATSDR's human health risk concerns at the site. Atlantic Richfield Company's comment fails to even acknowledge EPA's *Human Health Risk Addendum*, which examined more closely potential risks to recreational receptors and established the basis human health action levels for recreational use for children. The true findings of the human health risk assessments and ATSDR health evaluations are found in Part 2, *Decision Summary*, Sections 7.1 and 13.4. Based on these findings, EPA's human health risk components are appropriate and necessary, and go well beyond Atlantic Richfield Company's preferred remedy.

Also see EPA's response to comments at Section 2.1.8 of this *Responsiveness Summary* (page 3-34), which is incorporated herein by reference.

41) Page I.3 and page I.4, paragraph 4, fourth paragraph

Summary of Comments

EPA's Proposed Remedy presents short term risks to workers that will lead to fatalities.

Response

The worker safety fatalities predicted by Atlantic Richfield Company are just that—predicted estimates that may or may not prove true for this specific project. EPA believes that this project can be successfully managed in a safe manner to avoid worker fatalities. Careful safety plans developed under detailed Occupational Health and Safety Act criteria have been used by Atlantic Richfield Company and other PRPs to avoid and minimize work safety at other large construction sites, and that success can be translated here to this project. For example, Atlantic Richfield Company recently completed the construction of a large treatment plant within a permitted mine site under difficult physical conditions, and did so without a single safety incident, let alone a fatality. A similar removal project going on upstream at the Silver Bow Creek site has not resulted in worker fatality or significant worker safety issues. Appropriate sequencing of the work can also be used to reduce worker safety risks. EPA's further examination of this issue is found in its July 2003 memorandum at Exhibit 3, which is incorporated herein by reference. See also EPA's response to community safety concerns in Section 2.1.9.1 of this *Responsiveness Summary* (page 3-39).

42) Page I.4, second paragraph

Summary of Comments

Atlantic Richfield Company's preferred remedy mitigates ecological risk from slickens by in-situ treatment.

Response

The use of in-situ treatment on slickens would mitigate the risk from pulse events and slickens run-off if successful. However, as explained in detail in EPA's July 2003 memorandum and in Sections 2.1.5.1 and 2.1.17 of this *Responsiveness Summary* (pages 3-27 and 3-57, respectively), EPA does not believe that the use of in-situ treatment for slickens would be successful in the long run nor would it produce appropriate vegetation for these areas.

43) Page I.4, fourth paragraph, and page I.5, paragraph 2

Summary of Comments

Atlantic Richfield Company's preferred remedy protects the terrestrial environment and the geomorphic stability of the floodplain.

Response

Atlantic Richfield Company's Proposed Remedy does not address a considerable portion of the floodplain—at least 582 acres—that EPA has identified as impacted areas subject to terrestrial risk. Addressing these areas is necessary to produce sufficient vegetation to stabilize the floodplain, to reduce impacts on ground and surface waters, and to make the lands fully usable. Atlantic Richfield Company's plan is limited to those lower vegetation areas found at fringe areas around slickens areas only. Atlantic Richfield Company's plan does not address almost 242,000 feet of streambank that EPA finds are eroding at excessive rates and contributing to geomorphic instability, land loss, and contribution of metals to in-stream chronic aquatic risks identified in EPA's *Ecological Risk Assessment* and found unacceptable by EPA risk managers as described in the *Proposed Plan* and this *Record of Decision*. Therefore, Atlantic Richfield Company's plan would not be protective of the terrestrial environment, nor would it contribute significantly to the stabilization of the floodplain.

44) Page I.4, paragraph 3

Summary of Comments

EPA's *Proposed Plan* has similar effects on the aquatic environment as Atlantic Richfield Company's Preferred Remedy, but costs more and is more difficult to implement.

Response

EPA's *Proposed Plan* would more permanently and reliably address aquatic risks from slickens areas, and would comprehensively address the chronic risks from bank erosion—60 percent of the ongoing copper load to the stream. Atlantic Richfield Company measures protection of the aquatic environment in terms of trout TRV compliance only. EPA notes that reduction of total recoverable metals from bank stabilization and more comprehensive bank treatment to address geomorphic stability is necessary and these endpoints are not included in Atlantic Richfield Company's comparative assessment. Atlantic Richfield Company's remedy simply does not address major aquatic pathways and risk problems at the site, which the Selected Remedy does, and therefore it is not similar in protectiveness. The selected remedy will cost more and will be more difficult to implement than Atlantic Richfield Company's minimal preferred remedy, but Atlantic Richfield Company's Preferred Remedy would not be protective of the aquatic environment, and is not similar in its protectiveness of the aquatic environment to EPA's Selected Remedy. The additional components of the Selected Remedy are cost effective and necessary to fully protect the aquatic environment.

45) Page I.5, paragraph 1 and 2

Summary of Comments

EPA's *Proposed Plan* has similar effects on the terrestrial environment as Atlantic Richfield Company's Preferred Remedy, but costs more and is more difficult to implement.

Response

As noted above, Atlantic Richfield Company's preferred remedy does not address terrestrial risk at large portions of Reach A, which EPA has identified as impacted. Also, it does not fully protect terrestrial ecological health nor result in full production for landowners. Atlantic Richfield Company's Preferred Remedy also does not address the risks to the terrestrial environment from excessive erosion along Reach A of the Clark Fork River. Thus, it does not have similar effects to the Selected Remedy. The Selected Remedy does cost more than Atlantic Richfield Company's preferred remedy and would be more difficult to implement, but the additional components of the Selected Remedy are cost effective and necessary to fully protect the terrestrial environment.

46) Page I.5, paragraph 1, and page I.6, paragraph 1

Summary of Comments

Atlantic Richfield Company notes that their preferred remedy is estimated to lead to violations of the State's WQB-7 total recoverable copper standard 61 percent of the time for chronic values and 26 percent of the time for acute value at "certain locations," while EPA's remedy would lead to exceedances of 21 percent for chronic values and 9 percent of acute values at Deer Lodge. There is also a measurable difference between the two remedies in terms of exceedances when measured at the lower end of the OU at Turah. Atlantic Richfield Company argues that since a waiver of the copper standard would be required in either case, these exceedances do not relate to protectiveness in Atlantic Richfield Company's opinion. This should not be a factor in remedy selection.

Response

EPA appreciates Atlantic Richfield Company's candor in its comments, but disagrees on the significance of this fact. Congress declared that CERCLA remedies were to achieve ARARs as the assumed cleanup standard—see section 121(d)(2)(A) of CERCLA, 42 U.S.C. § 9621(d)(2)(A). This statutory requirement is independent of protectiveness or risk reduction concepts expressed elsewhere in CERCLA. EPA has an obligation to select remedies that achieve ARARs or when they can't fully achieve ARARs, come as close as possible to achieving them. EPA granted the waiver for the State's WQB-7 copper standard because none of the alternatives could achieve that standard fully. Still, EPA believes that the remedy should come as close as possible to the standard, while still representing the best tradeoffs among the other remedy selection criteria for the site. Atlantic Richfield Company's preferred remedy does not meet this remedy selection criteria.

Finally, EPA disagrees that reduction of total recoverable copper is unrelated to environmental risk protection. EPA's *Ecological Risk Assessment* found low level aquatic risk above EPA's Hazard Quotient Level of 1 at the site, due in large part to copper pathways from streambanks in total recoverable form. Reduction of this pathway is extremely important to protection of the aquatic environment.

47) Page I.6, paragraphs 2, 3, and 4

Summary of Comments

EPA should waive the instream standards for arsenic, based on Atlantic Richfield Company's modeling effort, which shows that no alternative could meet the standards. Atlantic Richfield Company also argues that the standard is unrelated to protectiveness of aquatic resources

Response

See EPA's response to comments at Section 2.2.2.2 of this *Responsiveness Summary* (page 3-66). EPA believes that the Selected Remedy can possibly achieve the arsenic standards for in-stream arsenic set forth in the *Record of Decision*—both the Federal 10 μg/L standard, measured as dissolved, and the State 18 μg/L standard, measured as total recoverable. EPA acknowledges that there is uncertainty with this finding and will continue to examine the possible need for an ARAR waiver of these standards, while still maintaining protectiveness, when the remedy is implemented and the effects of upstream cleanups have been ascertained.

EPA believes control of in-stream arsenic is necessary for protection of human health, and that compliance with the State's WQB-7 standards for total recoverable arsenic for aquatic protection is also necessary.

48) Page I.7, paragraph 1

Summary of Comments

Atlantic Richfield Company and EPA's preferred remedy would comply with groundwater arsenic ARARs in areas below 25 feet. Neither remedy would comply with groundwater arsenic standards in shallow aquifers, and thus both remedies are equivalent. Atlantic Richfield Company does not propose a groundwater ARAR waiver.

Response

EPA believes that the Selected Remedy will more likely achieve the arsenic groundwater standard of 10 μg/L dissolved in both aquifers than the Atlantic Richfield Company remedy, because it will eliminate the most contaminated areas from the system (the slickens areas) and will reliably place vegetation in the floodplain through the appropriate application of in-situ treatment which will reduce infiltration of contaminants into the groundwater. Elsewhere, Atlantic Richfield Company argues that the groundwater ARAR standard should somehow not apply to the shallow groundwater, but that conclusion would be contrary to the NCP. All groundwater classified by the State as usable for drinking water is subject to the groundwater ARARs, according to CERCLA and the NCP. The State has classified the shallow groundwater at the Clark Fork as potentially usable and current State standards that restrict such use may be changed in the future and are not consistently enforced. EPA believes the removal of 750 tons of arsenic from the system and its potential effect on groundwater cleanup is important and another reason to select removal of slickens areas rather than in-situ treatment of these areas.

49) Page 1.8, paragraph 2

Summary of Comments

The State's regulations addressing the management of solid waste in the floodplain are not appropriate ARARs.

Response

EPA and the State have previously addressed Atlantic Richfield Company's arguments regarding the use of the State's solid waste and floodplain protection prohibitions against the active management of waste such as the contaminated material found in the Clark Fork as ARARs, and continued to believe they are appropriate ARAR standards. See Appendix A, pages 5, 8, 16, and 19, of the *Streamside Tailings Operable Unit of the Silver Bow Creek/Butte Area NPL Site Record of Decision* (EPA and MDEQ 1995) and Appendix A, pages 9 and 13, of the *Anaconda Regional Water, Waste and Soils Record of Decision* (EPA and MDEQ 1998), which are incorporated herein by reference. EPA notes that Atlantic Richfield Company indicates that under the State's floodplain ARARs, the presence of historic mill tailings in the floodplain does not constitute management. EPA agrees with this statement—the action specific State floodplain ARARs become applicable once the agencies decide to address the waste in the floodplain. When any active management occurs, the ARARs apply.

50) Page I.7, paragraph 2

Summary of Comments

The State's floodplain standards should be waived based on equivalent level of performance, as shown in Tab 5 of the Atlantic Richfield Company package. There is precedent for this waiver in EPA actions at the Streamside Tailings OU and the Butte Property Soils OU.

Response

EPA has waived the State's floodplain management ARARs with respect to areas that are designated for treatment, because removal of all the wastes and contaminated soils in the floodplain would be technically impracticable. EPA does not find that removal of the more limited slickens areas—estimated to be around 170 acres—is technically impracticable and cannot invoke the ARAR waiver for those areas. The State of Montana, who administers these ARARs, strongly believes this limited waiver is the only appropriate one for this action.

EPA examined the equivalent level of performance standard demonstration by Atlantic Richfield Company, and does not believe it is appropriate for this site. First, as discussed elsewhere in this *Record of Decision*, EPA does not believe that implementation of in-situ treatment in slickens areas would be successful or reliable over the long term and therefore would not be equivalent to the ARAR requirement to remove the waste that would be reliable and eliminate the threat from these wastes. Secondly, EPA notes the success of in-situ treatment in appropriate areas in terms of vegetation, but notes that this level of performance, which requires long term monitoring, careful O&M, and has the potential for groundwater releases of arsenic through mobilization, is not "equivalent" to the removal of the material as required by the ARAR.

51) Page I.7, paragraph 3

Summary of Comments

The Grant-Kohrs Ranch related ARARs, identified by EPA in its ARAR attachment, are not appropriate ARARs.

Response

EPA has identified, and the remedy selected by this *Record of Decision* will attain, location-specific ARARs with respect to hazardous substance releases within or potentially affecting the Grant-Kohrs Ranch National Historic Site, which is a unit of the National Park System administered by the NPS. These ARARs are derived from the NPS Organic Act, 16 U.S.C. §§ 1 et seq. (the Organic Act), and the enabling legislation for Grant-Kohrs Ranch (Pub. L. 92-406, 86 Stat. 7632 [1972]; Grant-Kohrs Act). As described further, attainment of these ARARs requires restrictions, treatment, removal, or other measures addressing concentrations of hazardous substances to ensure that the historic ranch landscape of the late nineteenth century is reestablished, preserved, and sustained for future generations in a condition unimpaired by hazardous substances.

The Atlantic Richfield Company objected to the designation of the Organic Act and the Grant-Kohrs Act as ARARs on three grounds:

1. The Organic Act and Grant-Kohrs Act do not authorize the NPS to improve the condition of land where such land has been contaminated by mining wastes prior to the land's inclusion in the National Park System.
2. Identification of the Organic Act and Grant-Kohrs Act as sources of ARARs amounts to an impermissible attempt by EPA to require natural resource restoration rather than an appropriate use of remedial action authority.
3. The Organic Act and Grant-Kohrs Act contain only non-binding administrative and "aspirational" standards that lack the precision required by the NCP.

As explained below, EPA finds Atlantic Richfield's objections to be unpersuasive.

Application to Mining Wastes on NPS Property

Section 1 of the Organic Act directs that the NPS "shall promote and regulate the use of ... national parks ... by such means and measures as conform to the fundamental purpose of the said parks ... which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein ... in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."[1] Atlantic Richfield Company suggests that this mandate for the NPS to conserve in an unimpaired condition the scenery, wildlife, and natural and historic objects of a National Park in order to achieve the fundamental purposes of the park should not be read to allow for improvement of impacted lands to a better condition than the lands were in when they were added to the National Park system.[2]

EPA disagrees with this suggestion. The Organic Act expressly directs the NPS to manage and regulate national parks to conserve the "scenery" and "wildlife" within parks and to leave them unimpaired for the enjoyment of future generations.[3] The notion that the NPS does not have authority to improve sites added to the National Parks system so as to fulfill the purposes for which the site was acquired is contradicted by clear statutory directive and established precedent.[4] In particular, with respect to National Historic Sites, the NPS is directed by statute to "restore, reconstruct, rehabilitate, preserve, and maintain historic or prehistoric sites ... of national historical or archaeological significance" such as the Grant-Kohrs Ranch National Historic Site.[5] This congressional directive—*to restore, reconstruct, or rehabilitate*—clearly contemplates the improvement of National Historic Sites that have been damaged or impaired prior or subsequent to becoming National Parks.

The *Grant-Kohrs Ranch Cultural Landscape Inventory* conducted by the NPS identifies historic elements of the "Riparian/Woodland Landscape" type as those "natural landscape features that existed during the ranch's period of significance and contribute to the landscape

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1 16 U.S.C. §§ 1.

2 See Atlantic Richfield correspondence from Barry C. Duff to Scott Brown and D. Henry Elsen, Environmental Protection Agency, and Mary Capdeville and Kevin Kirley, Montana Department of Environmental Quality (June 8, 2000) (hereinafter "Duff correspondence).

3 16 U.S.C. §§ 1 et seq. The conservation of both "scenery" and "wildlife" includes conservation and rehabilitation of native vegetation. See, e.g., *Interim Final Guidance on Assessing Impacts and Impairment to Natural Resources*, pp. 11-20, NPS, Natural Resource Program Center (April, 2003).

4 *See, e.g., U.S. v. Chrysler Corp.*, Partial Consent Decree (Ford Motor Co., General Motors Corp., Department of Defense) (Civ. Action No. 5:97 CV00894, N.D. Ohio April 22, 2002) (Court Order approving remedy selected by the NPS that mandated removal of hazardous substances from Krejci Dump site, resulting in conditions better than those that existed when the site was added to the Cuyahoga Valley National Park).

5 16 U.S.C. § 462(f).

character of the ranch"[6] and recommends that "damage as the result of upstream mining activities" should be remedied by Grant-Kohrs Ranch.[7] To accept Atlantic Richfield's argument that the NPS is not authorized to require that such damage be remedied would preclude the NPS from rehabilitating the Grant-Kohrs Ranch National Historic Site to the condition it was in during the time period that it is intended to commemorate, thus depriving the Grant-Kohrs Ranch from fulfilling the principal purpose for which it was added to the National Park System.[8]

Restoration Rather than Remedial Action

Atlantic Richfield argues next that the mandates of the Organic Act and the Grant-Kohrs Act are not ARARs because they pertain to restoration of injured natural resources and not CERCLA remediation.[9]

EPA disagrees with the argument that measures to protect the environment from the consequences of hazardous substance releases are not authorized under remedial action authority if such measures also achieve the reestablishment of natural resources. CERCLA defines "remedial action" in broad terms that clearly include measures designed to mitigate or remedy adverse effects on the environment resulting from the release of hazardous substances. Such adverse effects include the degradation or elimination of native plant and animal species that, but for the release of hazardous substances, would be present within a site's environment. Remedial action measures include, without limitation, dredging or excavation of contaminated media, onsite or offsite treatment, and other actions necessary to reestablish native vegetative species that have been adversely impacted or eliminated as a result of exposure to hazardous substance releases.[10]

This authority to remedy adverse environmental effects is expressly manifested in CERCLA's requirement for remedial action to attain ARARs. In particular, attainment of location-specific ARARs is required to remedy adverse environmental effects in special areas that merit special protection. As described by EPA guidance, location-specific ARARs include "restrictions placed on the concentration of hazardous substances ... solely because they are in specific locations. Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats."[11] Examples of Federal statutes that establish location-specific ARARs include, without limitation, the National Historic Preservation Act, the Archeological and Historic Preservation Act, the Wild and Scenic Rivers Act, the Coastal Zone Management Act, the Fish and Wildlife Coordination Act, the Wilderness Act, and others.[12]

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[6] *Cultural Landscape Inventory and Analysis, Grant-Kohrs Ranch National Historic Site*, United States Department of the Interior, NPS Rocky Mountain Region (1991), p. 27.

[7] Id at p. 38.

[8] The House Report accompanying the passage of the Grant-Kohrs Act expressly provides that the principal purpose of the Grant-Kohrs Ranch is to "recreate the historic ranch scene of the 1880-1900 period." *See* House Report (Interior and Insular Affairs Committee) No. 92-1222, Cong. Record Vol. 118, p. 3073 (July 18, 1972) (hereinafter "House Report").

[9] Duff correspondence.

[10] 42 U.S.C. § 9601(24).

[11] CERCLA Compliance with Other Laws Manual, (August, 1988), Volume I, p. 1-25.

[12] CERCLA Compliance with Other Laws Manual, (August, 1988), Volume II.

Like these statutes, the Grant-Kohrs Act, read in combination with the Organic Act, establishes for the Grant-Kohrs Ranch National Historic Site location-specific requirements. The attainment of these requirements is necessary to enable this National Historic Site to fulfill the statutory purposes for which it was established. Foremost among these statutory purposes is that the Grant-Kohrs Ranch National Historic Site be managed so that it is unimpaired for future generations.[13] This means, among other things, that the Ranch "will be a living memorial to the pioneers of the West, and that a concentrated effort will be made to preserve and *recreate the historic ranch scene of the 1880-1900 period.*"[14] Accordingly, location-specific ARARs for the Grant-Kohrs Ranch include those restrictions or mitigation measures addressing concentrations of hazardous substances that are necessary to recreate the historic ranch landscape of the late nineteenth century and to preserve and sustain this landscape for future generations in a condition unimpaired by hazardous substances.

EPA recognizes that attainment of these location-specific ARARs, which will thereby enable the NPS to reestablish native riparian vegetative communities, is also a desirable outcome from a natural resource restoration standpoint. EPA believes that this reflects an appropriate integration of the goals established by Congress in authorizing both remedial action to address threats to public health and the environment as well as restoration to address injuries to natural resources. Notwithstanding the integration of these two statutory authorities, the legal authority for requiring that remedial action attain restrictions on hazardous substances necessary to reestablish native riparian vegetative communities is derived specifically from the requirements that ARARs be attained, absent a waiver, by remedial actions selected under section 121 of CERCLA.

Aspirational/Imprecise Standards

Atlantic Richfield Company also argues that the Organic Act and the Grant-Kohrs Act establish narrative standards that are administrative and aspirational that lack the precision required by the NCP.[15] EPA disagrees with this assertion. As set forth in the House Report accompanying the statute, the Grant-Kohrs Act requires that "the historic ranch scene of the 1880-1900 period" be recreated to the extent possible.[16] This is a specific standard that can be quantified with some precision. NPS has conducted extensive research to determine precisely what vegetative communities would have existed at the Grant-Kohrs Ranch National Historic Site during the 1880-1900 period.[17] This research can be used to define performance standards that must be achieved to attain these ARARs and to identify specific indicators to measure such attainment.

Moreover, the NPS has developed policies for interpreting the unimpaired standard of the Organic Act. These policies specify that an action or conditions constitute impairment of park resources or values if the action or conditions "harm the integrity of the park resources or values, including the opportunities that otherwise would be present for the enjoyment of

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13 16 U.S.C. § 1.

14 House Report, p. 3073 (emphasis added).

15 Duff Correspondence.

16 House Report, p. 3073.

17 *See, e.g., Baseline Vegetation Types for Grant-Kohrs Ranch,* Peter M. Rice, Division of Biological Sciences, University of Montana (March, 2002) (hereinafter "Rice Report (2002)").

those resources or values."[18] In particular, NPS guidance specifically provides that an "action that eliminates a naturally occurring native plant or animal population from the park ... (or) actions that ultimately preclude an extirpated species from being restored to the park or preclude populations becoming self-sustaining are also likely to impair park resources."[19] When such impairment has occurred, NPS guidance specifies that "the appropriate condition" (i.e. unimpaired condition) "is an essentially natural condition, with natural population levels, (and) a natural distribution" of species.[20]

Accordingly, the location-specific ARARs identified for the Grant-Kohrs Ranch establish defined performance standards for the remedial action to attain. These performance standards require that the remedial action selected and implemented recreates the Ranch's historic landscape through the reestablishment of self producing and sustaining native riparian vegetative communities and species that likely would be present but for the effects of hazardous substances released from mining operations upstream.

As previously indicated, NPS has conducted extensive research and analysis in order to define specifically the native riparian vegetative species that should be used as indicators to determine whether these performance standards are attained.[21] This research indicates that seventeen baseline plant communities should be found within the riparian zone of the Grant-Kohrs Ranch National Historic Site.[22] Baseline plant communities are those that would be present but for the past and ongoing releases of toxic metals from upstream mining activities. Of these 17 plant communities, 12 are currently found in the Ranch riparian zones and 5 are absent. Each baseline plant community has been defined in terms of which native plant species would be expected within each community and the relative abundance of each species.[23]

Using these baseline plant communities as indicators, the remedial actions necessary to attain the performance standards associated with recreating the historic landscape can be evaluated, monitored, and adjusted as necessary. Recreating the historic landscape generally will not necessitate the complete removal of hazardous substances or, as Atlantic Richfield Company has put it, require a "pristine ecosystem." Rather, recreating the historic landscape means that the remedial action must achieve the natural reestablishment of self reproducing and sustaining native riparian vegetation communities through a natural successional process. Native riparian communities do not include a predominance of acid or metal tolerant species (e.g., tufted hairgrass, redtop bentgrass), but instead are composed primarily of communities native to southwestern Montana riparian areas (e.g., willows, river birch, alder, sedges and rushes).[24] In addition, recreating the historic landscape requires that the remedial action provides for the recuperation and stability of the river

[18] NPS Management Policies, Section 1.4.5, (2001).

[19] *Interim Final Guidance on Assessing Impacts and Impairment to Natural Resources*, NPS, Natural Resource Program Center (April, 2003).

[20] Id at p. 16.

[21] Rice Report (2002).

[22] Id.

[23] Id.

[24] Id.

channel, streambanks, wildlife habitat, irrigation ditches, and other components of the historic landscape that have been adversely affected by the release of hazardous substances.

To ensure the long term effectiveness and permanence of the remedy, intensive monitoring will be required. Such monitoring will measure the long term success of revegetation and recuperation of the river channel and other resources. Such monitoring also is required to ensure that the Grant-Kohrs Ranch National Historic Site is protected from future upstream releases of hazardous substances that would undermine the long term effectiveness of the remedy or threaten the successful reestablishment of native riparian vegetation communities. In addition, ongoing maintenance activities will be required to sustain the long term effectiveness of the remedy in maintaining the successful reestablishment of the historic landscape.

52) Page I.7, paragraph 4

Summary of Comments

In-situ treatment will achieve ARARs for vegetation.

Response

EPA agrees that in-situ reclamation, at appropriate places such as those described in the *Record of Decision*, will likely achieve vegetation ARAR standards. EPA does not agree that in-situ treatment in slickens areas will be successful or reliable in the long run, as explained elsewhere, and therefore does not agree that use of in-situ reclamation in slickens areas would achieve vegetation ARARs.

53) Page I.8, paragraph 1

Summary of Comments

Both remedies will achieve wetlands no net loss ARARs. EPA's Proposed Remedy will result in adverse impacts to wetland functions.

Response

EPA agrees that under either remedy, as well as under any other examined alternative, wetlands no net loss ARAR compliance can be achieved because the potential for creating wetlands during construction, where appropriate and consistent with landowner uses, is possible with this project. EPA encourages Atlantic Richfield Company to utilize this potential fully to create wetlands as the project is implemented. EPA does not agree that the excavation required under the Selected Remedy will result in adverse impacts to wetland function in the floodplain, and notes that Atlantic Richfield Company provides no basis for this statement. EPA has consulted with the FWS extensively on the selection of the remedy, and it supports EPA's Selected Remedy. The FWS is the agency primarily responsible for the monitoring and protection of wetlands for the Clark Fork Basin projects.

54) Page I.8, second paragraph

Summary of Comments

Atlantic Richfield Company's preferred remedy ranks highly for permanence and long term effectiveness because in-situ treatment would address terrestrial risk, and localized bank stabilization would reduce bank erosion of metals and geomorphic stability. Groundwater exposure would be prevented by ICs. Slickens areas would be addressed and prevent pulse events. Atlantic Richfield Company's proposed techniques are proven and reliable. EPA's in-situ treatment panel report supports the permanence and reliability of in-situ treatment.

Response

This comment is addressed in issue 39 (page 3-105), among others. In short, EPA does not believe use of in-situ treatment in slickens areas is reliable or permanent, and EPA does not believe the large areas of streambank and impacted soils and vegetation areas that are unaddressed by Atlantic Richfield Company's preferred remedy do not fully address protectiveness or important pathways and therefore are not permanent or effective in the long term. The NCP specifically requires EPA to assess "the degree of certainty that the alternative will prove successful" when evaluating the long term effectiveness and permanence criteria—see section 430(e)(9)(iii)(C), 40 CFR § 300.430(e)(9)(iii)(C).

Finally, EPA notes that Atlantic Richfield Company refers to the reliability of groundwater controls through ICs. However, Atlantic Richfield Company's description of its preferred remedy does not include any mention or description of groundwater ICs. Atlantic Richfield Company's preferred remedy does nothing in relation to contaminated groundwater, and therefore is not permanent or effective over the long term.

EPA's Selected Remedy does carefully address the needs for streambank stabilization and describes that portion of the remedy with great care, after careful consideration by EPA's experts in this field. Because of this, EPA's streambank component will be effective over the long term and will adequately manage residual risks at the site. For further discussion of this component and the basis for this determination, see Section 2.1.2 of this *Responsiveness Summary* (page 3-12), which is incorporated herein by reference.

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55) Page II.9, second and third paragraph

Summary of Comments

Atlantic Richfield Company's preferred remedy reduces mobility through treatment. EPA's remedy also does this and reduces mobility too, but is not consistent with section 121(b)(1) of CERCLA because it uses off-site disposal when on site practicable treatment options are available.

Response

The Atlantic Richfield Company preferred remedy uses treatment, but not for large areas of impacted streambanks or soils and vegetation. The Selected Remedy also uses treatment of soils through in-situ treatment, but in areas where it will work reliably and in the larger area of Reach A where it is needed. EPA's use of removal and disposal of untreated wastes for the slickens area is fully consistent with section 121(b)(1) because that provision disfavors such disposal only when on-site treatment options are practicable. As demonstrated elsewhere, on-site treatment via in-situ methods for slickens areas is not practicable because it is not likely to work adequately or reliably over the long term and does not address groundwater issues associated with slickens area effectively.

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56) Page II.9, paragraph 5, and page II.10, paragraphs 2 and 3

Summary of Comments

EPA's Proposed Remedy will have significant traffic, dust, noise, access, loss of land use, and construction hazards.

Response

See EPA's response to community concerns at Section 2.1.9, page 3-39, of this *Responsiveness Summary*, and EPA response to worker concerns at issue 41, page 3-106. EPA acknowledges that these short term impacts are greater than they would be with Atlantic Richfield Company's preferred remedy, but EPA believes that they are manageable if the project is planned and implemented carefully. EPA believes that in the overall balance of tradeoffs among the balancing and modifying criteria, these impacts do not lead EPA to select a less intrusive remedy than that selected in this *Record of Decision*.

57) Page II.9, paragraph 5

Summary of Comments

EPA underestimates the time period for implementation of the Proposed Remedy, based on the time period it is taking to implement the Streamside Tailings remedy. EPA's *Proposed Plan* will take much longer to implement than Atlantic Richfield Company's preferred remedy.

Response

EPA has considered the experience of the agencies in implementing the streamside tailings remedy in developing its estimates. EPA believes that the two projects are dissimilar in many respects, and that the Clark Fork Project can be implemented in 10 years if carefully planned up front. The *Record of Decision* acknowledges that this time period may be adjusted as remedial design is completed and more project detail is known.

EPA acknowledges that the Selected Remedy will take longer to implement than Atlantic Richfield Company's preferred remedy. EPA believes that in the overall balance of tradeoffs among the balancing and modifying criteria, this longer time frame for implementation does not lead EPA to select a less intrusive remedy than that selected in this *Record of Decision*.

58) Page II.10, paragraphs 4 and 5, and page II.11, paragraph 1

Summary of Comments

The *Proposed Plan's* more extensive streambank work has high levels of short term environmental impacts and it will take longer to implement.

Response

EPA has consulted carefully with the FWS about the construction techniques used during implementation of the Selected Remedy, and has prepared a Biological Assessment under section 7 of the ESA to address these concerns. The FWS concurs with EPA's remedy selection and will continue to work closely with EPA as the project is implemented to avoid or mitigate the environmental impacts that may be associated with the streambank work.

59) Page II.11, paragraph 4

Summary of Comments

EPA's *Proposed Plan* is not implementable because of landowner resistance for access and opposition to the buffer zone.

Response

EPA believes that careful coordination with the landowners, as described in several places in this *Record of Decision*, as well as fair treatment for lost land use caused by remedial implementation, will result in general landowner cooperation for this project. EPA has modified the buffer zone requirement such that its width is flexible and can be tailored to landowner needs. EPA's initial discussion with several landowners has revealed a greater willingness to cooperate with implementation of the remedy if it is done with landowner needs in mind.

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60) Page II.11, paragraph 5

Summary of Comments

There are not sufficient mature willows available to implement the streambank and buffer zone requirements of the *Proposed Plan*.

Response

Mature willow transplants from the Clark Fork River floodplain will be minimized for a variety of reasons. The removal of a large number of mature willows from the floodplain may potentially destabilize portions of the river. Therefore, Section 13.8.2 of Part 2, *Decision Summary*, and Appendix B of the *Record of Decision* discuss the growing of both small and medium size willows for the remediation effort. Mature willows will only be used in specific locations to minimize shear stresses against a streambank. Therefore, the use of mature willow transplants from the Clark Fork River floodplain only represent a small fraction of the total willows needed for remediation.

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61) Page II.11, paragraph 6, and page II.12, paragraphs 1 and 2

Summary of Comments

The water rights and irrigation needs for the *Proposed Plan* project make it unimplementable.

Response

EPA notes that Atlantic Richfield Company has acquired substantial basin water rights throughout the years, which would be sufficient to meet any water rights needs that may result from this project. EPA and DEQ will work carefully with the Montana DNRC to ensure water rights compliance during the implementation of this project.

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62) Page II.12, paragraph 3

Summary of Comments

EPA's *Proposed Plan* remedy is not cost effective as required by CERCLA and the NCP, because it costs more than Atlantic Richfield Company's Preferred Remedy.

Response

EPA has provided a detailed explanation of its consideration of the cost effectiveness criteria in Part 2, *Decision Summary*, Sections 10.2.7 and 14.3. The benefits for the environment and for human health provided by the Selected Remedy are proportional to the expected benefits from the implementation of the Selected Remedy as required by section 430(f)(1)(ii)(D) of the NCP, 40 CFR § 300.430(f)(1)(ii)(D). Accordingly, this decision complies with section 9621(a) and (b) of CERCLA, which address the need for the selection of a cost effective response. As stated in EPA guidance and in Part 2, *Decision Summary*, Section 14.3, it is important to note that more than one cleanup alternative can be cost effective, and that Superfund laws and regulations do not mandate selection of the most cost effective alternative. Additionally, the most cost effective remedy is not the least costly alternative that meets EPA's threshold criteria. EPA recognizes the costs associated with the Selected Remedy are relatively high, but believes the costs are appropriate for the widespread contamination and extensive unacceptable risks at the site.

63) Page II.12, paragraph 4

Summary of Comments

When comparing Atlantic Richfield Company's preferred remedy and EPA's Proposed Remedy, Atlantic Richfield Company's preferred remedy meets the criteria better than does EPA's Proposed Remedy. EPA's remedy presents a solution that is worse than the problem.

Response

Atlantic Richfield Company's Section II analysis looks at each of the seven criteria that it chooses to examine individually, and assesses "compliance" with each. This is not how the remedy selection criteria and process is required to be applied. EPA must select a remedy that meets the threshold criteria. Atlantic Richfield Company's Preferred Remedy is not protective of human health or the environment, the overarching mandate of CERCLA, because it does not address the large area of tailings and impacted soils, does not sufficiently address streambank erosion and its contribution to land loss and in-stream chronic risk, and does not begin to completely address human health risks. It does not provide ARARs compliance either, because it does not address groundwater ARAR compliance or maximum practical efforts to achieve State water quality standards, nor does it provide a basis for floodplain and solid waste ARAR waivers. Thus the Atlantic Richfield Company preferred remedy does not meet the threshold criteria.

When looking at the remaining balancing criteria, Atlantic Richfield Company's analysis does not examine the tradeoffs among these criteria and attempt to balance these tradeoffs to come up with an appropriate remedy—it looks at each criteria in isolation and continually emphasizes the short term risks allegedly presented by the Selected Remedy. The NCP requires EPA to look at these criteria and their tradeoffs as a whole, and to emphasize long term effectiveness and reduction of toxicity, mobility, or volume in this analysis, 40 CFR § 300.430(f)(1)(ii)(E). Atlantic Richfield Company's analysis does not even address tradeoffs among the criteria, and emphasizes short term effectiveness and perceived risks, as well as the cost of the remedy, over all other criteria. This is not supportable.

Finally, Atlantic Richfield Company does not even attempt to address community or State acceptance, important criteria in remedy selection. The State adamantly opposed Atlantic Richfield Company's minimal preferred remedy because it would not do enough to address chronic aquatic risk, terrestrial risk, streambank stability, or compliance with ARARs. Many members of the community oppose Atlantic Richfield Company's preferred remedy and support EPA's Selected Remedy or want it to go further.

EPA's analysis of the nine criteria, as carefully reflected in the *Proposed Plan* and this *Record of Decision*, reflects the appropriate application of the nine criteria to this site, and results in the appropriate selection of a remedy for the Clark Fork River OU, as found in the Clark Fork River OU *Record of Decision*.

64) Part II of Atlantic Richfield Company's comment package and Tabs 8 and 9

Summary of Comments

Atlantic Richfield Company provides a detailed analysis of costs that it projects for both the *Proposed Plan* and its own preferred remedy, and asserts that the EPA cost estimate found in the *Proposed Plan* is inaccurate.

Response

EPA's current cost estimate for the Selected Remedy is found in a separate document titled *Cost Estimate for the U.S. Environmental Protection Agency's Cleanup Plan for the Clark Fork River Operable Unit* (to be released at the same time as this *Record of Decision*). That document was prepared after careful consideration of Atlantic Richfield Company's detailed cost information. Agency assumptions and considerations that form the basis of the current cost estimate are explained in detail in that document. The agencies' disagreements or acceptance of specific Atlantic Richfield Company cost comments on the Selected Remedy are found in that document, and it is incorporated herein by reference.

Atlantic Richfield Company's detailed cost estimate for its own preferred remedy was not examined in detail and is not responded to in this document. Those comments are outside the scope of the comment period for the *Proposed Plan*, and a detailed examination is unnecessary since EPA did not select Atlantic Richfield Company's preferred remedy.

EPA also notes that Atlantic Richfield Company's cost estimates are based on use of criteria and considerations in an early draft version of the CFR RipES document developed for use at this site. Atlantic Richfield Company's remedial design activities, on which it based many of its cost comments and criticism, were largely based on this early draft CFR RipES version. The final draft CFR RipES document will be released at the same time as this *Record of Decision*. It is considerably different than the early version used by Atlantic Richfield Company in the preparation of its comments. Accordingly, many of Atlantic Richfield Company's cost bases and assumptions are inaccurate. This further emphasizes why remedial design must follow the selection of a remedy—not preceed it—as required by the NCP.

65) Page IV.15, paragraphs 4 and 5

Summary of Comments

EPA disregarded the requirement that CERCLA remedies must be cost effective. EPA's *Proposed Plan* remedy contains unnecessary components such as the 50-foot buffer zone, streambank stabilization, and use of CFR RipES, and underestimates the value of in-situ treatment for slickens. EPA overestimates and overstates risks.

Response

EPA believes that all components of the Selected Remedy are necessary and appropriate. Responses to comments regarding bank stabilization and the buffer zone are found in great detail in Section 2.1.2 of this *Responsiveness Summary*, page 3-12. The CFR RipES remedial design tool has been modified since the publication of the *Proposed Plan*. CFR RipES is fully described in Part 2, *Decision Summary*, Section 13.6.1, and a description of CFR RipES development and field use is found in Section 2.1.18, page 3-61. EPA disagrees with Atlantic Richfield Company's assessment of risks at the site as limited to slickens areas, as stated in responses to issues 39, 40, 42, and others in this section, and are further addressed regarding ecological health risks (Section 2.1.5, page 3-27) and human health risks (Section 2.1.8, page 3-34). EPA's *Record of Decision* contains a detailed analysis of the cost effectiveness requirements for CERCLA remedial actions in Part 2, *Decision Summary*, Sections 10.2.7 and 14.3.

66) Page IV.16, page 16 paragraph 1

Summary of Comments

Atlantic Richfield Company's preferred remedy is fully protective of human health and the environment.

Response

This often repeated assertion is responded to in this section at issues 39, 40, 42, 44, 46, and 54, among others. It is also responded to in Section 2 of this *Responsiveness Summary*, in response to comments about human health risks (Section 2.1.8, page 3-34), and in response to comments about ecological health risks (Section 2.1.5, page 3-27). EPA's Selected Remedy focuses its most aggressive remedial actions towards principal waste areas. Other areas that are addressed in this remedy, such as the impacted areas that are not principal threat waste areas, present unacceptable risk conditions. EPA believes in-situ treatment and a BMP approach to these areas is an appropriate remedy for these non-principal threat wastes. Additional discussion of the protectiveness of the Selected Remedy is found in Part 2, *Decision Summary*, Sections 11.1.13.4, and 13.5.

67) Page IV.16, paragraph 3

Summary of Comments

EPA did not address the NRRB's recommendation to clarify the relationship of risks to remedy components.

Response

First of all, the NRRB and its recommendations, and response of an EPA region to those recommendations, are not regulatory or statutory requirements. They represent an internal EPA process established by guidance and do not give Atlantic Richfield Company or other commenters substantive rights outside of the CERCLA statutory or NCP requirements.

EPA Region 8 did address this concern of the NRRB by further clarifying the contamination and pathways found and the unacceptable risks found at the site in the *Proposed Plan* (see pages 4 through 11 of the *Proposed Plan*). EPA then described the Proposed Remedy in some detail and linked the remedial components to the risks and pathways presented (see the *Proposed Plan* at pages 20 through 25). This demonstrated the relationship of risks to remedy components in response to the Review Board's concern.

A great deal of detail linking the remedy components to site risks is presented in Part 2, *Decision Summary*, Sections 7, 8, 11, and 13.1. Specific detail about the expected outcome or benefits of the Selected Remedy is presented in Part 2, *Decision Summary*, Section 13.4. EPA believes that this detail adequately addresses Atlantic Richfield Company's concern that the remedial action be related to site risks. In summary, the component to remove slickens addresses acute aquatic and obvious terrestrial risks found at the site, as well as potential wildlife risks from contamination. It also addresses human health risks presented by groundwater at the site by removing the worst of the contamination source to the groundwater. The treatment of areas of impacted soils and vegetation addresses terrestrial and potential wildlife risks found at the site. The streambank stabilization and buffer zone component addresses chronic risk and ARAR compliance issues, the excessive erosion and land loss, and the threat of unraveling from lack of vegetation. There is no duplicative or unnecessary component among those components. The benefits from the Selected Remedy are proportional to the costs estimated for the remedy.

68) Page IV.17, paragraph 3

Summary of Comments

The 50-foot buffer zone of willows is unnecessary and unrelated to risk.

Response

The buffer zone is part of the streambank stabilization component and is essential to address ecological risks at the site. It is not a mass of willows, as Atlantic Richfield Company described, but an area of approximately 50 feet on each side of the river in Reach A and limited portions of Reach B. The 50-foot width can vary depending on site conditions and the width of the floodplain at a given piece of property.

Actions will be taken in this zone to address phytotoxic or poorly vegetated streambanks that are eroding because of a lack of vegetation. This erosion is releasing hazardous substances to the aquatic environment. Actions can range from removal of contaminated soils and revegetation to supplemental vegetation. Woody, deep binding vegetation is emphasized because that is what is necessary to stabilize the stream and prevent stream unravelling or the excessive or fast release of the substantial contamination that will be left within Reach A by the remedy. BMPs, described in detail in this *Record of Decision*, will then be employed, in cooperation with landowners, to protect these actions and ensure that vegetation is established and maintained. It is difficult to understand how these actions are not viewed as linked to the release of hazardous substances or effects from the release of hazardous substances by Atlantic Richfield Company. At the heart of its concern, Atlantic Richfield Company doesn't dispute the linkage but disputes the risks presented by streambank contributions to the environment. These risk disputes are previously addressed in this document.

For additional information regarding the streambank component, see Part 2, *Decision Summary*, Section 13.6.4.

69) Page IV.17, paragraph 4, and page IV.22, paragraphs 1 and 2

Summary of Comments

There is no basis for applying the streambank stabilization component to the entire length of Reach A, and no rationale is presented in the *Proposed Plan* for this decision.

Response

The *Proposed Plan* states that "the sub-alternative developed by EPA and made a part of each of these alternatives (that is, the application of streambank stabilization to the full length of Reach A) was judged to be crucial for addressing overall protection of the environment. It addresses sediment copper loading, erosion risks and exposure pathways. Other streambank protection sub-alternatives (that is, the limited bank length favored by Atlantic Richfield Company) do not fully address these pathways and are not reliable over time."

It is important to note that Atlantic Richfield Company acknowledges in earlier comments that the use of this component will reduce copper loading to the stream considerably (see issue 46, page 3-108, which notes that exceedances will occur 61 percent of the time with Atlantic Richfield Company's plan versus 21 percent of the time with EPA's plan). EPA's risk assessment found low level chronic but unacceptable risk from contaminated sediments, and the *Remedial Investigation* found that the unstable banks provided the greatest contribution of copper to the stream.

It is also important to note that the streambank component of the Selected Remedy will evaluate all of the Reach A streambank, but will not require action on all banks. For banks classified as Class 3 streambanks, the remedial action will be no action or minor action to enhance existing vegetation. See Part 2, *Decision Summary*, Section 13.6, and Appendix B of the *Record of Decision*. Thus, the extreme story that Atlantic Richfield Company attempts to portray in its comments is not accurate or based in fact.

70) Page IV.18, paragraphs 5 and 6

Summary of Comments

EPA has no basis to require education efforts to prevent ingestion of arsenic contaminated soils.

Response

Atlantic Richfield Company's remedial response would leave substantial waste and contamination in place, but opposes even minimal efforts to address the potential risks from children eating dirt. These requirements of the Selected Remedy are based on concern found in both the *Human Health Risk Assessment* and in various ATSDR health evaluations for risks to children if excessive dirt is eaten by them. A condition in children known as the pica child is rare, but can occur, and when it does, children eat excessive amounts of dirt when playing outside. EPA believes that a simple educational effort, done in conjunction with Powell County health authorities, will address this potential pathway and risk. The risks posed to a pica child are not within the normal risk range at Arrowstone Park, and EPA and ATSDR's 2001 Human Health Risk Addendum specifically notes this.

71) Page IV.19, paragraph 2

Summary of Comments

EPA's prior Deer Lodge Valley TCRA addressed all human health risks, and nothing further is needed for protection of human health.

Response

Atlantic Richfield Company incorrectly states that it did remediation work under the Deer Lodge Valley TCRA—it did response work under EPA's removal authority. Remediation work cannot occur until a remedial record of decision is issued by EPA. Atlantic Richfield Company also incorrectly states the Deer Lodge Valley TCRA work cleaned up all known yards and fields that exceeded risk based criteria. Atlantic Richfield Company did do work under the Deer Lodge Valley TCRA, but not all residences identified as exceeding the acceptable human health level for arsenic in soils were addressed, primarily because of lack of voluntary landowner participation. These sites remain to be addressed and the requirement to do so, as well as to provide for any follow-up operation and maintenance, is contained in the *Record of Decision*.

Additionally, the EPA *Human Health Risk Assessment* generally states that human health risks throughout the OU are within normally acceptable ranges, the remedial investigation did not sample each residential, agricultural, or recreational area along Reach A to verify that assumption. The *Human Health Risk Assessment* and its addendum did calculate RBCs that would be acceptable under EPA's risk range, and did that at the lower end of the range. The Selected Remedy requires the assumption that use areas are below the RBCs to be confirmed where it has not already been confirmed, and that is entirely consistent with EPA's *Human Health Risk Assessments* and EPA's direction from Congress to ensure that human health is protected.

Finally, the *Remedial Investigation* did note that four domestic wells sampled were above the current protective level for domestic consumption of 10 $\mu g/L$ for arsenic. It is appropriate for EPA to require limited ICs and conduct well surveys and monitoring activities to ensure that this pathway and risk is known and addressed, and that ICs to prevent domestic groundwater wells within the floodplain are clearly and enforceably implemented.

72) Page IV.19, paragraphs 3, 4, and 5, and page IV.20, paragraphs 1, 2, and 3, and page IV.23, paragraph 2

Summary of Comments

The *Proposed Plan* is not the appropriate place to state that funding for ICs must come from PRPs like Atlantic Richfield Company.

Response

Sections 104 and 121 of CERCLA, cited by Atlantic Richfield Company, do not state that remedial actions must be paid for by PRPs, but sections 106 and 107 of CERCLA do.

The *Proposed Plan* normally does not address where funding for a remedy component will come from. In this case, however, EPA added the statements that IC funding will come from the PRP to address local government concerns that the remedy will impose additional financial burdens on them. Atlantic Richfield Company's own comment notes that an existing Memorandum of Understanding with Powell County allows Atlantic Richfield Company to fund the types of ICs described in the *Proposed Plan* and the *Record of Decision*. Given that, the statements about IC funding are appropriate.

73) Page IV.21, paragraphs 2 and 3

Summary of Comments

Existing State law, which bans domestic wells in the upper 25 feet in a floodway—see ARM § 36.15.602; and which bars any groundwater well unless it is not connected to surface water—see MCA § 85-2-337, are sufficient to protect human health and groundwater threats, and additional ICs or payment mechanisms are not necessary.

Response

EPA is willing to evaluate the effectiveness of these laws during remedial design to determine if they are adequate and if enforcement of these laws within Reach A occurs. The Selected Remedy does not automatically require new provisions beyond these—only the evaluations of these laws under current conditions.

74) Page IV.21 paragraph 4, and page IV.22, paragraphs 3 and 4, and page IV.23 in its entirety, and page IV.24, paragraph 1

Summary of Comments

EPA's proposed BMPs are overly intrusive, not cost effective, and should not be applied to the entire length of Reach A but only in selected areas. EPA is adopting a unilateral approach rather than a cooperative approach through existing programs.

Response

EPA notes that in Atlantic Richfield Company's preferred remedy description, it describes the need for BMPs as part of the remedy, and explains that these BMPs, which it favors, are intended to enhance land management, restrict grazing until vegetation is established, provide for off site watering, and provide for fencing and grazing rotation. This description of BMPs is not significantly different from the BMPs described in EPA's *Proposed Plan* and this *Record of Decision*. The BMPs that the *Record of Decision* describes will be applied in cooperation with landowners, and will serve the same function that Atlantic Richfield Company describes as necessary in its comments. EPA does not see a significant disagreement.

Atlantic Richfield Company also proposes that BMPs run the entire length of the river (see page 2 of Atlantic Richfield Company's comment package), similar to EPA's proposal. Again, the rhetoric of this comment by Atlantic Richfield Company doesn't match any actual disagreement. EPA believes that the BMPs described in the *Record of Decision* are necessary to protect the remedy and are within EPA's broad remedial authority under CERCLA.

Finally, both EPA and Atlantic Richfield Company are looking towards existing Department of Agriculture programs, such as EQIP or CRP, to form a basis and structure for the BMP program. Again, the rhetoric of Atlantic Richfield Company's comment does not correspond to any real disagreement. If these programs can be used effectively and enforcement mechanisms can be clearly defined, EPA also believes in working with them—that is why we specifically described such cooperation in our *Proposed Plan*. We look forward to working together with Atlantic Richfield Company and landowners on this issue following issuance of this *Record of Decision*.

75) Page IV.24, paragraph 2

Summary of Comments

Atlantic Richfield Company has already provided for funding of the maintenance of Arrowstone Park.

Response

If Atlantic Richfield Company's existing Memorandum of Understanding with Powell County, which was not provided to EPA, fulfills the *Record of Decision* requirements for deed restrictions and funding of the Park, then this requirement of the *Record of Decision* may have been met by Atlantic Richfield Company already, and can simply be documented in the site record. If not, additional measures will have to be taken.

76) Page IV.24, paragraphs 3 and 4, and page IV.25, paragraphs 1 through 5

Summary of Comments

The *Proposed Plan's* comments regarding natural resource damages are not accurate and are inappropriate; EPA should not have given the trustees access to the risk assessment for a year and a half, and additional natural resource damage requirements will burden landowners. Atlantic Richfield Company states its defense to natural resource damages under section 107(f)(1) of CERCLA and contends it applies to this site.

Response

The *Proposed Plan* language regarding the distinction between remediation and restoration simply recognizes ongoing efforts by State and Federal trustees to further assess injury and restoration actions to achieve baseline conditions. EPA takes no position on whether baseline conditions are or are not achieved at the site, since it is not a natural resource damage trustee and does not have expertise in this area. EPA also takes no position on the asserted defense to natural resource damages for the same reason, although other Federal agencies disagree with Atlantic Richfield Company's assertions here. Atlantic Richfield Company can more appropriately make this argument directly to natural resource damage trustees, where trustees can address these arguments as appropriate.

EPA's coordination of the ecological risk assessment with trustees was in accordance with section 104(b)(2) of CERCLA and NCP provisions at 40 CFR § 300.170. It was fully in compliance with the law.

77) Page IV.25, paragraph 6, and page IV.26, paragraphs 1 through 3

Summary of Comments

EPA ignores property rights in its description of the *Proposed Plan* and does not need access to property because the Proposed Remedy is not necessary in Atlantic Richfield Company's view.

Response

EPA fully appreciates that much of the Selected Remedy will be implemented on private property. The *Record of Decision* emphasizes the need for careful cooperation and dialogue between the remedy implementor and the landowner. The *Record of Decision* also emphasizes the need for reasonable and appropriate compensation to obtain access for the remedial action, especially for lost land use and BMP implementation. EPA will ensure that this happens as well.

78) Page IV.26, paragraph 3

Summary of Comments

Water rights will be difficult to obtain.

Response

EPA believes that irrigation water can be obtained through normal irrigation well permitting under existing State law. EPA also notes that Atlantic Richfield Company has obtained significant water rights in the basin that could be used for this project if that is determined to be necessary. EPA will work with Atlantic Richfield Company and the State DNRC to ensure that the water rights aspects of this remedy, if any, proceed in an orderly, efficient, and lawful way.

79) Page IV.26 paragraph 4, and page IV.27, paragraph 1

Summary of Comments

The risks at the site do not justify the remedy provisions.

Response

See EPA's response to issue 65, page 3-121. EPA's Risk Assessments and other documents, such as the USGS studies and recommendations, document widespread environmental terrestrial, aquatic, and stream stability risks, as clearly described in Part 2, *Decision Summary*, Section 7. The Selected Remedy components are related to mitigation of these risks and pathways, as described in various place in the *Record of Decision*.

80) Page IV.27, paragraph 2

Summary of Comments

There are not human health risks at the site, as EPA states on page 7 of the *Proposed Plan*.

Response

Atlantic Richfield Company quotes only one part of one sentence from a long section of the *Proposed Plan* that discusses human health risks. See EPA's response to issue 65, page 3-121, for a complete discussion of EPA's views on human health risks and the remedy components in the Selected Remedy that address those risks.

81) Page IV.27, paragraph 2, through page IV.29, paragraph 2

Summary of Comments

Atlantic Richfield Company disagrees that there is any unacceptable risk to the aquatic environment at the Clark Fork River OU.

Response

EPA responded to Atlantic Richfield Company's criticisms and comments on the *Ecological Risk Assessment* in a lengthy document dated May 15, 2001, which is incorporated herein by reference. EPA stands by the findings of the risk assessment and by the finding of unacceptable risk described in the *Proposed Plan* and this *Record of Decision*, which includes aquatic risk. Both acute and chronic risks are documented and discussion is provided in Part 2, *Decision Summary*, Sections 13.5.1 and 13.5.2.

Atlantic Richfield Company sent a letter after the May 15, 2001, response to comments that emphasized the lack of actual measurements of storm water events, which were emphasized in EPA's *Ecological Risk Assessment*. EPA notes that there is no formal monitoring program established to monitor and record these events—just because they are not recorded does not mean they do not happen. Runoff waters from natural precipitation events were evaluated as part of the monitoring at the Governor's Demonstration. In a 20-month period, 15 runoff events were recorded from an untreated micro-watershed area along the Clark Fork River. Maximum concentrations in runoff water from barren slickens were reported to be 7,380 mg/L copper, 2,350 mg/L zinc, and 23 mg/L arsenic (Atlantic Richfield Company 1997). The pH of runoff water from these events ranged from 3.9 to 4.7. Section 13.5.1 of Part 2, *Decision Summary*, provides additional discussion of the causative factor in fish mortality due to a storm event that occurred in 1989. Recent data from the nearby Anaconda Regional Water, Waste, and Soils OU (CDM/FPC 2001) from surface water sampling and subsequent analysis during storm events in the summer of 2001 revealed elevated concentrations of metal and arsenic in storm water runoff.

Atlantic Richfield Company also criticizes as misleading the use in the *Proposed Plan* of a photograph that shows colored water runoff during a storm event at the Clark Fork with a paragraph below it that states that such water contributes high levels of dissolved copper to the river that are harmful to aquatic life. The data results described above and in Section 2.1.5.4 of this *Responsiveness Summary* (page 3-28) demonstrate that runoff water during storm events in this area do contain high levels of dissolved contaminants, and a great deal of research, described in EPA's *Ecological Risk Assessment*, documents that such high levels are harmful to aquatic life. There is nothing misleading about the photograph or the paragraph in question—only hard visual demonstrative evidence that Atlantic Richfield Company refuses to acknowledge.

Atlantic Richfield Company also cites recent studies that show no impairment to aquatic receptors in the Clark Fork River. EPA has examined this data and believes that the ecological risk findings contained in the *Ecological Risk Assessment* and the *Proposed Plan* and *Record of Decision* are consistent with this data. See a more detailed explanation of this in EPA's July 2003 memorandum, *Response to Comments and Other Information Received during the Public Comment Period for the Clark Fork River OU Proposed Plan.*

See also the response in Section 3.2 to issues 8 and 9 (pages 3-86 to 3-87).

82) Page IV.28

Summary of Comments

Atlantic Richfield Company indicates they do not believe that "pulse events" are likely, and, if they occur at all, they do not present an unacceptable risk to aquatic receptors. This is a comment that Atlantic Richfield Company made previously in great detail in its review comments regarding EPA's Public Review Draft of the Clark Fork River *Ecological Risk Assessment* (December 1999).

Response

EPA previously provided a detailed point-by-point response on this issue in the document titled *USEPA Response to Comments from AERL on the Clark Fork River Ecological Risk Assessment, May 2001*. That document was transmitted to Barry Duff, Atlantic Richfield Company Project Manager, on May 15, 2001. The response is found on pages 20 through 29 of that document, and is hereby referenced for this *Responsiveness Summary*.

83) Page IV.29

Summary of Comments

Atlantic Richfield Company indicates that EPA has not shown that there are unacceptable risks to terrestrial receptors other than vegetation in slickens areas and that EPA inappropriately continues to rely on screening level values in its determination of risks to terrestrial receptors.

Response

EPA's *Ecological Risk Assessment*, October 2001, states on pages 12 through 15 that, "there is good evidence that soil organisms (worms, microbes) are adversely impacted by soils from slickens areas." It also states that, "the hazard to some terrestrial animals is predicted to be quite high. However, direct observations to support this prediction are lacking, so the actual level of risk to terrestrial receptors from metal exposures is subject to uncertainty." The *Proposed Plan* recognized these limitations by stating that there was considerable uncertainty associated with this potential risk. The impacts to vegetation continue to be the main concern regarding terrestrial risks.

The remedy as outlined in the *Record of Decision* will address those areas where actual impacts on vegetation are apparent, as measured by objective standards defined in CFR RipES. While slickens are the areas most severely affected, the impacts to vegetation are not limited to slickens areas. Atlantic Richfield Company's suggestions that EPA should not address the areas with impacted vegetation ignores not only this terrestrial risk, but the groundwater and aquatic risks as well. An important objective of the cleanup is to establish a healthy vegetative community throughout the floodplain to protect the river from unraveling during a high flow event and to limit excessive erosion that would contribute metals and arsenic to the river.

84) Page IV.29

Summary of Comments
Atlantic Richfield Company indicates that reduced fish populations in the Clark Fork River are attributable to habitat and other factors and not to the influence of metals.

Response
EPA responded to this detailed comment on pages 38 through 44 of its May 15, 2001, response to AERL comments. That response is hereby incorporated by reference.

85) Page IV.30

Summary of Comments
Atlantic Richfield Company indicates there is no established risk to Clark Fork River benthic macroinvertabrates.

Response
EPA responded to this detailed comment on pages 29 through 38 of its May 15, 2001, response to AERL comments. That response is hereby incorporated by reference.

86) Page IV.30, paragraphs 3 and 4, and page IV.31, paragraphs 1 through 3

Summary of Comments
The findings by USGS consultant Dr. Jim Smith are not supportable and should not be used by EPA in the remedy decision making process.

Response
See response to issues 1, 4, and 5 in Section 3.2, *Summary of Comments and Responses* (pages 3-82 to 3-86).

87) Page IV.31, paragraph 5, through page IV.32, paragraph 4

Summary of Comments
The streambank component of the remedy is not necessary to protect the environment.

Response
See EPA's response to comments in Section 2.1.6 of this *Responsiveness Summary* (page 3-30), and the response to issues 1, 4, and 5 in Section 3.2, *Summary of Comments and Responses* (pages 3-82 to 3-86).

88) Page IV.32, paragraph 6, and page IV.33, paragraph 1

Summary of Comments

The estimated length of stream in Reach A of 56 miles is incorrect and inconsistent with the FS estimated length.

Response

See response to issue 27 in Section 3.2, *Summary of Comments and Responses* (page 3-96).

89) Page IV.33, paragraph 2

Summary of Comments

The cost estimate should not assume that active streambank stabilization will be needed in all portions of Reach A.

Response

EPA's Selected Remedy defines more accurately where certain types of streambank stabilization will be employed and where active stabilization is not necessary. The cost estimate appropriately takes these considerations into account in estimating the cost of streambank work.

90) Page IV.33 paragraph 3

Summary of Comments

Channel reconstruction should not be used in the *Proposed Plan.*

Response

EPA agrees. See response to issue 22 in Section 3.2, *Summary of Comments and Responses* (page 3-93).

91) Page IV.33, paragraphs 5, and page IV.34, paragraphs 1 and 2

Summary of Comments

Removal of slickens and the areas of impacted soils that are too deep or too wet is not necessary.

Response

EPA disagrees. EPA's July 2003 memorandum provides a detailed explanation of the reasons why EPA selected removal for the slickens areas, and that response is incorporated herein by reference. EPA explains the basis for the too wet and too deep exceptions for in-situ treatment of impacted soils and vegetation in issue 29 in Section 3.2, *Summary of Comments and Responses* (page 3-101). EPA's experience with in-situ treatment at nearby sites like Anaconda indicate that reliable and permanent in-situ treatment can be done only under certain conditions, and the too wet and too deep conditions described in the *Record of Decision* do not meet those conditions.

92) Page IV.34, paragraph 3

Summary of Comments

EPA should allow soil cover and revegetation for areas designated for removal, consistent with the NCP.

Response
The NCP establishes an expectation that EPA will use treatment to address principal threats posed by a site wherever practicable (NCP § 300.430(a)(1)(iii)(A)). A source material is one that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or acts as a source for direct exposure.

Arsenic in tailings, mixed tailings, and soils has been determined to be the principal threat to human health within the Clark Fork River OU. For mobile waste in floodplains associated with acute risks, such as the exposed tailings and phytotoxic streambanks, removal and permanent disposal outside of the floodplain is required.

Placement of cover soil over exposed tailings was considered in the *Feasibility Study* (Atlantic Richfield Company 2000) as an option in Alternative 2 (see Section 5.3.1.2.2.2 and Figure 5.3 of the *Feasibility Study* document). In the comparative analysis of alternatives, Alternative 2 was considered to be only moderately protective of human and environmental health, and would have a low to moderate achievement of compliance with ARARs (see Table 6.1 of the *Feasibility Study*).

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93) Page IV.34, paragraph 4

Summary of Comments
EPA's statements about the area of impacted soils and vegetation being 700 acres are not accurate.

Response
EPA agrees that the areas could be smaller or larger and exact estimates are not known at this time. EPA has indicated in Part 2, *Decision Summary*, Section 5.5, the range of acreage totals for this category.

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94) Page IV.35, paragraph 3, Appendix 2, and Tab 2

Summary of Comments
Atlantic Richfield Company criticizes EPA's riparian evaluation system as unreliable and biased.

Response
Atlantic Richfield Company invested a great deal of time and money criticizing an early and preliminary draft version of CFR RipES. The version of CFR RipES that will be released with the *Record of Decision* has been changed considerably from that version, after consideration of Atlantic Richfield Company's comments on CFR RipES and other technical information. For example, the number of questions, the weighting associated with each question, and the actual questions themselves have changed dramatically from the December 2000 draft. The current version of CFR RipES included three more years of field testing and field validation. EPA has found the current version to be reliable and accurate. EPA will release the CFR RipES version in final draft form and seek input from landowners and other stakeholders. If comments are received that indicate further refinement is necessary, EPA will make changes to the document. See also EPA's response to comments at Section 2.1.18 of this *Responsiveness Summary* (page 3-61).

95) Page IV.35, paragraph 4 and Tab 6

Summary of Comments

EPA's description of streambank stabilization techniques in the *Proposed Plan* is unclear.

Response

The *Record of Decision* contains a much more detailed description of the streambank stabilization component. See Appendix B to the *Record of Decision* for this detail and for the basis for these designs. See also EPA response to comments at Section 2.1.6 of this *Responsiveness Summary* (page 3-30).

96) Page IV.35, paragraph 5

Summary of Comments

EPA's *Human Health Risk Assessment* and Atlantic Richfield Company's prior work under the Deer Lodge Valley TCRA indicate that further human health remedial requirements are unnecessary.

Response

See EPA's response to issue 26 in Section 3.2, *Summary of Comments and Responses* (page 3-95), and issue 80 in this section (page 3-128). EPA has actively addressed human health risks resulting from arsenic exposure in residential areas near Deer Lodge, including playgrounds and parks, and residential areas along the East Side Road. This *Record of Decision* specifies that any similar exposures would also have to be addressed to ensure that human health is protected. This *Record of Decision* also specifically identifies that ICs, such as limiting residential use of the floodplain and potable water wells in the floodplain, will be implemented to ensure public health protection. Seven specific actions to reduce risks to human health are presented in Part 2, *Decision Summary*, Section 13.4. Some residences are identified under the Deer Lodge Valley Historically Irrigated Lands TCRA as exceeding the action level for arsenic in residential areas and were not addressed under the TCRA. These areas will be revisited and remediated consistent with that action. Other follow-up operation and maintenance activities from this action will be implemented.

EPA does not believe that other historically irrigated lands within the Clark Fork River OU exceed EPA's action level for reasonably anticipated land use for those lands. This shall be confirmed via sampling of these lands if necessary and confirmation that residential development is not planned for these areas. Confirmation sampling for in-situ treated areas is also required to ensure that these areas are below action levels for current and reasonably anticipated uses (which is likely to be agricultural for most lands) after treatment.

97) Page IV.35, paragraph 6, and page IV.36, paragraph 1

Summary of Comments

EPA's sequencing of actions that prioritize work on the Class I streambanks will produce hopscotching and inefficient work.

Response

EPA recognizes the need to work with landowners and attempt to complete work on a given landowner's property in one or two field seasons. These concepts and this flexibility are recognized in the *Record of Decision* and can be further refined in remedial design.

98) Pages IV.36 and IV.37

Summary of Comments

Atlantic Richfield Company restates certain landowner concerns regarding in-situ treatment for slickens areas, weed control, and safety issues.

Response

These issues were responded to in this *Responsiveness Summary*, Section 2, *Stakeholder Issues and Lead Agency Responses*. EPA believes it has been responsive to landowner concerns, as indicated in the changes to the *Proposed Plan* found in this *Record of Decision*, which are described in Part 2, *Decision Summary*, Section 15.

99) Page IV.39, Appendix A

Summary of Comments

The listed documents were not included in the Administrative Record.

Response

EPA has included most of the listed documents in the Administrative Record. Records that pertain to the Warm Springs Ponds OUs and the Butte Priority Soils OUs were not included because they did not pertain to the Clark Fork River remedy selection and were not relied on by EPA in making its Clark Fork River OU decision. Atlantic Richfield Company's document entitled *AERL's response to the July 5, 2001, Remedy Review Board Recommendations for the Clark Fork River OU, November 1, 2002*, was not included in the Administrative Record because under EPA guidance, Atlantic Richfield Company had no role in responding to the NRRB's comments—this is a function reserved to EPA Region 8 since the remedy review board is an internal deliberative process set up by EPA guidance.

The comments found in these many documents are included in the administrative record, and those that pertain to the selection of the remedial action and the *Proposed Plan* have been responded to either in separate detailed responses from EPA (as is the case for the comments on the *Ecological* and *Human Health Risk Assessments*) or in the prior responses to stakeholder or Atlantic Richfield Company comments above. The only exception to this statement is the detailed ARAR comments submitted by Atlantic Richfield Company and included in the administrative record. These comments are identical to comments Atlantic Richfield Company has submitted on other nearby Clark Fork Basin superfund sites. EPA incorporates its detailed response to these comments found in the responsiveness summary sections of the Streamside Tailings operable unit (EPA 1996) and the Anaconda Regional Water, Waste and Soils operable unit (EPA 1998).

100) Tab 3

Summary of Comments

Atlantic Richfield Company criticizes the selection of removal for slickens and certain impacted soils and vegetation areas because it does not produce environmental benefits.

Response

EPA has given a detailed rationale for its decision to remove slickens and certain impacted soils and vegetation areas in its July 2002 memorandum and attachments and in numerous responses to comments above. The technical memorandum found at Tab 3 does not add anything new to Atlantic Richfield Company's many prior comments on this topic.

101) Tab 5

Summary of Comments

Atlantic Richfield Company presents a basis for waiving State floodplain and solid waste standards based on the equivalent level of performance waiver provision of CERCLA and the NCP.

Response

See response to issues 48 and 49, pages 3-109 to 3-110. EPA believes that the technical impracticability waiver is the appropriate waiver for active management of waste in the floodplain and the State ARARs which apply to that action. Atlantic Richfield Company's Tab 5 document also makes a claim for waivers or variances for engineering related solid waste requirements relating to landfill requirements such as liners. EPA does not believe a waiver of these requirements for in-situ treated areas is needed, since the liner requirements do not become applicable for in-situ treatment methods described in the *Record of Decision*.

102) Tab 6

Summary of Comments

Atlantic Richfield Company submitted a remedial design for EPA consideration.

Response

As noted in Section 3.1, *Introduction*, of this *Responsiveness Summary*, remedial design occurs after selection of the remedial action and release of the *Record of Decision*. Atlantic Richfield Company's submittal of a remedial design for a portion of the Clark Fork River OU is therefore premature and outside the scope of the comment period on the *Proposed Plan*, as described in CERCLA and the NCP. Substantial detail and adjustments to the proposed action described in the *Proposed Plan* have been made in the *Record of Decision*. Additionally, Atlantic Richfield Company used an early draft version of CFR RipES in completing this design and that document has been substantially revised, and may be further revised, before remedial design can occur.

Accordingly, EPA has not examined the preliminary design in depth and does not respond to it in this *Responsiveness Summary*. We are hopeful that the substantial work and expense that Atlantic Richfield Company directed to this effort will be useful in the future as we move towards remedy implementation.

To the extent this design work factored into Atlantic Richfield Company's criticisms and comments on EPA's cost estimate, EPA revised and detailed Cost Estimate for the EPA's Cleanup Plan for the Clark Fork River OU contains EPA's response to those comments and criticisms and provides a detailed basis for EPA's current cost estimate.

103) Tab 7

Summary of Comments

Atlantic Richfield Company proposed a detailed revision to the ongoing Clark Fork River monitoring activities conducted by USGS for EPA.

Response

Similar to Tab 6 discussed in issue 102 above, Atlantic Richfield Company's detailed monitoring plans are more appropriately developed and discussed after the selection of the remedial action for the Clark Fork River OU. Accordingly, this *Responsiveness Summary* does not contain a detailed response to Atlantic Richfield Company's proposals. During remedial design, EPA will work with Atlantic Richfield Company and other stakeholders to determine the more exact monitoring plans that are needed during remedy implementation and afterwards. Until then, EPA intends to keep the existing monitoring program in place.

4 Stakeholder and PRP Categorized Comments

All of the comments provided by stakeholders and the Executive Summary of the PRP's comments are contained on the attached CD-ROM. To use this CD, insert it in the CD-ROM drive of your computer. The CD should auto-launch in Adobe Acrobat Reader as a PDF file. If CD does not auto-launch, click on "Start," and select "Run" in Windows. Type "D:/start.pdf," where "D" is your CD-ROM drive. This will open a home page from which to choose comment documents to review.

For stakeholder comments, the files are grouped into the following commenter types:

- **ATSDR:** Agency for Toxic Substances and Disease Registry
- **CFB Residents:** Clark Fork Basin Residents—anyone in Butte, Anaconda, Deer Lodge, Garrison, Missoula, Drummond, Clinton, Milltown, and the smaller communities
- **Group:** Citizen Groups and Organizations
- **Local Government:** City and County Officials, Conservation District Board
- **Meeting:** Oral comments provided to EPA at meeting or hearing
- **Natural Resources Trustees:** Federal, Tribal, and State Trustees
- **No Address:** People who did not supply an address
- **Others:** All Other Individuals
- **PRP:** Potentially Responsible Party

Upon opening the file, a table of contents is provided with the letter identification number and the commenter's name. For each letter, the original comment document appears on the left-hand side of the page. This document is marked with lines and numbers for where each comment within the document begins and ends. To the right, the number associated with each comment is listed, and the category and subcategory is identified. To see a response to a particular comment, refer to the specific category and subcategory in Section 2 of this *Responsiveness Summary*.

For the PRP, the comments were not categorized, but rather were responded to comment-by-comment in Section 3, *PRP Issues and Lead Agency Responses*.

If you do not have access to a computer, you may request a paper copy of your comments. To request this, please contact:

Bob Fox
10 W. 15th St.; Suite 3200
Helena, MT 59626
Fox.Bob@epamail.epa.gov
(406) 457-5033

If you desire a paper copy of all of the comments, a copying fee will be charged.

5/6/2004

NOTICE

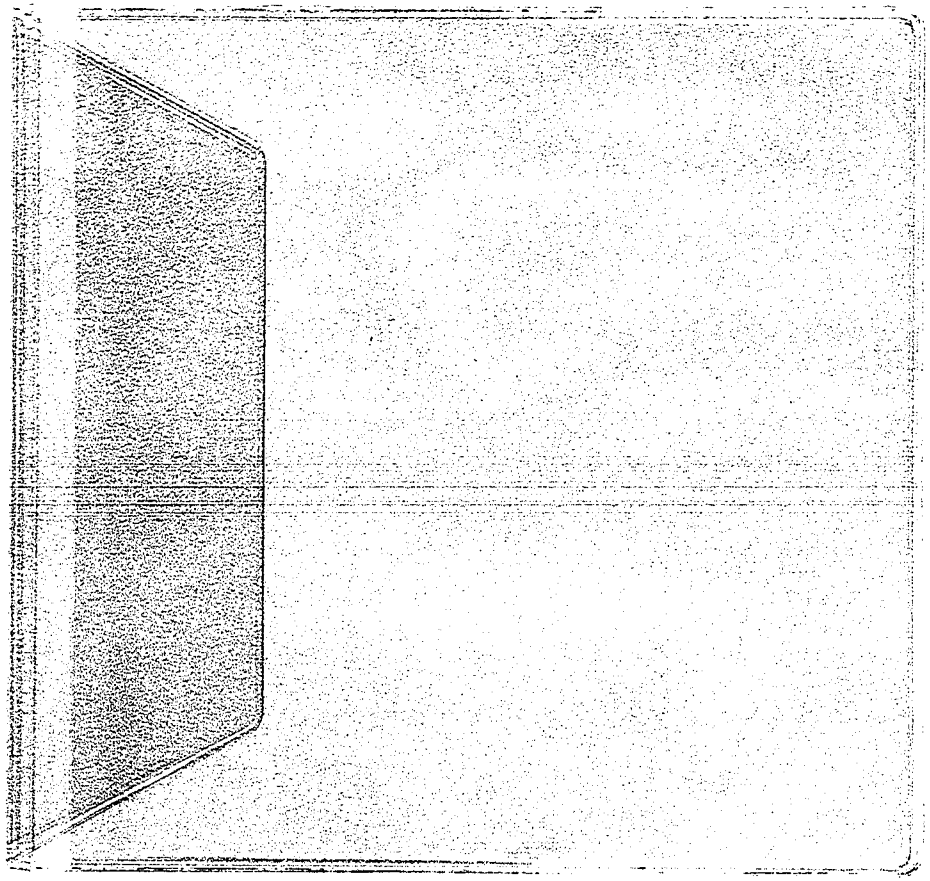
This item(s) is not suitable for microfilming, but is available for review at the Environmental Protection Agency, Region VIII Superfund Records Center, Helena, Montana

TITLE: "RECORD OF DECISION (ROD) CLARK FORK RIVER OPERABLE UNIT (OU) OF MILLTOWN RESERVOIR/CLARK FORK RIVER SUPERFUND SITE" (SIGNED)

DATE: APR. 2004

ITEM DESCRIPTION: CD ROM - STAKEHOLDER AND PRP CATEGORIZED COMMENTS

FILE: 3071004 DOCNO: **506049**



Clark Fork River Operable Unit
of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Part 4: Acronyms and Abbreviations, and References

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

Contents

Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirements for cleanup, such as regulatory requirements
ARCO	Atlantic Richfield Company
ARTS	Anaconda Revegetation Treatability Studies
ARWWSOU	Anaconda Regional Water and Waste Soils Operable Unit
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Federal Ambient Water Quality Criteria
BMPs	Best Management Practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act; also known as the Federal Superfund law
CFR RipES	Clark Fork River Riparian Evaluation System
CFRTAC	Clark Fork River Technical Assistance Committee
cfs	cubic feet per second
COCs	contaminants of concern
CT	community type
DEQ	Montana Department of Environmental Quality
DISS	Dissolved
DNRC	Department of Natural Resources Conservation
DOI	U.S. Department of the Interior
DQO	Data Quality Objective
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
EQIP	Environmental Quality Incentives Program
FEMA	Federal Emergency Management Agency
FWS	U.S. Fish and Wildlife Service
GIS	geographic information system
HT	habitat type

I-90	Interstate 90
IC	Institutional Control
kg/ha	kilograms per hectare
LAO	lower area one, an area along Silver Bow Creek
LRES	land reclamation evaluation system
MCA	Montana Code Annotated
MCL	Maximum concentration level
MFWP	Montana Fish, Wildlife, and Parks
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MSU	Montana State University
NCP	National Contingency Plan
NPL	National Priorities List; the Superfund list of sites
NPS	National Park Service
NPV	net present value
NRCS	Natural Resources Conservation Service
NRDP	Natural Resource Damages Program
NRRB	National Remedy Review Board
O&M	Operation and Maintenance
OU	operable unit
ppb	parts per billion
ppm	parts per million
PRAO	Preliminary Remedial Action Objective
PRP	Potentially Responsible Party
RG	Remedial Goal
RAO	Remedial Action Objective
RBC	risk-based concentration
RipES	Riparian Evaluation System

RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study
RRB	Remedy Review Board
SARA	Superfund Amendments and Reauthorization Act of 1986
SHPO	State Historic Preservation Office
TCRA	Time Critical Removal Action
TR	Total Recoverable
TRV	Toxicity Reference Values developed for the Upper Clark Fork River
UCL	upper confidence level
μg/L	micrograms per liter
USGS	U.S. Geological Survey

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Clark Fork River Operable Unit
of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix A:
Identification and Description of Applicable or Relevant and Appropriate Requirements

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances and Disease Registry
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollutant Control Technology
BPCTCA	Best Practicable Control Technology Currently Available
BPJ	Best Professional Judgment
BTCA	Best Technology Currently Available
CCC	Criterion Continuous Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
CFROU	Clark Fork River Operable Unit
CMC	Criteria Maximum Concentration
DEQ	State of Montana Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
GRKO	Grant-Kohrs Ranch National Historic Site
HWM	Hazardous Waste Management
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MGWPCS	Montana Groundwater Pollution Control System
MPDES	Montana Pollutant Discharge Elimination System
NCP	National Contingency Plan, as amended
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NPL	National Priorities List
NPDES	National Pollutant Discharge Elimination System
POTW	Public Owned Treatment Works
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RD/RA	Remedial Design and Remedial Action
ROD	Record of Decision
SHPO	State Historic Preservation Officer (Montana)
SIP	State Implementation Plan
TBC	To Be Considered
TU	Turbidity Unit
UIC	Underground Injection Control
WQB-7	Circular WQB-7, Montana Numeric Water Quality Standards

Contents

Section **Page**

Introduction

Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), certain provisions of the current National Contingency Plan (the NCP), 40 CFR Part 300, and guidance and policy issued by the Environmental Protection Agency (EPA) require that remedial actions taken pursuant to Superfund authority shall require or achieve compliance with substantive provisions of applicable or relevant and appropriate standards, requirements, criteria, or limitations from state environmental and facility siting laws, and from federal environmental laws, at the completion of the remedial action, during the implementation of the remedial action, or both, depending on the nature of the requirements, unless a waiver is granted[1]. If contaminant or location specific ARARs are not being met before the commencement of a remedial action, it is not necessary to invoke a waiver to justify their non-attainment during the action although they must be obtained (or appropriately waived) for remedial action to be complete and the remedy to be successful[2]. These requirements are threshold standards that any selected remedy must meet, unless adequate basis for a waiver is present. See Section 121(d)(4) of CERCLA, 42 U.S.C. § 9621(d)(4); 40 CFR § 300.430(f)(1). EPA calls standards, requirements, criteria, or limitations identified pursuant to section 121(d) "ARARs," or applicable or relevant and appropriate requirements.

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance found at a CERCLA site. 40 CFR § 300.5. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site. Id. Factors which may be considered in making this determination are presented in 40 CFR 300.400(g)(2). Compliance with both applicable and relevant and appropriate requirements is mandatory, unless compliance is waived. 42 U.S.C. § 121(d)(4); 40 CFR 300.430(f)(1)(ii)(B).

Each ARAR or group of related ARARs identified here is followed by a specific statutory or regulatory citation, a classification describing whether the ARAR is applicable or relevant and appropriate, and a description which summarizes the requirements and addresses how and when compliance with the ARAR will be measured (some ARARs will govern the conduct of the remedial action, some will define the measure of success of the remedial action, and some will do both)[3]. The descriptions given here are provided to allow the user

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1 See 55 Fed.Reg. 8666, 8755 (March 8, 1990)

2 EPA CERCLA Compliance with Other Laws Manual 1-8 (OSWER 9234.1-01, August 1988)

3 40 CFR § 300.435(b)(2); Preamble to the Proposed NCP, 53 Fed.Reg. 51440 (December 21, 1988); Preamble to the Final NCP, 55 Fed.Reg. 8755-8757 (March 8, 1990)

a reasonable understanding of the requirements without having to refer constantly to the statute or regulation itself. However in the event of any inconsistency between the law or regulations and the summary provided in this document, the applicable or relevant and appropriate requirement is ultimately the requirement as set out in the law or regulation, rather than any paraphrase of the law provided here.

Also contained in this list are policies, guidance or other sources of information which are "to be considered" in the implementation of the Record of Decision (ROD). Although not enforceable requirements, these documents are important sources of information which EPA and the State of Montana Department of Environmental Quality (DEQ) may consider during implementation of the remedy, especially in regard to the evaluation of the remedy's success in addressing public health and environmental risks.

Finally, this list contains a non-exhaustive list of other legal provisions or requirements which should be complied with during the implementation of the ROD[4].

ARARs are divided into contaminant specific, location specific, and action specific requirements, as described in the NCP and EPA guidance. For contaminant specific ARARs, ARARs are listed according to the appropriate media.

Contaminant specific ARARs include those laws and regulations governing the release to the environment of materials possessing certain chemical or physical characteristics or containing specific chemical compounds. Contaminant specific ARARs generally set health or risk based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Location specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs relate to the geographic or physical position of the site, rather than to the nature of site contaminants. Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

Only the substantive portions of the requirements are ARARs[5]. Administrative requirements are not ARARs and thus do not apply to actions conducted entirely on-site. Administrative requirements are those which involve consultation, issuance of permits, documentation, reporting, record keeping, and enforcement. The CERCLA program has its own set of administrative procedures which assure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion[6]1-12. Provision of statutes or regulations which contain general goals that merely express legislative intent about desired outcomes or conditions but are non-binding are not ARARs.[7]

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4 40 CFR § 300.400(g)(3); 40 CFR § 300.515(h)(2); Preamble to the Final NCP, 55 Fed.Reg. 8744-8746 (March 8, 1990)

5 40 CFR § 300.5. See also Preamble to the Final NCP, 55 Fed.Reg. 8756-8757 (March 8, 1990)

6 Preamble to the Final NCP, 55 Fed.Reg. 8756-8757 (March 8, 1990); Compliance with Other Laws Manual, Vol.1, pp. 1-11

7 Preamble to the Final NCP, 55 Fed.Reg. 8746 (March 8, 1990)

Many requirements listed here are promulgated as identical or nearly identical requirements in both federal and state law, usually pursuant to delegated environmental programs administered by both EPA and the states, such as many of the requirements of the federal Clean Water Act and the Montana Water Quality Act. The Preamble to the final NCP states that such a situation results in citation to the state provision as the appropriate standard, but treatment of the provisions as a federal requirement. ARARs and other laws which are unique to state law are identified separately by the State of Montana.

This list constitutes EPA's and DEQ's detailed description of ARARs for use in the implementation of the Milltown Reservoir/Clark Fork River Superfund Site, Clark Fork River operable unit, and resulting remedial design and remedial action decisions. The determination of the applicability of ARAR waivers to certain previously identified ARARs is also included here. ARARs waivers can be invoked after the ROD is issued if necessary and appropriate, and these waivers will be documented separately.

The ARAR analysis is based on section 121(d) of CERCLA, 42 U.S.C. § 9621(d); CERCLA Compliance with Other Laws Manual, Volumes I and II; OSWER Directives 9234.1-01 and -02 (August 1988 and August 1989 respectively; various CERCLA ARARs Fact Sheets issued as OSWER Directives; the Preamble to the Proposed NCP, 53 Fed. Reg. 51394 et seq. (December 21, 1988); the Preamble to the Final NCP, 55 Fed. Reg. 8666-8813 (March 8, 1990); and the NCP, 40 CFR Part 300; other applicable guidances; and the substantive provisions of law discussed in this document.

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Federal ARARs

I. Federal Contaminant Specific Requirements

A. Groundwater Standards—Safe Drinking Water Act (Relevant and Appropriate) [1]

The National Primary Drinking Water Standards (40 CFR Part 141), better known as maximum contaminant levels and maximum contaminant level goals (MCLs and MCLGs), are not applicable to the Clark Fork River Operable Unit (CFROU) because the aquifer underlying the area is not a current public water system, as defined in the Safe Drinking Water Act, 42 U.S.C. § 300f(4). These standards are relevant and appropriate standards, however, because the groundwater in the alluvial aquifer is a potential source of drinking water. Some domestic use of ground water occurs in the CFROU at various depths, and there are not specific laws or regulations which prevent the use of the CFROU aquifers. In addition, the aquifer discharges to the Clark Fork River which is designated as a potential source of drinking water. Since the Clark Fork River is also a potential source of drinking water, these standards are relevant and appropriate for that surface water as well.

Use of these standards for this action is fully supported by EPA regulations and guidance. The Preamble to the NCP clearly states that MCLs are relevant and appropriate for groundwater that is a current or potential source of drinking water (55 Fed.Reg. 8750, March 8, 1990), and this determination is further supported by requirements in the regulations governing conduct of the RI/FS studies found at 40 CFR § 300.430(e)(2)(i)(B). EPA's guidance on Remedial Action for Contaminated Groundwater at Superfund Sites states that "MCLs developed under the Safe Drinking Water Act generally are ARARs for current or potential drinking water sources." MCLGs which are above zero are relevant and appropriate under the same conditions (55 Fed.Reg. 8750-8752, March 8, 1990). See also, State of Ohio v. EPA, 997 F.2d 1520 (D.C. Cir. 1993), which upholds EPA's application of MCLs and non-zero MCLGs as ARAR standards for groundwater which is a potential drinking water source.

As noted earlier, standards such as the MCL and MCLG standards are promulgated pursuant to both federal and state law. Under the Safe Drinking Water Act, EPA has granted the State of Montana primacy in implementation of the Safe Drinking Water Act. The State has promulgated its own public water supply ground water standards through the Public Water Safety Act for most contaminants of concern, primarily through incorporation by reference of the federal standard. These standards, when the same or more stringent than federal standards, are also identified here.

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[1] 42 U.S.C. §§ 300f et seq.

Chemical	MCLG	MCL
Arsenic	NA	10 ug/l[2]
Cadmium	5 ug/l[3]	5 ug/l[4]
Copper	1300 ug/l[5]	1300 ug/l[6]
Lead	NA [7]	15 ug/l[8]

All ground water standards are measured as dissolved constituents. All are identified as Performance Standards in the CFROU ROD.

These standards incorporate potentially relevant and appropriate Resource Conversation Act (RCRA) standards for groundwater found at 40 CFR Part 264, Subpart F, which is incorporated pursuant to state law at ARM 17.53.801. The RCRA standards are the same or less stringent than the MCLs or MCLGs identified above.

B. Surface Water—Ambient and Point Source Discharges—Clean Water Act (Applicable or Relevant and Appropriate)

CERCLA and the NCP provide that federal water pollution criteria that match designated or anticipated surface water uses are the usual surface water standards to be used at Superfund cleanups, as relevant and appropriate standards, unless the state has promulgated surface water quality standards pursuant to the delegated state water quality act. The State of Montana has designated uses for the Clark Fork River, and has promulgated specific numeric water quality standards accordingly. Those standards as well as other surface water standards are included in the State ARARs identified in section IV.A.1. below. These standards will be applied to all contaminants of concern identified in the CFROU ROD, both to point sources affected or created by the CFROU ROD cleanup and to ambient water in CFROU, except for the State copper standard, which is waived in the CFR ROD and replaced with the federal copper water quality criteria. The FWQC standards for CFROU ROD designated contaminants of concern are identified here.

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2 40 CFR §§ 141.11(b) and 141.62.

3 40 CFR § 141.51

4 40 CFR § 141.62

5 40 CFR § 141.51

6 40 CFR § 141.80(c)(2) The requirement is an action level rather than a simple numerical standard.

7 The MCLG for arsenic and lead is zero, which is not an appropriate standard for Superfund site cleanups.

8 40 CFR § 141.80(c)(1). The requirement is an action level rather than a simple numerical standard.

Chemical	FWQC[9] CMC (acute)	FWQC CCC (chronic)
Arsenic	340 ug/l	150 ug/l
Cadmium	2.0 ug/l	0.25 ug/l
Copper	**13 ug/l**	**9.0 ug/l**
Lead	65 ug/l	2.5 ug/l
Zinc	120 ug/l	120 ug/l

As noted, the **bolded** copper standard above is the replacement standard for the waived state water quality standard, and is a Performance Standard for the CFROU ROD. Federal Water Quality Criteria are measured as dissolved constituents. The criteria assume a hardness of 100 ug/l, and the standards will likely be modified as applied to the CFROU surface waters which have a different hardness value.

Additionally, since the Clark Fork River is a potential drinking water source, the MCLs are relevant and appropriate requirements. The federal arsenic level of 10 ug/l, measured as a dissolved standard, sets the performance standard for surface water for the ROD.

C. Surface Water—Point Source Discharges—Stormwater Regulations—Clean Water Act (Applicable)

If point sources of water contamination from identifiable metals contamination are retained or created by any CFROU remediation activity, applicable Clean Water Act standards would apply to those discharges. These include the general requirements and storm water regulations found at 40 CFR Parts 122 and 125 (general conditions and industrial activity conditions). The storm water regulations address non-agricultural sources of storm water discharges which adversely affect water quality. Generally, the permits require the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment.[10] At the CFROU, it is likely that the actions required by the remedy would meet these requirements. However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, substantive standards associated with an individual National Pollutant Discharge Elimination System (NPDES) permit or alternative general permit may

[9] Pursuant to Section 304(a) of the Clean Water Act. National Recommended Water Quality Criteria-2002. US EPA, EPA 822-R-02-047 November 2002.

[10] For further explanation of storm water applications, see the letter from EPA to Chuck Stilwell, ARCO, dated February 2, 1999, which describes that treatment, in addition to BMPs, may be necessary if in-stream standards are not met after implementation of BMPs. The letter addresses the nearby Butte Priority Soils operable unit of the Silver Bow Creek/Butte Area Site but similar reasoning would apply to the CFROU.

be required (or Montana Pollutant Discharge Elimination System (MPDES) permit or alternative general permit under the State program).

D. Air Standards—Clean Air Act (Applicable)

Federal air quality standards are not currently exceeded in the CFROU. Limitations on air emissions resulting from cleanup activities or emissions resulting from wind erosion of exposed hazardous substances are set forth-in the action specific requirements, below.

II. Federal Location Specific Requirements

A. Fish and Wildlife Coordination Act (Applicable)

These standards are found at 16 U.S.C. §§ 661 et seq. and 40 CFR § 6.302(g). They require that federally funded or authorized projects ensure that any modification of any stream or other water body affected by a federally funded or authorized action provide for adequate protection of fish and wildlife resources. Compliance with this ARAR necessitates EPA consultation with the U.S. Fish and Wildlife Service (USFWS) and the State of Montana Department of Fish, Wildlife, and Parks. Consultation occurred during the selection of the CFROU remedy, and further consultation with these agencies will occur during cleanup implementation, and specific mitigative or other measures may be identified to achieve compliance with this ARAR, as the streambank remediation measures are implemented. The purpose of consultation is to develop measures to prevent, mitigate, or compensate for project-related losses to fish and wildlife. Mitigative measures must be performed by the persons who implement any selected remedy.

B. Floodplain Management Order (Applicable)

This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,988) mandates that federally funded or authorized actions within the 100 year floodplain avoid, to the maximum extent possible, adverse impacts associated with development of a floodplain. Compliance with this requirement is detailed in EPA's August 6, 1985 "Policy on Floodplains and Wetlands Assessments for CERCLA Actions." If the selected remedial action adversely impacts the Clark Fork River floodplain, specific measures to minimize adverse impacts may be identified following EPA consultation with the appropriate agencies.

In addition, if the remedial action selected for the CFROU is found to potentially adversely impact the floodplain, the following information will be produced: a Statement of Findings which will set forth the reasons why the proposed action must be located in or affect the floodplain; a description of significant facts considered in making the decisions to locate in or affect the floodplain or wetlands including alternative sites or actions; a statement indicating whether the selected action conforms to applicable state or local floodplain protection standards unless waived in the CFROU ROD; a description of the steps to be taken to design or modify the proposed action to minimize the potential harm to or within the floodplain; and a statement indicating how the proposed action affects the natural or beneficial values of the floodplain.

C. Protection of Wetlands Order (Applicable)

This requirement (40 CFR Part 6, Appendix A, Executive Order No. 11,990) mandates that federal agencies and potentially responsible parties (PRPs) avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands if a practicable alternative exists. Section 404(b)(1), 33 U.S.C. § 1344(b)(1), also prohibits the discharge of dredged or fill material into waters of the United States. Together, these requirements create a "no net loss" of wetlands standard.

Compliance with this ARAR will be achieved through EPA consultation with the U.S. Fish and Wildlife Service, to determine the existence and category of wetlands present at the site, and any avoidance or mitigation and replacement which may be necessary. Avoidance, mitigation, or replacement activities will be done by the persons who implement any selected remedy. Avoidance or mitigation and replacement of wetlands is a specific requirement of the CFROU Selected Remedy and will be further examined and detailed during remedy implementation. In December 1994, ARCO published a report titled "Determination of Functionally Effective Wetland Area with Threatened/Endangered Species inventory." EPA also approved ARCO's August 1992 Evaluation Form for Determining Wetland Functional Value and Effective Wetland Area in Upper Clark Fork River superfund Sites for use in wetland evaluations. Additional information regarding wetlands is found in Appendix G-1 of the CFROU Feasibility Study. These documents will form the basis for further action during remedial design and implementation to ensure compliance with this ARAR.

D. The Endangered Species Act (Applicable)

This statute and implementing regulations (16 U.S.C. §§ 1531—1544, 50 CFR Part 402, and 40 CFR § 6.302(h)) require that any federal activity or federally authorized activity may not jeopardize the continued existence of any threatened or endangered species known to live or to have lived in the affected environment or destroy or adversely modify a critical habitat. This ARAR requires EPA to ensure that the selected remedy is sufficiently protective of the environment containing the threatened or endangered species, with an emphasis on reducing the risks from the contaminants of concern to the listed species described in the EPA risk assessment to an acceptable level, with consideration given to the special status of the listed or threatened species—see 40 CFR Sections 300.430(d)(2)(vii) and (e)(2)(i)(G) and EPA Guidance Document OSWER Dir. No. 9285.7-28P, Ecological Risk Assessment and Risk Management principles for Superfund Sites (October, 1999) page 3; and to ensure that the selected remedy is implemented in a manner such that effects on any existing threatened or endangered species from the active remedy implementation activities are avoided or mitigated—see page 4-12 of the CERCLA Compliance with Other Laws Manual: Volume II (EPA August 1989).

In December 1994, ARCO published a report titled "Determination of Functionally Effective Wetland Area with Threatened/Endangered Species." The CFROU Feasibility Study contains additional information regarding threatened and endangered species at Appendix A-10. The bald eagle, the bull trout, the Canada lynx, and the gray wolf were identified as animals potentially frequenting or occurring at the CFROU.

Compliance with this ARAR has to date involved consultation with USFWS, and a determination of the presence of listed or proposed species or critical habitats present at the CFROU. Consultation has focused on the bull trout. The USFWS has indicated a strong interest in the CFROU remedial action and generally agrees with EPA that the Selected Remedy is adequately protective of the sensitive species found at the CFROU as reflected in the USFWS Biological Opinion.

EPA submitted a Biological Assessment (BA) for the CFROU to the US FWS in December 2002. The State of Montana submitted additional comments on the BA subsequent to EPA's submission. The decision by EPA to perform the BA itself, rather than require the PRP to perform the study, was a site specific decision related to the nature of ARCO's objections to EPA's risk assessments and the schedule associated with this project. The US FWS issued a Biological Opinion (BO) in response to these documents in April 2004. Continued consultation with the USFWS and the Montana Department of Fish, Wildlife and Parks will be required as remedial designs are completed. The measures identified in the BO must be implemented by the persons performing the CFROU Selected Remedy. The primary focus of the continued consultation are the best management practices to be undertaken during streambank construction work as the CFROU Selected Remedy is implemented.

E. The National Historic Preservation Act (Applicable)

This statute and implementing regulations (16 U.S.C. § 470 et seq, 40 CFR § 6.301(b), 36 CFR Part 800) require federal agencies or federal projects to take into account the effect of any federally assisted undertaking or licensing on any district, site building, structure, or object that is included in, or eligible for, the Register of Historic Places. If effects cannot be avoided reasonably, measures should be implemented to minimize or mitigate the potential effect. In addition, Indian cultural and historical resources must be evaluated, and effects avoided, minimized, or mitigated.

Compliance with this ARAR has been undertaken through a phase I summary of existing information about sites within the CFROU which may be eligible or are currently included in the National Registry of Historic Places. The results of this search are found in the Remedial Investigation Report, and are summarized in the CFROU Feasibility Study, page 2-23. In addition, the Salish and Kootenai Confederated Tribes are conducting a cultural resources survey of the CFROU. The most notable resource identified to date which may be impacted by the CFROU Selected Remedy is the Grant-Kohrs Ranch National Historic Site, a National Historic Landmark (December 19, 1960) and listed on the National Registry of Historic Places.

Compliance with this ARAR will require continued consultation with the State Historic Preservation Office and the Salish and Kootenai Tribes. Although not generally applicable to the CFROU site, consultation requirements with SHPO are described generally in the First and Second Programmatic Agreements (Programmatic Agreement, April 6, 1992 and Second Programmatic Agreement, December 14, 1994). The Second Programmatic Agreement in particular describes a notification and consultation process, which must be observed during remedial design and remedial action activities at CFROU. Consultation requirements for the Salish and Kootenai Confederated Tribe are described in an agreement between EPA and the Tribe dated July 2003. Consultation will focus on the further identification of specific eligible or listed resources which may be impacted by remedy implementation, avoidance of harmful effects to those areas if possible, and mitigative activities if avoidance is not possible.

F. Archaeological and Historic Preservation Act (Applicable)

The statute and implementing regulations (16 U.S.C. § 469 et seq., 40 CFR § 6.301(c)) establish requirements for evaluation and preservation of historical and archaeological data, including Indian cultural and historic data, which may be destroyed through alteration of terrain as a result of federal construction projects or a federally licensed activity or program. If eligible scientific, prehistorical, or archaeological data are discovered during site activities, they must be preserved in accordance with these requirements.

G. Historic Sites, Buildings, and Antiquities Act (Applicable)

This statute and implementing regulations (16 U.S.C. § 461 et seq., 40 CFR § 6.310(a)) state that in conducting an environmental review of an EPA action, the responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 36 CFR § 62.6(d) to avoid undesirable impacts upon such landmarks. The persons responsible for implementing the CFROU Selected Remedy will utilize this information during remedial design to accomplish the requirements of this act.

H. Migratory Bird Treaty (Applicable)

This requirement (16 U.S.C.§§ 703 et seq.) establishes a federal responsibility for the protection of the international migratory bird resource and requires continued consultation by EPA with the USFWS during remedial design and remedial construction to ensure that the cleanup of the site does not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance with this requirement as appropriate for performance by the persons who implement the remedy.

I. Bald Eagle Protection Act (Applicable)

This requirement (16 U.S.C. §§ 668 et seq.) establishes a federal responsibility for protection of bald and golden eagles, and requires continued consultation by EPA with the USFWS during remedial design and remedial construction to ensure that any cleanup of the site does not unnecessarily adversely affect the bald and golden eagle. Specific mitigative measures may be identified for compliance with this requirement as appropriate, and will be done by the persons who implement any selected remedy.

J. Resource Conservation and Recovery Act (Relevant and Appropriate)

Any discrete waste units created or actively managed at the CFROU site cleanup must comply with the siting restrictions and conditions at 40 CFR § 264.18 (a) and (b). These sections require management units to be designed, constructed, operated, and maintained to avoid washout, if they are within or near the current 100 year flood plain.

K. Native American Grave Protection and Repatriation Act, 25 U.S.C. § 3001; 43 CFR §§ 10.1—10.17 (Applicable or Relevant and Appropriate)

NAGPRA and its implementing regulations provide for the disposition of Native American remains and objects inadvertently discovered on federal or tribal lands after November, 1990. 25 U.S.C. Section 3002(d). If the response activities result in the discovery of Native American human remains or related objects, the activity must stop while the head of the federal land management agency (if federal lands are involved) and appropriate Indian tribes are notified of the discovery. After the discovery, the response activity must cease and a reasonable effort must be made to protect the Native American human remains or related objects. The response activity may later resume. 42 CFR Section 10.4. Accordingly, depending on the facts of the discovery and the location of the response action, NAGPRA could be applicable or relevant and appropriate to the response action.

L. Solid Waste Disposal in National Parks (Applicable)

Part of the CFROU contains portions of the Grant-Kohrs National Historic Site (GRKO), managed by the National Park Service. The substantive statutory provisions of this act, found at 16 U.S.C. §§ 4601 - 22(c) et seq., and its implementing regulations, found at 36 CFR Part 6, are applicable to the creation or expansion of new solid waste disposal units within the boundary of the GRKO.[11]

M. The National Park Service Organic Act, 16 U.S.C. §§ 1-3, certain implementing regulations at 36 CFR Parts 1-0 and P.L. 92-406, and the enabling legislation for the GRKO (Relevant and Appropriate)

The Organic Act and the park specific enabling legislation establish the purposes and uses of the Grant Kohrs Ranch National Historic Site, while the regulations proscribe certain conduct within the park. The statutes and regulations establish standards, requirements, criteria, or limitations for the GRKO, and the National Park Service and EPA have identified these as relevant and appropriate ARARs for remedial work done at the GRKO. EPA issued a more specific description of these ARARs and their application to the CFROU in a letter dated May 17, 2000, which is attached. The application of this ARAR to the GRKO site is described more completely in the ROD section 13.7. EPA and the National Park Service will work cooperatively in the oversight and approval of remedial design and remedial action at the GRKO. Specific Performance Standards related to this ARAR are described more fully in the ROD at Section 13.7.

[11] These regulations would not apply to, nor be relevant and appropriate to, the use of in situ treatment on wastes on site at the GRKO.

III. Federal Action Specific Requirements

A. Solid Waste (Applicable), Surface Mining Control and Reclamation (Relevant and Appropriate), and RCRA (Relevant and Appropriate) Requirements

The contamination at the CFROU is primarily mining waste from mining mills and smelters in Butte. This waste may not be RCRA hazardous waste, although EPA reserves its rights to make a more formal determination in this regard at a later date. For any active management (i.e., treatment, storage, disposal, grading, or in-situ treatment) or removal of tailings or mixed tailings and soils[12] contamination, the following requirements are ARARs.

1. Requirements described at 40 CFR §§ 257.3-1(a), 257.3-3, and 257.3-4, governing waste handling, storage, and disposal, including retention of the waste, in general[13], and 257.3-5, relating to precautions necessary to ensure that cadmium is not taken up into crops, including pasture grasses that may enter the food chain, at levels which may be a risk to human health.

2. For any discrete waste units which are created or actively managed by the CFROU cleanup, reclamation and closure regulations found at 30 CFR Parts 816 and 784, governing coal and to a lesser extent, non-coal mining, are relevant and appropriate requirements[14].

3. Portions of RCRA regulations found at 40 CFR §§ 264.116 and .119(a) and (b) (governing notice and deed restrictions)are relevant and appropriate requirements for any waste management units created or actively managed at the CFROU[15].

B. Air Standards—Clean Air Act (Applicable)

These standards, promulgated pursuant to section 109 of the Clean Air Act[16], are applicable to releases into the air from any CFROU cleanup activities.

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[12] Federal and State solid waste requirements may also be relevant and appropriate for contaminated soils in certain circumstances. Generally, if soils materials are determined by the agencies to be able to be used in conjunction with other removal or remedial measures such as deep plowing or capping, these requirements are not considered relevant and appropriate. At the CFROU, the solid waste waiver described in the Record of Decision applies to both mixed tailings and soils and contaminated soils at the site.

[13] Solid waste regulations are promulgated pursuant to the federal Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act, 42 U.S.C. §§ 6901 et seq. They are applicable regulations, although the State of Montana has the lead role in regulating solid waste disposal in the State of Montana.

[14] The Surface Mining Control and Reclamation Act is promulgated at 30 U.S.C. §§ 1201 - 1326.

[15] As noted earlier, federal RCRA regulations are incorporated by reference into applicable State Hazardous Waste Management Act regulations. See ARM 17.53.801. Use of select RCRA regulations for mining waste cleanups is appropriate when discrete units are addressed by a cleanup and site conditions are distinguishable from EPA generic determination of low toxicity/high volume status for mining waste. See Preamble to the Final NCP, 55 Fed.Reg. 8763 - 8764 (March 8, 1990), CERCLA Compliance with Other Laws Manual, Volume II (August 1989 OSWER Directive #9234.1-02) p. 6-4; Preamble to the Proposed NCP, 53 Fed.Reg. 51447 (Dec. 21, 1988); and guidance entitled Consideration of RCRA Requirements in Performing CERCLA Responses at Mining Wastes Sites, August 19, 1986 (OSWER).

[16] 42 U.S.C. §§ 7401 et seq.

1. Lead: No person shall cause or contribute to concentrations of lead in the ambient air which 3 exceed 1.5 micrograms per cubic meter (ug/m) of air, measured over a 90-day average. These standards are promulgated at ARM 17.8.222 as part of a federally approved State Implementation Plan (SIP), pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq. MCA. Corresponding federal regulations are found at 40 CFR § 50.12[17].

2. Particulate matter that is 10 microns in diameter or smaller (PM-10): No person shall cause or contribute to concentrations of PM-10 in the ambient air which exceed:

   - 150 ug/m3 of air, 24 hour average, no more than one expected exceedence per calendar year;

   - 50 ug/m3 of air, annual average.

These regulations are promulgated at ARM 17.8.223 as part of a federally approved SIP, pursuant to the Clean Air Act of Montana, §§ 75-2-101 et seq. MCA. Corresponding federal regulations are found at 40 CFR § 50.6.

Ambient air standards under section 109 of the Clean Air Act are also promulgated for carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and ozone. If emissions of these compounds were to occur at the site in connection with any cleanup action, these standards would also be applicable. See ARM 17.8.222 and .223, and 40 CFR Part 50.

C. Point Source Controls—Clean Water Act (Applicable)

If point sources of water contamination are retained or created by any CFROU remediation activity, applicable Clean Water Act standards would apply to those discharges. The regulations are discussed in the contaminant specific ARAR section, above, and in the State of Montana identification of ARARs. These regulations include storm water runoff regulations found at 40 CFR Parts 121, 122, and 125 (general conditions and industrial activity conditions). These would also include requirements for best management practices and monitoring found at 40 CFR §§ 122.44(i) and 440.148, for point source discharges.

D. Dredge and Fill Requirements (Applicable)

Regulations found at 40 CFR Part 230 address conditions or prohibitions against depositing dredge and fill material into water of the United States. If remediation activities would result in an activity subject to these regulations, they would be applicable. Compliance with this requirement will be achieved at the site of dredge and fill activity within the CFROU during construction activities through the use of construction best management practices.

[17] Ambient air standards established as part of Montana's approved State Implementation Plan in many cases provide more stringent or additional standards. The federal standards by themselves apply only to major sources, while the State standards are fully applicable throughout the state and are not limited to major sources. See ARM 17.8.205 and 17.8.212-223. As part of an EPA approved State Implementation Plan, the state standards are also federally enforceable. Thus, the state standards which are equivalent to the federal standards are identified in this section. A more detailed list of State standards, which include standards which are not duplicated in federal regulations, is contained in the State ARAR identification section.

E. Underground Injection Control (Applicable)

Requirements found at 40 CFR Part 144, promulgated pursuant to the Safe Drinking Water Act, allow the re-injection of treated groundwater into the same formation from which it was withdrawn for aquifers such as the aquifer at the CFROU, and addresses injection well construction, operation, maintenance, and capping/closure. These regulations would be applicable to any reinjection of treated groundwater.

F. Transportation of Hazardous or Contaminated Waste (Relevant and Appropriate)

40 CFR Part 263 establishes regulations for the transportation of hazardous waste. These regulations would govern any on-site transportation of contaminated material. Any off-site transportation would be fully subject to applicable regulations and permitting.

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State of Montana ARARs

As provided by Section 121 of CERCLA, 42 U.S.C. § 9621, only those state standards that are more stringent than any federal standard and that have been identified by the state in a timely manner are appropriately included as ARARs.

IV. Montana Contaminant Specific Requirements

A. Water Quality

Surface Water Quality Standards (Applicable)

Under the Montana Water Quality Act, §§ 75-5-101 et seq., MCA, the state has promulgated water quality standards to protect, maintain, and improve the quality and potability of the state's surface water for water supplies, wildlife, fish and aquatic life, agricultural, industry, recreation, and other beneficial uses. The requirements listed below are applicable water quality standards with which any remedial action must comply.

ARM 17.30.607 (1)(a)-(n) (Applicable) classifies the waters of the Clark Fork River as follows:

Newly constructed channel below Pond 2 outfall to the mainstem of Warm Springs Creek	B-1
Mainstem from Warm Springs Creek to Cottonwood Creek (Deer Lodge)	C-2
Mainstem from Cottonwood Creek to Little Blackfoot River	C-1
Little Blackfoot River to Milltown Reservoir	B-1

In addition, Mill and Willow Creeks flow into the Clark Fork River at the upstream end of the operable unit, and they are classified as B-1.

The B-1 classification standards are contained in ARM 17.30.623 (Applicable) of the Montana water quality regulations. This section states:

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.

The B-1 classification standards at ARM 17.30.623 include the following criteria: 1) dissolved oxygen concentration must not be reduced below the levels given in department circular WQB-7; 2) the maximum allowable increase above naturally occurring turbidity is 5 nephelometric turbidity units; 3) temperature increases must be kept within prescribed limits; 4) no increases above naturally occurring concentrations of sediment or suspended sediment, settleable solids, oils, 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 are allowed; 5) true color must be kept within specified limits; 6) induced variation of hydrogen ion cncentration (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.

ARM 17.30.623 (applicable) also provides that 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 the current version of circular WQB-7. Discharges shall conform with ARM Title 16, Chapter 20, subchapter 7 (the nondegradation rules) and may not cause receiving water concentrations to exceed the applicable standards specified in WQB-7 when stream flows equal or exceed the design flows specified in ARM 17.30.635(4).

The C-1 classification standards are contained in ARM 17.30.626 (Applicable) of the Montana water quality regulations. This section states:

Waters classified C-1 are 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.

The C-1 classification standards at ARM 17.30.626 include the following criteria: 1) dissolved oxygen concentration must not be reduced below the levels given in department circular WQB-7; 2) the maximum allowable increase above naturally occurring turbidity is 5 nephelometric turbidity units; 3) temperature increases must be kept within prescribed limits; 4) no increases above naturally occurring concentrations of sediment or suspended sediment, settleable solids, oils, 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 are allowed; 5) true color must be kept within specified limits; 6) induced variation 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.

ARM 17.30.626 also provides that concentrations of carcinogenic, bioconcentrating, toxic or harmful parameters may not exceed levels which render the water harmful, detrimental, or injurious to public health. Concentrations of toxic parameters also may not exceed the applicable standards specified in WQB-7. Discharges shall conform with ARM Title 16, Chapter 20, subchapter 7 (the nondegradation rules) and may not cause receiving water concentrations to exceed the applicable standards specified in WQB-7 when stream flows equal or exceed the design flows specified in ARM 17.30.635(4).

C-2 classification standards are found in ARM 17.30.627 (applicable) of the Montana Water Quality Regulations. This section states:

> Waters classified C-2 are suitable for bathing, swimming, and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; agricultural and industrial water supply.

The C-2 classification standards at ARM 17.30.627 include the following criteria: 1) dissolved oxygen concentration must not be reduced below the levels given in department circular WQB-7; 2) the maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units; 3) temperature increases must be kept within prescribed limits; 4) non increases above naturally occurring concentrations of sediment or suspended sediment, settleable solids, oils, 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 are allowed; 5) true color must be kept within specified limits; 6) induced variation 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.

ARM 17.30.627 provides that concentrations of carcinogenic, bioconcentrating, toxic or harmful parameters may not exceed levels which render the water harmful, detrimental, or injurious to public health. Concentrations of toxic parameters also may not exceed the applicable standards specified in WQB-7. Discharges shall conform with ARM Title 16, Chapter 20, subchapter 7 (the nondegradation rules) and may not cause receiving water concentrations to exceed the applicable standards specified in WQB-7 when stream flows equal or exceed the design flows specified in ARM 17.30.635(4).

If these standards are violated due to hazardous substances or Superfund response action, they must be complied with as part of any selected remedial action.

For the primary contaminants of concern, the WQB-7 levels are listed below. WQB-7 provides that "whenever both Aquatic Life Standards and Human Health Standards exist for the same analyte, the more restrictive of these values will be used as the numeric Surface Water Quality Standard."

Chemical	WQB-7 Standard (total recoverable standards)	
Arsenic	**Acute**	**340 ug/l**
	Chronic	**150 ug/l**
	Human Health	**18 ug/l**
Cadmium	**Acute**	**2.1 ug/l @ 100 mg/l hardness**
	Chronic	**0.27 ug/l @ 100 mg/l hardness**
Copper	Acute	18 ug/l @ 100 mg/l hardness
	Chronic	12 ug/l @ 100 mg/l hardness
	Human Health	1,300 ug/l @ 100 mg/l hardness

The copper standard is waived in the CFROU ROD and replaced with the federal water quality criteria for copper.

Lead	**Acute**	**81 ug/l @ 100 mg/l hardness**
	Chronic	**3.2 ug/l @ 100 mg/l hardness**
	Human Health	**15 ug/l**

Zinc	**Acute**	**119 ug/l @ 100 mg/l hardness**
	Chronic	**119 ug/l @ 100 mg/l hardness**
	Human Health	**2,100 ug/l @ 100 mg/l hardness**

Bolded water quality standards are Performance Standards for the CFROU.

Additional restrictions on any discharge to surface waters are included in:

ARM 17.30.637 (Applicable) which prohibits discharges containing substances that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film (or be present in concentrations at or in excess of 10 milligrams per liter) or globules of grease or other floating materials; (c) produce odors, colors or other conditions which create a nuisance or render undesirable tastes to fish flesh or make fish inedible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions which produce undesirable aquatic life.

ARM 17.30.637 also states that no waste may be discharged and no activities conducted which, either along or in combination with other waste activities, will cause violation of surface water quality standards.

ARM 17.30.1203 (Applicable), adopts and incorporates the provisions of 40 CFR Part 125 for criteria and standards for the imposition of technology-based treatment requirements in MPDES permits. Although the permit requirement would not apply to on-site discharges, the substantive requirements of Part 125 are applicable, i.e., for toxic and nonconventional pollutants treatment must apply the best available technology economically achievable (BAT) ; for conventional pollutants, application of the best conventional pollutant control technology (BCT) is required. Where effluent limitations are not specified for the particular industry or industrial category at issue, BCT/BAT technology based treatment requirements are determined on a case by case basis using best professional judgment (BPJ). See CERCLA Compliance with Other Laws Manual, Vol. I, August 1988, p. 3-4 and 3-7. These State standards would apply to both point source discharges and ambient water quality within the CFROU.

Section 75-5-308, MCA, allows DEQ to grant short-term exemptions from the water quality standards or short-term use that exceeds the water quality standards for the purpose of allowing certain emergency remediation activities. Such exemptions typically extend for a period of 30-60 days. However, any exemption must include conditions that minimize to the extent possible the magnitude of the violation and the length of time the violation occurs. In addition, the conditions must maximize the protection of state waters by ensuring the maintenance of beneficial uses immediately after termination of the exemption. Water quality and quantity monitoring and reporting may also be included as conditions.

Montana Pollutant Discharge Elimination System (MPDES)—stormwater and other point sources.

ARM 17.30.1342 - 1344 set forth the substantive requirements applicable to all MPDES permits. The substantive requirements, including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements.

Under ARM 17.30.601, ARM 17.30.1101 et seq., and ARM 17.30.1301 et seq., the Montana Department of Environmental Quality has issued general stormwater permits for certain activities. The substantive requirements of the following permits are applicable for the following activities:

- For construction activities: General Permit for Storm Water Discharges Associated with Construction Activity, Permit No. MTR 100000 (June 8, 2002);
- For mining activities: General Permit for Storm Water Discharges Associated with Mining and with Oil and Gas Activities, Permit No. MTR300000 (November 17, 2002)[1];
- For industrial activities: General Permit for Storm Water Discharges Associated with Industrial Activity, Permit No. MTR000000 (October 1, 2001).

Generally, the permits listed above require the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment.[2] However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, the substantive standards associated with an individual MPDES permit or alternative general permit may be required.

A related mine reclamation requirement is set out in ARM 17.24.633 (relevant and appropriate), which requires that all surface drainage from disturbed areas that have been graded, seeded or planted must be treated by the best technology currently available (BTCA) before discharge. Sediment control through BTCA practices must be maintained until the disturbed area has been reclaimed, the revegetation requirements have been met, and the area meets state and federal requirements for the receiving stream.

2. Groundwater Quality Standards (Applicable)

ARM 17.30.1006 (Applicable) classifies groundwater into Classes I through IV based upon the its specific conductance and establishes the groundwater quality standards applicable with respect to each groundwater classification. Based upon its specific conductance, the majority of the groundwater in the CFROU is considered Class I groundwater, with the remainder of the groundwater Class II.[3]

Concentrations of dissolved substances in Class I or II groundwater (or Class III groundwater which is used as a drinking water source) may not exceed the human health standards listed in department Circular WQB-7. For the primary contaminants of concern these levels are listed below. Ground water is measured in dissolved form, according to WQB-7.

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[1] This permit covers point source discharges of storm water from mining and milling activities (including active, inactive, and abandoned mine and mill sites) including activities with Standard Industrial Code 14 (metal mining).

[2] For further explanation of storm water applications, see the letter from EPA to Chuck Stilwell, ARCO, dated February 2, 1999, which describes that treatment, in addition to BMPs, may be necessary if in-stream standards are not met after implementation of BMPs.

[3] ARM 17.30.1006 provides that Class I groundwaters are those with specific conductance of less than 1000 microSiemens per centimeter at 25B C; Class II groundwaters: 1000 to 2500; Class III groundwaters: 2500 to 15,000; and Class IV groundwaters: over 15,000.

Chemical	WQB-7 Human Health Standards (December 2002 edition)
Arsenic	20 ug/1
Cadmium	5 ug/1
Copper	1300 ug/1
Lead	15 ug/1
Zinc	**2000 ug/1**

Zinc is not addressed under federal groundwater standards. Therefore, the State zinc standard is a Performance Standard for the CFROU ROD. Other state standards listed above are not as stringent or are duplicative of federal standards previously identified as Performance Standards.

For concentrations of parameters for which human health standards are not listed in WQB-7, ARM 17.30.1006 allows no increase of a parameter to a level that renders the waters harmful, detrimental or injurious to listed beneficial uses.

For Class I and II groundwaters, 17.30.1006 allows no increase of a parameter that causes a violation of the nondegradation provisions of § 75-5-303, MCA.

ARM 17.30.1011 also provides that groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation may be allowed under the principles established in § 75-5-303, MCA, and the nondegradation rules at ARM 17.30.701 et seq.

An additional concern with respect to ARARs for groundwater is the impact of groundwater upon the surface water. If significant loadings of contaminants from groundwater sources to the Clark Fork River contribute to the inability of the stream to meet its class standards, then alternatives to alleviate such groundwater loading must be evaluated and, if appropriate, implemented. Groundwater in certain areas may need to be remediated to levels more stringent than the groundwater classification standards in order to achieve the standards for affected surface water. See Compliance with Federal Water Quality Criteria, OSWER Publication 9234.2-09/FS (June 1990) ["Where the ground water flows naturally into the surface water, the ground-water remediation should be designed so that the receiving surface-water body will be able to meet any ambient water-quality standards (such as State WQSs or FWQC) that may be ARARs for the surface water."].

B. Air Quality

In addition to the standards identified in the federal action specific ARARs above, the State of Montana has identified certain air quality standards in the action-specific section of the State ARARs below.

V. Montana Location Specific Requirements

A. Floodplain and Floodway Management Act and Regulations (Applicable)

The Floodplain and Floodway Management Act and regulations specify types of uses and structures that are allowed or prohibited in the designated 100-year floodway[4] and floodplain[5]. These standards are applicable to all actions contemplated for this site within the floodplain.

1. Allowed Uses. The law recognizes certain uses as allowable in the floodway and a broader range of uses as allowed in the floodplain. Residential use is among the possible allowed uses expressly recognized in both the floodway and floodplain. "Residential uses such as lawns, gardens, parking areas, and play areas," as well as certain agricultural, industrial-commercial, recreational and other uses are permissible within the designated floodway, provided they do not require structures other than portable structures, fill or permanent storage of materials or equipment. 76-5-401, MCA; ARM 36.15.601.[6] In addition, in the flood fringe (i.e., within the floodplain but outside the floodway), residential, commercial, industrial, and other structures may be permitted subject to certain conditions relating to placement of fill, roads, floodproofing, etc. § 76-5-402, MCA; ARM 36.15.701. Domestic water supply wells may be permitted, even within the floodway, provided the well casing is watertight to a depth of 25 feet and the well meets certain conditions for floodproofing, sealing, and positive drainage away from the well head. ARM 36.15.602(6).

2. Prohibited Uses. Uses prohibited anywhere in either the floodway or the floodplain are:

   a. solid and hazardous waste disposal; and

   b. storage of toxic, flammable, hazardous, or explosive materials.

   ARM 36.15.605(2) and 36.15.703. These standards are waived in the CFROU ROD for areas designated for in-situ treatment.

   In the floodway, additional prohibitions apply, including prohibition of:

   a. a building for living purposes or place of assembly or permanent use by human beings;

   b. any structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway; and

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[4] The floodway is the channel of a watercourse or drainway and those portions of the floodplain adjoining the channel which are reasonably required to carry and discharge the floodwater of the water course or drainway. ARM 36.15.101(13)

[5] The floodplain is the area adjoining the water course or drainway which would be covered by the floodwater of a base (100 year) flood except for sheet flood areas that receive less than one foot of water per occurrence. The floodplain consists of the floodway and flood fringe. ARM 36.15.101

[6] However, see EPA's 1997 Human Health Risk Assessment for a determination of likely land use at the CFR OU, based on local zoning requirements and other factors.

c. the construction or permanent storage of an object subject to flotation or movement during flood level periods.

Section 76-5-403, MCA.

3. Applicable considerations in use of floodplain or floodway. Applicable regulations also specify factors that must be considered in allowing diversions of the stream, changes in place of diversion of the stream, flood control works, new construction or alteration of artificial obstructions, or any other nonconforming use within the floodplain or floodway. Many of these requirements are set forth as factors that must be considered in determining whether a permit can be issued for certain obstructions or uses. While permit requirements are not directly applicable to remedial actions conducted entirely on site, the substantive criteria used to determine whether a proposed obstruction or use is permissible within the floodway or floodplain are applicable standards. Factors which must be considered in addressing any obstruction or use within the floodway or floodplain include:

   1. the danger to life and property from backwater or diverted flow caused by the obstruction or use;
   2. the danger that the obstruction or use will be swept downstream to the injury of others;
   3. the availability of alternate locations;
   4. the construction or alteration of the obstruction or use in such a manner as to lessen the danger;
   5. the permanence of the obstruction or use; and
   6. the anticipated development in the foreseeable future of the area which may be affected by the obstruction or use.

See 76-5-406, MCA; ARM 36.15.216 (substantive provisions only).

Conditions or restrictions that generally apply to specific activities within the floodway or floodplain are:

1. the proposed activity, construction, or use cannot increase the upstream elevation of the 100-year flood a significant amount (one-half foot or as otherwise determined by the permit issuing authority) or significantly increase flood velocities, ARM 36.15.604 (Applicable, substantive provisions only); and
2. the proposed activity, construction, or use must be designed and constructed to minimize potential erosion, see ARM 36.15.605.

For the substantive conditions and restrictions applicable to specific obstructions or uses, see the following applicable regulations:

- Excavation of material from pits or pools—ARM 36.15.602 (1).
- Water diversions or changes in place of diversion—ARM 36.15.603.

- Flood control works—ARM 36.15.606.
- Roads, streets, highways and rail lines (must be designed to minimize increases in flood heights)—ARM 36.15.701(3) (c).
- Structures and facilities for liquid or solid waste treatment and disposal (must be floodproofed to ensure that no pollutants enter flood waters and may be allowed and approved only in accordance with MDEQ regulations, which include certain additional prohibitions on such disposal)—ARM 36.15.701(3) (d).
- Residential structures—ARM 36.15.702(1).
- Commercial or industrial structures—ARM 36.15.702(2).

B. Solid Waste Management Regulations (Applicable)

Regulations promulgated under the Solid Waste Management Act, §§ 75-10-201 et seq. MCA, specify requirements that apply to the location of any solid waste management facility. Under ARM 17.50.505, a facility for the treatment, storage or disposal of solid wastes:

- must be located where a sufficient acreage of suitable land is available for solid waste management;
- may not be located in a 100-year floodplain;
- may be located only in areas which will prevent the pollution of ground and surface waters and public and private water supply systems;
- must be located to allow for reclamation and reuse of the land;
- drainage structures must be installed where necessary to prevent surface runoff from entering waste management areas; and
- where underlying geological formations contain rock fractures or fissures which may lead to pollution of the ground water or areas in which springs exist that are hydraulically connected to a proposed disposal facility, only Class III disposal facilities may be approved[7].

Even Class III landfills may not be located on the banks of or in a live or intermittent stream or water saturated areas, such as marshes or deep gravel pits which contain exposed ground water. ARM 17.54.505(2)(j).

The above standards are waived in the CFROU ROD for those areas designated for in-situ treatment.

In addition, § 75-10-212 prohibits dumping or leaving any debris or refuse upon or within 200 yards of any highway, road, street, or alley of the State or other public property, or on privately owned property where hunting, fishing, or other recreation is permitted.

[7] Group III consist of primarily inert wastes, including industrial mineral wastes which are essentially inert and non-water soluble and do not contain hazardous waste constituents. ARM 17.50.503(1)(b)

However, the restriction relating to privately owned property does not apply to the owner, his agents, or those disposing of debris or refuse with the owner's consent.

C. Natural Streambed and Land Preservation Standards (Applicable)

Sections 87-5-502 and 504, MCA, (substantive provisions only) provide that a state agency or subdivision shall not construct, modify, operate, maintain or fail to maintain any construction project or hydraulic project which may or will obstruct, damage, diminish, destroy, change, modify, or the natural existing shape and form of any stream or its banks or tributaries in a manner that will adversely affect any fish or game habitat. The requirement that any such project must eliminate or diminish any adverse effect on fish or game habitat is applicable to the state in concurring upon any remedial actions to be conducted. The Natural Streambed and Land Preservation Act of 1975, MCA 75-7-101 et seq. includes substantive requirements and is applicable to private parties as well as government agencies.

While the administrative/procedural requirements including the consent and approval requirement set forth in these statutes and regulations are not ARARs, the party designing and implementing the remedial action for the CFROU is encouraged to continue to consult with the Montana Department of Fish, Wildlife and Parks and any conservation district or board of county commissioners (or consolidated city/county government) as provided in the referenced statutes, to assist in the evaluation of factors discussed above.

ARM 36.2.410 establishes minimum standards which would be applicable if a remedial action alters or affects a streambed, including any channel change. Projects must be designed and constructed using methods that minimize adverse impacts to the stream (both upstream and downstream) and future disturbances to the stream. All disturbed areas must be managed during construction and reclaimed after construction to minimize erosion. Temporary structures used during construction must be designed to handle high flows reasonably anticipated during the construction period. Temporary structures must be completely removed from the stream channel at the conclusion of construction and the area must be restored to a natural or stable condition. Channel alternation must be designed to retain original stream length or otherwise provide hydrologic stability. Streambank vegetation must be protected except where removal of such vegetation is necessary for the completion of the project. When removal of vegetation is necessary, it must be kept to a minimum. Riprap, rock, and other material used in a project must be of adequate size, shape and density and must be properly placed to protect the streambank from erosion. The placement of road fill material in a stream, the placement of debris or other materials in a stream where it can erode or float into the stream, projects that permanently prevent fish migration, operation of construction equipment in a stream, and excavation of streambed gravels are prohibited unless specifically authorized by the district. Such projects must also protect the use of water for any useful or beneficial purpose. See 75-7-102, MCA.

VI. Montana Action Specific Requirements

A. Water Quality Statute and Regulations (Applicable)

Causing of pollution: Section 75-5-605 of the Montana Water Quality Act prohibits the causing of pollution of any state waters. Pollution is defined as contamination or other alteration of physical, chemical, or biological properties of state waters which exceeds that permitted by the water quality standards. Construction Best Management Practices described in the CFROU ROD are intended to meet this requirement during remedial action implementation.

Placement of Wastes: Section 75-5-605, MCA, states that it is unlawful to place or cause to be placed any wastes where they will cause pollution of any state waters. Placement of waste is not prohibited if the authorization for placement contains provisions for review of the placement of materials to ensure it will not cause pollution to state waters.

Nondegradation: Section 75-5-303, MCA, states that existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected. Section 75-5-317, MCA, provides an exemption from nondegradation requirements which allows changes of existing water quality resulting from an emergency or remedial activity that is designed to protect the public health or the environment and that is approved, authorized, or required by the department. Changes determined to meet these requirements may be considered nonsignificant. In determining that remedial actions are protective of public health and the environment and in approving, authorizing, or requiring such remedial activities, no significant degradation should be approved, considering the criteria for a determination of non-significance set out in 75-5-301(5)(c), which (i) equate significance with the potential for harm to human health, a beneficial use or the environment, (ii) consider both the quantity and strength of the pollutant, (iii) consider the length of time the degradation will occur, and (iv) consider the character of the pollutant so that greater significance is associated with carcinogens and toxins that bioaccumulate or biomagnify and lesser significance is associated with substances that are less harmful or less persistent. Under ARM 17.30.715(1)(b), concentrations of carcinogenic parameters or parameters with a bioconcentration factor greater than 300 cannot exceed the concentration in the receiving water in order for a discharge to be considered nonsignificant and thus exempt from nondegradation requirements under § 75-5-317.

ARM 17.30.705 provides that for any surface water, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected unless degradation is allowed under the nondegradation rules at ARM 17.30.701 et seq.

ARM 17.30.1011 provides that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation may be allowed under the principles established in § 75-5-303, MCA, and the nondegradation rules at ARM 17.30.701 et seq.

B. Montana Pollutant Discharge Elimination System (MPDES)-stormwater and other point sources (Applicable or Relevant and Appropriate)

ARM 17.30.1342 - 1344 set forth the substantive requirements applicable to all MPDES permits. The substantive requirements, including the requirement to properly operate and maintain all facilities and systems of treatment and control are applicable requirements.

Under ARM 17.30.601, ARM 17.30.1101 et seq., and ARM 17.30.1301 et seq., the Montana Department of Environmental Quality has issued general stormwater permits for certain activities. The substantive requirements of the following permits are applicable for the following activities:

- For construction activities: General Permit for Storm Water Discharges Associated with Construction Activity, Permit No. MTR 100000 (June 8, 2002);
- For mining activities: General Permit for Storm Water Discharges Associated with Mining and with Oil and Gas Activities, Permit No. MTR300000 (November 17, 2002)[8];
- For industrial activities: General Permit for Storm Water Discharges Associated with Industrial Activity, Permit No. MTR000000 (October 1, 2001).

Generally, the permits listed above require the permittee to implement Best Management Practices (BMP) and to take all reasonable steps to minimize or prevent any discharge which has a reasonable likelihood of adversely affecting human health or the environment.[9] However, if there is evidence indicating potential or realized impacts on water quality due to any storm water discharge associated with the activity, the substantive standards associated with an individual MPDES permit or alternative general permit may be required.

A related mine reclamation requirement is set out in ARM 17.24.633 (relevant and appropriate), which requires that all surface drainage from disturbed areas that have been graded, seeded or planted must be treated by the best technology currently available (BTCA) before discharge. Sediment control through BTCA practices must be maintained until the disturbed area has been reclaimed, the revegetation requirements have been met, and the area meets state and federal requirements for the receiving stream.

C. Air Quality

Air Quality Regulations (Applicable)

Dust suppression and control of certain substances likely to be released into the air as a result of earth moving, transportation and similar actions related to remedial activity at the CFROU may be necessary to meet air quality requirements. Certain ambient air standards for specific contaminants and particulates are set forth in the federal action specific section

8 This permit covers point source discharges of storm water from mining and milling activities (including active, inactive, and abandoned mine and mill sites) including activities with Standard Industrial Code 14 (metal mining).

9 For further explanation of storm water applications, see the letter from EPA to Chuck Stilwell, ARCO, dated February 2, 1999, which describes that treatment, in addition to BMPs, may be necessary if in-stream standards are not met after implementation of BMPs. This letter was issued under the Butte Priority Soils operable unit, but similar reasoning applies to this site.

above. Additional air quality regulations under the state Clean Air Act, §§ 75-2-101 et seq., MCA, are discussed below.

ARM 17.8.604 (Applicable) lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers. Any waste which is moved from the premises where it was generated and any trade waste (material resulting from construction or operation of any business, trade, industry or demolition project) may be open burned only in accordance with the substantive requirements of 17.8.611 or 612.

ARM 17.8.308 (Applicable) provides that no person shall cause or authorize the production, handling, transportation or storage of any material, cause or authorize the use of any street, road, or parking lot, or operate a construction site or demolition project, unless reasonable precautions to control emissions of airborne particulate matter are taken. Normally, emissions of airborne particulate matter must be controlled so that they do not "exhibit an opacity of twenty percent (20%) or greater averaged over six consecutive minutes."

In addition, state law provides an ambient air quality standard for settled particulate matter. Particulate matter concentrations in the ambient air shall not exceed the following 30-day average: 10 grams per square meter. ARM 17.8.220 (Applicable). Whenever this standard is exceeded, the activity resulting in such exceedance shall be suspended until such time as conditions improve.

ARM 17.24.761 (Relevant and Appropriate) specifies a range of measures for controlling fugitive dust emissions during mining and reclamation activities. Some of these measures could be considered relevant and appropriate to control fugitive dust emissions in connection with excavation, earth moving and transportation activities conducted as part of the remedy at the site. Such measures include, for example, paving, watering, chemically stabilizing, or frequently compacting and scraping roads, promptly removing rock, soil or other dust-forming debris from roads, restricting vehicle speeds, revegetating, mulching, or otherwise stabilizing the surface of areas adjoining roads, restricting unauthorized vehicle travel, minimizing the area of disturbed land, and promptly revegetating regraded lands.

D. Solid Waste Management Regulations (Applicable)

As noted above, the Solid Waste Management Regulations are applicable to the disposal or active management of the tailings and similar wastes within the CFROU. Certain of these regulations are identified in the state location specific ARARs above. Action specific solid waste regulations are discussed below:

ARM 17.50.505(2) specifies standards for solid waste management facilities, including the requirements that:

1. Class II[10] landfills must confine solid waste and leachate to the disposal facility. If there is the potential for leachate[11] migration, it must be demonstrated that leachate will only

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[10] Generally Class II landfills are licensed to receive Group II and Group III waste, but not regulated hazardous waste. Class III landfills may only receive Group III waste.

[11] Leachate is defined as a liquid which has contacted passed through, or emerged from solid waste and contains soluble, suspended, or miscible materials removed from the waste. ARM 17.50.502(29).

migrate to underlying formations which have no hydraulic continuity with any state waters;

2. adequate separation of group II wastes from underlying or adjacent water must be provided[12]; and
3. no new disposal units or lateral expansions may be located in wetlands.

ARM 17.50.506 specifies design requirements for landfills[13]. Landfills must either be designed to ensure that MCLs are not exceeded or the landfill must contain a composite liner and leachate collection system which comply with specified criteria.

ARM 17.50.511 sets forth general operational and maintenance and design requirements for solid waste management systems. Specific operational and maintenance requirements specified in ARM 17.50.511[14] that are relevant and appropriate are requirements for run-on and runoff control systems, requirements that sites be fenced to prevent unauthorized access, and prohibitions of point source and nonpoint source discharges which would violate Clean Water Act requirements.

ARM 17.50.523 specifies that solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.

ARM 17.50.530 sets forth the closure[15] requirements for landfills. Class II landfills must meet the following criteria:

1. install a cover that is designed to minimize infiltration and erosion;
2. design and construct the final cover system to minimize infiltration through the closed unit by the use of an infiltration layer that contains a minimum 18 inches of earthen material and has a permeability less than or equal to the permeability of any bottom liner, barrier layer, or natural subsoils or a permeability no greater than 1 X 10-5 cm/sec, whichever is less;
3. minimize erosion of the final cover by the use of a seed bed layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth and protecting the infiltration layer from frost effects and rooting damage; and
4. revegetate the final cover with native plant growth within one year of placement of the final cover.

ARM 17.50.530(1)(b) allows an alternative final cover design if the infiltration layer achieves reduction in infiltration at least equivalent to the stated criteria and the erosion layer provides protection equivalent to the stated criteria.

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12 The extent of separation shall be established on a case-by-case basis, considering terrain and the type of underlying soil formations, and facility design. The Waste Management Section of DEQ has generally construed this to require a 10 to 20 foot separation from groundwater.

13 A landfill is defined as an area of land or an excavation where wastes are placed for permanent disposal, and that is not a land application unit, surface impoundment, injection well, or waste pile. ARM 17.50.502(27).

14 ARM 17.50.511(1)(j), 17.50.511(l)(k) and 17.50.511(1)(l)

15 Closure means the process by which the operator closes all or part of the facility.

ARM 17.50.531 sets forth post closure care requirements for Class II landfills. Post closure care must be conducted for a period sufficient to protect human health and the environment. Post closure care requires maintenance of the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cover and comply with the groundwater monitoring requirements found at ARM Title 17, chapter 50, subchapter 7.

Section 75-10-206, MCA, allows variances[16] to be granted from solid waste regulations if failure to comply with the rules does not result in a danger to public health or safety or compliance with specific rules would produce hardship without producing benefits to the health and safety of the public that outweigh the hardship. In certain circumstances relating to waste nature and volume and the provisions of the Superfund law regarding ongoing maintenance and review, certain of the Solid Waste regulations regarding design of landfills, operational and maintenance requirements, and landfill closure and post-closure care may appropriately be subject to variance for the CFROU. Similarly, the ground water monitoring requirements of ARM 17.50.701 et seq. can be considered and coordinated with any other monitoring requirements under CERCLA. In general, the Solid Waste requirements listed in this section will not be used to require additional activities at the CFROU in situ treatment areas other than those activities described in the ROD—either through application of the previously invoked CERCLA waiver or through application of the variance described above.

E. Reclamation Requirements

The Strip and Underground Mine Reclamation Act, §§ 82-4-201 through 254, MCA, technically applies to coal and uranium mining, but that statute and the regulations promulgated under that statue and discussed in this section set out the standards that mine reclamation should attain. Those requirements identified here have been determined to be relevant and appropriate requirements for this action. Section 82-4-231 (Relevant and Appropriate) requires the reclamation and revegetation of the land as rapidly, completely, and effectively as the most modern technology and the most advanced state of the art will allow. In developing a method of operation and plans of backfilling, water control, grading, topsoiling and reclamation, all measures shall be taken to eliminate damages to landowners and members of the public, their real and personal property, public roads, streams, and all other public property from soil erosion, subsidence, landslides, water pollution, and hazards dangerous to life and property. Sections 82-4-231(10)(j) and (10)(k)(i) and ARM 17.24.751 (Relevant and Appropriate) provide that reclamation of mine waste materials shall, to the extent possible using the best technology currently available, minimize disturbances and adverse impacts of the operation on fish, wildlife, and related environmental values and achieve enhancement of such resources where practicable, and shall avoid acid or other toxic mine drainage by such measures as preventing or removing water from contact with toxic producing deposits. ARM 17.24.641 (Relevant and Appropriate) also provides that drainage from acid forming or toxic-forming spoil into ground and surface water must be avoided by preventing water from coming into contact

[16] See the letter from EPA to Chuck Stilwell, ARCO, dated May 21, 2002, which describes the application of variances to solid waste management rules for the Railroad Bed Time Critical Removal Action (TCRA) at the BPSOU.

with such spoil. ARM 17.24.505 (Relevant and Appropriate) similarly provides that acid, acid forming, toxic, toxic-forming or other deleterious materials must not be buried or stored in proximity to a drainage course so as to cause or pose a threat of water pollution.

Reclamation Activities—Hydrology Regulations (Relevant and Appropriate)

The hydrology regulations promulgated under the Strip and Underground Mine Reclamation Act, §§ 82-4-201 et seq., MCA, provide detailed guidelines for addressing the hydrologic impacts of mine reclamation activities and earth-moving projects and are relevant and appropriate for addressing these impacts in the CFROU.

ARM 17.24.631 (Relevant and Appropriate) provides that long-term adverse changes in the hydrologic balance from mining and reclamation activities, such as changes in water quality and quantity, and location of surface water drainage channels shall be minimized. Water pollution must be minimized and, where necessary, treatment methods utilized. Diversions of drainage to avoid contamination must be used in preference to the use of water treatment facilities. Other pollution minimization devices must be used if appropriate, including stabilizing disturbed areas through land shaping, diverting runoff, planting quickly germinating and growing stands of temporary vegetation, regulating channel velocity of water, lining drainage channels with rock or vegetation, mulching, and control of acid-forming, and toxic-forming waste materials.

ARM 17.24.633 (Relevant and Appropriate) provides water quality performance standards that may be invoked in the event that runoff from the treated areas threatens water quality or sediments in the stream, including the requirement that all surface drainage from a disturbed area must be treated by the best technology currently available (BTCA). Treatment must continue until the area is stabilized.

ARM 17.24.634 (Relevant and Appropriate) provides that, in reclamation of drainages, drainage design must emphasize channel and floodplain dimensions that approximate the pre-mining configuration and that will blend with the undisturbed drainage above and below the area to be reclaimed. The average stream gradient must be maintained with a concave longitudinal profile. This regulation provides specific requirements for designing the reclaimed drainage to:

1. approximate an appropriate geomorphic habit or characteristic pattern;
2. remain in dynamic equilibrium with the system without the use of artificial structural controls;
3. improve unstable premining conditions;
4. provide for floods and for the long-term stability of the landscape; and
5. establish a premining diversity of aquatic habitats and riparian vegetation.

ARM 17.24.635 through 26.4.637 (Relevant and Appropriate) set forth requirements for temporary and permanent diversions.

ARM 17.24.638 (Relevant and Appropriate) specifies sediment control measures to be implemented during operations.

ARM 17.24.639 (Relevant and Appropriate) sets forth requirements for temporary and permanent sedimentation ponds.

ARM 17.24.640 (Relevant and Appropriate) provides that discharge from sedimentation ponds, permanent and temporary impoundments, and diversions shall be controlled by energy dissipaters, riprap channels, and other devices, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.

ARM 17.24.643 (Relevant and Appropriate) requires protection of groundwater resources.

ARM 17.24.645 (Relevant and Appropriate) sets forth requirements for groundwater monitoring.

ARM 17.24.646 (Relevant and Appropriate) sets forth requirements for surface water monitoring.

Reclamation and Revegetation Requirements (Relevant and Appropriate)

ARM 17.24.501 (Relevant and Appropriate) gives general backfilling and final grading requirements. Backfill must be placed so as to minimize sedimentation, erosion, and leaching of acid or toxic materials into waters, unless otherwise approved. Final grading must be to the approximate original contour of the land and final slopes must be graded to prevent slope failure, may not exceed the angle of repose, and must achieve a minimum long term static safety factor of 1:3. The disturbed area must be blended with surrounding and undisturbed ground to provide a smooth transition in topography.

ARM 17.24.519 (Relevant and Appropriate) provides that an operator may be required to monitor settling of regraded areas.

ARM 17.24.702(4), (5), and (6) (Relevant and Appropriate) requires that during the redistributing and stockpiling of soil (for reclamation):

1. regraded areas must be deep-tilled, subsoiled, or otherwise treated to eliminate any possible slippage potential, to relieve compaction, and to promote root penetration and permeability of the underlying layer; this preparation must be done on the contour whenever possible and to a minimum depth of 12 inches;
2. redistribution must be done in a manner that achieves approximate uniform thicknesses consistent with soil resource availability and appropriate for the postmining vegetation, land uses, contours, and surface water drainage systems; and
3. redistributed soil must be reconditioned by subsoiling or other appropriate methods.

ARM 17.24.703 (Relevant and Appropriate) requires that when using materials other than, or along with, soil for final surfacing in reclamation, the operator must demonstrate that the material (1) is at least as capable as the soil of supporting the approved vegetation and subsequent land use, and (2) the medium must be the best available in the area to support vegetation. Such substitutes must be used in a manner consistent with the requirements for redistribution of soil in ARM 17.24.701 and 702.

ARM 17.24.711 (Relevant and Appropriate) requires that a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected shall be established except on road surfaces and below the low-water line of permanent impoundments. See also § 82-4-233, MCA (Relevant and Appropriate). Vegetative cover is considered of the same seasonal variety if it consists of a mixture of species of equal or superior utility when compared with the natural vegetation during each season of the year (See also ARM 17.24.716 and 719 below regarding substitution of introduced species for native-species). This requirement may not be appropriate where other cover is more suitable for the particular land use or another cover is requested by the landowner.

ARM 17.24.713 (Relevant and Appropriate) provides that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation.

ARM 17.24.714 (Relevant and Appropriate) requires use of a mulch or cover crop or both until an adequate permanent cover can be established. Use of mulching and temporary cover may be suspended under certain conditions.

ARM 17.24.716 (Relevant and Appropriate) establishes the required method of revegetation, and provides that introduced species may be substituted for native species as part of an approved plan.

ARM 17.24.717 (Relevant and Appropriate) relates to the planting of trees and other woody species if necessary, as provided in § 82-4-233, MCA, to establish a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the affected area and capable of self-regeneration and plant succession at least equal to the natural vegetation of the area, except that introduced species may be used in the revegetation process where desirable and necessary to achieve the approved land use plan.

ARM 17.24.718 (Relevant and Appropriate) requires the use of soil amendments and other means such as irrigation, management, fencing, or other measures, if necessary to establish a diverse and permanent vegetative cover.

ARM 17.24.719 (Relevant and Appropriate) sets forth requirements for livestock grazing on reclaimed land.

ARM 17.24.721 (Relevant and Appropriate) specifies that rills or gullies in reclaimed areas must be filled, graded or otherwise stabilized and the area reseeded or replanted if the rills and gullies are disrupting the reestablishment of the vegetative cover or causing or contributing to a violation of water quality standards for a receiving stream.

ARM 17.24.723 (Relevant and Appropriate) sets forth requirements for vegetation, soils, wildlife, and other monitoring.

ARM 17.24.724 (Relevant and Appropriate) specifies that revegetation success must be measured against approved unmined reference areas or by comparison with technical standards from historic data. More than one reference area or historic record must be established for vegetation types with significant variation due to a number of factors.

ARM 17.24.726 (Relevant and Appropriate) sets forth vegetation production, cover, diversity, density, and utility requirements.

ARM 17.24.728 (Relevant and Appropriate) sets forth performance standards for native species and introduced species in revegetated areas.

ARM 17.24.733 (Relevant and Appropriate) sets forth performance standards for composition and stocking of trees, shrubs, and half shrubs on the revegetated area and for measurement of revegetation success.

To Be Considered Documents (TBCs)

The use of documents identified as TBCs is addressed in the Introduction, above. A list of TBC documents is included in the Preamble to the NCP, 55 Fed. Reg. 8765 (March 8, 1990). Those documents, plus any additional similar or related documents issued since that time, will be considered by EPA and DEQ during the remedy implementation.

Other Laws (Non-Exclusive List)

CERCLA defines as ARARs only federal environmental and state environmental and siting laws. Remedial design, implementation, and operation and maintenance must nevertheless comply with all other applicable laws, both state and federal, if the remediation work is done by parties other than the federal government or its contractors.

The following "other laws" are included here to provide a reminder of other legally applicable requirements for actions being conducted at this operable unit. They do not purport to be an exhaustive list of such legal requirements, but are included because they set out related concerns that must be addressed and, in some cases, may require some advance planning. They are not included as ARARs because they are not "environmental or facility siting laws." As applicable laws other than ARARs, they are not subject to ARAR waiver provisions.

Section 121(e) of CERCLA exempts removal or remedial actions conducted entirely on-site from federal, state, or local permits. This exemption is not limited to environmental or facility siting laws, but applies to other permit requirements as well.

Other Federal Laws

Occupational Safety and Health Regulations

The federal Occupational Safety and Health Act regulations found at 29 CFR § 1910 are applicable to worker protection during conduct of remedial activities.

Other Montana Laws

1. Groundwater Act

Section 85-2-505, MCA, (Applicable) precludes the wasting of groundwater. Any well producing waters that contaminate other waters must be plugged or capped, and wells must be constructed and maintained so as to prevent waste, contamination, or pollution of groundwater.

Section 85-2-516, MCA, states that within 60 days after any well is completed a well log report must be filed by the driller with the DNRC and the appropriate county clerk and recorder.

2. Public Water Supply Regulations

If remedial action at the site requires any reconstruction or modification of any public water supply line or sewer line, the construction standards specified in ARM 17.38.101 (Applicable) must be observed.

3. Water Rights

Section 85-2-101, MCA, declares that all waters within the state are the state's property, and may be appropriated for beneficial uses. The wise use of water resources is encouraged for the maximum benefit to the people and with minimum degradation of natural aquatic ecosystems.

Parts 3 and 4 of Title 85, Chapter 2, MCA, set out requirements for obtaining water rights and appropriating and utilizing water. All requirements of these parts are laws which must be complied with in any action using or affecting waters of the state. Some of the specific requirements are set forth below.

Section 85-2-301, MCA, of Montana law provides that a person may only appropriate water for a beneficial use.

Section 85-2-302, MCA, specifies that a person may not appropriate water or commence construction of diversion, impoundment, withdrawal or distribution works therefor except by applying for and receiving a permit from the Montana Department of Natural Resources and Conservation. While the permit itself may not be required under federal law, appropriate notification and submission of an application should be performed and a permit should be applied for in order to establish a priority date in the prior appropriation system.

Section 85-2-306, MCA, specifies the conditions on which groundwater may be appropriated, and, at a minimum, requires notice of completion and appropriation within 60 days of well completion.

Section 85-2-311, MCA, specifies the criteria which must be met in order to appropriate water and includes requirements that:

1. there are unappropriated waters in the source of supply;
2. the proposed use of water is a beneficial use; and
3. the proposed use will not interfere unreasonably with other planned uses or developments.

Section 85-2-402, MCA, specifies that an appropriator may not change an appropriated right except as provided in this section with the approval of the DNRC.

Section 85-2-412, MCA, provides that, where a person has diverted all of the water of a stream by virtue of prior appropriation and there is a surplus of water, over and above what is actually and necessarily used, such surplus must be returned to the stream.

4. Controlled Ground Water Areas

Pursuant to § 85-2-507, MCA, the Montana Department of Natural Resources and Conservation may grant either a permanent or a temporary controlled ground water area. The maximum allowable time for a temporary area is two years, with a possible two-year extension.

Pursuant to § 85-2-506, MCA, designation of a controlled ground water area may be proposed if: (i) excessive ground water withdrawals would cause contaminant migration; (ii) ground water withdrawals adversely affecting ground water quality within the ground water area are occurring or are likely to occur; or (iii) ground water quality within the ground water area is not suited for a specific beneficial use.

5. Occupational Health Act, §§ 50-70-101 et seq., MCA.

ARM § 17.74.101 addresses occupational noise. In accordance with this section, no worker shall be exposed to noise levels in excess of the levels specified in this regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR 1910.95 applies.

ARM § 17.74.102 addresses occupational air contaminants. The purpose of this rule is to establish maximum threshold limit values for air contaminants under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. In accordance with this rule, no worker shall be exposed to air contaminant levels in excess of the threshold limit values listed in the regulation. This regulation is applicable only to limited categories of workers and for most workers the similar federal standard in 29 CFR § 1910.1000 applies.

6. Montana Safety Act

Sections 50-71-201, 202 and 203, MCA, state that every employer must provide and maintain a safe place of employment, provide and require use of safety devices and safeguards, and ensure that operations and processes are reasonably adequate to render the place of employment safe. The employer must also do every other thing reasonably necessary to protect the life and safety of its employees. Employees are prohibited from refusing to use or interfering with the use of safety devices.

7. Employee and Community Hazardous Chemical Information

Sections 50-78-201, 202, and 204, MCA, state that each employer must post notice of employee rights, maintain at the work place a list of chemical names of each chemical in the work place, and indicate the work area where the chemical is stored or used. Employees must be informed of the chemicals at the work place and trained in the proper handling of the chemicals.

Appendix B

Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix B:
Clark Fork River OU Streambank Stabilization Design Consideration and Examples

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

APPENDIX B

Clark Fork River OU Streambank Stabilization Design Consideration and Examples

Flood Hydrology on the Upper Clark Fork River

Because of the short periods of record for Clark Fork River gage stations within Reach A, a procedure to correlate the data with downstream stations having longer periods of record was conducted by R2 Resource Consultants (2000) to refine estimates of flood flows for various return periods. Two different calculations of peak flows at the Deer Lodge gage station (#12324200) are presented in Exhibit B-1 for several return flow periods. One calculation is based solely on the 21 years of actual gage data at the Deer Lodge station. The other calculation is correlated with a downstream gage having a longer period of record, which is used to extend the effective period of record at Deer Lodge to 48.4 years.

Bankfull flow of the Clark Fork River at Deer Lodge has been calculated to be about 1,900 cfs (Griffin and Smith 2001). At this stage, the flow begins to spill out of the channel and disperse onto the floodplain. When a river floodplain is broad relative to its channel width, as is the case for the upper Clark Fork, a flow stage above bankfull produces a large increase in overbank discharge. However, this occurs with a very small increase within the channel (Smith and Griffin 2002) because the increased flow is distributed over the floodplain at a shallow depth. Since both shear stress and velocity are functions of flow depth, these critical factors of erosion potential increase very slowly as total discharge increases beyond bankfull stage.

Referring to Exhibit B-1, a 25-year flood at 2,830 cfs is about 900 cfs above bankfull discharge. Throughout Reach A, the Clark Fork River has access to a floodplain in excess of one channel width wide on at least one side of the channel. Only in the town of Deer Lodge do high banks on both sides of the river confine the flows above bankfull stage causing an increase in flow depth instead of dispersing over the floodplain.

EXHIBIT B-1
Annual Peak Flow Calculations for the Clark Fork River at Deer Lodge USGS Gage No. 12324200

Return Period	Peak Flow (cfs) 21 Year Record	Peak Flow (cfs) 48.4 Year Record (Extrapolated)
2-year flood	987	1,090
5-year flood	1,610	1,750
10-year flood	2,050	2,220
20-year flood	2,490	2,680
25-year flood	2,630	2,830
50-year fllod	3,080	3,330
100-year flood	3,530	3,770

Streambank Stabilization Considerations

Designers of streambank stabilization projects must ensure that the materials placed within the channel or on the streambanks will remain stable over the full range of conditions expected during the design life of the project. Unfortunately, techniques to characterize stability thresholds are limited. Empirical data for shear stress or stream power are generally lacking, but the existing body of information is summarized here. The presence of dense, woody vegetation on streambanks can decrease erosion substantially by reducing the shear stress along the streambanks, and by increasing the cohesion of the soil comprising the streambanks (Griffin and Smith 2001).

The stability of a stream refers to how it accommodates itself to the inflowing water and sediment load. Erosion occurs when the hydraulic forces in the flow exceed the resisting forces of the channel boundary. The two traditional approaches for characterizing stream flow erosion potential use maximum permissible velocity or critical shear stress. Flow velocity can be measured directly, but shear stress cannot; however, shear stress is a better measure of the fluid force on the channel boundary than is velocity. Moreover, conventional guidelines, including ASTM standards, rely upon the shear stress as a means of assessing the stability of erosion control materials.

Vegetation has a profound effect on the stability of both cohesive and non-cohesive soils. It serves as an effective buffer between the water and the underlying soil. It increases the effective roughness height of the boundary, thereby increasing flow resistance and displacing the flow velocity upwards away from the soil. This reduces drag and lift acting on the soil surface. Since boundary shear stress is proportional to the square of the near-streambank velocity, a reduction in this velocity produces a much greater reduction in the forces causing erosion.

Vegetation armors the soil surface, but the roots and rhizomes of plants also bind the soil and introduce extra cohesion beyond any intrinsic cohesion of the streambank material. The presence of vegetation does not render underlying soils immune from erosion, but the threshold for erosion of a vegetated bank is usually the point of breakage or uprooting of the plants rather than the threshold for movement of the soil particles. Vegetation failure usually occurs at much greater flow intensity than does soil erosion.

The stability of a waterway or the suitability of various channel linings can be determined by first calculating actual mean velocity and shear stress. These values can then be compared with allowable velocity and shear stress for a particular treatment application.

Mechanics of Stabilizing Streambanks

Treatments are designed for streambanks where engineered safety needs to be combined with ecological function and aesthetics. This means they incorporate live, source-identified, site-adapted, vegetation with various applications of structural materials to protect the streambank from the erosive forces of the river water. The material is flexible (i.e. forgiving of grading mistakes), yet strong and easy to use. These materials are typically used in strong currents, high-energy sites, on steep slopes as erosion control material, and revegetation units for difficult sites where energy conditions require an instant solution of strength and stability and simultaneous re-establishment of vegetation. Another prime criteria for inclusion in this approach is that the treatments all minimize disturbance to the aquatic and the terrestrial riparian system during installation.

Coconut fiber coir blankets, mats, and logs that can be pre-vegetated with native plants are widely accepted and used as appropriate materials to protect erodible streambanks. However, for protecting streambanks that are exposed to the most severe erosive forces, a heavier engineering approach may be required. In the United States, since the advent of heavy machinery for moving earth and large rock, the use of large rock has become the most frequently applied solution in these placations. However, there is a cost effective, functionally effective, and aesthetically pleasing alternative that uses smaller rock (4-to-6 inch) compatible to, and readily available in, most river systems. This material is used throughout Europe to stabilize rivers. Rock roll and chambered rock mattress are products consisting of heavy duty polypropylene (environmentally inert) net casings that are filled at the site with suitably sized rock native to the local area and placed at the toe of the most vulnerable streambanks. Heavy equipment is required for installation.

Typical applications in Europe of the chambered rock mattress are on steep embankments with high erosive forces where engineered safety has to be combined with ecological function and aesthetics. Typical uses include:

- Toe protection
- Steep bank slopes (1:1.5)
- Channel liners and bridge aprons
- Submerged dams and shelves
- Reservoir inlet and discharge channels
- Filling-in of scour holes
- Jetties and guide dams
- Breakwaters
- Drainage layers

A sediment filter screen within the net casing of the rock roll and chambered rock mattress may be included that will allow the enclosed rock to collect sediment and become integrated into the natural streambank as rooting medium for vegetation, while blocking sediment from entering the stream. A great advantage of this method of protecting the streambank toe is the reduced need to disturb either the streambank or the channel bottom. These net casings containing smaller rock do not require digging of keyways and will conform to subsurface contours.

In moderate shear stresses/water velocities, rock rolls are another treatment, and they act as small, flexible, and permanent gabions. In turbulent flows, rock rolls are used to provide a solid foundation on top of which pre-vegetation coir rolls can be installed. The roots of plants then quickly grow into the voids of the rock rolls giving long term erosion control and bank support. Rock rolls that are installed below coir units can also be used to support a filter fabric or biodegrading matting. This system retains the fines in the streambank while the roots of the plants from the pre-vegetated coir units establish themselves into the streambank and through the woven geotextile into the suitable fill.

Traditional Approach

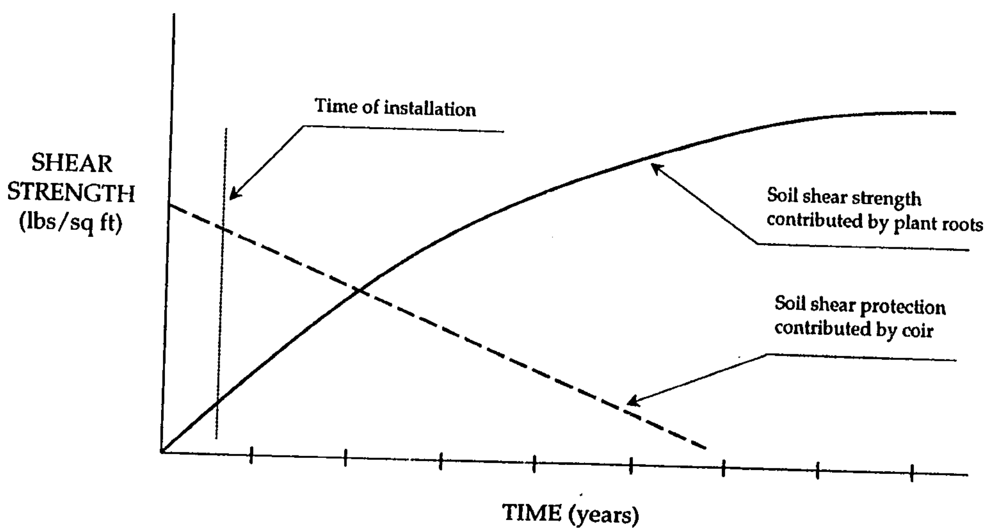
Traditional methods use a variety of methods for stabilizing various conditions of channel shear stress and flow velocity. Three typical levels of susceptibility to erosion and treatment types are:

1. Low to moderate (less than 3 to 4 feet per second velocity and less than 4 pounds per square feet shear stress), with treatment by revegetation
2. Moderate to high (less than 8 feet per second velocity and less than 6 pounds per square feet shear stress), with treatment by biotechnical methods (coir fabric, large rock toe protection, and revegetation)
3. High (exceeds 8 feet/sec velocity and exceeds 6 pounds per square feet shear stress), with hard structural treatment (rip-rap, with in-stream flow deflectors in some cases)

Bioengineering Approach

Commonly available bioengineered materials offer inherent resistance to shear stress on the order of 3 to 5 pounds per square foot. Several companies produce these materials in the form of logs in a variety of diameters for application along lines of high stress, and in mats for use on wider surfaces. These materials are available in several forms designed for particular applications in stabilizing disturbed sites with challenging potential for erosion. However, although these bioengineered materials (typically made of coir fiber from coconut husks) are very strong, they do biologically degrade over time, and are intended to supply stabilizing enforcement during the period necessary for live vegetation to become established and take over the mechanical soil stabilization duties (Exhibit B-2).

EXHIBIT B-2
Idealized relationship to show how over time the plant roots assume the entire role of reinforcing the soil strength to resist shear stress, as the coir biodegrades. Note that the actual strength is the sum of the two components, plus that of the soil's own cohesive strength.



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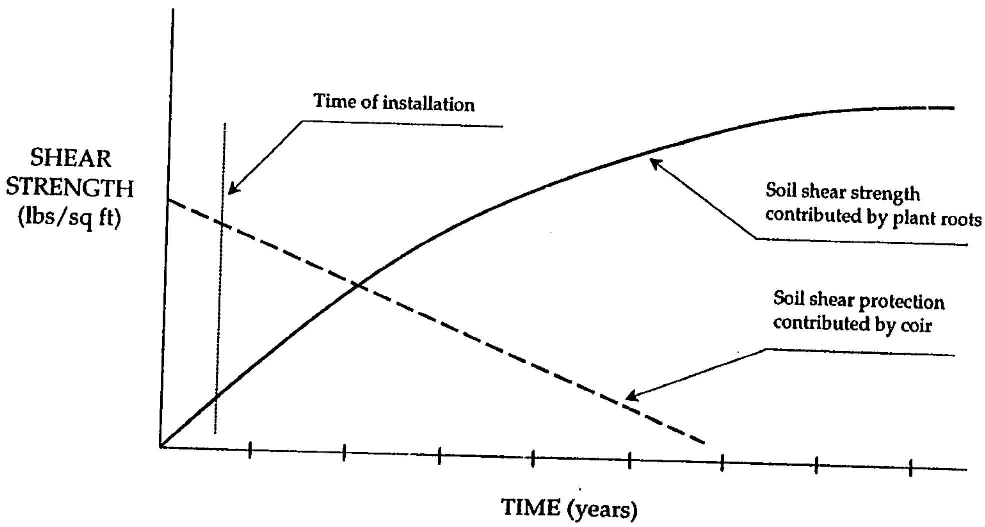


Modern techniques have now been developed to grow the plants in the coir material in advance of application on site. In this way, the inherent strength of the coir is augmented from initial installation beyond the 3 to 5 pounds per square foot by whatever additional strength is also provided by the integrated roots of the live plants. These pre-vegetated coir products typically have the plants growing in the material for one growing season before installation on a project, so that the root systems of the plants are well developed and already providing substantial fiber strength and biomass to the coir product.

Unvegetated soil is generally strong in compression, but weak in tension. The fibrous roots of vegetation have the opposite characteristics; therefore, a composite of a soil permeated by plant roots has enhanced strength (Simon and Collison 2001). The amount by which plant roots augment soil strength varies immensely by species. According to Hoitsma and Payson (1998) vegetation resistance to shear stress is reported to vary from 0.35 to 8.50 pounds per square feet. Simon and Collison (2001), found that, even with the negative surcharge of the weight of trees, the net effect of adding riparian species to unvegetated banks was to double the effective strength when compared to unvegetated soil during a dry year (in Mississippi), using several species of riparian trees and grasses commonly used in revegetation projects in that region.

Goldsmith (1998) reports laboratory tests of strain resistance to shear stresses on blocks of riparian soil (medium sand texture) containing various kinds of plant root structures. These tests found that sedges increased resistance of the soil block to failure by a factor of 18.5 over a block of soil with no vegetation. Similar tests on a block with a single willow stem (0.6 inch diameter) and its associated sparse roots showed an increased resistance to failure by a factor of 3. A listing of ten studies measuring increases in soil cohesion due to the addition of roots of a variety of plant species shows universal increase that ranges from a factor of 2 to a factor of 17.5 (average increase = 5.7 times) (Coppin and Richards 1990). While we are less concerned with the load bearing strength of soils in the context of streambank stabilization and resistance to erosion, Goldsmith's comparison does reveal the magnitude of relative gains in soil strength contributed by the addition of plant roots. The following shear load to deform in pounds per square foot, according to Goldsmith, is as follows:

- Bare Soil (No Plant Roots): 64
- Soil with Sedge Roots: 1,184
- Soil with Willow Roots: 191

While every application is unique and all plant species differ in pertinent characteristics, we can be assured that integrating live plant roots into a coir product will significantly increase its inherent resistance to shear stresses. The intent is to transfer shear stress on the soil to tensile resistance of plant roots as a function of the interface friction along the root surfaces. This process can be greatly augmented and hastened by reinforcing a high-strength growth medium that comes with its own inherent resistance to shear stress. The tensile strength of plant roots also varies among species. Species of the genera *Salix* (willow), *Betula* (birch), and *Alnus* (alder) all have roots with tensile strengths in the range of 24.17 pounds per square feet to 27.92 pounds per square foot (Coppin and Richards 1990). Exhibit B-3 shows a comparison of properties of some of the different materials discussed above.

Pre-vegetated coir products described above can easily satisfy structural requirements for stabilizing streambanks in all but the most critical sites where public works infrastructure installations have to be protected in place by absolutely rigid structures. These pre-vegetated coir products provide even further gains in protection of banks through the added friction to flowing water from roughness because the plants grow from the coir. This added roughness slows the water velocity at the critical surface boundary layer, and steadily increases in effectiveness over time.

EXHIBIT B-3
Comparison of Streambank Material Properties

Boundary Material	Critical Boundary Shear Stress (lb/ft²)	Critical Water Velocity (ft/sec)	Reference
Bare Soils			
Sandy Loam	0.03 – 0.04	1.75	(Chang 1988)
Alluvial Silt	0.045 – 0.05	2	(Chang 1988)
Mixed Silt to Cobble	0.43	4	(Chang 1988)
Rock			
1-inch Gravel	0.33	2.5 – 5	(Chang 1988)
2-inch Gravel	0.67	3 – 6	(Chang 1988)
6-inch Gravel	2.0	4 – 7.5	(Chang 1988)
Large Rock (Rip-Rap) (D50 = 2 feet)	10.1	14 – 18	(Kouwen, Li, Simons 1980)
Gabion	10	14 – 19	(Goff 1999)
Rock Roll (16 – 20 in. diameter)	12 (estimate)	At Least 16	
Chamber Rock Mattress (1 feet thick by 5 feet wide)	15 (estimate)	At Least 16	
Vegetated Soil			
Long, Native Grasses	1.2 – 1.7	4 – 6	(Fischenich 2001)
Hardwood Trees	0.45 – 2.5	Unknown	(Fischenich 2001)
Bioengineering			
Coir Roll-Sod (Unvegetated)	5	15	(Santha 2003)
Coir Roll-Sod (Vegetated)	4 – 8	9.5	(Gray and Sotir 1996)
Coir Roll-Sod (Pre-vegetated)[a]	12+	At Least 15	(Di Pietro and Brunet 2002)
Coir Fiber Roll (Un-vegetated)	3 – 5	8 – 16	(Fischenich 2001, Santha 2003)
Coir Fiber Roll (Pre-vegetated)[a]	12+	At Least 16	(Di Pietro and Brunet 2002)

[a] Critical shear stress and water velocity are based upon values at installation. After installation, the roots of the plants grow into the streambank and the values increase greatly.

Anchoring the Critical Streambank Toe—Traditional methods typically offer a design utilizing large rock to anchor the streambank toe. The toe of the streambank slope is where shear stress is greatest against the streambank, and where streambank failure is most likely to happen. Angular rock is typically required for such applications to achieve stability. Most sources of such material are distant and expensive. A simpler solution utilizes smaller rounded rock, readily available within the floodplain, in rock rolls or rock mattresses. These are tubes of strong netting in various configurations that are filled with this smaller rock on site and laid in place to protect the streambank toe. The netting is typically made of an environmentally inert material that holds the rock in place 10 to 20 years, or until the banks are well protected by natural vegetation. Added benefits are that the rock used in the rock rolls is locally obtained in the valley and is round. This means that the rock is native to the floodplain and the round rock is similar to the rock in the streambed and that it will provide interstitial spaces for macroinvertebrate habitat, which are an indicator of water quality and overall health. Large, angular rip-rap does not provide the same type and amount of such spaces.

Matching Streambank Stabilization Techniques and Materials to Site-Specific Criteria

The following paragraphs offer a general procedure for matching streambank stabilization techniques and materials to specific site applications in terms of actual erosion potential (Fischenich 2001).

Step 1: Estimate Mean Hydraulic Conditions

Flow of water in a channel is governed by the discharge, hydraulic gradient, channel geometry, and roughness coefficient. This functional relationship may be evaluated using normal depth computations that take into account principles of conservation of linear momentum, which take into account variations in momentum slope directly related to shear stress. Several models are available to aid in assessing hydraulic conditions. Notable examples include HEC-2, HEC-RAS, and WSP2. Channel cross sections, slopes, and Manning's coefficients should be determined based upon surveyed data and observed or predicted channel boundary conditions. Output from the model should be used to compute main channel velocity and shear stress at each cross section.

Step 2: Estimate Local/Instantaneous Flow Conditions

The computed values for velocity and shear stress may be adjusted to account for local variability and instantaneous values higher than mean. A number of procedures exist for this purpose. Most commonly applied are empirical methods based upon channel form and irregularity. Local maximum shear stress can be assumed from the following simple equations (Fischenich 2001):

$$\lambda_{max} = 1.5t \text{ (for straight channels)}$$
$$\lambda_{max} = 2.65(R_c/W)^{-0.5} \text{ (for sinuous channels)}$$

Where λ is the computed value of actual shear stress at a cross section, R_c is the radius of curvature, and W is the top width of the channel. These equations adjust for the spatial distribution of shear stress; however, temporal maximums in turbulent flows can be 10 to 20 percent higher. A further adjustment is needed to account for instantaneous maximums, and a factor of 1.15 is usually applied (Fischenich 2001).

Step 3: Determine Existing Stability

Existing stability should be assessed by comparing estimates of local and instantaneous shear and velocity to values for the materials available for use. Both the underlying soil and the soil/vegetation condition should be assessed. If the existing conditions are deemed stable and are in agreement with other project objectives, then no further action is required. Otherwise, proceed to Step 4.

Step 4: Select Channel Lining Material

If existing conditions are unstable, or if a different material is needed along the channel perimeter to meet project objectives, then the new material or stabilization measure should be selected by using the critical threshold values as a guideline. Only material with a threshold exceeding the predicted value plus safety factor should be selected.

Suggested Design Criteria for Clark Fork River Streambank Treatments

Exhibit B-4 shows the suggested maximum values of shear stress and flow velocity for the proposed streambank treatment designs for the Upper Clark Fork River.

EXHIBIT B-4
Allowable Maximum Values of Shear Stress and Flow Velocity for Bioengineered Streambank Treatment Designs

Treatment	Description	Maximum Allowable Shear Stress (lb/ft^2)	Maximum Allowable Flow Velocity (ft/sec)
Treatment 2	Pre-vegetated Coir	8[a]	9.5[a]
Treatment 3	Pre-vegetated Coir and Rock Roll	10[b]	15[b]
Treatment 4	Pre-vegetated Coir and Rock Mattress	12[b]	16[b]

[a] from Gray and Sotir (1996)
[b] from Di Pietro and Brunet (2002)

Examples of Streambank Treatments for Various Conditions

Once the data for various streambank reaches is completed and interpreted and the appropriate lengths of banks by classification is determined, appropriate streambank stabilization designs, depending on classification, can then can be determined. Components of the following designs includes a bio-engineering component for physically stabilizing the streambank and streambank toe if appropriate. Also included are revegetation plans for the riparian corridor that further serve to stabilize and protect the installed streambank erosion protection component but further serve to protect the riparian corridor from floodplain flow erosion as well. Over time, as these differing sizes of woody vegetation mature, both streambank and floodplain erosion protection will increase.

The following treatment designs are those designs developed as examples for the Upper Clark Fork River. Final decision on the actual design specifications will be made in the remedial design phase. As the streambank work progresses, site-specific designs or other designs will be necessary. The treatments are ordered from low shear stresses and flow velocities to high shear stresses and high velocities. The diagrams shown throughout this discussion are not drawn to scale.

1. **No Treatment Necessary**—This applies to streambanks where there is adequate deep, binding woody vegetation already in place, and no additional work on the site is necessary.

2. **Treatment 1 (vegetation augmentation)**—Augment existing vegetation with additional small-containerized plants. May require scalping and weed barriers for better survival. Assumption is that in this treatment, the average canopy cover of deep, binding woody vegetation is 50 percent. Therefore, the treatment will be the planting of 10 containerized plants at a level of 10 plants per 10 feet or 1 plant per linear feet of streambank. The mixture would be as follows:

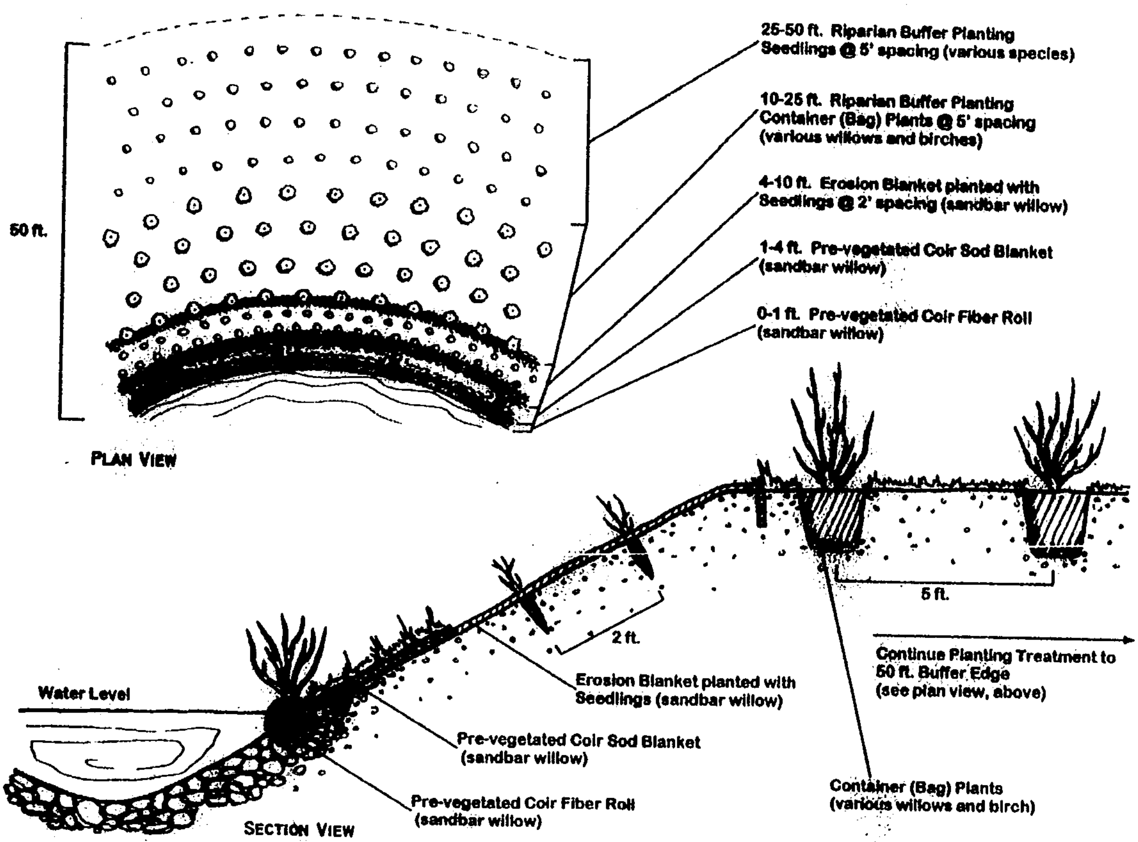
- 25 percent *Salix exigua* (sandbar willow) wet areas
- 25 percent *Betula occidentalis* (water birch) wet areas
- 50 percent equal mixture of *Salix lutea* (yellow willow), wet areas; *Salix boothii* (Booth willow), wet areas; *Salix bebbiana* (Bebb willow), wet areas; *Alnus incana* (mountain alder), wet areas; *Cornus stolonifera* (red-osier dogwood), wet areas; *Prunus virginiana* (common chokecherry), dry areas; and *Amelanchier alnifolia* (western serviceberry), dry areas.

3. **Treatment 2 (low shear stresses/flow velocities)**—Pre-vegetated coir roll-sod with a toe protection of pre-vegetated fiber-rolls (comprised of sandbar willow [*Salix exigua*]) is considered Treatment 2 (see Exhibit B-5). Because of the sandy/gravelly streambank material (relatively unconsolidated in many places), the species mix for the roll-sods will be exclusively *Salix exigua* (sandbar willow). In other words, it is too sandy (therefore too droughty) for sedges to take hold. They need to have more silt/clay in the soil profile. Within the nominal 50-foot zone, the following will apply:

   a. 1-to-25 foot zone
      i. Pre-vegetated coir fiber-roll for toe protection (*Salix exigua* [sandbar willow]).
      ii. 3 feet of pre-vegetated coir roll-sod planted with *Salix exigua* (sandbar willow).
      iii. 6 feet of coir woven blanket (23 oz./square yard) planted with two rows of 10T containerized *Salix exigua* (sandbar willow) on a 2-foot spacing.
      iv. Three rows of bag plants of *Salix exigua* (sandbar willow) and *Betula occidentalis* (water birch) at a ratio of 2:1 (sandbar willow:water birch). The three rows will be on 5-foot spacing with the first plant at 10 feet and the last plant at 20 feet from the edge of the stream. These plants will be augered into the floodplain so that the roots are in constant contact with capillary fringe throughout the growing season.
      v. One row of bag plants of an equal mixture of *Salix lutea* (yellow willow), *Salix bebbiana* (Bebb willow), and *Salix boothii* (Booth willow).

   b. 25 to 50 foot zone
      i. Four rows of 10T containerized shrubs at a 5 foot spacing. The plants include *Salix lutea* (yellow willow) wet areas; *Salix boothii* (Booth willow) wet areas; *Salix bebbiana* (Bebb willow) wet areas; *Alnus incana* (mountain alder) wet areas; *Cornus stolonifera* (red-osier dogwood) wet areas; *Prunus virginiana* (common chokecherry) dry areas; and *Amelanchier alnifolia* (western serviceberry) dry areas.

EXHIBIT B-5
Streambank Treatment 2—Low Shear Stresses/Flow



4. **Treatment 3 (moderate shear stresses/flow velocities)**—Pre-vegetated coir roll-sod with a toe protection of pre-vegetated fiber-rolls comprised of *Salix exigua* (sandbar willow) on top of rock roll is considered Treatment 3 (see Exhibit B-6). Also included is tipped over mature willow on a spacing of 15 feet along the streambank to deflect and dissipate the energy of the stream. The design for the zone behind the immediate streambank work is the same as Type 2 Treatment.

   Exhibit B-7 illustrates the typical installation for the rock roll and pre-vegetated coir fiber roll.

EXHIBIT B-6
Streambank Treatment 3—Moderate Shear Stresses/Flow

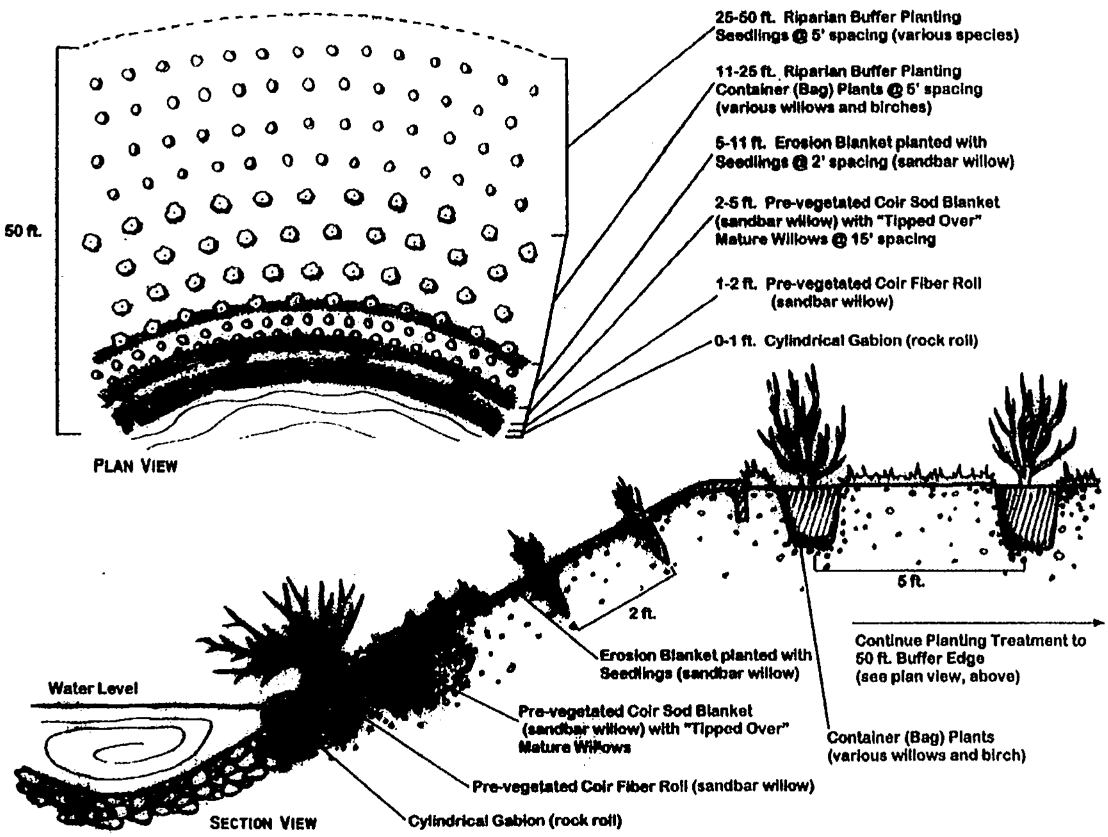
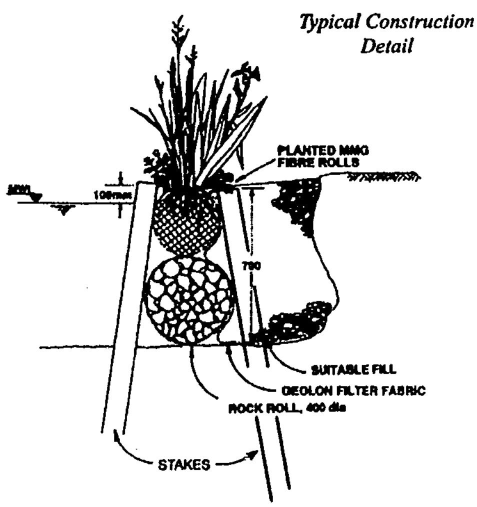
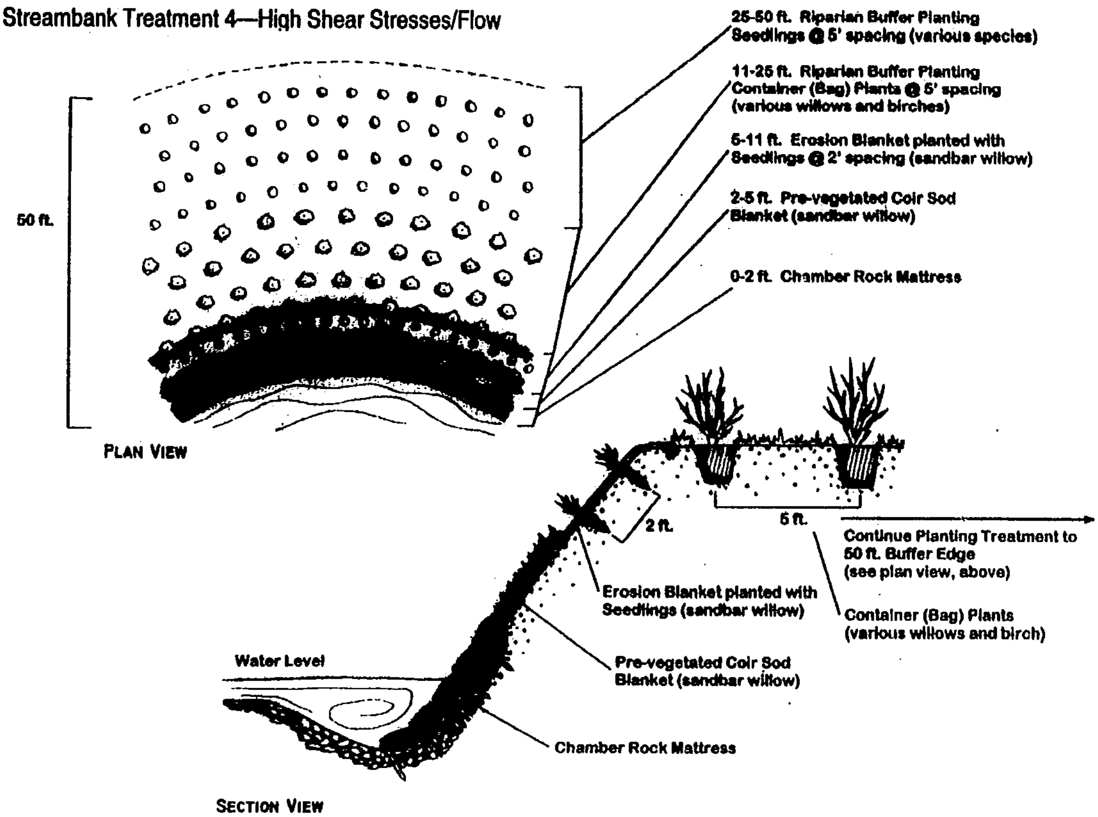


EXHIBIT B-7
Typical Construction Detail



5. **Treatment 4 (high shear stresses/flow velocities)**—Pre-vegetated coir roll-sod with a toe protection of rock mattress is considered Treatment 4 (see Exhibit B-8.) Also included is tipped over mature willow on a spacing of 15 feet along the streambank to deflect and dissipate the energy of the stream. The design for the zone behind the immediate streambank work is the same as Type 2 Treatment.

EXHIBIT B-8
Streambank Treatment 4—High Shear Stresses/Flow



Bio-Stabilization

As shown in the illustrations above, willow sprigs planted near the edge of the river and tipped-over willows (which deflect water flow away from the streambank) are to be the first structures to stabilize the banks of the river. Additional stabilization is achieved by planting "bagged" willows and mature willow transplants. These four types of bio-stabilization are implemented within the first 25 feet away from the river streambank. The second 25 feet away from the streambank is planted with additional bagged willows, and other woody vegetation including chokecherry, red dogwood, alder, serviceberry, water birch, and others. The intensity of woody plants is less for inside bends compared to outside bends of the river. Herbaceous communities are also to be established within this zone to provide riparian pastures for use by livestock and wildlife. This approach will provide herbaceous forage production for the landowner and maximum growth of woody vegetation to protect against erosion, soil loss, and floodplain deformation. A key component in establishing successful woody and herbaceous vegetation within the riparian corridor buffer will be supplemental irrigation for 2 to 3 years following implementation. This will provide optimum growth of these stabilizing plants, thereby reducing the time to attain streambank stability, as well as overall floodplain stability. In addition, supplemental irrigation will hasten establishment of grasses and forbs, and retard the invasion of unwanted plant species, specifically weeds.

Salix exigua (sandbar willow) is considered either an obligate wetland species or a facultative wetland species. Therefore, *Salix exigua* (sandbar willow) needs to be close to the water table to survive. If supplemental watering is not available, planting depth of the root-control bags can be adjusted to compensate. The planting depth should be deep enough so that the plant is in constant contact with the capillary fringe throughout the growing season. Planting *Salix exigua* (sandbar willow) at this depth will not affect the health of the plant. *Salix exigua* (sandbar willow) evolved in an environment where sediment deposition of up to 1 to 2 meters after a single high flow event (e.g., flood) can occur. When this happens, the plant develops new roots along the entire length of the buried stems. Therefore, augering the holes deeper can be used to compensate for supplemental watering concerns.

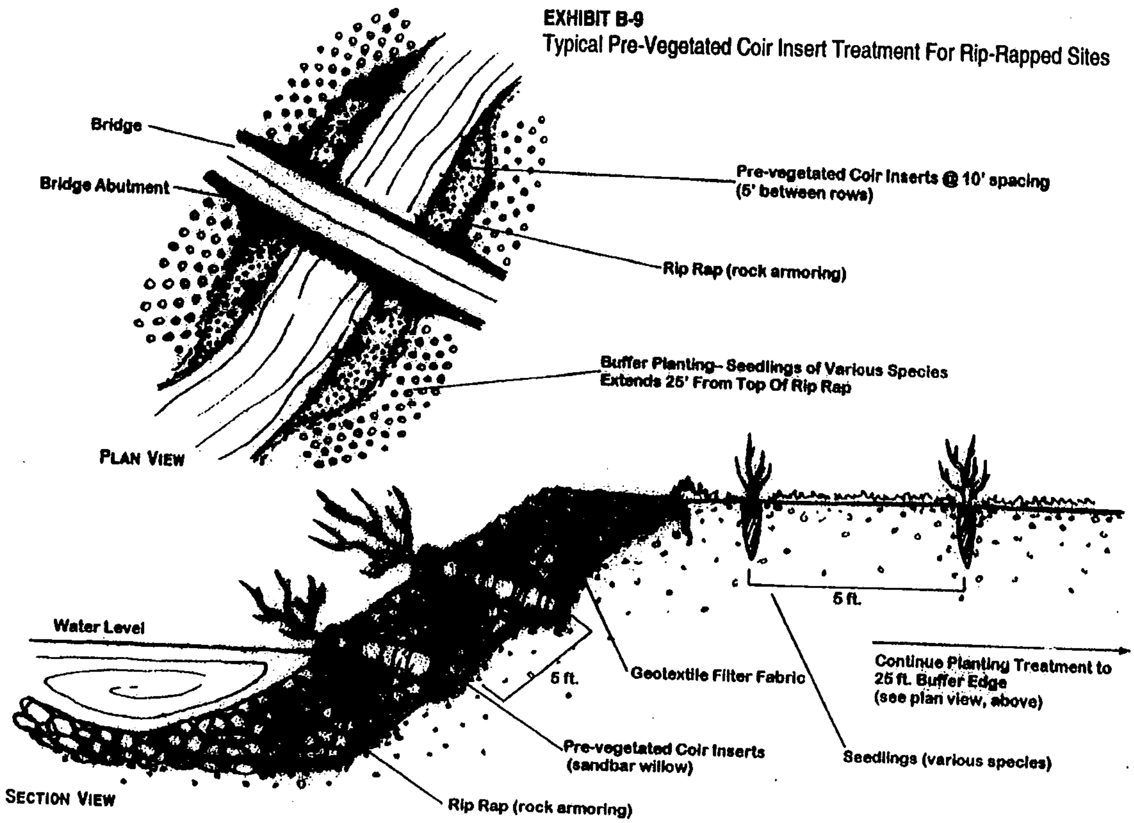
Additional Possible Streambank Treatments

The following examples are possible treatments for unique locations along the upper Clark Fork River. They have not been included in the cost analysis for the river.

1. **Modification of Existing Rip-Rap**—Existing rip-rap can be supplemented with pre-vegetated coir inserts (comprised of *Salix exigua* [sandbar willow]). Currently, rip-rap is associated with public infrastructure, such as bridges, irrigation diversion ditches, sewage lagoons, City of Deer Lodge, etc. The pre-vegetated coir inserts will be two rows, with the first row near the water level for the middle of the summer and another row 5 feet higher on the rock. The inserts will be spaced at 10 foot intervals. Behind the rip-rap, those areas outside an immediate transportation corridor right-of-way will include a buffer of 25 feet with four rows of 10T containerized shrubs at a 5 foot spacing. The plants include *Salix lutea* (yellow willow), wet areas; *Salix boothii* (Booth willow), wet areas; *Salix bebbiana* (Bebb willow), wet areas; *Alnus incana* (mountain alder), wet areas; *Cornus stolonifera* (red-osier dogwood), wet areas; *Prunus virginiana* (common chokecherry), dry areas; and *Amelanchier alnifolia* (western serviceberry) dry areas. See Exhibit B-9.

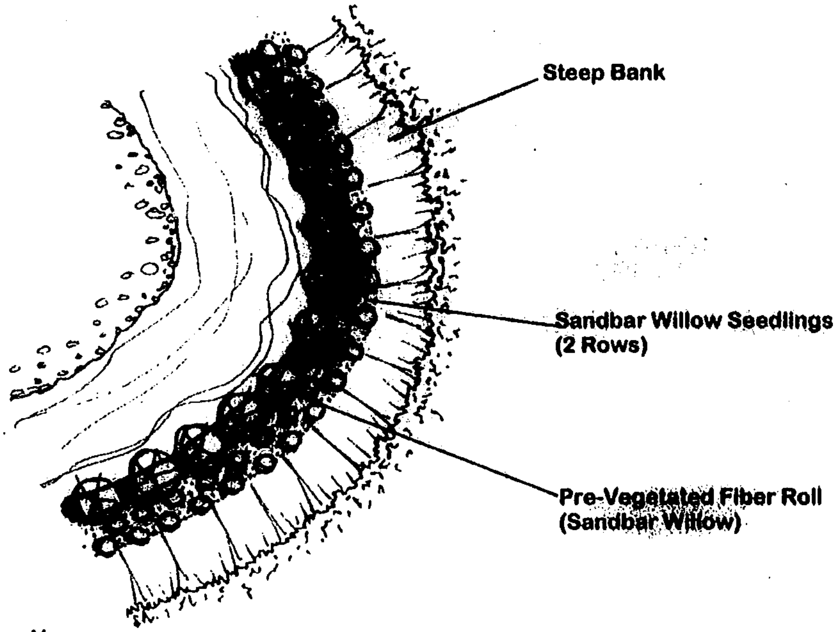
2. **In-stream Flow Deflectors or Low Rock Barbs**—See the Atlantic Richfield Company's Type 4 streambank stabilization option for a drawing of this type of structure (2002, *Feasibility Study*, Figure 5-12). (In the *Feasibility Study*, the Company does not include a cost estimate or a linear foot estimate.)

EXHIBIT B-9
Typical Pre-Vegetated Coir Insert Treatment For Rip-Rapped Sites

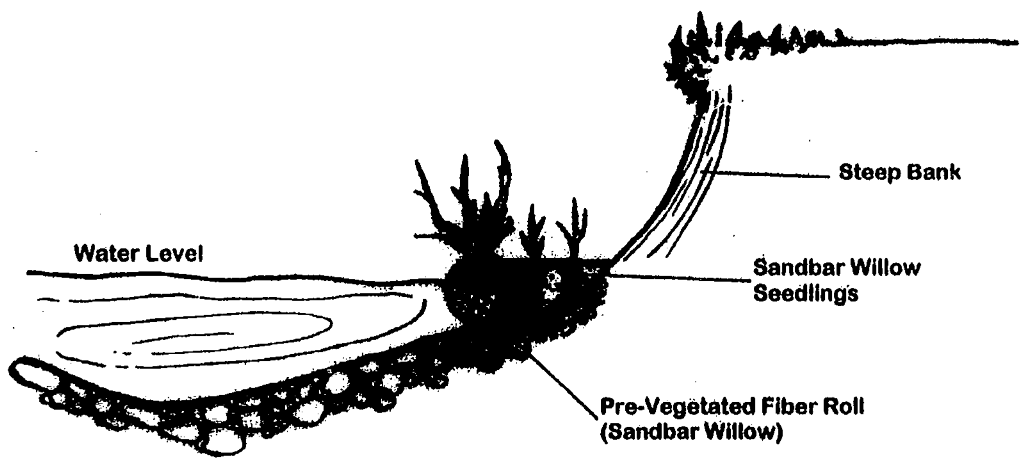


3. **Pre-vegetated Coir Fiber-rolls (comprised of *Salix exigua* [sandbar willow])**—Used along the base of high eroding banks. Immediately behind the fiber-rolls are two rows of small-containerized plants comprised of *Salix exigua* (sandbar willow). See Exhibit B-10.

EXHIBIT B-10
Typical Pre-Vegetated Coir Fiber Roll Treatment For Steep Banks



PLAN VIEW



SECTION VIEW

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Tabbed Page: Appendix C

Clark Fork River Operable Unit

of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix C:
Clark Fork River OU BMPs and Riparian Management Plan Considerations

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

APPENDIX C

Clark Fork River OU BMPs and Riparian Management Plan Considerations

Developing an Effective Riparian Grazing Management Plan

Benefits Of Proper Riparian Management To Ranchers

1. Water storage and availability
2. Increased vegetation
3. Better forage quantity and quality
4. Flood protection and reduction
5. Reduced streambank erosion
6. Increased water quality
7. Shelter for livestock
8. Acceptance and "security"

General Principles For Grazing Livestock In Riparian Zones

1. Tailor the approach to the specific situation and landowner objectives (have clearly defined goals and objectives).
2. Incorporate riparian management into an overall plan.
3. Select season of use so grazing occurs, as often as possible, during periods compatible with animal behavior, conditions in the riparian zone, and riparian objectives.
4. Determine *riparian* objectives.
5. *Monitor* change.
6. Limit livestock time in pastures with riparian areas.
7. Control (influence) distribution of livestock within a pasture.
8. Ensure adequate residual vegetation cover.
9. Provide adequate regrowth time and rest for plants.

Be actively involved by:

1. Determine an appropriate season for grazing a specific riparian zone.

2. Use various methods for reducing intensity and use in the riparian area through control and distribution of livestock within a pasture.

Techniques for Controlling Distribution of Livestock

1. Offstream water development
2. Stable access points
3. Salt and mineral block placement
4. Improve upland forage
5. Riding/herding
6. Drift fences
7. Turn-in location
8. Smaller pastures with a riparian area in each
9. Fencing: permanent or temporary

Early Season (Spring) Ranchers

Best Used When:

1. Succulent forage in the uplands that discourages livestock impacts in the riparian zone
2. Temperatures encourage livestock to stay out of the riparian zone
3. Wet soils discourage livestock use
4. Well-drained soils reduce soil compaction

Potential Advantages:

1. Less soil compaction and streambank shearing *if* livestock use is minimized
2. Provides time for regrowth of riparian and upland vegetation
3. Less browsing pressure on woody vegetation

Possible Drawbacks:

1. High potential for soil compaction, trampling, and erosion
2. Has potential for reducing plant vigor thereby changing plant community composition
3. Upland forage nutrition may be low
4. High potential to affect wildlife

Late Season (Fall) Grazing

Best Used When:

1. Mostly herbaceous plant communities rather than woody communities

2. Palatable cool season forage in uplands
3. Offstream water available or other conditions draw livestock out the riparian zone

Possible Benefits:

1. Drier conditions on the floodplain reduce soil compaction, streambank shearing, and erosion
2. Plants have a completed growth cycle (e.g., set seed)
3. Less impact on wildlife.

May be Detrimental When:

1. No regrowth due to soil moisture and temperature
2. No incentives to induce livestock to move out of the riparian zone
3. When woody species maintenance and regeneration objectives are not met

Hot Season (Mid-Summer) Grazing

Least Likely to be Negative When:

1. Conditions are closely monitored and grazing period is limited in duration and frequency
2. Actions taken to induce livestock to move out of the riparian zone
3. Opportunities are provided for regrowth based upon time of removal, climatic conditions, and frequency of use

Possible Disadvantages:

1. Greater tendency to hang in the riparian zone
2. More intense use may reduce plant vigor and change plant communities
3. Damage to trees and shrubs

Potential Advantages

1. Drier and more stable soils and streambanks
2. Potential for regrowth after hot season cessation of growth by plants
3. Palatability of riparian forage is greater than upland plants

Winter Grazing

Especially Beneficial When:

1. Pasture is large enough to feed away from the stream
2. Cold drainages or south-facing slopes reduce riparian use
3. Soil compaction, streambank shearing is more likely during other periods

Possible Advantages:

1. Minimal soil compaction and streambank damage—provided the livestock are removed before the soils/streambanks thaw
2. Livestock use will not affect plant development (plants are dormant)
3. Livestock distribution is easily influenced by location of feed and water

Possible Detrimental Impacts:

1. Grazing of dead material can reduce streambank protection and sediment trapping in the spring when run-off occurs
2. Browsing and physical damage to woody plants may be high

Conclusion of Good Riparian Management

1. What operators do to encourage livestock not to loiter in the riparian zone while they are in a pasture is more important than either season of use or length of time in the pasture per se.
2. Two common threads for good riparian management:
   a. Presence of offstream water developments; and
   b. Operator involvement.
3. Many useful techniques were not tied to any particular grazing "system."

Thus, riparian grazing might be incorporated into each of the traditional grazing systems, except season-long, ***as long as the condition of the riparian zone itself remains of primary concern.***

Management, not the system, is the key.

Developing a Riparian or Wetland Management Plan

An objective is defined as something toward which effort is directed; an aim or end of action. Objectives should contain the following five elements (e.g., five W's): 1) who, 2) what, 3) when, 4) where, and 5) why. For example, the John Doe Ranch (who) will provide for survival and recruitment of cottonwood trees from a frequency of 0 percent (what) in 2004 (when) to a frequency of 5 percent (what) in 2009 (when) along Big Creek in the Longhorn Pasture (where) to provide for future perching/resting sites for great blue herons (why). Do not confuse the management practice to achieve an objective (how) with the elements of the objective.

Once objectives have been clearly defined, the next step is to develop a management plan. The following discussion uses riparian or wetland areas as an example in how a management plan is developed and monitored.

Introduction and Development of a Plan

A management plan based only on objectives related to non-riparian (uplands) or wetland areas does not usually result in maintenance or improvement of riparian or wetland areas. Therefore, where maintenance or improvement of riparian or wetland areas is desired, the land use plan, activity plan objectives, and management prescriptions must be determined specifically for the riparian or wetland features while considering the needs of the entire watershed. The establishment of specific objectives, description of the desired plant community, and selection of key species should be an interdisciplinary effort. Management objectives need to be focused, achievable, measurable, repeatable, have a starting and ending point in time and location, be reasonable, clear, concise, and affordable. In short, management objectives need to have realistic and attainable goals. In addition, they should be dictated by the present condition and trend of the riparian or wetland habitat in relation to management goals, the resource potential for change, and the importance of other resource values. Major considerations in establishing management objectives in riparian or wetland areas should include the following:

1. Vegetation
    a. The potential of the site (that is, the riparian or wetland plant association).
    b. The desired plant community.
        i. If the potential of the site is woody vegetation, then the health and reproduction of woody vegetation should receive equal consideration as the herbaceous vegetation (depending on the riparian or wetland objectives). If one of the objectives for a riparian or wetland area is streambank stability, then woody vegetation vigor should be of utmost importance due to the vastly different streambank stability protection afforded by the woody vegetation when compared to the herbaceous vegetation.
        ii. The development and/or maintenance of different age classes (for example, seedlings, saplings, poles, and mature for trees; seedlings, saplings, and mature age classes for shrubs) of the key woody plant species on the site to maintain a viable plant community. (Once again, only if the potential of the site is for woody vegetation.)
        iii. The type of vegetation cover necessary to minimize the erosive effects of run-off events.
        iv. The vegetation structure necessary for wildlife cover diversity.
    c. The stabilization of streambanks.
    d. The value of the site for forage production.
    e. The amount of vegetation stubble required to trap and hold sediment deposits during run-off events to rebuild streambanks and restore/recharge aquifers. It is important to realize that on streams with high gradients and low silt loads, it is more difficult to improve them than those with low gradients and high silt loads (that is, mud management).

f. The kind and amount of "weedy species" present. The more persistent and difficult the weedy species are to control, the more limited the management opportunities. Therefore, proper understanding of the ecology of weeds present will help the manager(s) make realistic and attainable goals.

2. Water Quality/Quantity Issues
   a. Raising the elevation of the present water table and expanding the sponge effect.
   b. The improvement or maintenance of water quality and quantity or change in the timing of the flow.
3. Streambank Stability
   a. The establishment of proper stream channels, streambanks, and floodplain conditions and functions.
   b. The maintenance of long term adjustment processes that may affect channel or wetland conditions. These processes include sediment deposition, streambank development, floodplain development, and stream dynamics (meandering).
4. Wildlife
   a. The improvement or maintenance of the fishery habitat.
   b. The importance of the riparian or wetland community to riparian or wetland dependent wildlife and to wildlife species that occur primarily on upland sites but are periodically attracted to riparian or wetland areas.
5. Other
   a. The aesthetic values of a healthy riparian or wetland zone.
   b. The period of time that is acceptable or necessary for riparian or wetland rehabilitation/restoration.
   c. The reduction of upland erosion and stream sediment load and the maintenance of soil productivity.

Implementation of the Plan

Once a management plan has been written, the following steps should be taken:

1. Implement the management plan.
2. Design a monitoring plan that will evaluate the effectiveness of the management plan and provide information for identifying the cause of any failures. Monitoring needs to be done at the initiation of management plan in order to establish a baseline or "starting point."
3. Monitor the site or the stream reach over time. Management must be flexible enough to accommodate changes based on experience. Mistakes need to be documented and not repeated elsewhere.

4. Once the management plan is in progress, the most important element is frequent supervision.

5. Determine the outcome of the management plan. If it is successful, then proceed with the existing management plan. If the plan was either a partial or complete failure, then modify the management objectives. *Remember, mistakes need to be documented and not repeated elsewhere.*

Developing the Monitoring Plan

Key Areas—As objectives are considered and developed for riparian or wetland areas, key areas for monitoring must be located in representative portions of the riparian or wetland areas as well as in the uplands. These key areas will indicate where appropriate monitoring will be conducted and will provide the basis for decisions as to whether management objectives are being met or not. Key areas must possess (or have the potential to produce) all the specific elements in the objective(s) because these will provide data for evaluation of management efforts. In many cases, it is appropriate to select the key areas first and then develop objectives specific to each.

Key Plant Species—Key plant species will vary with the potential of each individual site. Selected key plant species should be those that are necessary to the operation of the natural stream functions. The type of vegetation present will affect channel roughness and the dissipation of stream energy. Willows and other large woody vegetation (trees) filter large water-borne organic material, and their root systems provide streambank stabilization. Sedges, rushes, grasses, and forbs capture and filter out the finer materials while their root masses help stabilize streambanks and colonize captured sediments. On sites where the potential exists for both woody and herbaceous vegetation, the cumulative effect of plant diversity greatly enhances stream function. Finally, it is essential that the physiological and ecological requirements of the key woody species, along with key herbaceous species, be understood so that a proper management program can be designed. This includes determining the effects of grazing/browsing on the particular growth characteristics of the species involved.

Utilization Guidelines (if appropriate)—Utilization target guidelines are a tool that can be used to help ensure that long-term objectives are met. Utilization levels of browse or forage can be monitored annually, or more often; whereas progress in reaching long-term resource objectives (such as streambank stabilization, rebuilding of the streamside aquifer, and the re-establishment of beaver, fish, moose, or other big game habitat) can only be determined over a longer period of time. The accomplishment of these long-term objectives relates directly or indirectly to the need to leave a certain amount of vegetation available for other functions (soil stabilization, trapping sediment, wildlife cover, or forage). Utilization monitoring provides a means of insuring that the necessary amount of vegetation is left to protect the site and provide for reaching other vegetation-dependent objectives.

Summary

The establishment of utilization targets for riparian or wetland key plant species and the management of browsing/grazing to ensure these targets are met are critical factors involved in proper riparian or wetland area management. The establishment of utilization targets requires that the manager know the growth habitats and characteristics of the important plant species for which they are managing and how the plant species respond to browsing and grazing. The manager must know the characteristics, preferences, and requirements of the grazing/browsing animals. Therefore, utilization targets should be developed for riparian or wetland areas that:

1. Will maintain both woody species and herbaceous species in a healthy and vigorous state and promote their ability to reproduce and maintain different age classes in the desired riparian or wetland plant community.
2. Will leave sufficient plant residue necessary to protect streambanks during run-off events and provide for adequate sediment filtering, and dissipation of flood water energy.
3. Are consistent with other resource values and objectives (such as aesthetics, water quality, water quantity, and wildlife populations).
4. Will limit streambank instability to acceptable levels.

In many instances, proper utilization guidelines can only be derived over time through trial and error by monitoring, analyzing, and evaluating the results. Initial results may be different than expected. The manager should not hesitate to make changes in key species or utilization guidelines where required to meet objectives.

When establishing utilization targets to ensure riparian or wetland area improvements, guidelines should be considered that will provide a margin of safety for those years when production is less than average. This could take the form of reduction in the utilization targets for both riparian or wetland areas and upland areas to provide additional carryover forage and vegetation necessary for streambank protection and sediment filtering. The importance of providing for adequate vegetation vigor and regeneration at the end of the growing season can not be emphasized enough.

Finally, because of the variation in riparian or wetland sites and management, one standard utilization target is not appropriate. However, utilization should be considered, together with regrowth potential, to ensure the presence of vegetation stubble necessary to the operation of natural stream functions or accomplishment of other land use objectives.

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Clark Fork River Operable Unit
of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix D:
Clark Fork River OU Weed Prevention and Management Planning Information and Weed Species Fact Sheets

U.S. Environmental Protection Agency
Region 8

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April 2004

APPENDIX D

Clark Fork River OU Weed Prevention and Management Planning Information

Invasive Plant Species Prevention

Invasive plants specialize in colonizing disturbed ground. They possess a number of physical traits that allow them to arrive at disturbed sites sooner and grow faster than other plants. With these advantages, they are able to out-compete native species, at least for a time. To counter this, EPA plans to avoid disturbing existing vegetation whenever possible. Such disturbance exposes the soil surface and reduces desirable vegetation, creating ideal opportunities for weed colonization. If disturbance cannot be avoided, all disturbed areas would be re-seeded or re-planted immediately. Native species or carefully chosen non-invasive introduced species will be used so that "vacant" or bare ground is quickly occupied by desirable plants.

Weeds also invade plant communities that have been degraded by land management practices that expose the soil surface and stress the desirable vegetation. Healthy native plant communities resist weed invasion. One of the best ways to avoid damaging plant communities is to manage livestock grazing to maintain good vigor of native perennial vegetation, especially grasses. Recreationists can also damage vegetation by overusing popular camping areas and creating trails. Dense, vigorous stands of perennial grasses are highly resistant to weed invasion. However, certain very aggressive weeds such as leafy spurge (*Euphorbia esula*), spotted knapweed (*Centaurea maculosa*), and Canada thistle (*Cirsium arvense*) can invade even well managed lands that have dense, vigorous vegetation.

All remedial activities on a property will follow strict guidelines for preventing the spread or introduction of invasive species to the site. Specific practices designed to avoid transporting weed materials and introducing weeds will be strictly followed and monitored. These will include the following:

- Educating all project personnel in weed identification and prevention. Local Weed Boards, such as the Powell County Weed Board can provide assistance in this process.
- Ascertaining that all equipment used in remediation (including all vehicles and digging tools) be thoroughly washed and inspected for plant matter before entering the OU, and before entering a new property or new site.
- Requiring adherence by all personnel on site to prescribed practices for prevention of weed dispersal.
- Minimizing movement of personnel and vehicles on the property, and limiting access to specifically identified necessary routes, parking, and staging points.
- Designing all work to minimize soil surface disturbance.

- Re-vegetating all disturbed soil surfaces with appropriate vegetation (e.g., native species, including agronomic varieties for rangelands, and appropriate species for croplands, such as alfalfa) to deny opportunity to invasive species.
- Identification and control of pre-existing weed populations on the site to remove nearby sources of invasive species.

Integrated Weed Management Monitoring and Evaluation Plan

Factors to Consider

If a monitoring program is simple and straightforward, it is more likely to be completed and to provide useful information. The effort you invest in monitoring depends on what could happen if your management actions are not working or are counter productive. A higher risk of failure means more effort should go toward monitoring. For example, using high densities of livestock to control weeds requires close and frequent attention to the forage available to avoid overgrazing. Also, eradicating high-priority weed species may require more monitoring than the suppression of low-priority species because eradication of high-priority species will be a much more important goal.

Monitoring, like weed control, is an ongoing process. Although the information gathered in the early days of a monitoring study is certainly valuable, its value is enhanced by comparison with every future piece of data. Even a simple monitoring program may not yield easily interpreted results with the first few repetitions. However, the likelihood of detecting useful trends increases with each year of monitoring.

One of the limitations of most monitoring programs is their inability to determine cause and effect. Although monitoring data can tell you if a weed species decreased in abundance, the data cannot definitely tell you if your weed control actions *caused* the decline. It is possible that a decline in weed abundance would have happened anyway, due to unfavorable weather or other factors. Determining cause and effect requires replicated, controlled experiments where all relevant factors are closely controlled except for one that is varied. Such experimentation is normally performed by university, government, and industry researchers, and is not usually practical for private landowners or public land managers. However, there are some places where land managers could conduct experiments; for example, testing whether two weed treatments differ in their ability to control a weed species.

Setting Monitoring Priorities

Using your previously identified high-priority weed species and infestations, decide which of the species and infestations you will monitor, based on the number of weed species and weed infestations and the resources at your disposal. In addition, you need to decide how intensively to monitor the species and infestations, that is, how much effort you are willing to devote to monitoring.

Establish a minimal level of monitoring for each high-priority weed species and high-priority weed infestation in each of your weed management units. In addition, you should establish a system of recording and tracking herbicide applications and bio-control releases.

We suggest that you monitor at least:

- Two sites where each high-priority weed species occurs
- One high-priority weed patch

There will probably be some overlap in the above categories that will reduce your monitoring work. For example, if one of your high-priority weed species is Canada thistle (*Cirsium arvense*) and two of your high-priority weed infestations are patches of Canada thistle (*Cirsium arvense*), monitoring those two patches would satisfy your minimal monitoring needs for Canada thistle (*Cirsium arvense*).

Designing Monitoring Actions

The challenge of monitoring is to find a balance between the time and money spent monitoring and the value of the information you expect to obtain from monitoring. There is a direct relationship in monitoring between the time required to collect information and your ability to determine if your weed control objectives are being met. If you spend less time collecting and analyzing monitoring data, you will be less able to evaluate your weed management actions. Conversely, if you spend more time and money monitoring, you will have a better idea if you are meeting weed management objectives.

The methods used to monitor the high-priority weed species and infestations depend on weed management objectives. Thus, the complexity of monitoring depends on what you need to know to determine if weed management objectives are being met. Examples of several weed management objectives and monitoring methodologies are presented below. Note that many of the monitoring actions are very simple and their "analysis" is largely self-evident. Keep monitoring actions as simple as possible to increase the likelihood that you will actually monitor your weeds and understand the results of the monitoring. Most private landowners will not need to conduct complicated monitoring programs involving formal statistical tests, and will not need to monitor as many plots.

Review your weed management objectives to see if you can re-word them so they can be evaluated with simple monitoring actions. Make sure your objectives specify time, numbers, and location.

Written Records

The most basic form of monitoring consists of taking careful notes of:

- Sizes of the high-priority infestations and the general abundance of the weeds in those infestations.

- General extent and abundance of the high-priority weed species that are not found in the high-priority infestations.

For weed management objectives that specify eradicating a patch of weeds, the only monitoring required it to note whether the patch is present or not. A few sentences in a field notebook will be sufficient documentation. Consider buying a field book of the type that surveyors use. These books are very sturdy and will last for years. A very simple way to monitor weeds is to use a tape recorder to record observations while you drive, ride, or walk around your property. You can transcribe the tapes during the winter when you are not as busy.

Photographic Records

Photographs can be extremely useful in documenting changes in weeds over time, especially if they are taken from permanent locations (called photo points) each time. Photographs work best for monitoring weed species, which can be easily distinguished from other plants during flowering. Examples of these types of species include leafy spurge (*Euphorbia esula*), whitetop (*Cardaria draba*), Dalmatian toadflax (*Linaria dalmatica*), and spotted knapweed (*Centaurea maculosa*).

Photo points can be established adjacent to high-priority weed infestations since these sites are likely be relatively small. Carefully select the location of the photo point so that all or nearly all of the area can be seen from the photo point. Mark the location of the photo point with a permanent marker to enable it to be relocated for subsequent monitoring photographs. Sturdy red 18-inch plastic stakes (Plastake®) are also available from mail order outlets such as Ben Meadows or Forestry Suppliers.

Take photographs when the target weed is most visible, usually during the period of peak flowering. Try to include obvious background features such as fences, trees, cliffs, and distant mountains as an aid to repeating the photograph with the same scene every year. Carry prints of last year's photographs mounted in plastic sleeves in the field, to help you frame the scenes correctly and to provide instant visual comparisons of weed abundance. One or more photographs may be taken at each photo point depending on the place. Use a 35-mm camera with color film or a digital camera. Note the locations of the photo points on your weed map with an arrow showing the direction of the photograph, and give each point a unique number. Keep a log of pictures taken (possibly in the field notebook), matching the number of the exposure with the number of the photo point and the scene being photographed. Write the photo point number and the date on each developed photograph or slide as soon as you receive them otherwise you may forget to do it. Cameras that automatically include the date in the picture are handy for photo monitoring.

Test Monitoring Actions

Monitoring actions should be tested to see if they will really work in the field. Often ideas that seemed great in the office do not work very well in the field. Testing your monitoring methods before embarking on your monitoring program can save time and money in the end. It is much easier to redesign a monitoring protocol after a failed test than to redesign the program half way through the monitoring period. Questions to consider during the pilot phase of a monitoring program include:

- Will the data collection methods really work in the field? You may discover that it is not practical to count certain species to estimate density, or that thick vegetation prevents sampling plots from being laid out uniformly. Permanently marked plots may not be easy to relocate after all. Such problems need to be identified and corrected before you commit large amounts of time and resources to a monitoring program.
- Is the cost and time of performing monitoring acceptable? You may discover that it takes too long to collect the data called for in your original monitoring design, or that

monitoring actions are too expensive. It is important to design a monitoring program that you can afford to implement. A less ambitious program is better than none at all.

- Will the observations allow you to detect changes? Given the constraints of field methods, time and money, the bottom line is whether or not the monitoring will allow you to evaluate the effectiveness of weed control actions.

Keep in mind that the usefulness of monitoring arises from its repeated nature. You must continue to monitor to detect changes, which will affect your management decisions.

Implement the Monitoring Plan

The most critical step in any monitoring program is to begin doing it. If you do not do the monitoring, you will not be able to determine if you are meeting your weed management objectives. Monitoring will save you money by insuring that your control efforts are as effective as possible. After you begin monitoring, perform the following cycle of tasks:

1. Perform monitoring by collecting field data according to plan.
2. Analyze and evaluate monitoring results immediately after each data collection.
3. Determine whether weed management actions need to be revised, given the results of monitoring analysis.
4. Implement weed management actions again, revise as necessary.
5. Evaluate monitoring actions (analyze data), revise as necessary.
6. Begin the cycle again.

Whenever possible, share the results of your monitoring with other weed managers, and help to build a base of weed control knowledge that others can use in the fight against noxious weeds. Do not over-respond to your monitoring results. You may need to give a treatment method more than one year of trial. Check with other land managers in your area to see if it was a particularly "good" year for your weed species.

Do not forget to include repeated reconnaissance for new weed species and infestations in your monitoring program.

Information on monitoring and evaluation used is from a variety of sources including the Center for Invasive Plant Management (CIPM) at Montana State University (2003) and the Colorado Department of Agriculture (2000). Monitoring is an essential component of a weed control program. Monitoring is the repeated collection and analysis of information to evaluate progress in meeting resource management objectives. Periodic observation of weeds being managed is necessary to evaluate the effectiveness of a weed control program. Monitoring saves money by helping to determine what is working and what is not.

Integrated Weed Management Options

The *Record of Decision* for the Clark Fork River Operable Unit (OU) states that on each remedial site, a plan for management and control of invasive species will be written to address those weeds already present, as well as the potential for further invasion. Taken into account will be the unique set of physical site and managerial factors identified for the property in consultation with the landowner and other involved parties. This plan will be designed as an Integrated Weed Management approach based on the invasive species identified. It will draw from individually prescribed practices for each weed species using such types of options as those described herein (CIPM 2003, Colorado Department of Agriculture 2000).

Cultural Control

Cultural control seeks to control weed problems by establishing desired plant species in healthy populations that will deny opportunity for weed establishment. Cultural techniques include manipulating the plant community through seeding desired species, planting of established containerized material, and cultivating areas previously invaded by weeds (cutting through and turning over the soil, re-seeding, fertilizing and irrigating).

Best suited for:

- Large construction projects. Cultivating is often necessary to reduce the number of weed seeds in the soil before planting desirable plant species. Cultivating for a year prior to reseeding kills weeds that have sprouted since the last cultivation and progressively reduces the bank of weed seeds.
- Re-establishing native plant communities on disturbed or depleted areas so desirable plants can prevent or reduce weed infestation.

Limitations include:

- Cultivating is appropriate only for restoration of drastically disturbed sites.
- Lack of seeds from locally adapted plants.
- Lack of seeds of certain native species, especially forbs and shrubs.

Pitfalls include:

- Seed mixes may be contaminated with weed seeds.
- Cultivation may result in wholesale germination and establishment of weed species if there is not adequate follow-up weed control.
- Temporary cover crops such as wheat, rye, or barley used to reduce soil erosion must be mowed or grazed to eliminate their seed production.
- Promoting weed growth by adding unneeded nitrogen fertilizers. Native plant species are generally adapted to low-nitrogen conditions, while weed species are adapted to high nitrogen conditions. Only add nitrogen fertilizer if tests show that soil nitrogen levels are insufficient to support native species.
- Common components of commercial seed mixes such as yellow sweet clover (*Melilotus officinalis*), smooth brome (*Bromus inermis*), and Kentucky bluegrass (*Poa pratensis*) are often considered weeds in the context of natural lands and natural areas.
- Importing weed seeds on borrowed or rented equipment. You can reduce this risk by inspecting equipment before it enters your property or you can insist that the equipment must be cleaned first.

Biological Control

Biological control is the use of insects or other natural predators to control the growth of a specific plant species. The insects usually come from the invasive plant's native habitat and all have been extensively tested to ensure that they will not attack plants other than the one they are targeting. Once insect populations are established, they can often support their own growth and expansion. Different insects attack different parts of plants at different times, but over time may decrease seed production and growth rate.

Best suited for:

- Reducing seed production or weakening plants.
- Large, dense infestations where other control methods are not cost-effective.
- Situations where a reduced but effectively permanent presence of a noxious weed species is acceptable.

Limitations include:

- Failing to eradicate the target plant species. Do not use bio-control agents where you seek to eradicate a weed population. Eradication of weeds with biological agents never occurs.
- Use of biological control is effectively an admission that a particular weed species is here to stay and that this is acceptable.
- Feasible for only a handful of weed species because of the high cost of finding, screening and testing potential control organisms. Biological controls have a mixed record with some tremendous successes but also with many failures.
- Rarely successful as the sole means of control of a weed species.
- Lack of effective biological control agents for most noxious weed species.
- Biological control agents may be unavailable when you want them.
- Necessity of having a reservoir of host weeds to support biological agents over the long term. Thus, it may be necessary to leave some weeds to support populations of control organisms. This may be unpopular with neighbors or the public.
- Degree of control is variable and will take several years to achieve.

Pitfalls include:

- Insects attacking beneficial, non-target plants. The weevil *Larinus planus*, introduced for control of Canada thistle (*Cirsium arvense*), has been reported to attack native thistle species as well. Insects that have been released to control St. Johnswort (*Hypericum perforatum*) also feed on native *Hypericum* species, and some insects released for controlling leafy spurge (*Euphorbia esula*) also attack native spurge species.
- Inability to establish populations of biological control organisms for reasons relating to climate, soils and so forth that are not well understood.

Grazing

Grazing is the use of sheep, goats, cattle, or horses to control weed growth. Sheep and goats are most commonly used in this function because they often eat plants rejected by cattle and horses. Animals will eat plants at specific stages of the plants' growth, so it is important to be informed about what animal is the best agent at different times of the year. It is also very important to make sure the land is not over-grazed and that the animals are moved before they start to eat the desired plants, which would eliminate the desired plant community competition with the invaders.

Best suited for:

- Weeds that are palatable (at least at some point during the year) and non-toxic to livestock. Weeds vary greatly in their palatability to types of livestock. Generally speaking, the preference for grasses declines from horses to cattle to sheep to goats. Furthermore, goats and sheep are more likely than horses or cattle to relish broadleaf weeds (forbs).
- Leafy spurge (*Euphorbia esula*) control. Goats and sheep are very effective control agents for all but the smallest infestations, especially in riparian areas.
- Low-level, widespread weed infestations where other control techniques are not cost-effective.

Limitations include:

- Lack of availability of goats and sheep or even cattle when and where you need them.
- Need for water and fencing or herding to control livestock movement.
- The need to manage the intensity and duration of livestock grazing carefully to avoid overgrazing, and allow desirable species to recover from grazing impacts.
- Areas where predators such as coyotes, mountain lions, and black bears may kill grazing animals, especially sheep and goats.
- Using the proper kind of animal to manage the weeds on your property.
- Need for someone with knowledge of animal husbandry to manage the animals.
- Palatability of weeds varying widely throughout the growing season. For example, young shoots of Canada thistle (*Cirsium arvense*) are very palatable to cattle, while old, mature stalks are not. However, palatability of many weeds can be greatly increased by spraying them with a dilute solution of molasses.

Pitfalls include:

- Expecting livestock to control weeds without close management. Simply turning animals into a pasture and expecting weed problems to vanish would likely be counterproductive.

- Failing to manage the intensity and duration of livestock grazing to prevent the animals from depleting the desirable plant species they are grazing, or creating disturbance, which favors the establishment of weeds.
- Spreading weed seeds in fur or in manure when animals are moved from one area to another. Grazing should be done before weeds set seed.
- Toxicity of weeds such as poison hemlock, halogeton, St. Johnswort (*Hypericum perforatum*), and Russian knapweed (*Centaurea repens*) to grazing animals; toxicity can vary greatly by type of animal.

Herbicide

Although herbicides must be used with extreme care and caution, they are one of the most effective ways of quickly managing weed populations for the short term. When considering what herbicide to use, look at what weeds are present, how close they are to water, and what time of year is best to apply the chemical. Herbicides often work best if applied more than once and in conjunction with other control methods.

Best suited for:

- Eradicating some weed species in certain places. Herbicides are most effective on pure stands of a single weed species where desirable non-target plants are scarce or absent. In this place, one often has the option of selecting from several different herbicides.
- Rhizomatous weed species that are unpalatable to livestock, require repeated pulling or cutting for control, or are located in remote areas where pulling or cutting are not feasible.
- Small patches of weeds where hand pulling or cutting is not effective or feasible.
- Use in combination with other control methods. For example, Canada thistle (*Cirsium arvense*) can be controlled by repeated cutting during the growing season followed by treatment with clopyralid herbicide in the fall. Russian olive (*Elaeagnus angustifolia*) can be controlled very effectively by cutting stems very close to the ground in the fall then immediately spraying or painting the cut stems with triclopyr herbicide.

Limitations include:

- Damaging or killing non-target plants. Herbicides are not completely selective in their toxicity to the target plant species. Effects on non-target plants can be minimized by selecting an appropriate herbicide and using a wick or a backpack sprayer. A wick is made from adsorbent material and saturated with herbicide. This wick is rubbed directly against the weeds so the herbicide is not applied to adjacent, desirable plants.
- Difficulty of using herbicides to control small weeds when they occur among taller desirable plant species.
- Toxicity to humans to varying degrees. Thus, their use is regulated by federal and state laws. People who use herbicides need to know these regulations. Certain herbicides are classified as "restricted use herbicides" whose application is limited by federal and state regulations.

- Restricted use herbicides are often available only at licensed outlets such as your local farm co-op or by ordering through reputable distributors.
- Property owners must possess a private applicator's license to apply a restricted use herbicide on their property.
- Herbicides must be applied in conformance with the label. With herbicides, the label is the law, and applying an herbicide beyond the bounds specified on the label is illegal.
- Certain herbicides may not be used around or on water. This is an important consideration for weeds that grow in wetlands or riparian areas.
- One must possess the proper equipment and requisite knowledge to apply chemicals safely. Proper clothing must be used, and materials to contain spills must be on hand when using herbicides.
- Herbicides can move beyond the area where they are applied and affect non-target plants and animals. This drift can be eliminated by using a wick or reduced by spraying under calm wind conditions and by adjusting the sprayer apparatus to produce large droplets.
- Populations of weeds may develop resistance to a particular herbicide over time.
- Opposition to the use of chemicals in the environment, especially in urban areas. Local opposition in some areas may pose challenges for the use of some or all herbicides.
- Like most other control methods, herbicides are short-term solutions that do not address reasons for weed problems in the first place. Therefore, spraying an herbicide treats a symptom of a problem. Even if an herbicide eradicates a weed infestation, another infestation may appear if the underlying cause of the infestation persists.

Pitfalls include:

- Simplifying diverse plant communities by suppressing certain plant species, although this effect may be temporary.
- Herbicide applicators who cannot distinguish noxious weeds from desirable plant species, resulting in accidental damage to the latter.

Hand Pulling

One of the most labor-intensive methods of weed management, hand pulling is a viable option for small infestations. Hand pulling does not work on plants with rhizomatous root systems because it will stimulate the plant's growth. Pulling is often best in the spring before the weeds have an extensive root system. Tools like the weed wrench greatly assist in pulling small bushes or plants with long taproots.

Best suited for:

- Small infestations where the entire patch can be pulled.
- Annual and biennial plants (although seed banks will remain for some time).

- Shallow-rooted species that do not resprout from any residual roots.
- Plants growing on sandy or gravelly soils. (If possible, concentrate on pulling when the soil is moist and soft, such as after a soaking rain.)
- Places where more effective methods cannot be used or are undesirable.

Limitations include:

- Pulling generally may not remove the entire root system of the plant. Thus, pulling is ineffective for rhizomatous species such as Canada thistle (*Cirsium arvense*) or leafy spurge (*Euphorbia esula*), even if used in conjunction with other techniques. *If pulled weeds contain seeds, they should be removed from the site and burned or disposed in a landfill. Do not compost this material!*
- Pulling will not reduce a soil seed bank, although it can keep a seed bank in the soil from increasing.
- Pulling is not cost effective for large infestations.
- Pulling may not be cost effective for small infestations, either; unless plants are easy to pull and a volunteer work force is available.

Pitfalls include:

- Volunteer burnout from endless hours of boring work.
- Soil disturbance which stimulates germination of weed seeds in soil.
- Creating bare soil spots as sites for weed seed germination and establishment.
- Some weeds produce chemicals causing allergic reactions in some people. Always wear gloves and a long-sleeved shirt for pulling plants. Wash your hands with soap and water afterwards.

Cutting and Mowing

Mowing can be effective in some places if it is done at the correct time of the weed's growth cycle. However, mowing can stimulate many plants' growth. Additionally, mowing damages as many native plants as invasive and usually requires multiple field entries over a span of years to kill all the weeds. Generally, after mowing the sites will need to be re-seeded, which is another step in a labor-intensive procedure. Nonetheless, used in conjunction with other methods, mowing can be an adequate option in a long-term plan.

Best suited for:

- Large, relatively flat and dry areas that can be mowed with few safety or equipment concerns.
- Preventing tall, erect biennial weed species, such as mullein, from setting seed when other control techniques are not feasible.
- Preventing the "tumbleweed" action of certain weed species such as kochia and Russian thistle that spreads seeds across wide areas.

- Weakening the plants by depleting root reserves through repeated mowing.
- Combining with other control methods, such as herbicide treatment. Cutting can be extremely effective for killing certain trees and shrubs if it is combined with herbicide treatment of the cut stumps. For example, cutting the stems as close to the ground as possible in the fall and immediately (within 30 seconds) painting the cut stumps with triclopyr herbicide kills Russian olive (*Elaeagnus angustifolia*).
- Small infestations of fleshy-stemmed biennial thistles are easy to cut with a sharp machete. These thistles include Scotch, musk, plumeless, and bull thistles.

Limitations include:

- Rarely killing weeds.
- Sites that are inaccessible or too rocky cannot be mowed, although weed whips and machetes can be effective in such places.
- Having to repeat mowing frequently for control to be effective.
- Cut plants re-sprouting to larger sizes than prior to cutting (Russian olive [*Elaeagnus angustifolia*]).
- Weakening rhizomatous plants only slightly, unless the frequency of cutting is very high.

Pitfalls include:

- Failing to remove and dispose of cut stems if they contain seeds.
- Dislodging rocks from the mower may be dangerous to the mower operator.

Weed seeds spread by mowing equipment to areas previously free of infestations. Clean equipment which has been used in weed infested areas before moving it to another area. Make sure that borrowed or rented equipment is free of weed seeds by inspecting equipment before it enters your property. Or, you can insist that the equipment must be cleaned first.

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Invasive Plant Species of the Clark Fork River OU

Several invasive plant species are already well established within the Clark Fork River OU, while several others have quite limited occurrence in Reach A. Some species are among the most commonly encountered plants in some areas, while others are rare thus far. Included below is a list of twelve species of invasive plants. Brief individual fact sheets are provided for each weed species. The information for this list came from a variety of sources, including CIPM at Montana State University (2003), and the Colorado Department of Agriculture (2000). The species include the following:

- Canada thistle (*Cirsium arvense*)
- Common tansy (*Tanacetum vulgare*)
- Dalmatian toadflax (*Linaria dalmatica*)
- Houndstongue (*Cynoglossum officinale*)
- Kochia (*Kochia scoparia*)
- Leafy spurge (*Euphorbia esula*)
- Perennial pepperweed (*Lepidium latifolium*)
- Russian olive (*Elaeagnus angustifolia*)
- Russian thistle (*Salsola iberica*)
- Spotted knapweed (*Centaurea maculosa*)
- Yellow toadflax (*Linaria vulgaris*)
- Whitetop (*Cardaria draba*)

Canada Thistle

Cirsium arvense (L.) Scop.

Family: *Asteraceae* (Sunflower)
Other Names: field thistle, Californian thistle
Six Letter Code: CIRARV
USDA Code: CIAR4

Keys to Identification:
- Purple flowers form in clusters of 1-5 per branch.
- The floral bracts of Canada thistle are spineless.
- Small heads, vanilla scent.

Identification

Growth form: Perennial forb.
Flower: Flower heads are white to purple and borne in clusters of 1-5 per branch, with a strong vanilla scent. Heads are only about 1 cm in diameter.
Seeds/Fruit: One-seeded fruits (achenes) are straw or light brown in color, straight or slightly curved (Moore 1975).
Leaves: Leaves are spiny, alternate, oblong or lance-shaped, with the base leaves stalkless and clasping, or extended down along the stem.
Stems: Mature plants range from 2-4 ft in height.
Roots: Canada thistle has two types of roots, horizontal and vertical. The horizontal roots produce numerous shoots, while vertical roots store water and nutrients in their many small branches.
Seedling: Early spring growth appears as rosettes with spiny-tipped, wavy leaves.
Other: The floral bracts of Canada thistle are spineless.

Similar Species

Exotics: Bull thistle (*Cirsium vulgare*); flower bracts are somewhat tapered and covered with spines. Musk thistle (*Carduus nutans*); floral bracts are broad with spiny tips. Russian knapweed and Canada thistle are often confused.
Natives: Wavyleaf thistle (*Cirsium undulatum*): flower bracts often have a prominent white glandular dorsal ridge (often sticky to touch) and minutely hairy margins (Whitson et al. 1996).

Impacts

Agricultural: Canada thistle is an aggressive, creeping, perennial weed. It infests crops, pastures, rangelands, roadsides, and riparian areas (Beck 1996).
Ecological: Canada thistle spreads rapidly through horizontal roots, which give rise to shoots (Moore 1975). Its root system can be extensive, growing horizontally as much as 18 ft in one season (Nuzzo 1998). Most Canada thistle patches spread at a rate of 3-6 ft/year, crowding out more desirable species and creating thistle monocultures.
Human: Spiny thickets of Canada thistle can restrict recreational access to infested areas.

Habitat and Distribution

General requirements: Canada thistle thrives in the Northern Temperature Zone due to its day length response and a high temperature limitation on growth (Haderlie et al. 1991). Although Canada thistle mainly invades disturbed areas, it does invade native plant communities, open meadows (including wetlands), and ponderosa pine savanna (Rutledge and McLendon 1998). Canada thistle is adapted to a wide range of soil types and environmental conditions (FEIS 1996). It is best adapted to rich, heavy loam, clay loam, and sandy loam, with an optimum soil depth of 20 inches (FEIS 1996, Rutledge and McLendon 1998). Canada thistle can tolerate saline soils (up to 2 percent salt) and wet or dry soil (Rutledge and McLendon 1998). However, it does not tolerate waterlogged or poorly aerated soils. Canada thistle usually occurs in 17-35 inch annual precipitation zones or where supplemental soil moisture is available (Beck 1996). Canada thistle is also somewhat shade intolerant. It can grow along the edge of forested areas, but is rarely found within forests.

Distribution: Canada thistle is found throughout the northern half of the United States and lower portions of Canada. It is common found along roadsides, fields, pastures, meadows, and other disturbed areas statewide in Montana.

Historical: Canada thistle is a native of southeastern Eurasia. It was introduced to Canada as a contaminant of crop seed as early as the late 18th century. Since its introduction, it has spread throughout North America (Whitson et al. 1996).

Biology/Ecology

Life cycle: Over-wintering roots develop new underground roots and shoots in January and begin to elongate in February (Nuzzo 1998). Shoots emerge between March and May, when mean weekly temperatures reach 5° C, and form rosettes (Nuzzo 1998). Early in the spring, plants remain near the soil surface until long days (over 14 hours of light) trigger flowering and stem elongation (Haderlie et al. 1991, FEIS 1996). Canada thistle is dioecious (male and female flowers are produced on separate plants). Female flowers can be readily distinguished from male flowers by the absence of pollen (abundant in male flowers) and presence of a distinct vanilla-like fragrance. Flowering occurs from June to October (Rutledge and McLendon 1998). Seeds mature July to October.

Mode of reproduction: Canada thistle reproduces primarily vegetatively through creeping horizontal roots, and can quickly form dense stands. Every piece of the root system is capable of forming a new plant (Rutledge and McLendon 1998). This allows dense monocultures of Canada thistle to form even without seed production. Canada thistle growth is limited or stopped when temperatures exceed 30° C for extended periods of time.

Seed production: A female Canada thistle plant can produce up to 5,200 seeds in a season, but the average is about 1,500 seeds/plant (Rutledge and McLendon 1998).

Seed bank: Mature seeds germinate most readily in mid-spring. Seeds that do not germinate may remain dormant for several years but most studies indicate that the majority of seeds do not remain viable after three years of burial (Rutledge and McLendon 1998).

Dispersal: Seeds are distributed by wind.

Hybridization: No information available.

Control

Biocontrol: Currently, there is no single biological control agent that effectively controls Canada thistle. However, there are several agents that have been reported to provide very limited control. One species, *Urophora cardui* (a gall fly), may hold some promise.

Keys to Control:
- Eliminate seed production.
- Reduce the plant's nutrient reserves through persistent management.

Mechanical: Mowing pastures and hay meadows can be an effective control if it is repeated at about one-month intervals throughout the growing season. Combining mowing with herbicides will further enhance control of Canada thistle. However, a recent study (Beck and Sebastian 2000) found that mowing or mowing plus herbicide was only effective where the root system of Canada thistle is restricted by a high water table, such as near rivers or subirrigated meadows.

Fire: Prescribed burning in the spring has been proposed as a means of slowing the spread of Canada thistle. Such fires could reduce the number of mature plants, decrease seed production, and stimulate the growth of native grasses (FEIS 1996).
Herbicides: Chemical control of Canada thistle should be conducted in the spring or fall depending on local environmental conditions. In general, fall treatments are more effective as herbicide absorption is enhanced in the late summer and fall when shoot to root translocation is the greatest. However, translocation of the herbicide is dependent on moist soil conditions. If fall is a dry period in your area, a spring application around the flower bud stage (early June), when root carbohydrate reserves are at their lowest, is recommended. Clopyralid + 2,4-D (commonly sold as Curtail®) applied at a rate of 2-3 quarts/acre will effectively control Canada thistle. Curtail should either be applied in the late spring (when Canada thistle plants are entering the bud growth stage) or in the fall (October) when Canada thistle roots are actively growing. The performance of Curtail can be improved when proceeded by two or three mowings under conditions when the root systems are restricted (Beck 1996, Beck and Sebastian 2000). Begin mowing when Canada thistle is 12-15 inches tall and repeat at about one month intervals (Beck 1996). Apply Curtail in October or about one month after the last mowing. Clopyralid alone can be applied at a rate of 2/3 to 1 pint/acre in the spring or fall. Spring applications should be timed to the rosette to bud growth stages. 2,4-D or picloram are effective when applied at a rate of 1 lb active ingredient/acre in the spring when Canada thistle is in the pre-bud to early bud growth stages (about 10-15 inches tall). For increased control, retreat with dicamba (1 lb active ingredient/acre) in the fall to prevent regrowth of plants.
Cultural/Preventive: Reduce the spread of Canada thistle seeds by always purchasing "weed free" seeds. Quickly eliminate new seedlings before they have a chance to form a well-developed root system.

Integrated Management Summary

The tendency of this species to grow in wet areas may restrict the use of certain herbicides. Control efforts should target Canada thistle plants in high-quality areas first (typically areas that contain mostly native species and few undesirable species), and then work on controlling lower quality areas (areas that are already infested with undesirable species and have fewer desirable species present). Management strategies should be adjusted to reflect weather conditions (Nuzzo 1998). For example, drought stress reduces the effectiveness of most herbicides, but increases the effectiveness of mechanical controls (e.g., mowing or burning). It takes at least two years of control to determine whether a particular method is effective. Several studies have recorded a temporary decline in Canada thistle in the first year of control followed by a return to the pre-treatment conditions the second growing season (Nuzzo 1998). For one example of Canada thistle control, see page 60.

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Common Tansy

***Tanacetum vulgare* L.**

Family: *Asteraceae* (Sunflower)
Other Names: garden tansy
Six Letter Code: TANVUL
USDA Code: TAVU

Keys to Identification:
- Flower heads contain button like flowers without ray flower "petals."
- Stems are often purplish-red in color.

Identification

Growth form: Perennial forb.
Flower: Yellow flowers are numerous in flat-topped dense clusters at the tops of the plants. Button like flower heads lack ray flowers.
Seeds/Fruit: Seeds are yellowish brown achenes with short, five-toothed crowns.
Leaves: Leaves are alternate, deeply divided into numerous narrow, individual leaflets.
Stems: Mature plants are 1.5 to 6 ft tall. Stems are often purplish-red in color.
Roots: Rhizomatous.
Seedling: No information available.
Other: Rank smelling foliage.

Similar Species

Exotics: None known.
Natives: None known.

Impacts

Agricultural: Common tansy is considered undesirable forage for livestock. Although it may be toxic, animals rarely ingest it.
Ecological: May displace native, more desirable species.
Human: Can be toxic if large quantities are consumed.

Habitat and Distribution

General requirements: Common tansy is commonly found along roadsides, stream banks, in waste places, and in pastures. It grows best in full sun and on fertile, well-drained soil.
Distribution: Found throughout the United States.
Historical: Common tansy is a native of Europe that was introduced into North America as an ornamental and medicinal herb (Whitson et al. 1996). It has been used for treating various ailments and as an insect repellent.

Biology/Ecology

Life cycle: Flowering typically occurs from July to September.
Mode of reproduction: Reproduces by both seed and creeping rootstocks.
Seed production: No information available.
Seed bank: No information available.
Dispersal: No information available.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Common tansy can be mowed before flowering and seed set to eliminate seed production. This method may have to be repeated to eliminate regrowth from the rootstocks.
Fire: No information available.
Herbicides: Picloram or dicamba at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre can be used to control common tansy. The best time for treatment is between the early flower (bud) to bloom stage (Dow AgroSciences 1998).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Keys to Control:
- Eliminate seed production and vegetative reproduction from creeping rootstocks.
- Re-seed controlled areas with desirable species.

Integrated Management Summary

As with other rhizomatous perennials, mechanical controls such as mowing or hand cutting are most effective in combination with other methods. Plants can regrow from severed roots, and cut stems may still produce viable seed. Control the spread of common tansy by preventing seed production and dispersal, minimizing the spread of cut rootstocks, and establishing healthy stands of desirable species on controlled areas.

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Dalmatian Toadflax

Linaria dalmatica **(L.) Miller**

Family: *Scrophulariaceae* (Figwort)
Other Names: broad-leaved toadflax, wild snapdragon
Six Letter Code: LINDAL
USDA Code: LIDAM

Keys to Identification:

- Dalmatian toadflax can be easily identified by its bright-yellow, snapdragon-shaped flowers.
- Dalmatian toadflax can be distinguished from yellow toadflax by its larger flowers and more ovate leaves (rather than the linear, somewhat pointed leaves that are characteristic of yellow toadflax).

Identification

Growth form: Perennial forb.
Flower: Flowers are borne in loose, elongate, terminal racemes. Flowers are bright yellow and resemble snapdragons.
Seeds/Fruit: Fruits are egg-shaped to nearly round capsules. Seeds are sharply angular, and slightly winged.
Leaves: Leaves are broad, ovate to ovate-lanceolate, and are alternate, generally clasping but crowded.
Stems: Mature plants are up to three ft tall. A single toadflax plant contains from 1-25 vertical floral stems which are thick-walled and somewhat woody.
Roots: The taproot may penetrate one meter into the soil. Horizontal roots may grow to be several meters long, and can develop adventitious buds that may form independent plants.
Seedling: No information available.

Similar Species

Exotics: Yellow toadflax *(Linaria vulgaris)* is similar in appearance, but has more linear pointed leaves, and is generally a smaller plant.
Natives: None known.

Impacts

Agricultural: Low-till cultivation practices have contributed to the resurgence of toadflax populations on agricultural lands (McClay 1992). Dalmatian toadflax contains a glucoside, a quinoline alkaloid, and peganine, which make it toxic to livestock (Rees et al. 1996). However, dalmatian toadflax is generally considered unpalatable, and reports of livestock poisonings are rare.
Ecological: Dalmatian toadflax is a persistent, aggressive invader and capable of forming colonies through adventitious buds from creeping root systems. These colonies can push out native grasses and other perennials, thereby altering the species composition of natural communities. New infestations of dalmatian toadflax can occur in naturally occurring disturbances or in small openings in pristine or excellent-condition rangeland (Lajeunesse 1999). Dalmatian toadflax can rapidly colonize open sites. It is most commonly found along roadsides, fences, rangelands, croplands, clear cuts, and pastures. Disturbed or cultivated ground is a prime candidate for colonization. Toadflax can significantly reduce crop yields and stress native communities. In one study, toadflax-free plots produced 2.5 times more grass than plots where toadflax was present (Robocker 1974). The seedlings of toadflax are considered ineffective competitors for soil moisture with established perennials and winter annuals (Morishita 1991).

However, once established both species of toadflax suppress other vegetation mainly by intense competition for limited soil water. Mature plants are particularly competitive with winter annuals and shallow-rooted perennials (Robocker 1974).
Human: No information available.

Habitat and Distribution

General requirements: Dalmatian toadflax can adapt its growth to fit a wide range of environmental conditions, and is tolerant of low temperatures and coarse-textured soils.
Distribution: Dalmatian toadflax in Montana this weed has escaped from gardens to become a serious invader of rangeland, mountain meadows, and waste areas. Large infestations of it are found in Missoula and Lake Counties in western Montana.
Historical: Dalmatian toadflax is a native of the Mediterranean region from Yugoslavia to Iran (Robocker 1974).

Biology/Ecology

Life cycle: Spring emergence occurs about mid-April and depends primarily on temperature. During the first year the plant forms a rosette and develops a deep root system. Prostrate stems emerge in September and produce ovate leaves. Prostrate stems are tolerant to freezing and are associated with floral stem production the following year (Robocker 1974). The strong upright floral stems that characterize mature toadflax plants develop after a winter's dormancy, and emerge about the same time as new seedlings in mid-April. A single plant will produce from 1-25 floral stems. Flowering occurs from May-August and seeds mature from July-September. Dalmatian toadflax can also reproduce vegetatively. Stems develop from adventitious buds on primary and lateral roots. Vegetative reproduction from root buds can occur as early as 2-3 weeks after germination, and is possible from root fragments as short as 1 cm in length (Zimmerman 1996). These buds can grow their own root and shoot systems, and become independent plants the next year. In addition to promoting growth, the large, deep, root systems of dalmatian toadflax exploit water efficiently. The taproot may penetrate 3-4 ft into the soil and lateral roots may be 6-12 ft long.
Mode of reproduction: By seeds and vegetatively
Seed production: A mature dalmatian toadflax can produce up to 500,000 seeds annually (Morishita 1991).
Seed bank: Seeds may remain viable in the soil for up to ten years.
Dispersal: Seeds are winged, and wind-dispersed.
Hybridization: No information available.

Control

Keys to Control:
- Maintain a dense cover of vigorous perennial plants.
- Picloram, dicamba, and glyphosate are effective when applied during flowering.
- Hand pulling is effective for small areas, especially in sandy soils.

Biocontrol: The Division of Plant Industry's Biological Pest Control Section currently has one species, *Calophasia lunula*, that may be available for redistribution on dalmatian toadflax infestations. *C. lunula* larvae feed extensively on leaves and flowers of toadflax, severely damaging the plants.
Mechanical: Cutting or removal of the above ground portion of toadflax plants reduces the current year growth, but it will not kill the plant. Cutting toadflax stands in spring or early summer is an effective way to eliminate plant reproduction through seed production and dispersal. However, the long dormancy of toadflax seeds requires that the process be repeated annually for up to ten years. Hand pulling toadflax before seed set each year can be an effective control method. The hand pulling experiment on The Nature Conservancy's Magnusson Butte Preserve in Washington showed that toadflax can be significantly reduced by pulling once a year as long as new seed is eliminated. Again, this method must be repeated annually for up to ten years to completely

remove a stand. Sheep can help suppress dalmatian toadflax infestations and reduce seed production. The sheep showed no ill effects from eating toadflax and showed good weight gain (Lajeunesse 1999).
Fire: No information available.
Herbicides: Herbicides have highly variable effects on dalmatian toadflax, probably due to its high genetic variability. Fall applications of picloram 0.5-1.0 lb active ingredient/acre has provided excellent control for one year. However, the higher concentrations of picloram may be injurious to desirable plants, plus picloram has been ineffective on some sites. A tank mix of picloram + 2,4-D controlled over 90 percent of dalmatian toadflax when applied pre-bloom or in the fall. A six-year study found that phenoxypropionic herbicides such as diclorprop were more effective at controlling toadflax than phenoxyacetic herbicides such as 2,4-D (Robocker 1968). 2,4-D, MCPA, MCPB, and mecoprop used alone do not control toadflax.
Cultural/Preventive: Intensive clean cultivation techniques are recommended for successful toadflax control on agricultural land. Discing can be an effective method of toadflax control on agricultural lands. This method requires at least two years with eight to ten cultivations in the first year, and four to five cultivations the second year (Morishita 1991). Weed control should be accompanied by reseeding with a variety of plant species to occupy the site so as to prevent re-establishment of toadflax. An ideal mix of species would include cool- and warm-season plants as well as plants that root at a variety of depths. For example, shallow rooted, cool-season species such as Sandberg bluegrass (*Poa secunda*) compete with toadflax seedlings.

Integrated Management Summary

Management of dalmatian toadflax must focus on both reducing the rate of vegetative spread and reducing seed production (Lajeunesse 1999). Successful management requires integrating as many control tactics as possible. Dalmatian toadflax has high genetic variability, and local populations can respond differently to control actions, especially herbicide treatments. Successful control can be obtained by pulling, or killing the plants with herbicide before toadflax seed production begins (Carpenter and Murray 1998). Since the plant also spreads through vegetative propagation, and the seeds can remain dormant for up to ten years, this process must be repeated every year for at least ten years to completely remove a stand. Competitive perennial grasses and forbs should be planted to utilize water and nutrients that would otherwise be readily available to toadflax.

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Houndstongue

Cynoglossum officinale **(L.)**

Family: *Boraginaceae* (Borage)
Other Names: hound's tongue, dog bur, gypsy flower
Six Letter Code: CYNOFF
USDA Code: CYOF

Keys to Identification:
- Five-petaled reddish-purple flowers in panicles.
- Prickly nutlets are distinctive.

Identification

Growth form: Biennial or short-lived perennial forb.
Flower: Flowers are reddish-purple, with five petals, arranged in panicles in the upper leaf axils.
Seeds/Fruit: The fruit is composed of four prickly nutlets each about 1/3 inch long (Whitson et al. 1996).
Leaves: Leaves are alternate, 1-12 inches long, 1-3 inches wide, rough, hairy, and lacking teeth or lobes (Whitson et al. 1996). Leaves often appear dusty and insect-ridden. Basal leaves are elliptical to oblanceolate and tapered at the base.
Stems: Houndstongue produces a single flowering stem. The stem is erect, stout, heavy, 1.5 to 3 ft high and usually branched above.
Roots: Houndstongue has a thick, black, woody taproot.
Seedling: Houndstongue forms a rosette the first year of its life cycle.

nutlets

Similar Species

Exotics: Rosettes may resemble burdock.
Natives: If not flowering, could be mistaken for members of the *Hackelia* or *Lappula* genus (stickseeds).

Impacts

Agricultural: Houndstongue contains toxic alkaloids that stop liver cells from reproducing. Therefore, houndstongue reduces livestock and wildlife forage and grazing animals should be kept away from houndstongue infested areas. Animals may live six or more months after eating a lethal dose of houndstongue. Sheep are more resistant to houndstongue poisoning that cattle or horses. The burs may reduce the value of wool.
Ecological: Houndstongue is an early successional species on recently disturbed sites.
Human: Due to its toxicity to grazing animals, houndstongue should not be eaten by humans.

Habitat and Distribution

General requirements: Houndstongue prefers areas with more than 10 percent bare ground (Butterfield et al. 1996), and is common on gravelly, alkaline soils (Stubbendieck et al. 1995).
Distribution: Houndstongue is found over much of North America. It grows on rangeland, pastures, abandoned cropland, roadsides, and waste places (Butterfield et al. 1996). Houndstongue is found on rangeland, pastures, and roadsides throughout Montana.

Houndstongue

Cynoglossum officinale **(L.)**

Family: *Boraginaceae* (Borage)
Other Names: hound's tongue, dog bur, gypsy flower
Six Letter Code: CYNOFF
USDA Code: CYOF

Keys to Identification:
- Five-petaled reddish-purple flowers in panicles.
- Prickly nutlets are distinctive.

Identification

Growth form: Biennial or short-lived perennial forb.
Flower: Flowers are reddish-purple, with five petals, arranged in panicles in the upper leaf axils.
Seeds/Fruit: The fruit is composed of four prickly nutlets each about 1/3 inch long (Whitson et al. 1996).
Leaves: Leaves are alternate, 1-12 inches long, 1-3 inches wide, rough, hairy, and lacking teeth or lobes (Whitson et al. 1996). Leaves often appear dusty and insect-ridden. Basal leaves are elliptical to oblanceolate and tapered at the base.
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Historical: Houndstongue is a native of Eurasia that was introduced to North America as a contaminant in agricultural seed.

Biology/Ecology

Life cycle: Houndstongue is a biennial that produces a rosette the first year. During the second year a flowering stem bolts and produces fruit.
Mode of reproduction: Reproduces solely by seed.
Seed production: Mature plants can produce up to 2,000 seeds (Butterfield et al. 1996).
Seed bank: Seeds remaining on the parent plant may remain viable for 2-3 years. Buried seed rarely survive more than one year (Butterfield et al. 1996).
Dispersal: Seeds stick to clothing and animals and have the ability to be spread great distances.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Mowing second year plants during flowering but before seed maturation reduces seed production and may kill the plant.
Fire: No information available.
Herbicides: Picloram at 0.25-0.5 lb, 2,4-D, or dicamba at 1.0 lb, or metsulfuron at 0.6 oz active ingredient/acre applied in spring provides control of houndstongue. Spring treatments with picloram, dicamba, or metsulfuron are more effective than fall treatments (Sebastian and Beck 1995). Chlorsulfuron applied 0.5 lb active ingredient/acre gave complete control when applied any time beginning with the rosette stage until the bolted plant had attained 10 inches in height (Butterfield et al. 1996).
Cultural/Preventive: Maintaining a healthy population of native perennials the best way to prevent the establishment and spread of houndstongue.

Keys to Control:
- Eliminate seed production.
- Re-seed controlled areas with desirable species.

Integrated Management Summary

Houndstongue is poor competitor with native perennials and requires disturbed or bare areas to establish. Once established, it quickly forms dense monocultures. Treat first year plants with herbicides. Mow bolted plants to eliminate seed production. Repeat this process for several years to exhaust the seed bank. It is imperative to establish a healthy population of native perennials on treated areas to prevent the re-establishment of houndstongue or other noxious weeds.

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Kochia

Kochia scoparia (L.) Schrad.

Family: *Chenopodiaceae* (Goosefoot)
Other Names: kochia, summer cypress
Six Letter Code: KOCSCO
USDA Code: KOSC

Keys to Identification:
- Flowers are inconspicuous forming dense spikes in leaf axils.
- Five-hook bassia (Bassia hyssopifolia) is distinguished from kochia by the five hooked structures on each seed.

Identification

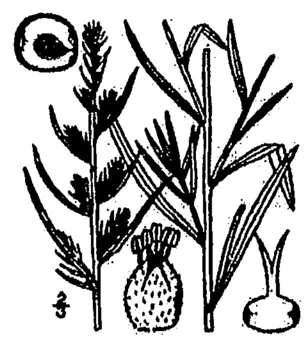
Growth form: Annual forb.
Flower: Flowers are inconspicuous, stalkless in the axils of upper leaves and form short, dense, bracted spikes (Whitson et al. 1996).
Seeds/Fruit: Seeds are wedged shaped, dull brown, slightly ribbed.
Leaves: Leaves are 0.5-2 inches long, alternate, and lance-shaped. The upper surface of the leaf is usually smooth, while the lower surface is covered with soft hairs.
Stems: Mature plants are 1-6 ft tall with numerous branches. Stems are erect, simple to much-branched, and often form pyramidal or rounded tops. Stems are usually hairy, but are occasionally smooth.
Roots: Roots generally penetrate to depths of 6-8 ft.
Seedling: No information available.

Similar Species

Exotics: Five-hook bassia (*Bassia hyssopifolia*) is easily distinguished from kochia by the five hooked structures on each seed.
Natives: None known.

Impacts

Agricultural: Although kochia is readily grazed by livestock, it sometimes contains high nitrate levels and sulfate toxicity (Whitson et al. 1996).
Ecological: Kochia colonizes rapidly and may suppress other vegetation. It is an early successional plant on disturbed sites and can dominate vegetation for the first two years following disturbance (FEIS 1996). Kochia may spread into undisturbed sites when growing conditions are ideal.
Human: No information available.



Habitat and Distribution

General requirements: Kochia is most often found in open, sunny areas on disturbed sites. It grows on a variety of soil types, and is often found on saline/alkaline soils (FEIS 1996). Kochia can also be found in grasslands, mixed-grass prairie, shortgrass prairie, floodplains, riparian areas, sagebrush, and desert shrub communities. Other common associates include salt-cedar (*Tamarix* spp.), sand dropseed (*Sporobolus cryptandrus*), saltgrass (*Distichlis spicata*), and western wheatgrass (*Agropyron smithii*) (FEIS 1996).

Distribution: In Montana, kochia occurs on disturbed grasslands and desert shrub communities.
Historical: Kochia is a native of Eurasia that has become naturalized in the Great Plains and western states (FEIS 1996).

Biology/Ecology

Life cycle: Seedlings emerge very early in the spring. Flowering and seed production may occur from July to October. Kochia is very responsive to elevated soil nitrogen levels, either through some type of soil disturbance or due to fertilization. It will often grow rapidly for 1-2 years in abandoned fields or in badly overgrazed rangeland until the readily available nitrogen is depleted. Then kochia plants are often small, presumably due to the nitrogen limitation. Kochia is rarely a problem in areas where healthy stands of perennial grasses exist.
Mode of reproduction: Kochia reproduces exclusively by seed.
Seed production: Typically, a single plant will produce about 14,600 seeds per year.
Seed bank: Kochia seeds have little seed bank viability, as they either germinate or decay in one year (FEIS 1996).
Dispersal: The major means of seed dispersal is through a "tumbleweed" process.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Grazing or mowing alone will not control kochia or stop seed production (FEIS 1996). Small infestations can be pulled by hand.
Fire: No information available.
Herbicides: Kochia is commonly controlled with herbicides but it is not by phenoxy herbicides at rates recommended for crops (FEIS 1996). Dicamba at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre will control it. Metsulfuron+dicamba is effective.
Herbicides should be applied in early spring after seedling emergence (Whitson et al. 1996).
Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Keys to Control:
- Exhaust the root system and eliminate seed production by mowing or treating with herbicides.
- Maintain a healthy cover of perennial plants to discourage the establishment and spread of hoary cress.

Integrated Management Summary

Even though kochia exhibits extreme reproductive plasticity (in that one plant can produce over 50,000 seeds under favorable conditions, but only 5 seeds under stressful conditions), the limited viability of kochia seeds increases the effectiveness of control methods. As with other plants which reproduce solely by seed, integrated management efforts should focus on the elimination of seed production and the depletion of the seed bank. Combine herbicide or mechanical removal of rosettes with removal of seed heads from any plants that have bolted.

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Leafy Spurge

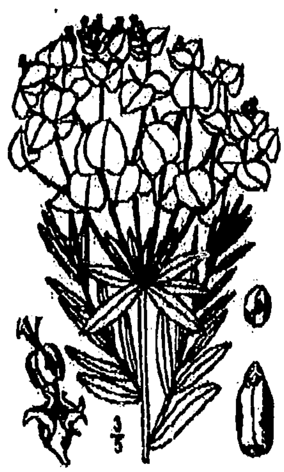
***Euphorbia esula* L.**

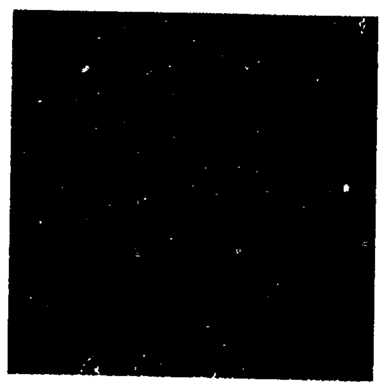
Family: *Euphorbiaceae* (Spurge)
Other Names: none widely accepted
Six Letter Code: EUPESU
USDA Code: EUES

Keys to Identification:
- Flowers are yellowish-green and have a pair of heart shaped yellow green bracts below each inconspicuous flower.
- The entire plant contains white, milky latex.

Identification

Growth form: Perennial forb.
Flower: Flowers are yellowish-green, small, arranged in numerous small clusters and subtended by paired heart-shaped yellow-green bracts.
Seeds/Fruit: Seeds are oblong, grayish to purple, contained in a 3- celled capsule.
Leaves: Leaves are alternate, narrow, 1-4 inches long.
Stems: Mature plants are up to 3 ft tall. Stems are thickly clustered.
Roots: Extensive lateral root system.
Seedling: Seed leaves (cotyledons) are linear to lanceolate, with entire margins.
Other: The entire plant contains white, milky latex. Foliage of the plant is smooth and hairless.





Similar Species

Exotics: None known.
Natives: Leafy spurge is distinguished from native spurges such as *Euphorbia brachycera* by its long linear leaves.

Impacts

Agricultural: Leafy spurge can invade rangeland that is in excellent condition, making it worthless for cattle and horse grazing and reducing land values (Lajeunesse et al. 1999).
Ecological: Leafy spurge is an aggressive, long-lived, perennial weed that can displace all other vegetation in rangeland, pasture, and native habitats (Biesboer 1998). Leafy spurge decreases rangeland diversity, threatens native plants and degrades wildlife habitat (Lajeunesse et al. 1999). It produces a large number of seeds and underground shoot buds. These two reproductive techniques allow it to rapidly displace native species, and form a monoculture. Rapid re-appearance of treated stands often follows an apparently successful eradication because of the large nutrient reserve in the roots. Leafy spurge produces an allelopathic compound that inhibits the growth of other plants (Butterfield et al. 1996).
Human: The milky latex sap of leafy spurge can cause irritation, blotching, blisters, and swelling in sensitive individuals.

Habitat and Distribution

General requirements: Leafy spurge grows in a wide range of habitats. It is most aggressive in semi-arid areas, but can be found in xeric to subhumid and subtropic to subarctic habitats (Butterfield et al. 1996). Leafy spurge occurs most commonly on untilled, non-crop areas such as rangeland, pastureland, woodland, prairies, roadsides, stream and ditches, and waste sites. It grows on all kinds of soils, but is most abundant in coarse-textured soils and least abundant on clayey soils (Butterfield et al. 1996).

Distribution: Leafy spurge is widely distributed in Montana and throughout the United States.

Historical: Leafy spurge is native to Eurasia. It was brought to northeastern United States in 1829 as an ornamental, and had spread to the west coast by the early 1900s.

Biology/Ecology

Life cycle: Leafy spurge is one of the earliest plants to emerge in the spring, usually in mid-April to late May (Butterfield et al. 1996). The development of terminal flower clusters begins 1 to 2 weeks after stem emergence. Flower clusters have 8 to 16 branches. Each branchlet forms a greenish yellow bract in May. Flowering generally ends in late June to mid-July as the plants do not usually flower, and growth is reduced, during the hotter portion of the summer. However, if conditions are favorable, leafy spurge may produce a few lateral flowers throughout the summer and in the fall. Thus, it is possible for the plant to produce seed until frost. Seeds mature about 30 days following pollination. Peak germination occurs from late-May to early June. If adequate moisture is present, germination can occur throughout the growing season.

Mode of reproduction: Despite being a successful seed producer, leafy spurge primarily reproduces vegetatively through its extensive lateral root system. Long roots have the capability to produce shoots and can reach nearly 15 ft laterally, and about 30 ft in depth. As many as 300 buds have been counted on these long roots (Butterfield et al. 1996).

Seed production: Each flowering stem produces from 10-50 capsules with a seed yield range of 200-250 seeds per flowering shoot (Best et al. 1980). A large plant may produce up to 130,000 seeds (Rutledge and McLendon 1998).

Seed bank: Seeds can remain viable in the soil for 5-8 years although 99 percent of the viable seeds will germinate in the first two years (Butterfield et al. 1996).

Dispersal: The three-sided capsules explode when ripe, sending the enclosed seeds up to 15 ft from the parent plant. Seeds float on water, and can be transported and deposited by floodwater.

Hybridization: No information available.

Control

Biocontrol: Currently, there is extensive research on biological control agents for leafy spurge with over 15 insects being studied (Biesboer 1998). However, control of leafy spurge by insects is often limited by the thick milky latex, which tends to clog the mouth or sucking parts of most insects (Butterfield et al. 1996). Successful biological control will most likely require a combination of insects and a long-term management program to establish them. The Division of Plant Industry's Biological Pest Control Section has released eight species in an effort to control leafy spurge. Three of these species, *Aphthona nigriscutis*, *A. cyparissiae*, and *A. czwalinae/lacertosa*, have become established and may be available for distribution from the Insectary. The most effective biological control agents seem to be six species of root- and foliage-feeding beetles in the genus *Aphthona*, and a stem- and root-boring beetle *Obera erythrocephala* (Lajeunesse et al. 1999).Grazing sheep on infested areas has been used successfully to control spurge on ranches in Montana, but ranchers agree that once the sheep were removed the spurge

Keys to Control:

- Develop a management scheme that uses several control methods that are compatible with your site.
- Persistently monitor your area and quickly control new infestations.

would quickly return (Biesboer 1998). Sheep grazing is likely to be most effective in the spring and summer when the spurge plants are succulent and when sheep tend to prefer forbs over grasses, rather than in fall when sheep forage more on grasses (Lajeunesse et al. 1999). Two grazing periods during the spring-summer with a recovery period (for the grasses) between are recommended rather than season-long grazing. Fall grazing by goats followed by application of picloram and 2,4-D (each 1 quart/acre) can provide good control (Lajeunesse et al. 1999). A recent study near Denver found that sheep grazing for a short period in early July every year for 5 years reduced leafy spurge density by 90 percent. This study also produce excellent results by combining sheep with *Apthona* beetles (Beck and Rittenhouse, 2000).

Mechanical: Tillage is not generally a practical control method for areas where leafy spurge grows. Mowing can actually increase the density of leafy spurge, and may not be effective even when combined with herbicide (K.G. Beck, personal comm.). Pulling leafy spurge is ineffective, even for small infestations because of the deep root system and the presence of numerous root buds.

Fire: Burning alone will not likely provide adequate control of leafy spurge due to regeneration from the root system. However, combinations of burning and herbicide application 5 weeks later might provide adequate control (Biesboer 1998). In one study, plots of leafy spurge were sprayed with a mix of 2,4-D and picloram in September and burned the following April. The plots were sprayed again in June and burned again in October (Biesboer 1998). This process is designed to exhaust the nutrient reserves in the root system of the plant and hinder its ability to compete with other species. Therefore, reseeding desirable species is also necessary.

Herbicides: Herbicides can provide some control of leafy spurge. However, due to its extensive root system and general hardiness, follow up applications are necessary for herbicides to be effective. Picloram is recommended for eradication of small infestations, with herbicide application extending for 10-15 ft beyond the leafy spurge patches (Lajeunesse et al. 1999). A combination of picloram and 2,4-D (1-1.5 pints of picloram with 1-1.5 quarts of 2,4-D) was shown to provide the best control when applied in the spring when flowers emerge (Beck 1996). Research in North Dakota has shown that a tank mix of picloram (1 pt./ac) and 2,4-D (1 quart/acre) (based on concentrate of 4 pounds active ingredient/gallon) applied 2 weeks after the yellow bracts appear and applied annually is a cost effective treatment for leafy spurge (Lym et al. 1993). Picloram at 1 quart/acre for 2-3 consecutive years is also effective, but more expensive. An annual combination of dicamba plus 2,4-D (4-8 oz + 0.5-1 quart/acre) also provided good control (Beck 1996). Glyphosate is most effective when applied sequentially at 1 quart/acre at one month intervals, coupled with fall grass seeding (Beck 1996).

Cultural/Preventive: Long-term control of leafy spurge requires, among other things, a competitive plant community dominated by desirable species. For reseeding, select a mixture of grass species with early-, mid-, and late-season growth, and with shallow-, intermediate-, and deep-rooting depths. The resulting plant community will maximize the use of water and nutrients by the desirable species and will effectively compete with leafy spurge. After reseeding, it is imperative to manage grazing animals carefully so as to invigorate and not harm perennial grasses. Consider grazing sheep or goats with cattle so the former can graze spurge plants.

Note of Caution: The milky latex associated with leafy spurge can cause irritation, blotching, blisters, and swelling in sensitive individuals. The eyes should never be rubbed until after the hands are thoroughly washed. Gloves should be worn while pulling or coming into contact with this plant.

Integrated Management Summary

Persistent monitoring of areas with known or potential infestations is crucial to managing leafy spurge. New infestations are much more easily controlled than established infestations. 100 percent eradication of leafy spurge is rarely achieved, but infestations can be reduced to manageable levels. Herbicides are most commonly used to control leafy spurge. However, damage to non-target species is always a concern. Sheep and goats can be used to control leafy spurge. Leafy spurge is extremely difficult to control by chemical means and is almost impossible to control by cultural or physical methods. Therefore a management scheme that combines control methods over four to five years is recommended (Beck 1996). Lym (1998) recommends combinations of re-seeding with competitive grasses, biological control insects, sheep or goat grazing and herbicide (2,4-D + picloram) treatment. Grazing animals and biological agents are generally appropriate only for larger infestations. Although leafy spurge can be poisonous to cattle, sheep can be taught to feed on it and goats will seek it out.

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Perennial Pepperweed

***Lepidium latifolium* L.**

Family: ***Brassicaceae*** (Mustard)
Other Names: tall whitetop, broad-leaved peppergrass, Virginia pepperweed
Six Letter Code: LEPLAT
USDA Code: LELA2

Keys to Identification:

- Perennial pepperweed has dense clusters of white flowers that appear in early summer.
- The leaves and stem are covered with a waxy layer.

Identification

Growth form: Perennial forb.
Flower: White flowers are packed in dense clusters near the ends of branches. **Seeds/Fruit:** Fruits are nearly round, about 0.1 inch in diameter and usually sparsely hairy.
Leaves: Leaves are alternate, lance-shaped, entire to toothed, bright green to gray-green, and do not have clasping bases (whitetop leaves have clasping bases). The basal leaves are larger than the upper leaves.
Stems: Mature plants are 1-3 feet tall.
Roots: Perennial pepperweed roots grow deep into the soil.
Seedling: No information available.
Other: The leaves and stem are covered with a waxy layer (Whitson et al. 1996).

Single flower - enlarged

Similar Species

Exotics: Whitetop (*Cardaria draba*) leaves have clasping bases; perennial pepperweed can also be distinguished by its waxy appearance.
Natives: Many native members of the sunflower *(Asteraceae)* family resemble this species in the rosette stage.

Impacts

Agricultural: Perennial pepperweed invades irrigated pastures, cropland, and native meadows (FEIS 1996).
Ecological: Perennial pepperweed is an aggressive colonizer of riparian habitats. It establishes rapidly and can eliminate competing vegetation (FEIS 1996).
Human: No information available.

Habitat and Distribution

General requirements: Perennial pepperweed is most often found in open, unshaded areas on disturbed, and often saline soils.
Distribution: Perennial pepperweed is found in riparian habitats of the Intermountain region (FEIS 1996).
Historical: Perennial pepperweed was introduced from Eurasia.

Biology/Ecology

Life cycle: Dense flower clusters appear in early summer and continue through August.
Mode of reproduction: Perennial pepperweed reproduces mainly by spreading rhizomes, and can be an aggressive colonizer of disturbed areas (FEIS 1996).
Seed production: Perennial pepperweed produces an abundance of highly germinable seeds. Seed production is from June to August.
Seed bank: Seeds have no apparent dormancy.
Dispersal: Seeds drop from the plant or travel short distances by wind/water.
Hybridization: No information available.

Control

Biocontrol: None known.
Mechanical: Periodic mowing and spring burning have reduced perennial pepperweed density in Utah (FEIS 1996).
Fire: (See above)
Herbicides: Metsulfuron at the rate of 0.45 oz. active ingredient/acre is the most effective herbicide treatment. Dicamba at 1 lb. active ingredient/acre, glyphosate at 1.5 lb. active ingredient/acre or glyphosate+2,4-D at 54 fl. oz. product/acre will control perennial pepperweed. Other herbicides that proved to be effective include chlorsulfuron and imazapyr.

Keys to Control:
- Plants must not be allowed to produce seed if control is to be successful.
- Use a combination of mechanical techniques and herbicide applications to control

Cultural/Preventive: Treat new infestations of perennial pepperweed as soon as they are found.
Integrated Management Summary A combination of mechanical (cutting or pulling) and herbicide applications can provide effective control of perennial pepperweed. Plants should be cut or pulled during the flower bud stage. Herbicides should be applied to the recovering stems when they return to flower bud stage later the same year.

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Russian Olive

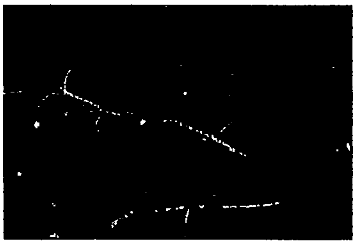
***Elaeagnus angustifolia* L.**

Family: *Elaeagnaceae* (Oleaster)
Other Names: Russian olive, oleaster
Six Letter Code: ELAANG
USDA Code: ELAN

Keys to Identification:
- Russian olive is known by its silvery-gray color, short tree stature, fragrant flowers, and small, silvery fruits.

Identification

Growth form: Russian olive is a large, spiny, perennial, deciduous shrub or small tree to 30 ft tall.
Flower: Highly aromatic, creamy yellow flowers appear in June and July.
Seeds/Fruit: Clusters of abundant silvery fruits, about 1/2 inch long, mature from August to October and stay on the tree through the winter.
Leaves: The dull green to gray, elliptical to lanceolate shaped leaves are alternate and simple, 1 to 3 inches long by about 1/2 inch wide, distinctly scaly above and silvery-scaly below.
Stems: The branches are silvery, scaly and thorny when young; and shiny, light brown when mature. The bark is at first smooth and gray, becoming unevenly rigid and wrinkled.



Similar Species

Exotics: None known
Natives: Silverberry *(Elaeagnus commutata)* is a smaller shrub of similar coloration that occurs on drier riparian and upland sites.

Impacts

Ecological: Russian olive, with its tendency to spread quickly, is a menace to riparian woodlands, threatening strong, native species like cottonwood and willows. Russian olive has out competed native vegetation, interfering with natural plant succession and nutrient cycling, and choking irrigation canals and marshlands, displacing native plants and critical wildlife habitats. Areas dominated by Russian olive do not have a high concentration of wildlife. Although Russian olive is a source of food and habitat for some wildlife, ecologists have found that bird species richness is actually greater in areas with a higher concentration of native vegetation.
Human: Russian olive was introduced by humans as an attractive landscape species. Its dense, silvery foliage forms a good hedge to screen out unwanted views. Until recently, it was planted for wildlife habitat and windbreaks by the USDA Natural Resource and Conservation Service.

Habitat and Distribution

General requirements: Russian olive can tolerate a variety of temperature, water, and soil conditions, including bare mineral substrates. The species is very adaptive and is an initial colonizer of disturbed sites. It grows along floodplains, riverbanks, streams and marshes. It can tolerate large amounts of

salinity and can grow well in a variety of soils from sand to heavy clay. It can survive temperatures from –50 to 115 degrees F. It is shade tolerant, allowing it to withstand competition from taller trees. It can absorb nitrogen into its roots, giving it the ability to grow on bare, mineral surfaces.
Distribution: Russian olive is found throughout North America, but mainly in the central and western portions of the United States. It has naturalized and been planted in 17 western states from the Dakotas, Nebraska, Kansas, Oklahoma, and Texas westward to the Pacific coast. It is most abundant in the Great Basin Desert region and the riparian zones of the Great Plains.

Biology/Ecology

Mode of reproduction: Seed primarily, but also resprout of cut stems
Seed production: Abundant
Seed bank: Seeds are persistent
Dispersal: Birds and small mammals foraging on the fruit scatter seeds widely.

Control

Russian olive is very difficult to control or eradicate, due to its capacity to produce root sprouts and "suckers." Although the species can thrive without water, it becomes stressed when there is a severe lack of water, often causing fungus to appear.

Keys to Control:
- Eradicate initial colonizer plants by cutting and applying herbicide to the stump or digging out the roots.

Biocontrol: Few animals and insects feed or bother Russian olive, so there tends to be no effective biological control. There are two kinds of fungus that can affect it: Verticillium wilt and Phomopsis canker. Verticillium wilt attacks and usually kills Russian olive in eastern areas that are very humid and wet or poorly drained, causing the leaves to wilt. Canker disease is a reddish-brown to black canker that appears on smaller branches, resulting in a kind of "bleeding" on the diseased areas. Once the fungus covers the branch, lack of water causes the leaves to wilt and the branches die off.
Mechanical: Cutting has little effect on it, as it resprouts heartily from the stump. Mowing Russian olive with a brush type mower, removing cut material, and then spraying is probably the most effective way to eradicate the species.
Fire: Russian olive is fire resistant and tends to colonize burned areas, yet burning with a combination of herbicide spraying on the stump may prevent it from resprouting.
Herbicides: Systemic herbicides, such as Roundup®, Glypro®, Garlon 3A®, and Garlon 4® can be effective when applied to cut stumps or when used as a foliar spray. A small amount of Tordon Kit in the mixture will control resprouting. Basal bark application of Garlon 4® with Penevator Basal Oil® can also be an effective control.

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Russian Thistle

Salsola iberica **Sennen**

Family: *Chenopodiaceae* (Goosefoot)
Other Names: tumbleweed
Six Letter Code: SALIBE
USDA Code: SAIB

Keys to Identification:
- Stems of Russian thistle have purple stripes.
- Inconspicuous flowers are borne in leaf axils.
- Seedling plants have long, fleshy leaves.

Identification

Growth form: Annual forb
Flower: Inconspicuous flowers are borne in axils of the upper leaves. Each flower is accompanied by a pair of spiny, floral bracts (Whitson et al. 1996).
Seeds/Fruit: Small one-seeded fruits with winged tips. Seeds are round, black, smooth and shiny.
Leaves: Leaves are alternate; the first leaves are long, string-like and soft. Later leaves are short, scale-like and tipped with a stiff spine (Whitson et al. 1996).
Stems: Mature plants are 0.5-3 ft tall and are rounded, bushy, and highly branched. Stems are red or purpled striped.
Roots: The root system consists of a taproot that can grow 3 ft or more in depth with extensive lateral roots
Seedling: Seedling plants have long, fleshy leaves.

Similar Species

Exotics: Young Russian thistle plants resemble young halogeton plants, although halogeton lacks spines.
Natives: None known.

Impacts

Agricultural: It is well adapted to cultivated dryland agriculture, but is also found on disturbed rangeland, and wasteland.
Ecological: Russian thistle colonizes barren desert areas that cannot support other flora, and invades many different disturbed plant communities. Since its introduction, it has become one of the most common and troublesome weeds in the drier regions of the United States (Whitson et al.1996). Russian thistle occurs in many communities. It is most common along disturbed grassland and desert communities. In disturbed big sagebrush communities, Russian thistle dominated for the first two years. After this time plants became overcrowded and stunted, and were replaced by mustards (FEIS 1996).
Human: No information available.

Habitat and Distribution

General requirements: Russian thistle grows in disturbed or unoccupied sites. (FEIS 1996). It grows on any type of well-drained, uncompacted soil with a sunny exposure. Russian thistle cannot tolerate saturated soil for extended periods.
Distribution: Found throughout central and western North America, up to 8,550 ft (FEIS 1996).
Historical: No information available.

Biology/Ecology

Life cycle: In spring, Russian thistle seeds will germinate at virtually any conceivable seedbed temperature (FEIS 1996). Plants typically flower from July through October. Seeds mature during August through November. Russian thistle seedlings are poor competitors, and do not establish well in crowded communities (FEIS 1996).

Mode of reproduction: Reproduces by seeds.

Seed production: One plant can produce up to about 250,000 seeds (FEIS 1996).

Seed bank: Seeds remain viable less than a year.

Dispersal: After seeds mature in the fall the plant stem separates from the root. The plant is then blown by wind. Seeds, held in the leaf axils, fall to the ground as the plant tumbles.

Hybridization: No information available.

Control

Keys to Control:

- Maintain vigorous stands of perennial plants.
- Herbicides should be applied at the seedling growth stage for best results.
- Small infestations can be controlled by mowing or pulling young plants.

Biocontrol: The Division of Plant Industry's Biological Pest Control Section has two moth species, *Coleophora klimeschiella* and *C. parthenica*, that may be available for redistribution.

Mechanical: Mowing or pulling young plants can be used to control Russian thistle. However this process may have to be repeated for several years to be successful.

Fire: Prescribed burning is not recommended for control of Russian thistle, since it favors disturbed communities and readily recolonizes burned areas (FEIS 1996).

Herbicides: Dicamba at 0.5 lb, 2,4-D at 1 lb, or glyphosate at 1.5 lb active ingredient/acre, have been used to successfully control Russian thistle (Calweed 1997).

Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal, eliminating seed production and maintaining healthy native communities.

Integrated Management Summary

For effective control of Russian thistle, control methods should be accompanied by a program to maintain or enhance the natural plant cover. As with other annual plants which reproduce by seeds, Russian thistle can eventually be controlled by eliminating seed production until the soil seed bank is depleted. Cut/pull or treat plants with herbicide prior to seed set.

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Spotted Knapweed

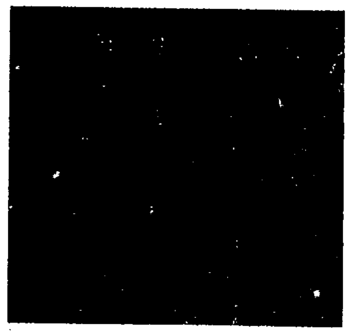
***Centaurea maculosa* L.**

Family: *Asteraceae* (Sunflower)
Other Names: none widely accepted
Six Letter Code: CENMAC
USDA Code: CEMA4

Keys to Identification:
- Spotted knapweed can be distinguished from other similar looking knapweeds by the dark tips and fringed margins of the floral bracts.

Identification

Growth form: Short-lived perennial forb (rarely biennial).
Flower: Flowering heads are solitary at the ends of branches. The floral bracts are stiff and tipped with a dark comb-like fringe. The flowers are pinkish-purple or rarely cream colored.
Seeds/Fruit: Seeds have a tuft of persistent bristles.
Leaves: Rosette leaves are up to 6 inches long, and deeply lobed. The principal stem leaves are pinnately divided, have smooth margins, and become smaller toward the top of the shoot. Leaves are alternate.
Stems: Mature plants are 1-3 ft tall with one or more stems.
Roots: Spotted knapweed has a stout taproot.
Seedling: Rosettes of spotted and diffuse knapweed are nearly indistinguishable. Leaves are narrow and 1-2 times pinnately divided (Stubbendieck et al. 1995).
Other: Closely related to diffuse knapweed (*Centaurea diffusa*).



Similar Species

Exotics: Other knapweeds include diffuse knapweed (*Centaurea diffusa*) which has a distinct terminal spine on the floral bracts, Russian knapweed (*Centaurea repens)* whose flowers are smaller than those of spotted knapweed and do not have black mottling on the flower bracts, squarrose (*Centaurea virgata)* and black (*Centaurea nigra)* knapweeds.
Natives: American star-thistle (*Centaurea americana*). Other native members of the sunflower family can resemble knapweed in the seedling/rosette stage.

Impacts

Agricultural: Spotted knapweed reduces or displaces desirable plant species, thereby reducing livestock and wildlife forage (Sheley et al. 1999).
Ecological: Spotted knapweed is a highly competitive weed that invades disturbed areas and degrades desirable plant communities. It forms near monocultures in some areas of western North America (FEIS 1996). There is evidence that spotted knapweed produces allelopathic chemicals that inhibit growth of other plants (Rutledge and McLendon, 1998). This allows it to form dense monocultures. However, Kelsey and Bedunah (1989) reported that resource capture was more important than allelopathy in spotted knapweed success. Although it is usually found in disturbed areas, once a colony is established, it may invade adjacent undisturbed areas (Rutledge and McLendon, 1998).

Human: The sap of spotted knapweed can cause skin irritation in some people. As a precaution, anyone working with spotted knapweed should wear protective gloves and avoid getting knapweed sap into open cuts or abrasions. Workers should wash hands and exposed skin with soap and water following contact with this plant.

Habitat and Distribution

General requirements: Spotted knapweed is adapted to well-drained, light to coarse-textured soils. It is not tolerant of shade. It tends to inhabit somewhat moister sites than diffuse knapweed, preferring areas that receive 12 to 30 inches mean annual precipitation.
Distribution: Spotted knapweed has heavily infested large areas of several states in the Pacific Northwest, with lesser infestations throughout much of the United States.
Historical: Native to central Europe and Asia.

Biology/Ecology

Life cycle: Spotted knapweed germinates in spring or fall (Beck 1997). Spotted knapweed seedlings develop into and remain as rosettes for at least one growing season while root growth occurs (FEIS 1996). It usually bolts for the first time in May of its second growing season and flowers August through September (Rutledge and McLendon, 1998). Individual flowers bloom for 2-6 days (FEIS 1996). Plants are self fertile and are also cross-pollinated by insects.
Mode of reproduction: Spotted knapweed reproduces entirely by seed and is a prolific seed producer.
Seed production: Plants may produce up to 140,000 seeds/m2 (Rutledge and McLendon, 1998). Most seeds are shed immediately after reaching maturity.
Seed bank: Spotted knapweed seeds exhibit three germination behaviors: dormant light-sensitive, dormant light insensitive, and non-dormant (FEIS 1996). Dormant seeds form a seed bank and may remain viable in the soil for over 8 years (Rutledge and McLendon, 1998).
Dispersal: Knapweed seeds are often spread in hay and on vehicle undercarriages.
Hybridization: No information available.

Control

Biocontrol: Currently, there is no single biological control agent that effectively controls knapweed populations. Some researchers believe that it will take a combination of up to twelve different insects to reduce knapweed infestations (Beck 1997). The Division of Plant Industry's Biological Pest Control Section has five species that may be available for redistribution. These five species are *Urophora affinis, U. quadrifasciata, Agapeta zoegana,* and *Sphenoptera jugoslavica, Cyphocleonus achates*. The seedhead flies *U. affinis* and *U. quadrifasciata* have been released in many Front Range communities (Beck 1997). These insects cause plants to produce fewer viable seeds and abort terminal or lateral flowers (Beck 1997). Biological control insects may help reduce knapweed plants in stands of desirable plant species. For this reason, insects may be beneficial in combination with other control methods. Cattle and sheep will both graze spotted knapweed, although sheep appear to be the more effective control animal. Olson et al. (1997) found that limited duration sheep grazing of spotted knapweed when associated grasses were dormant reduced knapweed seedlings and rosettes and reduced knapweed reproduction.

Keys to Control:

- The most effective method of control for spotted knapweed is to prevent its establishment. Areas should be monitored two to three times a year (spring, summer, and fall) and any new rosettes should be destroyed.
- Established plants or stands of spotted knapweed can be pulled or spot treated with picloram, or a combination of picloram and dicamba.
- Burning may be an effective means of controlling knapweed in areas where seasonal or occasional fires are part of the natural ecosystem.

Goats would also probably be effective in controlling spotted knapweed.

Mechanical: Cutting, mowing, or removing the above ground portion of the plant after flowering, but before seed set, may be an effective way to eliminate seed production. However, spotted knapweed seeds can remain dormant in the soil for nearly a decade, requiring any cutting program to be repeated annually to be effective. A long-term program with repeated cuts of bolted plants only for several years will strongly reduce numbers and cover of spotted knapweed. Pulling can control spotted knapweed in small areas. Pulling works best when the soil is wet so the entire plant crown and taproot can be removed.

Fire: Burning has either promoted or controlled spotted knapweed; this variability in effect probably reflects differences in environmental conditions before and after the burns occurred and differences in the competitiveness of the native plant communities that were burned. Burning has been shown an effective control of knapweed with strong grass re-growth occurring on burned sites (Watson and Renney 1974). However, herbicide efficacy may increase when applied on post-burn rangeland, possibly due to the removal of standing dead material that would otherwise intercept herbicide (Lacey et al. 1995). A low-severity fire may only top-kill knapweed, but a severe fire will probably kill the plant. Dry soil conditions associated with burns may discourage knapweed re-infestation as moisture is the limiting factor for knapweed seed germination. Re-seeding desirable species should be part of any burning program to deter a re-infestation of knapweed or other exotic species.

Herbicides: Several herbicides are relatively effective at controlling knapweed. Picloram at 1.0 lb active ingredient/acre is the most effective, but has a long soil life and can damage non-target species (Harris and Cranston 1979, Watson and Renney 1974). Davis (1990) found that picloram applied at 0.25 lb active ingredient/ac provided 100 percent spotted knapweed control for 3-5 years. Other effective herbicides include dicamba or 2,4-D at 1 lb active ingredient/acre, or glyphosate at 1.5 lb active ingredient/acre. To save money and reduce grass injury resulting from higher use rates of a single herbicide, several of these herbicides can be combined (Beck 1997). Tank-mixes of picloram and dicamba (0.25 to 0.5 lb/acre + 0.125 to 0.25 lb/acre), picloram plus 2,4-D (0.188 lb/acre + 1.0 lb/acre), and dicamba plus 2,4-D (0.5 lb/acre + 1.0 lb/acre) all control knapweed (Beck 1997). Clopyralid applied at 0.24 lb active ingredient/ac and at 0.2 lb active ingredient/ac + 2,4-D at 1.0 lb active ingredient/ac provide control comparable to picloram when applied at the bolt or bud growth stages (Sheley et al. 1999). A backpack sprayer or a wick is highly recommended in small areas to minimize damage to non-target plants. Herbicides should be applied before the mature plants set seed to maximize effectiveness.

Cultural/Preventive: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal.

Integrated Management Summary

Spotted knapweed can spread readily by stems that are carried on vehicles or in infested hay or seed. Early detection and prompt control of small spotted knapweed infestations are by far the most economical ways to manage this weed. Spotted and diffuse knapweed can be managed similarly (Beck 1997). They are readily controlled with herbicides but will re-invade unless cultural techniques are used (Beck 1997). Sheley and Jacobs (1997) found that a ninety percent reduction in diffuse knapweed was necessary to shift the competitive relationship in favor of bluebunch wheatgrass. The sap of spotted knapweed can cause skin irritation in some people. As a precaution, anyone working with spotted knapweed should wear protective gloves and avoid getting knapweed sap into open cuts or abrasions. Workers should wash their hands and exposed skin with soap and water following contact with this plant.

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Whitetop

Cardaria draba **(L.) Desv.**

Family: *Brassicaceae* (Mustard)
Other Names: heart-podded whitetop, hoary cress, pepperweed
Six Letter Code: CARDRA
USDA Code: CADA

Keys to Identification:
- Whitetop can be easily identified by the clusters of numerous, four-petal, white flowers that give it a flat-topped appearance.

Identification

Growth form: Perennial forb.
Flower: Numerous white flowers with four petals, give the plant a white, flat-topped appearance.
Seeds/Fruit: Seed capsules are heart shaped, and contain two reddish brown seeds.
Leaves: Leaves are alternate, 1.6-4 inches long, blue green in color, and lance-shaped. Lower leaves are stalked, while the upper leaves have two lobes clasping the stem.
Stems: Mature whitetop plants are up to two ft tall with erect stems.
Roots: Roots are rhizomatous and usually occur at depth of 29-32 inches, but have been recorded to penetrate to a depth of 30 ft in the Pacific Northwest (FEIS 1996).
Seedling: No information available.

Similar Species

Exotics: Two other closely related species, *Cardaria pubescens* and *Cardaria chalapensis* are designated as noxious weeds in some states (Sheley and Stivers 1999).
Natives: Rosettes of gumweed *(Grindelia squarrosa)* are similar, and are found in similar habitat.

Impacts

Agricultural: Whitetop is generally considered unpalatable to livestock.
Ecological: Whitetop is invading rangelands throughout North America. It is highly competitive, once it becomes established, and spreads primarily by extremely persistent roots. Stands eventually eliminate desirable vegetation, becoming a monoculture.
Human: No information available.

Habitat and Distribution

General requirements: Whitetop is typically found on generally open, unshaded, disturbed ground. It grows well on alkaline soils that are wet in late spring and generally does better in areas with moderate amounts of rainfall. It is widespread in fields, waste places, meadows, pastures, croplands, and along roadsides (FEIS 1996).

Distribution: Whitetop is widespread in the United States except along the southern boundary of the western and southcentral states (USDA 1971). In Montana whitetop was first identified in Gallatin County in 1916. This weed has been introduced in all but two of Montana's 56 counties and infests about 32 thousand acres. It is predominantly found in alfalfa, pastures, rangeland and small grain.
Historical: Whitetop is a weed of Eurasian origin.

Biology/Ecology

Life cycle: The root system of whitetop consists of vertical and horizontal roots from which new rosettes and flowering shoots arise (Mulligan and Findlay 1974). Plants emerge in very early spring. The first leaves appear aboveground 5 to 6 weeks after planting (Mulligan and Findlay 1974, FEIS 1996). During this period, the first leaves emerge and form a loose rosette (Mulligan and Findlay 1974, FEIS 1996). Stems arise from the center of each rosette in late April (FEIS 1996). Plants flower from May to June, are self-incompatible, and are pollinated by insects. The plants set seed by mid-summer (Whitson et al. 1996). If conditions are favorable, a second crop of seeds can be produced in the fall (Sheley and Stivers 1999).
Mode of reproduction: Whitetop reproduces both by seeds and vegetatively. It spreads vigorously by creeping roots (FEIS 1996). Within three weeks of germination, a seedling root can begin producing buds (FEIS 1996). One plant can eventually result in a large colony and push out other vegetation to form a monoculture.
Seed production: One plant can produce from 1,200-4,800 seeds.
Seed bank: 84 percent of seed produced are viable the first season (Mulligan and Findlay 1974, FEIS 1996). Buried seeds can remain viable for three years in the soil (Sheley and Stivers 1999).
Dispersal: No information available.
Hybridization: No information available.

Control

Keys to Control:
- Exhaust the root system and eliminate seed production by mowing or treating with herbicides.
- Maintain a healthy cover of perennial plants to discourage the establishment and spread of hoary cress.

Biocontrol: Currently, there is little information about biological controls that attack whitetop. Sheep grazing may control it, but evidence is limited. Managing the grazing is important so desirable species are not damaged.
Mechanical: Mowing 2-3 times a year for several years may slow the spread and reduce seed production. Mowing may increase the effectiveness of subsequent herbicide application (Sheley and Stivers 1999). Mowing should be conducted during the bud stage and repeated when the plants re-bud. The effectiveness of a mowing program can be increased by planting perennial grasses as competitors.
Fire: Rapid growth rate may favor hoary cress after fires, which temporarily eliminate native vegetation. Plants may resprout from rhizomes or establish from seeds (FEIS 1996).
Herbicides: Whitetop is most commonly controlled with herbicides. However, multiple applications are usually needed to provide lasting control. The best time to apply herbicides is in May or June before flowering. The non-crop herbicides metsulfuron and chlorsulfuron are most effective herbicides while the plants still have green tissue (CSU 1998a). It is important to use a non-ionic surfactant with the herbicide (Sheley and Stivers 1999). 2,4- D + dicamba is very effective when applied during the early pre-bud stage (late May through early June) (CSU 1998a). Glyphosate at 1.5 lb active ingredient/acre applied during the flower stage will provide good control. Picloram does not control whitetop. Spraying followed by spring mowing can control whitetop by up to 90 percent (FEIS 1996).
Cultural/Preventive: Cultivation alone will control whitetop when tillage begins at flower bud stage and is repeated every ten days throughout the growing season (FEIS 1996). Reseeding of depleted areas with competitive grasses would probably be an effective complement to sheep grazing.

Nitrogen fertilization can increase the growth of grasses and slow the rate of whitetop invasion (Sheley and Stivers 1999).

Integrated Management Summary

Whitetop is an aggressive weed, reproducing from seed and vegetatively. It can crowd out desirable species and form a monoculture. In the absence of competition, a single plant can spread over an area 12 ft in diameter in a single year (FEIS 1996). Whitetop is commonly controlled with herbicides and less commonly controlled by mowing. Control is difficult because of the perennial root system, abundant seed production, and diverse habitats of the plant (FEIS 1996).

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Yellow Toadflax

Linaria vulgaris **P. Miller**

Family: *Scrophulariaceae* (Figwort)
Other Names: butter and eggs, wild snapdragon, common toadflax
Six Letter Code: LINVUL
USDA Code: LIVU2

> **Keys to Identification:**
> - Yellow toadflax can be identified by its yellow, snapdragon-like, flowers and disagreeable turpentine-like scent.
> - It can be distinguished from dalmatian toadflax by its leaves. The leaves of yellow toadflax are narrow, lance-shaped, and pointed at both ends. The leaves of dalmatian toadflax are shorter, wider, and broad-based.

Identification

Growth form: Perennial forb
Flower: Flowers are bright yellow and resemble snapdragons. Flowers are arranged in a raceme at the ends of the branches.
Seeds/Fruit: Seed capsules are round-ovate, 0.3-0.5 inches long, and two-celled. Seeds are brown or black, circular, and surrounded by a notched wing.
Leaves: Leaves are soft, lance-shaped, and pale green. Leaves are mainly alternate but lower leaves appear to be opposite due to crowding.
Stems: Mature yellow toadflax plants are 1-3 feet tall with 1-25 smooth erect floral stems.
Roots: Taproots may be up to a meter in length. Horizontal roots may grow to be several meters long, and can develop adventitious buds that may form independent plants.
Seedling: No information available.
Other: Closely related to dalmatian toadflax *(Linaria dalmatica).*

Similar Species

Exotics: Leaves of dalmatian toadflax *(Linaria dalmatica)* are shorter, wider, broad based, and clasping the stem.
Natives: None known.

Impacts

Agricultural: Yellow toadflax contains a poisonous glucoside that is reported to be mildly poisonous to cattle (Morishita 1991). However, the plant is considered unpalatable and reports of livestock poisonings are rare.
Ecological: Yellow toadflax is quick to establish in open sites and is capable of adapting growth to a wide range of environmental conditions. Yellow toadflax aggressively forms colonies through adventitious buds from creeping root systems. These colonies can push out native grasses and other perennials, thereby altering and simplifying the species composition of natural communities and reducing forage production for livestock and wildlife.
Human: No information available.

Habitat and Distribution

General requirements: Yellow toadflax has a highly variable habitat that depends on environmental factors such as shading, grazing, and soil type (Saner et al. 1995).
Distribution: Yellow toadflax now occurs throughout the continental United States and in every Canadian province and territory (Saner et al. 1995).
Historical: Yellow toadflax is native to the steppes of southeastern Europe and southwestern Asia. Yellow toadflax was introduced to New England in the late 1600s as an ornamental and medicinal plant and continues to be sold in nurseries and seed catalogs (FEIS 1996).

Biology/Ecology

Life cycle: Spring emergence occurs around mid-April and depends primarily on temperature. A smaller flush of seedlings can occur in the fall. Prostrate stems emerge in September and produce leaves that are ovate, 0.9-1.5 inches in size. Prostrate stems are tolerant to freezing and are associated with floral stem production the following year (Robocker 1974). The strong, upright floral stems that are characteristic of mature toadflax plants develop after a winter's dormancy, and emerge about the same time as seedlings in mid-April. Flowering occurs from May through August and seeds mature from July through October (Saner et al. 1995). Yellow toadflax is self-incompatible and relies on insects for pollination. The two most important pollinators are bumblebees and halictid bees (Zimmerman 1996).
Mode of reproduction: Yellow toadflax can reproduce both by seeds and vegetatively. Vegetative reproduction enables a stand of toadflax to spread rapidly. Stems develop from adventitious buds on primary and lateral roots. These buds can grow their own root and shoot system, and become independent plants the next year. Yellow toadflax colonies persist mostly via vegetation means while those of dalmatian toadflax persist both by vegetative and seed reproduction (Lajeunesse 1999).
Seed production: A mature plant can produce up to 30,000 seeds annually. A single stem has been reported to contain over 5,000 seeds (Saner et al. 1995).
Seed bank: Seeds can remain dormant for up to ten years.
Dispersal: Winged seeds aid wind dispersal. Seeds may also be dispersed by water and ants (Rutledge, 1998).
Hybridization: No information available.

Control

Keys to Control:
- Limit vegetative spread of colonies.
- Destroy seedlings that emerge from the soil seed bank.
- Maintain a cover of native perennial plants to discourage infestation elsewhere.

Biocontrol: The Division of Plant Industry's Biological Pest Control Section currently has one species, *Calophasia lunula*, that may be available for redistribution on yellow toadflax infestations. *C. lunula* larvae feed extensively on leaves and flowers of toadflax, severely damaging the plants.
Mechanical: Hand pulling toadflax before seed set each year can be an effective control method especially in coarse-textured soils where large portions of the roots can be pulled. However, this method must be repeated as long as there are viable seeds in the soil (up to 10 years). Cutting or mowing yellow toadflax reduces the current year growth and possibly seed dispersal, but will not kill the plant. These techniques are not recommended to control any toadflax species (Lajeunesse 1999).
Fire: Burning is not a recommended control method for yellow toadflax (Saner et al. 1995). The large, deep root system protects the plant from burning. In fact, areas that have been recently disturbed by fire are susceptible to increased toadflax infestation.
Herbicides: Effectiveness of herbicides on both toadflax species is highly variable, reflecting in part their high genetic variability (Lajeunesse 1999). Yellow toadflax is difficult to control with herbicides. Herbicides should be applied during flowering when carbohydrate reserves in the root of the plants

are at their lowest. Picloram or dicamba at 1 lb. active ingredient/acre, or glyphosate at 1.5 lb. active ingredient/acre, will kill yellow toadflax plants in some situations. 2,4-D, MCPA, 2,4-DB, MCPB and mecoprop are ineffective on yellow toadflax (Lajeunesse 1999). Picloram+2,4-D at 0.5+1.0 lb. active ingredient/acre (as Grazon P+D®) controlled 95-100% of yellow toadflax when applied for 1-3 consecutive years (Sebastian and Beck 1999).

Cultural/Preventive: In agricultural areas, minimum-till cultivation practices have contributed to the resurgence of toadflax populations (McClay 1992). By not tilling the soil, and subsequently damaging the root system of toadflax plants, toadflax colonies have been able to flourish. Intensive clean cultivation techniques are recommended for successful toadflax control on agricultural land. This requires at least two years with 8-10 cultivations in the first year and 4-5 cultivations in the second year (Morishita 1991).

Integrated Management Summary Yellow toadflax rapidly colonizes open sites. It is most commonly found along roadsides, fences, rangelands, croplands, clear cuts, and pastures. Disturbed or cultivated ground is a prime candidate for colonization. The seedlings of yellow toadflax are considered ineffective competitors for soil moisture with established perennials and winter annuals (Morishita 1991). However, once established, yellow toadflax suppresses other vegetation mainly by intense competition for limited soil water. Mature plants are particularly competitive with winter annuals and shallow-rooted perennials. The key to controlling yellow toadflax is to limit vegetative spread of established colonies (by cutting, pulling, or spraying seed stalks prior to seed set, or by using insects to destroy flowers, seeds, or damage plants). Once current seed production has been controlled, toadflax seedlings that emerge from the soil seed bank must be destroyed every year until the seed bank is diminished.

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Clark Fork River Operable Unit
of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix E:
Grant-Kohrs Ranch National Historic Site

E.1: List of Riparian Plant Communities

E.2: Planting Criteria and Vegetation Performance Standards After 10 years for Remediated Sites (for Individual Habitat Types and Community Types)

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April 2004

APPENDIX E.1—GRANT-KOHRS RANCH NATIONAL HISTORIC SITE

List of Riparian Plant Communities

Introduction

As discussed in Section 13.7 and elsewhere throughout the Record of Decision for the Clark Fork River Operable Unit (OU), remedial action within the Grant-Kohrs Ranch National Historic Site (GRKO) must attain location-specific Applicable or Relevant and Appropriate Requirements (ARARs) derived from the National Park Service Organic Act and the enabling legislation establishing GRKO. Attainment of these ARARs requires remedial measures that ensure the historic ranch landscape of the late nineteenth century is reestablished, preserved, and sustained for future generations in a condition unimpaired by hazardous substances. The "Grant-Kohrs Ranch National Historic Site Riparian Plant Communities" and "Planting Criteria and Vegetation Performance Standards after 10 years for Remediated Sites of the Grant-Kohrs Ranch National Historic Site" documents in this appendix (Appendix E.1 and E.2, respectively) define the performance standards by which attainment of these location-specific ARARs will be measured. These performance standards require that the selected remedial action reestablish self-producing native riparian vegetation communities as further described in this appendix.

To facilitate development of these performance standards, GRKO submitted to EPA a list of habitat types (HT) and community types (CT) (Rice 2003) that would be present within the riparian zone of GRKO but for the past and ongoing releases of hazardous substances from upstream mining activities. This list was derived from statistical analysis of a statewide wetland and riparian site classification (Hansen et al. 1995). In this appendix, the GRKO list is further refined to meet the site-specific physiographic conditions encountered within Reach A of the Clark Fork River OU.

Ecological Site Potential for Riparian and Wetland Types

The distribution of natural plant communities in an area, and the relative acres covered by each, depends on site potential and how it varies within the area, as well as on site disturbance. Within a relatively small area, such as the GRKO, the greatest determinant of vegetation potential is hydrology as modified by soil type. This parameter can vary greatly within short distances.

The remedial activities planned for contaminated areas within Reach A of the Clark Fork River OU, which includes the GRKO, include either in-place treatment with lime or removal. These activities may alter every treated site's vegetation potential.

Exotic (Non-native) Species

Non-native, or introduced exotic, species were not considered. However, they will invade remediated sites. Species such as Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pratense*), redtop (*Agrostis stolonifera*), common dandelion (*Taraxacum officinale*), and others will inevitably account for some of the understory canopy cover and species diversity. The most (perhaps only) effective way to prevent their taking dominance of remediated sites is to cover the soil as quickly as possible with desired native species.

Required Types for GRKO

Table E.1-1 presents an estimate of the fractional breakdown of the GRKO floodplain area among the types that, in order to attain the site-specific ARAR, should occupy the remediated floodplain on the GRKO. This breakdown reflects our knowledge of riparian habitat type, community type, and riparian species distribution and relative abundance in the different regions of Montana.

TABLE E.1-1
Fifteen Required Habitat Types (HT) and Community Types (CT) Grouped by Overstory Lifeform Dominance (i.e., trees, shrubs, graminoids, and forbs) and Ranked by Estimated Percentage of Area Represented by the Type

Type	Deer Lodge Valley Distribution Category*	Estimated Percentage (%) of Total Area Represented	Typical Floodplain Position of the Type
Tree Dominated Types			
Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT	Minor	8-12	Recent point bars and low floodplain terraces.
Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT	Incidental	<1	Slightly moist to mesic floodplain sites
Shrub Dominated Types			
Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT	Major	18-23	Drier areas in old oxbows, floodplain terraces.
Water Birch (*Betula occidentalis*) CT	Major	12-18	Moist areas, old oxbow banks, streambanks.
Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT	Major	12-18	Moist areas, old oxbow, streambanks.
Sandbar Willow (*Salix exigua*) CT	Minor	8-12	Recent point bars, streambanks.
Woods Rose (*Rosa woodsii*) CT	Minor	1-3	Drier areas on upper floodplain terraces.
Western Snowberry (*Symphoricarpos occidentalis*) CT	Minor	1-3	Drier areas on upper floodplain terraces.
Mountain Alder (*Alnus incana*) CT	Minor	1-3	Moist areas, old oxbow banks, streambanks.
Graminoid Dominated Types			
Beaked Sedge (*Carex rostrata*) HT	Minor	5-8	Wet sites, old oxbow, or slough bottoms.
Bluejoint Reedgrass (*Calamagrostis canadensis*) HT	Minor	3-6	Moist areas, old oxbow, and streambanks.
Western Wheatgrass (*Agropyron smithii*) HT	Minor	3-6	Drier open areas away from the river channel.
Water Sedge (*Carex aquatilis*) HT	Minor	2-4	Wet sites, old oxbow, or slough bottoms.
Common Spikesedge (*Eleocharis palustris*) HT	Incidental	<1	Ponded areas, water edges.

TABLE E.1-1
Fifteen Required Habitat Types (HT) and Community Types (CT) Grouped by Overstory Lifeform Dominance (i.e., trees, shrubs, graminoids, and forbs) and Ranked by Estimated Percentage of Area Represented by the Type

Type	Deer Lodge Valley Distribution Category*	Estimated Percentage (%) of Total Area Represented	Typical Floodplain Position of the Type
Forb Dominated Types			
Common Cattail (*Typha latifolia*) HT	Minor	2-4	Ponded areas, old oxbow, and slough bottoms.

*A ***major type*** occupies extensive acreages in at least some portion of the riparian or wetland zone; a ***minor type*** seldom occupies large acreages but may be common on smaller areas within the riparian or wetland zone; and an ***incidental type*** rarely occurs within the region, or is limited to narrow site conditions and/or very localized occurrence.

Species Composition of Required Habitat Types and Community Types

The ecological amplitude (the range of distribution across all site parameters—which translates to geographic range) of a habitat type or community type is never identical to that of all its constituent species. For this reason, when designing the species list for a given type, the geographic position of the particular site within the overall range of the type must be considered. Knowledge of the distribution and ecology of local natural vegetation is essential to correct prescriptions for "what and how much to plant where" in any installation of natural vegetation communities onto radically disturbed sites.

Not all species listed for any type can be expected to occur in any given stand of that type. The listed species are those deemed as appropriately adapted and reasonably likely to naturally occur in a stand of that type in the Deer Lodge Valley. Listed species are intended to constitute a design list, from which implementation design and performance standards can be drawn.

Tree Dominated Types

Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) Community Type—Although very little of the Upper Clark Fork River Valley (Reach A) supports any tree types, GRKO does have several small stands of black cottonwood (*Populus trichocarpa*). Re-establishing young stands of black cottonwood (*Populus trichocarpa*) on suitable sites following remedial treatment will require selection of sites with dependable ground water contact, full sunlight, and little competition from other taller plants. This species may seed naturally on moist, suitably bare sites. The seed source is present, but success of this is dependent on flooding events. Competition from aggressive weeds and weedy herbaceous plants is the greatest obstacle to success of natural re-establishment of this type on sites free from excess grazing pressure. Table E.1-2 provides a list of native species that commonly occur in stands of the Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) Community Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-2
Native Plant Species that may be Present in a Mature Stand of the Black Cottonwood/Red-Osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) on a Typical Stand Having the Species Present
Trees	
black cottonwood (*Populus trichocarpa*)	40-70
Shrubs	
mountain alder (*Alnus incana*)	5-10
western serviceberry (*Amelanchier alnifolia*)	5-10
water birch (*Betula occidentalis*)	5-10
western virgins-bower (*Clematis ligusticifolia*)	1-3
red-osier dogwood (*Cornus stolonifera*)	20-40
common chokecherry (*Prunus virginiana*)	5-10
swamp current (*Ribes lacustre*)	1-3
Missouri gooseberry (*Ribes setosum*)	1-3
woods rose (*Rosa woodsii*)	2-5
common red raspberry (*Rubus idaeus*)	1-3
Bebb willow (*Salix bebbiana*)	5-10
Booth willow (*Salix boothii*)	5-10
sandbar willow (*Salix exigua*)	5-10
Geyer willow (*Salix geyeriana*)	5-10
yellow willow (*Salix lutea*)	2-5
western snowberry (*Symphoricarpos occidentalis*)	2-5
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
fringed brome (*Bromus ciliatus*)	1-3
bluejoint reedgrass (*Calamagrostis canadensis*)	30-60
Canada wildrye (*Elymus canadensis*)	1-3
fowl bluegrass (*Poa palustris*)	1-3
Forbs	
baneberry (*Actaea rubra*)	1-2
western aster (*Aster occidentalis*)	1-3
field horsetail (*Equisetum arvense*)	2-5
sweetscented bedstraw (*Galium triflorum*)	2-5
fringed loosestrife (*Lysimachia ciliata*)	1-2
field mint (*Mentha arvensis*)	1-2
mountain sweet-cicely (*Osmorhiza chilensis*)	1-3
starry Solomon-plume (*Smilacina stellata*)	1-3
streambank groundsel (*Senecio pseudaureus*)	1-2
Canada goldenrod (*Solidago canadensis*)	2-5
western meadowrue (*Thalictrum occidentalis*)	1-3
American vetch (*Vicia americana*)	1-2

Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type—Although quaking aspen (*Populus tremuloides*) is not presently found on the GRKO, the species is recorded on several sites within the Upper Clark Fork River Valley (Reach A) on sites both upstream and downstream from GRKO. The Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type occurs on higher floodplain terrace sites that are not frequently flooded. Table E.1-3 provides a list of native species that commonly occur in stands of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-3
Native Plant Species that may be Present in a Mature Stand of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) on a Typical Stand Having the Species Present
Trees	
quaking aspen (*Populus tremuloides*)	40-70
Shrubs	
western serviceberry (*Amelanchier alnifolia*)	5-10
water birch (*Betula occidentalis*)	3-5
shrubby cinquefoil (*Potentilla fruticosa*)	1-3
Missouri gooseberry (*Ribes setosum*)	1-3
woods rose (*Rosa woodsii*)	3-5
common red raspberry (*Rubus idaeus*)	1-3
Bebb willow (*Salix bebbiana*)	3-5
western snowberry (*Symphoricarpos occidentalis*)	3-5
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
fringed brome (*Bromus ciliatus*)	1-2
bluejoint reedgrass (*Calamagrostis canadensis*)	50-80
Canada wildrye (Elymus canadensis)	1-3
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	1-3
Forbs	
western aster (*Aster occidentalis*)	2-5
field horsetail (*Equisetum arvense*)	2-5
Virginia strawberry (*Fragaria virginiana*)	1-2
white geranium (*Geranium richardsonii*)	1-2
large leaved avens (*Geum macrophyllum*)	1-2
sweetscented bedstraw (*Galium triflorum*)	1-2
fringed loosestrife (*Lysimachia ciliata*)	1-2
field mint (*Mentha arvensis*)	1-2
mountain sweet-cicely (*Osmorhiza chilensis*)	1-2
streambank groundsel (*Senecio pseudaureus*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2

TABLE E.1-3
Native Plant Species that may be Present in a Mature Stand of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) on a Typical Stand Having the Species Present
Canada goldenrod (*Solidago canadensis*)	1-2
western meadowrue (*Thalictrum occidentalis*)	1-2
American vetch (*Vicia americana*)	1-2
Canada violet (*Viola canadensis*)	1-2

Shrub Dominated Type

Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) Habitat Type—The Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) Habitat Type represents the potential of a large portion of the area within the floodplain in the Deer Lodge Valley on slightly drier sites than the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type. Presently, as with the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type, much of this area is disturbed to the extent of successional regression to various early seral community types and disclimaxes. Many of the stands still supporting willows have their understories converted to disturbance-induced exotic species. Table E.1-4 provides a list of native species that commonly occur in stands of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) Habitat Type at this elevation and in this portion of its range. *NOTE*: Each stand of this type will not contain all species in this list.

TABLE E.1-4
Native Plant Species That May be Present in a Mature Stand of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/ Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
Geyer willow (*Salix geyeriana*)	30-60
Booth willow (*Salix boothii*)	20-40
water birch (*Betuia occidentalis*)	5-10
red-osier dogwood (*Cornus stolonifera*)	5-10
sandbar willow (*Salix exigua*)	5-10
mountain alder (*Alnus incana*)	2-5
Bebb willow (*Salix bebbiana*)	2-5
swamp current (*Ribes lacustre*)	1-3
Missouri gooseberry (*Ribes setosum*)	1-3
woods rose (*Rosa woodsii*)	1-3
shrubby cinquefoil (*Potentilla fruticosa*)	1-2
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	40-60
narrow-spiked reedgrass (*Calamagrostis stricta*)	5-10

TABLE E.1-4
Native Plant Species That May be Present in a Mature Stand of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/ Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
tufted hairgrass (*Deschampsia cespitosa*)	1-2
bearded wheatgrass (*Agropyron caninum*)	3-5
fringed brome (*Bromus ciliatus*)	1-3
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	1-3
fowl mannagrass (*Glyceria striata*)	1-2
Forbs	
fireweed (*Epilobium angustifolium*)	1-3
cow parsnip (*Heracleum lanatum*)	1-3
common yarrow (*Achillea millefolium*)	1-2
leafy aster (*Aster foliaceus*)	1-2
western aster (*Aster occidentalis*)	1-2
field horsetail (*Equisetum arvense*)	1-2
Virginia strawberry (*Fragaria virginiana*)	1-2
northern bedstraw (*Galium boreale*)	1-2
large leaved avens (*Geum macrophyllum*)	1-2
field mint (*Mentha arvensis*)	1-2
slender cinquefoil (*Potentilla gracilis*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2

Water Birch (*Betula occidentalis*) Community Type—The Water Birch (*Betula occidentalis*) Community Type is appropriate for a large fraction of the floodplain area on moist sites that are in early-to-mid seral successional stage in the Deer Lodge Valley. This type is well represented along the Clark Fork River by older, mature stands on slightly elevated floodplain terraces. Young stands that are to be established with seedling and small sapling nursery stock will need to be located on lower sites, having a shallow water table. Table E.1-5 provides a list of native species that commonly occur in stands of the Water Birch (*Betula occidentalis*) Community Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-5
Native Plant Species That May be Present in a Mature Stand of the Water Birch (*Betula occidentalis*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
mountain alder (*Alnus incana*)	5-10
western serviceberry (*Amelanchier alnifolia*)	2-5
water birch (*Betula occidentalis*)	40-60
red-osier dogwood (*Cornus stolonifera*)	5-10
shrubby cinquefoil (*Potentilla fruticosa*)	1-2
common chokecherry (*Prunus virginiana*)	2-5
woods rose (*Rosa woodsii*)	1-3
Bebb willow (*Salix bebbiana*)	2-5
Booth willow (*Salix boothii*)	1-5
sandbar willow (*Salix exigua*)	5-10
Geyer willow (*Salix geyeriana*)	1-5
yellow willow (*Salix lutea*)	1-5
western snowberry (*Symphoricarpos occidentalis*)	1-3
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
bluejoint reedgrass (*Calamagrostis canadensis*)	30-50
Nebraska sedge (*Carex nebraskensis*)	3-5
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	3-5
Forbs	
spreading dogbane (*Apocynum androsaemifolium*)	2-5
wartberry fairy-bell (*Disporum trachycarpum*)	1-2
common willow herb (*Epilobium ciliatum*)	1-2
field horsetail (*Equisetum arvense*)	1-2
smooth scouring rush (*Equisetum laevigatum*)	1-2
Virginia strawberry (*Fragaria virginiana*)	1-2
northern bedstraw (*Galium boreale*)	1-2
Nuttall's sunflower (*Helianthus nuttallii*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2

Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type—The Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type represents the potential of another large fraction of the floodplain in the Deer Lodge Valley. Presently much of this area is disturbed to the extent of successional regression to various early seral community types and disclimaxes. Many of the stands still support willow communities, but have understories converted to disturbance-induced exotic species. Table E.1-6 provides a list of native species that commonly occur in stands of the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex* *rostrata*) Habitat Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-6
Native Plant Species That May be Present in a Mature Stand of the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) Habitat Type Within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
mountain alder (*Alnus incana*)	2-5
water birch (*Betula occidentalis*)	2-5
shrubby cinquefoil (*Potentilla fruticosa*)	1-2
Bebb willow (*Salix bebbiana*)	2-5
Booth willow (*Salix boothii*)	20-40
sandbar willow (*Salix exigua*)	3-5
Geyer willow (*Salix geyeriana*)	30-60
yellow willow (*Salix lutea*)	1-2
Graminoids	
tickle grass (*Agrostis scabra*)	1-2
fringed brome (*Bromus ciliatus*)	1-2
narrow-spiked reedgrass (*Calamagrostis stricta*)	1-2
bluejoint reedgrass (*Calamagrostis canadensis*)	5-10
water sedge (*Carex aquatilis*)	10-30
soft-leaved sedge (*Carex disperma*)	2-5
wooly sedge (*Carex lanuginosa*)	2-5
beaked sedge (*Carex rostrata*)	40-70
inflated sedge (*Carex vesicaria*)	1-2
tufted hairgrass (*Deschampsia cespitosa*)	1-2
fowl mannagrass (*Glyceria striata*)	1-2
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	1-2
Forbs	
leafy aster (*Aster foliaceus*)	1-2
western aster (*Aster occidentalis*)	1-2
large leaved avens (*Geum macrophyllum*)	1-3
common willow herb (*Epilobium ciliatum*)	1-2
field horsetail (*Equisetum arvense*)	1-2
Virginia strawberry (*Fragaria virginiana*)	1-2
small bedstraw (*Galium trifidum*)	1-2
field mint (*Mentha arvensis*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2
Canada violet (*Viola canadensis*)	1-2

Sandbar Willow (*Salix exigua*) Community Type—Sandbar willow (*Salix exigua*) is a major species throughout the Deer Lodge Valley. It is a pioneer of broad ecological amplitude, meaning it can grow on a wide array of site types. It is adapted for most sites of exposed, moist, mineral soil. The Sandbar Willow (*Salix exigua*) Community Type represents an early seral stage that will develop into one of several later seral stages, as late seral species assume dominance. Large amounts of sandbar willow (*Salix exigua*) may be planted throughout the Clark Fork River OU on or near the streambank for stabilization purposes. Most of these sites will proceed along this successional path through the sandbar willow (*Salix exigua*) to one of the other willow dominated habitat types over the coarse of 50 to 75 years. Table E.1-7 provides a list of native species that commonly occur in stands of the Sandbar Willow (*Salix exigua*) Community Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-7
Native Plant Species That May be Present in a Mature Stand of the Sandbar Willow (*Salix exigua*) Community Type Within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
mountain alder (*Alnus incana*)	2-5
western serviceberry (*Amelanchier alnifolia*)	1-2
water birch (*Betula occidentalis*)	3-5
red-osier dogwood (*Cornus stolonifera*)	5-10
woods rose (*Rosa woodsii*)	2-5
Bebb willow (*Salix bebbiana*)	1-2
Booth willow (*Salix boothii*)	2-5
sandbar willow (*Salix exigua*)	80-100
Geyer willow (*Salix geyeriana*)	3-5
yellow willow (*Salix lutea*)	1-2
western snowberry (*Symphoricarpos occidentalis*)	2-5
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
western wheatgrass (*Agropyron smithii*)	1-2
bluejoint reedgrass (*Calamagrostis canadensis*)	30-60
narrow-spiked reedgrass (*Calamagrostis stricta*)	5-10
beaked sedge (*Carex rostrata*)	2-5
fowl bluegrass (*Poa palustris*)	1-2
Forbs	
hemp dogbane (*Apocynum cannabinum*)	1-2
field horsetail (*Equisetum arvense*)	1-2
wild licorice (*Glycyrrhiza lepidota*)	1-2
field mint (*Mentha arvensis*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2

Woods Rose (*Rosa woodsii*) Community Type—The Woods Rose (*Rosa woodsii*) Community Type is appropriate for a small areas on drier sites on upper terraces near the outer edges of the floodplain along the Clark Fork River in the Deer Lodge Valley. Table E.1-8 provides a list of native species that commonly occur in stands of the Woods Rose (*Rosa woodsii*) Community Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-8
Native Plant Species That May be Present in a Mature Stand of the Woods Rose (*Rosa woodsii*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
woods rose (*Rosa woodsii*)	50-80
western snowberry (*Symphoricarpos occidentalis*)	10-30
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	5-10
western wheatgrass (*Agropyron smithii*)	20-40
Canada wildrye (*Elymus canadensis*)	1-3
Baltic rush (*Juncus balticus*)	1-3
satin-grass (*Muhlenbergia racemosa*)	1-2
fowl bluegrass (*Poa palustris*)	1-3
Forbs	
common yarrow (*Achillea millefolium*)	1-2
Virginia strawberry (*Fragaria virginiana*)	1-2
northern bedstraw (*Galium boreale*)	1-3
wild licorice (*Glycyrrhiza lepidota*)	3-5
Canada goldenrod (*Solidago canadensis*)	1-3

Western Snowberry (*Symphoricarpos occidentalis*) Community Type—Western snowberry (*Symphoricarpos occidentalis*) is common throughout the Deer Lodge Valley on dry-to-slightly moist sites. It is an early-to-mid seral species that is a common constituent of many other types, but it occasionally develops dominance of stands in open sites. Table E.1-9 provides a list of native species that commonly occur in stands of the Western Snowberry (*Symphoricarpos occidentalis*) Community Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-9
Native Plant Species That May be Present in a Mature Stand of the Western Snowberry (*Symphoricarpos occidentalis*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
woods rose (*Rosa woodsii*)	10-20
western snowberry (*Symphoricarpos occidentalis*)	50-80
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
western wheatgrass (*Agropyron smithii*)	20-40
Canada wildrye (*Elymus canadensis*)	2-3
Forbs	
common yarrow (*Achillea millefolium*)	1-2
prairie sagewort (*Artemisia ludoviciana*)	1-2
northern bedstraw (*Galium boreale*)	1-2
wild licorice (*Glycyrrhiza lepidota*)	1-2
satin grass (*Muhlenbergia racemosa*)	1-2
Canada goldenrod (*Solidago canadensis*)	1-2

Mountain Alder (*Alnus incana*) Community Type—The Mountain Alder (*Alnus incana*) Community Type is appropriate for small areas on moist sites along streambanks and edges of sloughs along the Clark Fork River in the Deer Lodge Valley. This type is represented in the Deer Lodge Valley by small stands that are usually associated with entering tributary streams. Table E.1-10 provides a list of native species that commonly occur in stands of the Mountain Alder (*Alnus incana*) Community Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-10
Native Plant Species That May be Present in a Mature Stand of the Mountain Alder (*Alnus incana*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Shrubs	
mountain alder (*Alnus incana*)	50-80
red-osier dogwood (*Cornus stolonifera*)	10-20
stinking current (*Ribes hudsonianum*)	1-3
woods rose (*Rosa woodsii*)	1-3
common red raspberry (*Rubus idaeus*)	3-5
Bebb willow (*Salix bebbiana*)	3-5
sandbar willow (*Salix exigua*)	3-5
yellow willow (*Salix lutea*)	3-5

TABLE E.1-10
Native Plant Species That May be Present in a Mature Stand of the Mountain Alder (*Alnus incana*) Community Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
bluejoint reedgrass (*Calamagrostis canadensis*)	30-50
beaked sedge (*Carex rostrata*)	5-10
drooping woodreed (*Cinna latifolia*)	1-3
tall mannagrass (*Glyceria elata*)	1-3
fowl bluegrass (*Poa palustris*)	1-3
Forbs	
western aster (*Aster occidentalis*)	1-3
ladyfern (*Athyrium filix-femina*)	1-2
common willow herb (*Epilobium ciliatum*)	1-2
field horsetail (*Equisetum arvense*)	1-2
meadow horsetail (*Equisetum pratense*)	1-2
sweetscented bedstraw (*Galium triflorum*)	2-5
large leaved avens (*Geum macrophyllum*)	1-2
cow parsnip (*Heracleum lanatum*)	1-3
field mint (*Mentha arvensis*)	1-2
starry Solomon-plume (*Smilacina stellata*)	1-2

Graminoid Dominated Types

Beaked Sedge (*Carex rostrata*) Habitat Type, Beaked Sedge (*Carex rostrata*) and Water Sedge (*Carex aquatilis*) Phases—Beaked sedge (*Carex rostrata*) is common throughout the Deer Lodge Valley on wet-to-very-wet sites. It is a late seral constituent species of many other types, but that occasionally develops stand dominance on open sites, such as in slough bottoms, along old channels, and around beaver ponds. The Beaked Sedge (*Carex rostrata*) Habitat Type typically forms dense stands that inhibit the invasion of other species, as long as the site remains undisturbed. Table E.1-11 provides a list of native species that commonly occur in stands of the Beaked Sedge (*Carex rostrata*) Habitat Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-11
Native Plant Species That May be Present in a Mature Stand of the Beaked Sedge (*Carex rostrata*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	2-5
narrow spiked reedgrass (*Calamagrostis stricta*)	3-5

TABLE E.1-11
Native Plant Species That May be Present in a Mature Stand of the Beaked Sedge (*Carex rostrata*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
water sedge (*Carex aquatilis*)	10-20
awned sedge (*Carex atherodes*)	2-5
beaked sedge (*Carex rostrata*)	80-100
inflated sedge (*Carex vesicaria*)	10-20
tufted hairgrass (*Deschampsia cespitosa*)	1-2
common spikesedge (*Eleocharis palustris*)	3-5
Baltic rush (*Juncus balticus*)	1-3
Forbs	
common willow herb (*Epilobium ciliatum*)	2-5
water horsetail (*Equisetum fluviatile*)	1-2
small bedstraw (*Galium trifidum*)	1-2
large leaved avens (*Geum macrophyllum*)	1-3
field mint (*Mentha arvensis*)	1-2
water smartweed (*Polygonum amphibium*)	3-5
purple cinquefoil (*Potentilla palustris*)	1-2

Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type—The Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type represents the potential of certain positions on the floodplain of the Clark Fork River floodplain in the Deer Lodge Valley that are slightly drier than the requirements for beaked sedge (*Carex rostrata*), but that do usually receive short periods of springtime flooding. Table E.1-12 provides a list of native species that commonly occur in stands of the Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-12
Native Plant Species That May be Present in a Mature Stand of the Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
tickle grass (*Agrostis scabra*)	1-2
bluejoint reedgrass (*Calamagrostis canadensis*)	80-100
narrow-spiked reedgrass (*Calamagrostis stricta*)	10-20
water sedge (*Carex aquatilis*)	2-5
tufted hairgrass (*Deschampsia cespitosa*)	1-2
Baltic rush (*Juncus balticus*)	1-3
fowl bluegrass (*Poa palustris*)	1-3

TABLE E.1-12
Native Plant Species That May be Present in a Mature Stand of the Bluejoint Reedgrass (*Calamagrostis canadensis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Forbs	
sharptooth angelica (*Angelica arguta*)	2-5
leafy aster (*Aster foliaceus*)	1-2
western aster (*Aster occidentalis*)	2-5
common willowherb (*Epilobium ciliatum*)	1-3
cow parsnip (*Heracleum lanatum*)	2-3
slender leafed licorice root (*Ligusticum tenuifolium*)	1-2
field mint (*Mentha arvensis*)	1-2
elephant's head (*Pedicularis groenlandica*)	2-5
western groundsel (*Senecio integerrimus*)	2-5
arrowleaf groundsel (*Senecio triangularis*)	5-10
Canada violet (*Viola canadensis*)	1-2

Western Wheatgrass (*Agropyron smithii*) Habitat Type—The Western Wheatgrass (*Agropyron smithii*) Habitat Type represents the driest, open areas on the river floodplain that may be flooded for short periods during spring runoff, but that lack potential for natural succession to taller communities. These will be the highest terrace benches that lie within the floodplain. Table E.1-13 provides a list of native species that commonly occur in stands of the Western Wheatgrass (*Agropyron smithii*) Habitat Type, at this elevation, and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-13
Native Plant Species That May be Present in a Mature Stand of the Western Wheatgrass (*Agropyron smithii*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	3-5
western wheatgrass (*Agropyron smithii*)	90-100
Baltic rush (*Juncus balticus*)	1-5
green needlegrass (*Stipa viridula*)	2-5
Forbs	
common yarrow (*Achillea millefolium*)	1-2
prairie sagewort (*Artemisia ludoviciana*)	1-3
wild licorice (*Glycyrrhiza lepidota*)	1-2
American vetch (*Vicia americana*)	1-2

Water Sedge (*Carex aquatilis*) Habitat Type, Water Sedge (*Carex aquatilis*) Phase—Water sedge (*Carex aquatilis*) is common throughout the Deer Lodge Valley on moist-to-wet sites. It is a late seral constituent species of many other types, but it occasionally develops stand dominance on sites such as sloughs, old channels, and around beaver ponds. The Water Sedge (*Carex aquatilis*) Habitat Type can form dense stands that inhibit the invasion of other species, as long as they remain undisturbed. Table E.1-14 provides a list of native species that commonly occur in stands of the Water Sedge (*Carex aquatilis*) Habitat Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-14
Native Plant Species That May be Present in a Mature Stand of the Water Sedge (*Carex aquatilis*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
Columbia sedge (*Carex aperta*)	3-5
water sedge (*Carex aquatilis*)	80-100
lentil fruited sedge (*Carex lenticularis*)	3-5
Nebraska sedge (*Carex nebraskensis*)	2-5
beaked sedge (*Carex rostrata*)	10-20
short beaked sedge (*Carex simulata*)	3-5
inflated sedge (*Carex vesicaria*)	2-5
common spikesedge (*Eleocharis palustris*)	3-5
few flowered spikesedge (*Eleocharis pauciflora*)	3-5
Baltic rush (*Juncus balticus*)	2-3

Common Spikesedge (*Eleocharis palustris*) Habitat Type—Common spikesedge (*Eleocharis palustris*) occurs throughout the Deer Lodge Valley in very small, usually narrow, linear stands on sites of very specific hydrologic regime at the water's edge along sloughs, ponds, and borrow pits where the water is still or slow moving. Table E.1-15 provides a list of native species that commonly occur in stands of the Common Spikesedge (*Eleocharis palustris*) Habitat Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-15
Native Plant Species That May be Present in a Mature Stand of the Common spikesedge (*Eleocharis palustris*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
western wheatgrass (*Agropyron smithii*)	1-5
short awn foxtail (*Alopecurus aequalis*)	1-2
American sloughgrass (*Beckmannia syzigachne*)	1-2
slender beaked sedge (*Carex athrostachya*)	1-2
needle spikesedge (*Eleocharis acicularis*)	5-10
common spikesedge (*Eleocharis palustris*)	80-100
foxtail barley (*Hordeum jubatum*)	3-5 (on more saline sites)
Nuttall's alkaligrass (*Puccinellia nuttalliana*)	1-2 (on more saline sites)

TABLE E.1-15
Native Plant Species That May be Present in a Mature Stand of the Common spikesedge (*Eleocharis palustris*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Forbs	
common willow herb (*Epilobium ciliatum*)	1-2
field mint (*Mentha arvensis*)	1-2
arumleaf arrowhead (*Sagittaria cuneata*)	1-2
alkali marsh butterweed (*Senecio hydrophilus*)	1-2
simplestem bur reed (*Sparganium emersum*)	1-5

Forb Dominated Types

Common Cattail (*Typha latifolia*) Habitat Type—Common cattail (*Typha latifolia*) occurs throughout the Deer Lodge Valley on sites with ponded surface water. It is a late seral species that develops dense stands on such sites as sloughs, old channels, and borrow pits. The Common Cattail (*Typha latifolia*) Habitat Type typically forms dense stands that inhibit the invasion of other species, as long as they remain undisturbed. Table E.1-16 provides a list of native species that commonly occur in stands of the Common Cattail (*Typha latifolia*) Habitat Type at this elevation and in this portion of its range. *NOTE:* Each stand of this type does not necessarily contain all species in this list.

TABLE E.1-16
Native Plant Species That May be Present in a Mature Stand of the Common Cattail (*Typha latifolia*) Habitat Type within the Upper Clark Fork River Valley

Species	Range of Canopy Cover (%) On a Typical Stand Having the Species Present
Graminoids	
softstem bulrush (*Scirpus validus*)	5-10
Forbs	
common willow herb (*Epilobium ciliatum*)	3-5
field mint (*Mentha arvensis*)	1-2
water smartweed (*Polygonum amphibium*)	3-5
common cattail (*Typha latifolia*)	80-90

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APPENDIX E.2—GRANT-KOHRS RANCH NATIONAL HISTORIC SITE

Planting Criteria and Vegetation Performance Standards After 10 Years for Remediated Sites

(for Individual Habitat Types and Community Types)

Overall Planting Criteria and Vegetation Performance Standards

Remedial action will be implemented to achieve the GRKO-specific ARARs on the basis of habitat types (HT) and community types (CT). Therefore, planting criteria must be designed and performance assessed on the basis of those HTs and CTs. Each HT or CT must have individual planting criteria and standards of performance written in terms of species richness and species canopy cover that are to be met after a development period of 10 years after remedy implementation. Implementation of the remedy is understood to mean the first year of full scale on-site revegetation activities at GRKO. Success in achieving the performance standards defining the ARAR will be assessed on polygons drawn around stands of individual types, and will be based on whether or not:

- Prescribed amounts of key species are present;
- Minimum numbers of members from certain species groups or unions are present;
- Minimum canopy cover of members from certain species groups or unions are present;
- A maximum canopy cover by certain species is not surpassed in some types;
- A minimum total canopy cover by the aggregate of all preferred plant species is present;
- No human-caused unvegetated soil surface is present;
- A maximum canopy cover by undesirable herbaceous species (e.g., dandelions, plantains, Kentucky bluegrass, etc.) is not surpassed; and
- Invasive species (noxious weeds) are absent.

A union is defined as a subdivision of a plant association (Daubenmire 1968, 1978). It may be a single species of high abundance and distinctive ecology, or a rather well defined list of species, which are restricted to approximately the same narrow range of environmental variation in the vegetation mosaic. Commonly unions have physiognomic as well as taxonomic distinctiveness, i.e., they may consist of tall shrubs, or herbs, or of tree species, but this is not necessarily true. Therefore, union is a more flexible term than layer, emphasizing ecology as judged by similar patterns of distribution rather than height. The unions in a landscape typically occur in different combinations.

Canopy cover is defined as the percentage of ground covered by the gross outline of an individual plant's foliage; or collectively covered by all individuals of a species within a stand or sample plot (Daubenmire 1959).

Interim Vegetation Performance Standards—To assure that performance standards will be met after the 10 year time frame, interim criteria will need to be developed and evaluated after 1, 2, 4, and 7 years for stands of each HT and CT to provide a means for detecting deficiencies of stand development while there is still time for correcting any problems.

Individual Plant Species Importance—Very few species occur in all the stands that make up a particular habitat type or community type. In addition, not all species normally occurring within a given type are equal in the amount of information their presence conveys. The presence of some species is diagnostic, but others are merely incidental and/or opportunistic in their occurrence. Therefore, the species installed on a stand of a particular type must be carefully chosen using the following criteria:

- Include all overstory and understory diagnostic species (species named in the key);
- Include as many as possible of the species with constancy greater than 20 percent (frequency of occurrence in sampled stands—information available in *Classification and Management of Montana's Riparian and Wetland Sites* [Hansen and others 1995]);
- When using an index that averages abundance across all stands sampled for the type, be careful of species that have great abundance on few stands (i.e., high canopy cover, but low constancy [constancy is defined as the percentage of sampled stands in which a species occurs]);
- It is better to consider constancy (frequency) and average canopy cover (abundance) separately;
- Use the average canopy cover on those stands sampled that have the species present to prescribe the design amount for that species; and
- Consider the local setting with respect to the type's overall distribution range to further screen species selections for ecological appropriateness (look especially at elevation).

Levels of Species Importance—A multi-tier species list approach will be used for assessing performance. Each union represents a different level of species importance. This same list will also be used for planting criteria. The format will be as follows:

- Union A would list essential species and prescribe their required minimum percent canopy cover;
- Union B would list important, but non-essential, species—of which a minimum number must be present with a prescribed minimum total combined percent canopy cover; and
- Unions C, D, and E would list less important species from which a minimum number must be present with a smaller prescribed minimum total combined percent canopy cover.

Woody Types—More complex types, such as the Black Cottonwood/Red-Osier Dogwood (*Populus trichocarpa/ Cornus stolonifera*) CT, or any of the willow types could need as many as 4 or 5 different unions. Simpler types, such as herbaceous ones, might need only two (the required dominant and a few possible other species).

Each union of plant species has a prescribed minimum canopy cover for the group. The top union contains the species that are required to be present. Progressively lower unions tend to have more species listed, but with a smaller fraction of them required to be present, and with a smaller total canopy cover prescribed.

Herbaceous Types—Some herbaceous types tend to form monospecific stands of a species under favorable conditions. These types may include varying amounts of several other species, depending of the degree of stand development or level of disturbance. For example, a well-developed and undisturbed stand of the Common Cattail (*Typha latifolia*) HT should have very little presence of other species. For this reason, these simpler types, lower unions are prescribed with a maximum total canopy cover (not to exceed), rather than a minimum that must be met.

Geographic Distribution of Plant Species

The *Classification and Management of Montana's Riparian and Wetland Sites* (Hansen and others 1995) was used as the basis for determining how much of each species to expect on a well developed, remediated site of a given type. However, since types described range over large regions, and GRKO is a localized area within a much broader range, the published type species lists were "customized" to more closely fit local conditions. The information contained in Hansen and others (1995) was modified based upon our understanding of the distribution limitations of individual plant species. For instance, the species list for the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT in Hansen and others (1995) shows a strong presence of bog birch (*Betula glandulosa*). However, we know that this species normally occurs farther to the northwest at lower elevations in Montana, or at higher elevations in southwest Montana, and is not likely to occur in the Deer Lodge Valley. There are many other such examples of species recorded in sampled stands of a type that are unlikely to occur in the Deer Lodge Valley.

Special Considerations

Certain species, such as bluejoint reedgrass (*Calamagrostis canadensis*), are described below with greater canopy cover than is indicated in the documentation for the HT or CT. This is due to the fact that sampling also occurred on slightly to moderately disturbed stands that comprised a HT or CT.

Later seral shrub species, such as Geyer willow (*Salix geyeriana*) and Booth willow (*Salix boothii*) are prescribed for inclusion with the early seral CTs, such as the Sandbar Willow (*Salix exigua*) CT and the Water Birch (*Betula occidentalis*) CT, although these species may not have been recorded with high constancy in the documentation for the CT. This is necessary to provide for a normal seral progression on the GRKO where these willows represent the majority of the climax vegetation area of the floodplain.

Grant-Kohrs Ranch National Historic Site Types

We recommend 15 HTs and CTs that are adapted for this location and appropriate for installation onto remediated sites on GRKO. Table E.2-1 contains a rough estimate of the fractional breakdown of the area each of these types might occupy on the GRKO floodplain after remediation is completed. This breakdown reflects our knowledge of riparian habitat types, community types, and riparian species distribution and relative abundances in the different regions and ecological zones of Montana.

TABLE E.2-1
Fifteen Required Habitat Types (HT) and Community Types (CT) Grouped by Overstory Lifeform Dominance (i.e., Trees, Shrubs, Graminoids, and Forbs) and Ranked by Estimated Percentage of Area Represented by the Type

Type	Deer Lodge Valley Distribution Category*	Estimated Percentage of Total Area Represented	Typical Floodplain Position of the Type
Trees			
Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT	Minor	8-12	Recent point bars and low floodplain terraces.
Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT	Minor	<1	Drier areas in old oxbows, floodplain terraces.
Shrubs			
Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT	Major	18-23	Drier areas in old oxbows, floodplain terraces.
Water Birch (*Betula occidentalis*) CT	Major	12-18	Moist areas, old oxbow banks, streambanks.
Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT	Major	12-18	Moist areas, old oxbow, streambanks.
Sandbar Willow (*Salix exigua*) CT	Minor	8-12	Recent point bars, streambanks.
Mountain Alder (*Alnus incana*) CT	Minor	2-4	Moist areas, old oxbow banks, streambanks.
Woods Rose (*Rosa woodsii*) CT	Minor	2-4	Drier areas on upper floodplain terraces.
Western Snowberry (*Symphoricarpos occidentalis*) CT	Minor	1-3	Drier areas on upper floodplain terraces.
Graminoids			
Beaked Sedge (*Carex rostrata*) HT	Minor	3-6	Wet sites, old oxbow, or slough bottoms.
Bluejoint Reedgrass (*Calamagrostis canadensis*) HT	Minor	3-6	Moist areas, old oxbow, and streambanks.
Western Wheatgrass (*Agropyron smithii*) HT	Minor	3-6	Drier open areas away from the river channel.
Water Sedge (*Carex aquatilis*) HT	Minor	2-4	Wet sites, old oxbow, or slough bottoms.
Common Spikesedge (*Eleocharis palustris*) HT	Incidental	<1	Ponded areas, water edges.
Forbs			
Common Cattail (*Typha latifolia*) HT	Minor	2-4	Ponded areas, old oxbow, and slough bottoms.

*A ***major type*** occupies extensive acreages in at least some portion of the riparian or wetland zone; a ***minor type*** seldom occupies large acreages but may be common on smaller areas within the riparian or wetland zone; and an ***incidental type*** rarely occurs within the region, or is limited to narrow site conditions and/or very localized occurrence.

Planting Criteria and Performance Standards

Planting criteria and performance standards are specified for each HT/CT individually in terms of species presence and abundance requirements. The required standards are written for the end point of the remedial action phase and/or the beginning point of the operation and maintenance phase of the project, which is set at a period of 10 years after the remedial action is implemented, as defined on page 1 of this document. Therefore, remedial design must be written to accomplish these requirements; and interim monitoring on a 1, 2, 4, and 7-year time frame must be done to detect community development that is not on a trajectory to meet the required performance standard at the end of 10 years. Therefore, additional or supplemental plantings may need to be done 1, 2, 4, and 7 years after initial installation. In the event such additional plantings do not result in attainment of performance standards, previously treated areas of contamination will require removal and revegetation as stipulated in the Record of Decision.

Individual Habitat Types and Community Types

Tree Dominated Types

Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT—The Black Cottonwood/Red-osier Dogwood) (*Populus trichocarpa/Cornus stolonifera*) CT is a mid-seral successional type that is common along western Montana riverine floodplains. It is structurally complex, having multiple stories of tall trees over tall shrubs, over short shrubs, over an herbaceous layer. More than 140 species were recorded in 21 stands sampled of this type across its range (Hansen and others 1995). There are four unions described in Table E.2-2:

- Union A lists the type indicator dominants of both the upper and understory canopies, as well as a required grass species as an essential ground cover to reduce weedy species invasion.
- Union B lists a set of important shrubs that constitute most of the tall shrub structural layer and that represent the later successional stage to eventually replace the cottonwood trees as stand dominants.
- Union C contains a longer list of less important shrubs, of which several are typically present in healthy stands of the CT.
- Union D contains a list of herbaceous species that will not individually represent much canopy cover, but which are likely present in smaller amounts in healthy stands of the CT.

TABLE E.2-2
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Trees	
black cottonwood (*Populus trichocarpa*)	MINIMUM CANOPY COVER = 40%
Shrubs	
red-osier dogwood (*Cornus stolonifera*)	MINIMUM CANOPY COVER = 20%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 4 of the following 5 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
western serviceberry (*Amelanchier alnifolia*)	
water birch (*Betula occidentalis*)	
Booth willow (*Salix boothii*)	
sandbar willow (*Salix exigua*)	
Geyer willow (*Salix geyeriana*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION C SPECIES (At least 5 of the following 10 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
western virgins-bower (*Clematis ligusticifolia*)	
common chokecherry (*Prunus virginiana*)	
swamp currant (*Ribes lacustre*)	
Missouri gooseberry (*Ribes setosum*)	
woods rose (*Rosa woodsii*)	
common red raspberry (*Rubus idaeus*)	
Bebb willow (*Salix bebbiana*)	
yellow willow (*Salix lutea*)	
western snowberry (*Symphoricarpos occidentalis*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION D SPECIES (At least 6 [minimum of 2 graminoids and 4 forbs] of the following 15 species must be present with combined total canopy cover of at least 20 percent)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
blue wildrye (*Elymus glaucus*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
baneberry (*Actaea rubra*)	
western aster (*Aster occidentalis*)	
field horsetail (*Equisetum arvense*)	
sweetscented bedstraw (*Galium triflorum*)	
fringed loosestrife (*Lysimachia ciliata*)	
field mint (*Mentha arvensis*)	

TABLE E.2-2
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Trees	
black cottonwood (*Populus trichocarpa*)	MINIMUM CANOPY COVER = 40%
Shrubs	
red-osier dogwood (*Cornus stolonifera*)	MINIMUM CANOPY COVER = 20%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 4 of the following 5 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
western serviceberry (*Amelanchier alnifolia*)	
water birch (*Betula occidentalis*)	
Booth willow (*Salix boothii*)	
sandbar willow (*Salix exigua*)	
Geyer willow (*Salix geyeriana*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION C SPECIES (At least 5 of the following 10 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
western virgins-bower (*Clematis ligusticifolia*)	
common chokecherry (*Prunus virginiana*)	
swamp currant (*Ribes lacustre*)	
Missouri gooseberry (*Ribes setosum*)	
woods rose (*Rosa woodsii*)	
common red raspberry (*Rubus idaeus*)	
Bebb willow (*Salix bebbiana*)	
yellow willow (*Salix lutea*)	
western snowberry (*Symphoricarpos occidentalis*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION D SPECIES (At least 6 [minimum of 2 graminoids and 4 forbs] of the following 15 species must be present with combined total canopy cover of at least 20 percent)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
blue wildrye (*Elymus glaucus*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
baneberry (*Actaea rubra*)	
western aster (*Aster occidentalis*)	
field horsetail (*Equisetum arvense*)	
sweetscented bedstraw (*Galium triflorum*)	
fringed loosestrife (*Lysimachia ciliata*)	
field mint (*Mentha arvensis*)	

TABLE E.2-2
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/Cornus stolonifera*) CT

Species	Percent Canopy Cover
mountain sweet-cicely (*Osmorhiza chilensis*)	
streambank groundsel (*Senecio pseudaureus*)	
starry Solomon-plume (*Smilacina stellata*)	
Canada goldenrod (*Solidago canadensis*)	
western meadowrue (*Thalictrum occidentalis*)	
American vetch (*Vicia americana*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-2, these conditions must be met at the end of 10 years:

- Minimum of 170 percent total canopy cover of individual species listed in Table E.2-2;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT—The Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/Calamagrostis canadensis*) HT is a late-seral type that is common along western Montana riverine floodplains but less abundant than it historically was. The type has suffered decline in the past century across most of its range due to understory alteration and prevention of regenerative success of the aspen. The type is structurally complex, having multiple stories of tall trees over a few tall shrubs, over a few short shrubs, over a dense herbaceous layer of grass. There are three unions described in Table E.2-3:

- Union A lists the type indicator dominants of both the upper and understory canopies.
- Union B lists a set of important shrubs and herbaceous species.
- Union C contains a longer list of less important herbaceous species that will not individually represent much canopy cover, but which are likely present in smaller amounts in healthy stands of the type.

TABLE E.2-3
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/ Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Trees	
quaking aspen (*Populus tremuloides*)	MINIMUM CANOPY COVER = 40%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%

TABLE E.2-3
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Quaking Aspen/Bluejoint Reedgrass (*Populus tremuloides/ Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION B SPECIES (At least 6 of the following 11 species must be present [minimum of 1 shrub, 2 graminoids, and 3 forb species] with a combined total canopy cover of at least 30 percent)	
Shrubs	
western serviceberry (*Amelanchier alnifolia*)	
water birch (*Betula occidentalis*)	
Bebb willow (*Salix bebbiana*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
western aster (*Aster occidentalis*)	
large leaved avens (*Geum macrophyllum*)	
mountain sweet-cicely (*Osmorhiza chilensis*)	
streambank groundsel (*Senecio pseudaureus*)	
Canada goldenrod (*Solidago canadensis*)	
western meadowrue (*Thalictrum occidentalis*)	COMBINED MINIMUM CANOPY COVER = 30%
UNION C SPECIES (At least 6 of the following 17 species must be present [minimum of 2 shrubs, 1 graminoid, and 3 forbs] and a combined total canopy cover of at least 20 percent)	
Shrubs	
shrubby cinquefoil (*Potentilla fruticosa*)	
Missouri gooseberry (*Ribes setosum*)	
woods rose (*Rosa woodsii*)	
common red raspberry (*Rubus idaeus*)	
western snowberry (*Symphoricarpos occidentalis*)	
Graminoids	
fringed brome (*Bromus ciliatus*)	
Canada wildrye (Elymus canadensis)	
Baltic rush (*Juncus balticus*)	
Forbs	
field horsetail (*Equisetum arvense*)	
Virginia strawberry (*Fragaria virginiana*)	
white geranium (*Geranium richardsonii*)	
sweetscented bedstraw (*Galium triflorum*)	
fringed loosestrife (*Lysimachia ciliata*)	
field mint (*Mentha arvensis*)	
starry Solomon-plume (*Smilacina stellata*)	
American vetch (*Vicia americana*)	
Canada violet (*Viola canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-3, these conditions must be met at the end of 10 years:

- Minimum of 150 percent total canopy cover of individual species listed in Table E.2-3;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Shrub Dominated Types

Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT—The Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT is a complex community with a core of key willow and grass species required. There are four unions described in Table E.2-4:

- Union A lists indicator dominants of both upper and understory canopies. Both of these layers may have either of two species in any combination totaling the shown minimum amount.
- Union B lists a set of important shrubs that are usually present in the tall shrub layer.
- Union C contains a list of shorter shrubs and other important herbaceous species, of which several should be present in healthy stands of the CT.
- Union D contains a list of herbaceous species that will not individually represent much canopy cover, but which are likely present in smaller amounts in healthy stands of the CT.

TABLE E.2-4
Plant Community Composition, Separated into Unions with Specified aMounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
Booth willow (*Salix boothii*)	MINIMUM CANOPY COVER = 10%
Geyer willow (*Salix geyeriana*)	MINIMUM CANOPY COVER = 40%
Graminoids (One or both of these species must be present with total combined canopy cover of at least 60 percent)	
bluejoint reedgrass (*Calamagrostis canadensis*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	COMBINED MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 3 of the following 5 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
water birch (*Betula occidentalis*)	
red-osier dogwood (*Cornus stolonifera*)	
Bebb willow (*Salix bebbiana*)	
sandbar willow (*Salix exigua*)	COMBINED MINIMUM CANOPY COVER = 15%

TABLE E.2-4
Plant Community Composition, Separated into Unions with Specified aMounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Geyer Willow/Bluejoint Reedgrass (*Salix geyeriana/Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION C SPECIES (At least 6 of the following 13 species must be present [minimum of 2 shrubs, 1 graminoid, and 3 forbs] with combined total canopy cover of at least 15 percent)	
Shrubs	
shrubby cinquefoil (*Potentilla fruticosa*)	
swamp currant (*Ribes lacustre*)	
Missouri gooseberry (*Ribes setosum*)	
woods rose (*Rosa woodsii*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
fringed brome (*Bromus ciliatus*)	
fowl mannagrass (*Glyceria striata*)	
Forbs	
leafy aster (*Aster foliaceus*)	
western aster (*Aster occidentalis*)	
large leaved avens (*Geum macrophyllum*)	
cow parsnip (*Heracleum lanatum*)	
purple cinquefoil (*Potentilla gracilis*)	
Canada goldenrod (*Solidago canadensis*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION D SPECIES (At least 5 of the following 10 species must be present [minimum of 1 graminoid and 4 forbs] with combined total canopy cover of at least 15 percent)	
Graminoids	
tufted hairgrass (*Deschampsia cespitosa*)	
Baltic rush (*Juncus balticus*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
common yarrow (*Achillea millefolium*)	
fireweed (*Epilobium angustifolium*)	
field horsetail (*Equisetum arvense*)	
Virginia strawberry (*Fragaria virginiana*)	
northern bedstraw (*Galium boreale*)	
field mint (*Mentha arvensis*)	
starry Solomon-plume (*Smilacina stellata*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 15%

Additional requirements. In addition to the requirements specified in Table E.2-4, these conditions must be met at the end of 10 years:

- Minimum of 155 percent total canopy cover of individual species listed in Table E.2-4;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Water Birch (*Betula occidentalis*) CT—The Water Birch (*Betula occidentalis*) CT is a mid seral successional community with a minimum canopy of water birch required. There are three unions described in Table E.2-5:

- Union A lists the type indicator dominant species and a required grass species as an essential ground cover to preempt weedy species invasion with minimum canopy cover amounts.
- Union B lists a set of other important tall shrubs that are usually present and that may represent the later successional stage.
- Union C contains a list of other shrubs and herbaceous species, of which several should be present in smaller amounts in healthy stands of the CT.

TABLE E.2-5
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Water Birch (*Betula occidentalis*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
water birch (*Betula occidentalis*)	MINIMUM CANOPY COVER = 50%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 4 of the following 6 species must be present with combined total canopy cover of at least 15 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
western serviceberry (*Amelanchier alnifolia*)	
red-osier dogwood (*Cornus stolonifera*)	
Booth willow (*Salix boothii*)	
sandbar willow (*Salix exigua*)	
Geyer willow (*Salix geyeriana*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION C SPECIES (At least 10 of the following 20 species must be present [minimum 3 shrubs, 2 graminoids, and 5 forbs] with combined total canopy cover of at least 20 percent)	
Shrubs	
shrubby cinquefoil (*Potentilla fruticosa*)	
common chokecherry (*Prunus virginiana*)	
woods rose (*Rosa woodsii*)	
Bebb willow (*Salix bebbiana*)	
yellow willow (*Salix lutea*)	
western snowberry (*Symphoricarpos occidentalis*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
Nebraska sedge (*Carex nebraskensis*)	
Baltic rush (*Juncus balticus*)	
fowl bluegrass (*Poa palustris*)	

TABLE E.2-5
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Water Birch (*Betula occidentalis*) CT

Species	Percent Canopy Cover
Forbs	
spreading dogbane (*Apocynum androsaemifolium*)	
common willow herb (*Epilobium ciliatum*)	
wartberry fairy-bell (*Disporum trachycarpum*)	
field horsetail (*Equisetum arvense*)	
smooth scouring-rush (*Equisetum laevigatum*)	
Virginia strawberry (*Fragaria virginiana*)	
northern bedstraw (*Galium boreale*)	
Nuttall's sunflower (*Helianthus nuttallii*)	
starry Solomon-plume (*Smilacina stellata*)	
Canada goldenrod (*Solidago canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-5, these conditions must be met at the end of 10 years:

- Minimum of 145 percent total canopy cover of individual species listed in Table E.2-5;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT—The Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT is a complex community with a core of key willow and sedge species required. There are four unions described in Table E.2-6:

- Union A lists type indicator overstory dominants. This layer may have either of these two species in any combination totaling the prescribed minimum amount.
- Union B lists the indicator herbaceous understory dominants. Any combination of one or more of these species totaling the prescribed minimum canopy cover amount must be present.
- Union C lists a set of important shrubs that are usually present in the tall shrub layer.
- Union D contains a list of other less important species, of which several should be present in healthy stands of the CT. These species will not individually represent much canopy cover, but are likely present in smaller amounts in healthy stands of the HT.

TABLE E.2-6
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
Booth willow (*Salix boothii*)	MINIMUM CANOPY COVER = 10%
Geyer willow (*Salix geyeriana*)	MINIMUM CANOPY COVER = 40%
UNION B SPECIES (At least 2 of the following 4 species must be present with combined total canopy cover of at least 60 percent)	
Graminoids	
water sedge (*Carex aquatilis*)	
lentil-fruit sedge (*Carex lenticularis*)	
beaked sedge (*Carex rostrata*)	
inflated sedge (*Carex vesicaria*)	COMBINED MINIMUM CANOPY COVER = 60%
UNION C SPECIES (At least 3 of the following 5 species must be present with combined total canopy cover of at least 20 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
water birch (*Betula occidentalis*)	
Bebb willow (*Salix bebbiana*)	
sandbar willow (*Salix exigua*)	
yellow willow (*Salix lutea*)	COMBINED MINIMUM CANOPY COVER = 20%
UNION D SPECIES (At least 8 of the following 22 species must be present [minimum 4 graminoids and 4 forbs] with a combined total canopy cover of at least 20 percent)	
Shrubs	
shrubby cinquefoil (*Potentilla fruticosa*)	
Graminoids	
tickle grass (*Agrostis scabra*)	
fringed brome (*Bromus ciliatus*)	
bluejoint reedgrass (*Calamagrostis canadensis*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	
soft-leaved sedge (*Carex disperma*)	
wooly sedge (*Carex lanuginosa*)	
tufted hairgrass (*Deschampsia cespitosa*)	
Baltic rush (*Juncus balticus*)	
fowl bluegrass (*Poa palustris*)	
fowl mannagrass (*Glyceria striata*)	
Forbs	
leafy aster (*Aster foliaceus*)	
western aster (*Aster occidentalis*)	
common willow herb (*Epilobium ciliatum*)	
field horsetail (*Equisetum arvense*)	
Virginia strawberry (*Fragaria virginiana*)	
small bedstraw (*Galium trifidum*)	

TABLE E.2-6
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Geyer Willow/Beaked Sedge (*Salix geyeriana/Carex rostrata*) HT

Species	Percent Canopy Cover
large leaved avens (*Geum macrophyllum*)	
field mint (*Mentha arvensis*)	
starry Solomon-plume (*Smilacina stellata*)	
Canada goldenrod (*Solidago canadensis*)	
Canada violet (*Viola canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-6, these conditions must be met at the end of 10 years:

- Minimum of 150 percent total canopy cover of individual species listed in Table E.2-6;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Sandbar Willow (*Salix exigua*) CT—Sandbar willow (*Salix exigua*) is an early seral, pioneering community type that naturally colonizes streamside sites and other bared, moist sites. There are three unions described in Table E.2-7:

- Union A lists the type indicator overstory dominant and a required grass species as an essential ground cover to preempt weedy species invasion.
- Union B lists a set of important shrubs that are usually present in the tall shrub layer.
- Union C contains a list of other less important shrubs and herbaceous species, of which several should be present in healthy stands of the CT.

TABLE E.2-7
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Sandbar Willow (*Salix exigua*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
sandbar willow (*Salix exigua*)	MINIMUM CANOPY COVER = 60%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 50%
UNION B SPECIES (At least 4 of the following 6 species must be present with combined total canopy cover of at least 20 percent)	
Shrubs	
mountain alder (*Alnus incana*)	
western serviceberry (*Amelanchier alnifolia*)	
water birch (*Betula occidentalis*)	
red-osier dogwood (*Cornus stolonifera*)	
Booth willow (*Salix boothii*)	
Geyer willow (*Salix geyeriana*)	COMBINED MINIMUM CANOPY COVER = 20%

TABLE E.2-7
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Sandbar Willow (*Salix exigua*) CT

Species	Percent Canopy Cover
UNION C SPECIES (At least 6 of the following 14 species [minimum 1 shrub, 2 graminoids, and 3 forbs] must be present with combined total canopy cover of at least 20 percent)	
Shrubs	
woods rose (*Rosa woodsii*)	
Bebb willow (*Salix bebbiana*)	
yellow willow (*Salix lutea*)	
western snowberry (*Symphoricarpos occidentalis*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
western wheatgrass (*Agropyron smithii*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	
beaked sedge (*Carex rostrata*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
hemp dogbane (*Apocynum cannabinum*)	
field horsetail (*Equisetum arvense*)	
wild licorice (*Glycyrrhiza lepidota*)	
field mint (*Mentha arvensis*)	
Canada goldenrod (*Solidago canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-7, these conditions must be met at the end of 10 years:

- Minimum of 150 percent total canopy cover of individual species listed in Table E.2-7;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Woods Rose (*Rosa woodsii*) CT—The Woods Rose (*Rosa woodsii*) CT is an early to mid seral community that occupies the drier edge of sites that can support woody types. This community usually occurs as small patches, unless some physical disturbance has extended it. Table E.2-8 shows two unions:

- Union A lists the type indicator overstory dominant.
- Union B lists other less important shrubs and herbaceous species, of which several should be present in healthy stands of the CT.

TABLE E.2-8
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Woods Rose (*Rosa woodsii*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
woods rose (*Rosa woodsii*)	MINIMUM CANOPY COVER = 70%
UNION B SPECIES (At least 6 of the following 12 species must be present [minimum 3 graminoids and 2 forbs] with combined total canopy cover of at least 40 percent)	
Shrubs	
western snowberry (*Symphoricarpos occidentalis*)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
western wheatgrass (*Agropyron smithii*)	
Canada wildrye (*Elymus canadensis*)	
Baltic rush (*Juncus balticus*)	
satin-grass (*Muhlenbergia racemosa*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
common yarrow (*Achillea millefolium*)	
Virginia strawberry (*Fragaria virginiana*)	
northern bedstraw (*Galium boreale*)	
wild licorice (*Glycyrrhiza lepidota*)	
Canada goldenrod (*Solidago canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 40%

Additional requirements. In addition to the requirements specified in Table E.2-8, these conditions must be met at the end of 10 years:

- Minimum of 110 percent total canopy cover of individual species listed in Table E.2-8;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Western Snowberry (*Symphoricarpos occidentalis*) CT—Western Snowberry (*Symphoricarpos occidentalis*) is an early to mid seral community that occupies the drier edge of sites that can support woody types. This community usually occurs as small patches, unless some physical disturbance has extended it. Table E.2-9 shows two unions:

- Union A lists the type indicator overstory dominant.
- Union B lists other less important shrubs and herbaceous species, of which several should be present in healthy stands of the CT.

TABLE E.2-9
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Western Snowberry (*Symphoricarpos occidentalis*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
western snowberry (*Symphoricarpos occidentalis*)	MINIMUM CANOPY COVER = 70%
woods rose (*Rosa woodsii*)	MINIMUM CANOPY COVER = 10%
UNION B SPECIES (At least 5 of the following 10 species [minimum 2 graminoids and 3 forbs] must be present with combined total canopy cover of at least 20 percent)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
western wheatgrass (*Agropyron smithii*)	
Canada wildrye (*Elymus canadensis*)	
satin grass (*Muhlenbergia racemosa*)	
Forbs	
common yarrow (*Achillea millefolium*)	
prairie sagewort (*Artemisia ludoviciana*)	
northern bedstraw (*Galium boreale*)	
wild licorice (*Glycyrrhiza lepidota*)	
starry Solomon-plume (*Smilacina stellata*)	
Canada goldenrod (*Solidago canadensis*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-9, these conditions must be met at the end of 10 years:

- Minimum of 110 percent total canopy cover of individual species listed in Table E.2-9;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Mountain Alder (*Alnus incana*) CT—The Mountain Alder (*Alnus incana*) CT is a mid-seral successional community with a minimum canopy of mountain alder required. There are three unions described in Table E.2-10. Union A contains the site indicator dominant and a grass species that is also required:

- Union A lists the type indicator overstory dominant and a required grass species as an essential ground cover to preempt weedy species invasion.
- Union B lists a set of important tall shrubs and herbaceous species that are usually present.
- Union C contains a list of other less important shrubs and herbaceous species, of which several should be present in healthy stands of the CT.

TABLE E.2-10
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Mountain Alder (*Alnus incana*) CT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Shrubs	
mountain alder (*Alnus incana*)	MINIMUM CANOPY COVER = 50%
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	MINIMUM CANOPY COVER = 60%
UNION B SPECIES (At least 5 of the following 11 species must be present [minimum 2 shrubs, 1 graminoid, and 2 forbs] with combined total canopy cover of at least 15 percent)	
Shrubs	
red-osier dogwood (*Cornus stolonifera*)	
Bebb willow (*Salix bebbiana*)	
sandbar willow (*Salix exigua*)	
yellow willow (*Salix lutea*)	
Graminoids	
water sedge (*Carex aquatilis*)	
beaked sedge (*Carex rostrata*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
western aster (*Aster occidentalis*)	
ladyfern (*Athyrium filix-femina*)	
large leaved avens (*Geum macrophyllum*)	
cow parsnip (*Heracleum lanatum*)	COMBINED MINIMUM CANOPY COVER = 15%
UNION C SPECIES (At least 6 of these 13 species [including at least 2 shrubs, 1 graminoid, and 3 forbs] must be present with combined total canopy cover of at least 20 percent)	
Shrubs	
red raspberry (*Rubus idaeus* common)	
stinking currant (*Ribes hudsonianum*)	
swamp currant (*Ribes lacustre*)	
woods rose (*Rosa woodsii*)	
Graminoids	
narrow-spiked reedgrass (*Calamagrostis stricta*)	
drooping woodreed (*Cinna latifolia*)	
tall mannagrass (*Glyceria elata*)	
Forbs	
common willow herb (*Epilobium ciliatum*)	
field horsetail (*Equisetum arvense*)	
meadow horsetail (*Equisetum pratense*)	
sweetscented bedstraw (*Galium triflorum*)	
field mint (*Mentha arvensis*)	
starry Solomon-plume (*Smilacina stellata*)	
Plus other unlisted native volunteer species	COMBINED MINIMUM CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-10, these conditions must be met at the end of 10 years:

- Minimum of 150 percent total canopy cover of individual species listed in Table E.2-10;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Graminoid Dominated Types

Beaked Sedge (*Carex rostrata*) HT—Beaked sedge is a late seral community that naturally dominates very wet sites that are slightly wetter than sites of the Water Sedge (*Carex rostrata*) HT. There are three unions described in Table E.2-11:

- Union A is the type indicator species required to be present.
- Union B species may also be present in large amounts up to an aggregate maximum.
- Union C species may be present, but much less if the stand is healthy and undisturbed.

TABLE E.2-11
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Beaked Sedge (*Carex rostrata*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Graminoids	
beaked sedge (*Carex rostrata*)	MINIMUM CANOPY COVER = 80%
UNION B SPECIES (These species may be present with combined total ***maximum*** canopy cover of 40 percent)	
Graminoids	
water sedge (*Carex aquatilis*)	
awned sedge (*Carex atherodes*)	
lentil fruited sedge (*Carex lenticularis*)	
inflated sedge (*Carex vesicaria*)	***MAXIMUM*** COMBINED CANOPY COVER = 40%
UNION C SPECIES (These species may be present with combined total ***maximum*** canopy cover of 20 percent)	
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	
narrow spiked reedgrass (*Calamagrostis stricta*)	
tufted hairgrass (*Deschampsia cespitosa*)	
common spikesedge (*Eleocharis palustris*)	
Baltic rush (*Juncus balticus*)	
Forbs	
common willow herb (*Epilobium ciliatum*)	
water horsetail (*Equisetum fluviatile*)	
small bedstraw (*Galium trifidum*)	
large leaved avens (*Geum macrophyllum*)	
field mint (*Mentha arvensis*)	
water smartweed (*Polygonum amphibium*)	
purple cinquefoil (*Potentilla palustris*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-11, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-11;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Bluejoint Reedgrass (*Calamagrostis canadensis*) HT—The Bluejoint Reedgrass (*Calamagrostis canadensis*) HT is a late seral herbaceous community that establishes dense grass stands on moist site openings that do not become flooded for too long during the growing season. Normally, when the site is undisturbed, bluejoint reedgrass forms dense mono-specific stands. However, physical or hydrologic disturbance will promote the invasion of other plant species. Table E.2-12 has two unions for this type:

- Union A is the pair of reedgrass species that in combination dominate the site.
- Union B lists other species that may also be present in large or small amounts up to an aggregate maximum.

TABLE E.2-12
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Bluejoint Reedgrass (*Calamagrostis canadensis*) HT

Species	Percent Canopy Cover
UNION A SPECIES (Some combination of these species must be present with the specified minimum combined canopy cover)	
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	
narrow-spiked reedgrass (*Calamagrostis stricta*)	COMBINED MINIMUM CANOPY COVER = 80%
UNION B SPECIES (These species may be present with combined total ***maximum*** canopy cover of 20 percent)	
Graminoids	
tickle grass (*Agrostis scabra*)	
water sedge (*Carex aquatilis*)	
tufted hairgrass (*Deschampsia cespitosa*)	
Baltic rush (*Juncus balticus*)	
fowl bluegrass (*Poa palustris*)	
Forbs	
sharptooth angelica (*Angelica arguta*)	
leafy aster (*Aster foliaceus*)	
western aster (*Aster occidentalis*)	
common willowherb (*Epilobium ciliatum*)	
cow parsnip (*Heracleum lanatum*)	
slender leafed licorice root (*Ligusticum tenuifolium*)	
field mint (*Mentha arvensis*)	
elephant's head (*Pedicularis groenlandica*)	
western groundsel (*Senecio integerrimus*)	
arrowleaf groundsel (*Senecio triangularis*)	
Canada violet (*Viola canadensis*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-12, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-12;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Western Wheatgrass (*Agropyron smithii*) HT—The Western Wheatgrass (*Agropyron smithii*) HT represents drier, open sites that lack potential for woody types. This is one of the driest of functional wetland types, and not all sites dominated by western wheatgrass performs much wetland function. Sites of this type are often on clayey soils along alluvial fans at the outer edges of valley bottoms. Table E.2-13 shows two unions for this type. As with most of the herbaceous types, well developed, undisturbed stands are usually almost mono-specific. However, physical or hydrologic disturbance will promote the invasion of other plant species.

- Union A is the type indicator species required to be present.
- Union B lists other species that may also be present in large or small amounts up to an aggregate maximum.

TABLE E.2-13
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Western Wheatgrass (*Agropyron smithii*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Graminoids	
western wheatgrass (*Agropyron smithii*)	MINIMUM CANOPY COVER = 80%
UNION B SPECIES (These species may be present with combined total ***maximum*** canopy cover of 30 percent)	
Graminoids	
bearded wheatgrass (*Agropyron caninum*)	
tickle grass (*Agrostis scabra*)	
Baltic rush (*Juncus balticus*)	
green needlegrass (*Stipa viridula*)	
Forb	
common yarrow (*Achillea millefolium*)	
prairie sagewort (*Artemisia ludoviciana*)	
wild licorice (*Glycyrrhiza lepidota*)	
American vetch (*Vicia americana*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 30%

Additional requirements. In addition to the requirements specified in Table E.2-13, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-13;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Water Sedge (*Carex aquatilis*) HT—Water Sedge is a late seral community that naturally dominates very wet sites that are slightly drier than sites of the Beaked Sedge (*Carex aquatilis*) HT. There are three unions described in Table E.2-14:

- Union A is the type indicator species required to be present.
- Union B species may also be present in large amounts up to an aggregate maximum.
- Union C species may be present, but probably not if the stand is healthy and undisturbed.

TABLE E.2-14
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Water Sedge (*Carex aquatilis*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Graminoids	
water sedge (*Carex aquatilis*)	MINIMUM CANOPY COVER = 70%
UNION B SPECIES (These species may be present with combined total maximum canopy cover of 20 percent)	
Graminoids	
Columbia sedge (*Carex aperta*)	
lentil fruited sedge (*Carex lenticularis*)	***MAXIMUM*** COMBINED CANOPY COVER = 30%
UNION C SPECIES (These species may be present with combined total maximum canopy cover of 20 percent)	
Graminoids	
bluejoint reedgrass (*Calamagrostis canadensis*)	
Nebraska sedge (*Carex nebraskensis*)	
beaked sedge (*Carex rostrata*)	
short beaked sedge (*Carex simulata*)	
inflated sedge (*Carex vesicaria*)	
common spikesedge (*Eleocharis palustris*)	
few flowered spikesedge (*Eleocharis pauciflora*)	
Baltic rush (*Juncus balticus*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-14, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-14;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Common Spikesedge (*Eleocharis palustris*) HT—Common spikesedge (*Eleocharis palustris*) HT is a minor type that occurs commonly in very small stands on narrowly defined hydrologic conditions along the edges of ponded or slowly moving water. Although the Common Spikesedge (*Eleocharis palustris*) HT defines site potential, this community is adapted to quickly changing potential. A narrow band of common spikesedge can move up or down slope to follow changing water level rapidly. Table E.2-15 shows two unions for this type:

- Union A is the type indicator species required to be present.
- Union B lists other species that may also be present in large or small amounts up to an aggregate maximum.

TABLE E.2-15
Plant Community Composition, Separated into Unions with Specified Amounts of Canopy Cover, Required 10 Years After Remediation for Stands of the Common Spikesedge (*Eleocharis palustris*) HT

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Graminoids	
needle spikesedge (*Eleocharis acicularis*)	
common spikesedge (*Eleocharis palustris*)	COMBINED MINIMUM CANOPY COVER = 70%
UNION B SPECIES (These species may be present with combined total maximum canopy cover of 40 percent)	
Graminoids	
western wheatgrass (*Agropyron smithii*)	
short awn foxtail (*Alopecurus aequalis*)	
American sloughgrass (*Beckmannia syzigachne*)	
slender beaked sedge (*Carex athrostachya*)	
foxtail barley (*Hordeum jubatum*)	
Nuttall's alkaligrass (*Puccinellia nuttalliana*)	
Forbs	
common willow herb (*Epilobium ciliatum*)	
field mint (*Mentha arvensis*)	
arum leaf arrowhead (*Sagittaria cuneata*)	
alkali marsh butterweed (*Senecio hydrophilus*)	
simplestem bur reed (*Sparganium emersum*)	
Plus other unlisted native volunteer species	***MAXIMUM*** COMBINED CANOPY COVER = 40%

Additional requirements. In addition to the requirements specified in Table E.2-15, these conditions must be met at the end of 10 years:

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-15;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

Forb Dominated Types

Common Cattail (*Typha latifolia*) HT—The Common Cattail (*Typha latifolia*) HT is a late seral type that dominates very wet sites that retain standing ponded water for most of the growing season each year. Under normal hydrologic circumstances, and free of disturbance, this type forms a dense, mono specific stand. Table E.2-16 shows two unions for this type:

- Union A is the type indicator species required to be present.
- Union B lists other species that may also be present in large or small amounts up to an aggregate maximum.

TABLE E.2-16
Plant community composition, separated into unions with specified amounts of canopy cover, required 10 years after remediation for stands of the Common Cattail (*Typha latifolia*) HT (*NOTE: Exempt area of open water more than 2 ft deep from polygon area*)

Species	Percent Canopy Cover
UNION A SPECIES (These species must be present with the listed minimum canopy cover)	
Forbs	
common cattail (*Typha latifolia*)	MINIMUM CANOPY COVER = 80%
UNION B SPECIES (These species may be present with combined total maximum canopy cover of 20 percent)	
Graminoids	
softstem bulrush (*Scirpus validus*)	
Forbs	
common willow herb (*Epilobium ciliatum*)	
field mint (*Mentha arvensis*)	
water smartweed (*Polygonum amphibium*)	
Plus other unlisted native volunteer species	*MAXIMUM* COMBINED CANOPY COVER = 20%

Additional requirements. In addition to the requirements specified in Table E.2-16, these conditions must be met at the end of 10 years (*NOTE: Exempt area of open water more than 2 feet deep*):

- Minimum of 90 percent total canopy cover of individual species listed in Table E.2-16;
- No unvegetated soil surface is present; and
- Maximum canopy cover of undesirable herbaceous species does not exceed 20 percent.

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Clark Fork River Operable Unit
of the Milltown Reservoir/Clark Fork River Superfund Site

Record of Decision

Appendix F:
Concurrence Letter from the State of Montana

U.S. Environmental Protection Agency
Region 8

10 West 15th Street
Suite 3200
Helena, Montana 59626

April 2004

Montana Department of
ENVIRONMENTAL QUALITY

Judy Martz, Governor

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April 22, 2004

Max H. Dodson
Assistant Regional Administrator
US EPA Region
One Denver Place
999 18th Street
Denver, CO 80202-2405

Re: The Montana Department of Environmental Quality's Concurrence in the Record of Decision for the Clark Fork River Operable Unit of the Milltown Reservoir NPL Site in Montana

Dear Mr. Dodson:

The Montana Department of Environmental Quality (DEQ) concurs in the Record of Decision (ROD) for the Clark Fork River Operable Unit of the Milltown Reservoir NPL Site in Montana. DEQ fully supports EPA's determination that there are present and potential human health and environmental risks in the Operable Unit that must be addressed pursuant to CERCLA and the NCP. In concurring, however, DEQ does not necessarily agree with all statements and opinions expressed in the ROD. While DEQ generally supports EPA's determination of the areas where these risks must be addressed, DEQ has reservations concerning certain issues, including those discussed below. In addition, the Department wishes to identify certain concerns that it believes should be addressed in designing and implementing the remedy and in evaluating the effectiveness and protectiveness of the remedy in EPA's five-year reviews.

Limitations on the Effectiveness of In-situ Treatment

DEQ has concerns about the extensive use of in-situ treatment within the floodplain. Specific limitations of in-situ treatment that DEQ commented on in the development of the remedy for the Clark Fork River included: the continued migration of metals into groundwater and surface water; increased mobility of arsenic and increased migration of arsenic into both surface water and groundwater; the inability of in-situ treatment to meet human health action levels in certain circumstances; the limitations of in-situ treatment where materials are too deep or too wet to be treated in place; the difficulty of calculating and applying the correct lime amendment amount; the lack of certainty as to the permanence of in-situ treatment; and the continued re-entrainment of contaminants into the river system.

These limitations have to a large extent been acknowledged in the ROD. However, DEQ believes these limitations will play an important role in the development of the remedial design and the implementation of the remedial action. In addition, these limitations should be explicitly addressed in each five-year review, although DEQ notes that additional removal of materials from the floodplain may occur as part of the State of Montana's Natural Resource Damage Program's (NRD) restoration efforts in the Clark Fork River Operable Unit.

Surface Water Arsenic Concentrations

DEQ is concerned with the arsenic concentrations that have been reported in the Clark Fork River from Warm Springs Ponds to Turah Bridge. Arsenic concentrations here often exceeded both the EPA Maximum Contaminant Level (MCL) of 10 $\mu g/L$ and the State WQB-7 standard of 18 $\mu g/L$. These concentrations are a concern because of potential human health effects and because arsenic has been identified as a significant chronic stress risk to trout. These high levels of arsenic need to be recognized and addressed during the remedial design, in future monitoring, and in each five-year review.

Significance of Chronic Stress on Fish

In the Ecological Risk Assessment, EPA determined unacceptable acute risk to fish from pulse events causing the release of copper. Major fish kills have been attributable to sudden precipitation events that wash copper and other mining wastes into the river. EPA also found that metals and arsenic in the aquatic environment are also imposing a low-level chronic stress on trout and other fish and that the most likely manifestation of this stress is decreased growth.[1] The State of Montana believes that chronic stress is even a more important risk factor. Recently, Stratus Consultants conducted a trout feeding study for the NRD program that showed reduced growth in rainbow trout fed a diet of aquatic invertebrates that bioaccumulated arsenic and metals from Clark Fork River sediments.[2] Research scientists at EPA's Duluth office, as well as others, have documented similar growth effects in rainbow trout resulting from arsenic contamination in trout diets.[3]

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[1]Ecological Risk Assessment for the Clark Fork River Operable Unit, EPA December 1999.

[2]The Stratus study showed a diet of aquatic invertebrates containing 129 mg As/kg caused a 44% reduction in growth rate of rainbow trout. "Reduced Growth of Rainbow Trout Fed a Live Invertebrate Diet Pre-exposed to Metal Containated Sediments Collected from the Clark River Basin, Montana," Dec. 5, 2002, Hansen, James, et al. (accepted for publication).

[3]Drs. Dave Mount and Russ Erickson observed an average 40% reduction in growth in fish consuming 100 mg As/kg diet, and 10% reduction in growth (LOEC) in fish consuming 35 mg As/kg.

Cockell, Hilton, and Bettger, 1991, "Chronic Toxicity of Dietary Disodium Arsenate Heptahydrate to Juvenile Rainbow Trout," Arch. Environ. Contam. Toxicol., 21:518-527, (Found significant reduced growth [LOEC] at 33 mg As/kg in diet.)

Cockell, Hilton, and Bettger, 1992, "Hepatobillary and Hematological Effects of Dietary Disodium Arsenate Heptahydrate in Juvenile Rainbow Trout," Comp. Biochem. Physiol., 103C: 453-458, (Found significant growth reduction [LOEC] at 55 and 60 mg As/kg in diet.)

Scientists working for the NRD program determined that overall trout populations in the Upper Clark Fork River are approximately one-sixth of reference stream populations and found that this reduced population is not due to differences in available habitat or other non-contaminant-related factors.[4] These depressed trout populations can be explained, at least in part, by chronic stress and decreased growth resulting from metals and arsenic in the trout diet. The evidence also suggests avoidance of metals and arsenic may be responsible, in part, for the depressed trout populations, including the absence of bull trout, in the upper Clark Fork River. Therefore, post-remedy concentrations must be closely monitored.

Floodplain Stability, Streambank Stabilization and Width of the Riparian Buffer Zone

EPA, in the ROD and Responsiveness Summary, recognizes that floodplain stability is a significant issue. This is consistent with the State's finding that terrestrial resources in the river's riparian zone, including, soils, vegetation, wildlife and wildlife habitat, have suffered significant injuries.[5] In a substantial part of Reach A, vegetation, affected by soil phytotoxicity, is absent or very sparse in areas of exposed and nearly exposed tailings, and there is decreased abundance and diversity in other areas containing contaminated soils. EPA also determined that soil organisms are adversely affected, and wildlife is potentially affected by the contaminants of concern (COCs).[6] As EPA's and the State's scientists have recognized, this has resulted in an unstable floodplain which may be subject to unraveling during overbank floods.

As stated in the Responsiveness Summary, Dr. Dungan Smith indicated that the width of riparian buffer zone to be revegetated should be greater than 50 feet in order to adequately protect floodplain stability and prevent unraveling.[7] Also, a large number of public comments supported a wider riparian buffer zone. DEQ believes that the implementation of a wider buffer zone is feasible, and efforts should be made to increase the zone's width where practicable during remedy implementation.

DEQ also has reservations about certain aspects of the streambank component of the proposed remedy. The Department of Fish, Wildlife and Parks and other Montana streambank experts feel that some of the streambank stabilization techniques proposed in the ROD may not be sufficient to decrease erosion and stabilize the banks. However, this component can be evaluated in the remedial design and the best streambank stabilization techniques can be implemented during construction.

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[4] Aquatic Resources Injury Assessment Report, Upper Clark Fork River Basin, State of Montana, 1995.

[5] Terrestrial Resources Injury Assessment Report, Upper Clark Fork River Basin, State of Montana, 1995.

[6] Ecological Risk Assessment for the Clark Fork River Operable Unit, EPA, December 1999.

[7] Letter to Scott Brown from J. Dungan Smith dated October 29, 2001

Protection of Human Health

DEQ has concerns regarding the level of protectiveness of human health in the ROD. The arsenic cleanup levels selected are based on a 1.499×10^{-4} risk. The least stringent cleanup level considered acceptable under CERCLA and the NCP is 1×10^{-4}. More protective levels, using a 1×10^{-6} risk as the point of departure, are encouraged under the law. Although the cleanup levels selected by EPA represent a 1.499×10^{-4} risk, the 1.499 was rounded down to 1 for purposes of finding that the risk was within the acceptable risk range. No corresponding adjustment was made in the cleanup levels. Use of a true 1×10^{-4} risk level would have resulted in more protective cleanup levels.

Moreover, the cleanup levels chosen in the ROD are based on risks to the general population and are not necessarily protective of all sensitive subgroups. Under the NCP and EPA guidance, the levels should be set to be protective of all subgroups. EPA proposes to address the risk to pica children (defined as children with a medical condition that makes them prone to eat dirt) through an educational program, as part of the remedy. For arsenic, protective levels for pica children may represent levels below arsenic background concentrations. An aggressive educational program offers the best option for protecting this sensitive subgroup.

The Atlantic Richfield Company, in its comments on the Clark Fork River Proposed Plan, asserts that it cannot be required to fund such an educational program. In the event that educational programs are, for any reason, not successful in ensuring that all sensitive subgroups are protected, cleanup levels should be adjusted and additional action implemented to make the remedy more protective. This also can and should be evaluated as part of each five-year review.

The State of Montana looks forward to working closely with EPA, the responsible party, and landowners along the Clark Fork in designing and implementing this remedy and any related restoration actions to ensure a clean and healthful environment for the citizens of the State, especially for those who live or work along the Clark Fork River.

Sincerely,

Tom Livers

for Jan P. Sensibaugh
Director
Montana Department of Environmental Quality