Conceptual Restoration Plan for the Upper Blackfoot Mining Complex

Restoration of the Stream and Floodplain Ecosystem

Prepared For

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Section 1 Introduction

This document describes a conceptual restoration approach for the Upper Blackfoot Mining Complex (UBMC) project area. Currently, remedial actions related to removal of the Mike Horse Dam and impoundments, and removal of mining tailings associated with the UBMC, are in the planning stages. The purpose of preparing the conceptual restoration plan is to define the restoration vision for the site so removal and remediation actions can support a desired restoration outcome. Additionally, during conceptual restoration plan development, specific integration issues are identified so remediation and restoration can be done in an efficient and compatible manner in order to maximize benefits to the ecosystem and native fish habitat given the available resources.

To support these purposes, the document is organized into the following sections:

- **Section 1. Introduction** provides project background, descriptions of reach breaks, and descriptions of the project area setting and resources that are important relative to restoration potential.
- **Section 2. Restoration Concepts by Reach** includes descriptions of existing conditions, limiting factors and constraints, desired conditions, objectives and restoration strategies for six reaches that have been identified because they each have specific characteristics and needs that will drive the restoration approach within the reach.
- **Section 3. Restoration Treatments** includes descriptions of general restoration treatments with examples that will likely be included as part of restoration designs for the UBMC project area.
- **Section 4. Integration with Remedial Actions** describes the current schedule for integrated remediation and restoration work, and identifies important issues that need to be considered so remediation work supports restoration work and both activities can be accomplished in an efficient, integrated manner.
- **Section 5. Next Steps** describes future restoration planning phases necessary to move from a conceptual restoration plan to project implementation that will result in a restored ecosystem in the UBMC project area.

1.1 Project Background

Several reports and studies have been prepared for the UBMC project area that discuss the history of the site as well as the current conditions and proposed remedial and restoration actions. A few of these recent reports are listed below:

- Engineering Evaluation/Cost Analysis for the Mike Horse Dam and Impounded Tailings, Lower Mike Horse Creek, Beartrap Creek and the Upper Blackfoot River Floodplain Removal Areas Upper Blackfoot Mining Complex Lewis and Clark County, MT (Hydrometrics 2007).

- Action Memorandum for the Removal Action for the Mike Horse Dam and Impounded Tailings, Lower Mike Horse Creek, Beartrap Creek and the Upper Blackfoot River Floodplain Removal Areas, Upper Blackfoot Mining Complex Site (Helena National Forest 2007).
- Draft Assessment of Injuries and Damages: Upper Blackfoot Mining Complex, Lewis and Clark County, Montana (Stratus Consulting 2007).
- Mike Horse Preliminary Design Report Draft (MT DEQ 2010).

Mining activities began in the UBMC project area in the late 1800s and continued into the 1950s. The 1930s and 1940s were the most active mining periods with mining ceasing in the 1950s; however, exploration activities continued after the 1950s. Lead, zinc, and copper were the major mine products, with some minor production of gold and silver. In 1941, the Mike Horse Dam was constructed across Beartrap Creek creating the Mike Horse Tailings Impoundment where tailings from the Mike Horse Mine mill were disposed. In 1975 the Mike Horse Dam was breached during a spring storm event that produced heavy runoff that combined with rapid spring runoff. The breach released an estimated 100,000 tons of tailings and other materials into the UBMC project area below the dam. The dam was modified and repaired in the fall of 1975 after this breach event (Hydrometrics 2007).

Regulatory activities began in the UBMC in 1987 to reclaim the Mike Horse Mine under Montana's abandoned mine reclamation program (Hydrometrics 2007). To support reclamation activities, several studies evaluated soils, surface water and groundwater in the project area. Water quality impairments were described for the Blackfoot River above Lander's Fork, Mike Horse Creek, and Beartrap Creek within the Blackfoot Headwaters TMDL Planning Area (MT DEQ 2003). Findings of these reports have shown soils, mine waste tailings, and surface waters in the project area pose potential risks to human health and the environment due to metal concentrations. The integrity and safety of the Mike Horse Dam has also been evaluated and was found to have insufficient spillway capacity during flood events (Hydrometrics 2001a as cited in Hydrometrics 2007). Further analysis of the dam found that it could be susceptible to damage or failure in the event of an earthquake (USFS 2005 as cited in Hydrometrics 2007). Due to these findings the United States Forest Service (USFS) recommended that the dam be taken out of service (USFS 2005 as cited in Hydrometrics 2007).

In 2007, Stratus Consulting prepared an assessment of injuries and damages within the Upper Blackfoot River drainage based on existing data. This report found that groundwater in the project area has metal concentrations that exceed Montana's human health standards. It also found that surface water in Mike Horse Creek, Beartrap Creek, and the Upper Blackfoot River have concentrations of zinc and cadmium that exceed acute criteria and are sufficiently high to cause harm to aquatic life. Metal concentrations collected from sediments from Mike Horse Creek and the Upper Blackfoot River were found to be high enough to be likely to cause injury to benthic invertebrates. Macroinvertebrates were found to be absent from some portions of the Upper Blackfoot River and in other locations, only metal tolerant species are present. Mine tailings in the project area form sites that may be devoid of riparian vegetation.

In 2007, Hydrometrics prepared an Engineering Evaluation and Cost Estimate to provide a process and rationale for developing, screening, and evaluating potential response actions designed to address mining-related impacts on portions of the UBMC project area. The objective of the document is to develop, present, and compare removal action alternatives that may be used to reduce or eliminate potential human health and environmental risks posed by mining-related impacts on certain USFS managed lands in the UBMC project area. The comparative analysis of alternatives was based on their relative effectiveness, ability to be implemented, and costs. Based on this document, the USFS prepared an Action Memorandum (2007) that selected and approved the following action alternatives:

- Total removal of Mike Horse Dam and associated impounded tailings.
- Total removal of mine wastes below Mike Horse Dam.
- Removal of concentrated and intermixed mine tailings along the Beartrap Creek channel.
- Total removal of mine waste material from a portion of the Upper Blackfoot River.

A draft preliminary design report is currently being prepared (MT DEQ 2010). The draft preliminary design report describes concepts being considered for removing tailings from the Mike Horse Dam and storing them in a repository. Once the tailings have been removed, the site will be reclaimed and restored. This document focuses on the restoration aspect of the project. Restoration activities will be coordinated and integrated with remedial actions.

1.2 Project Vision, Goals and Objectives

The vision for the project area is to restore self-sustaining ecological processes that will result in clean, connected habitat for westslope cutthroat trout, support downstream populations of bull trout and other important aquatic species, and maintain adjacent riparian and terrestrial habitat to support wildlife populations that depend on those habitats. Specific project area goals and objectives are described below. Ecological restoration described for this project integrates a range of disciplines regarding river restoration (e.g. empirical, analog, and analytical based methods), and principles outlined by the Society for Ecological Restoration.

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. It is an intentional activity that initiates or accelerates ecosystem recovery with respect to species composition, community structure, ecological function, suitability of the physical environment to support biota and connectivity with the surrounding landscape (Clewell et al. 2007). The restored ecosystem is sufficiently resilient to endure the normal periodic stresses that serve to maintain the integrity of the ecosystem (Naimen et al. 2005). A common goal for the restoration of natural ecosystems is to recover self-renewing processes to the point where assistance or maintenance from restoration practitioners is no longer needed (SER 2004). At the same time, it is recognized that the cost-effectiveness of any component of plan will be a key consideration given the finite quantity of funds for both remedy and restoration.

Remedy is expected to substantially reduce injuries to the UBMC and provide immediate benefits to the ecosystem. However, remedial actions will not address the full spectrum of ecosystem functions. Ecological restoration, on the other hand, sets the system on a trajectory of self-sustaining ecological processes that support functions like maintaining clean water, and providing both aquatic and terrestrial habitat over the long-term. While the remedial actions focus on removing the source of ecosystem degradation (mainly contamination from mining activities), ecological restoration will focus on creating conditions that can sustain a resilient stream and riparian system where ecological processes are driven by natural disturbances, and the system is able to respond to disturbances in ways that do not result in degraded habitat. Because ecological restoration ultimately relies on natural processes, the time frame to achieve desired future conditions described in this document will vary. For example, some components of aquatic habitat will function soon after restoration actions are implemented; on the other hand, it will take several decades to achieve a multi-layered conifer-dominated riparian area within some portions of the floodplain.

Specific elements of the restoration vision include: channel and floodplain are connected; a diverse riparian forest is present and contributing nutrients to the aquatic environment, providing roughness to the floodplain surface and reducing flood flow velocities, filtering nutrients and sediments before they reach the aquatic environment; and providing habitat for insects, birds, and other wildlife. The exact differences between remedy and restoration will not be ascertained until remedial designs are completed. It is expected that remedial contractors will often perform both remedy and restoration actions at the site and coordination will be critical. In summary, the intention is for restoration to be planned and implemented in an integrated manner with the remediation actions set forth in the Action Memorandum (Helena National Forest 2007).

Table 1-1 summarizes over-arching restoration objectives development for the UBMC project area. As noted, these objectives are common to all reaches with the exception of Reach 1 Upper Mike Horse Creek where the presence of permanent infrastructure will impose several constraints on restoration. In particular, adit drains will remain a perpetual source of acid mine drainage and the infrastructure to remain in place will limit the width of the restored channel and floodplain corridor. In addition, it is likely the inherent steep slopes of the channel and valley historically inhibited fish passage from Upper Beartrap Creek into Mike Horse Creek. For these reasons, providing clean water that supports aquatic life in Reach 1, and minimizing sediment inputs to the channel through road decommissioning/relocation and removal of unnecessary infrastructure, have been identified as the primary restoration objectives.

Table 1-1. Summary of restoration objectives for UBMC project reaches.

Objectives	UBMC Project Reach					
	1	2	3	4	5	6
Produce clean water consistent with supporting aquatic life and/or westslope cutthroat and bull trout habitat.	✓	✓	✓	✓	✓	✓
Create complex aquatic habitat components such as depth, velocity,	✓	✓	✓	✓	✓	✓

Table 1-1. Summary of restoration objectives for UBMC project reaches.

substrate, cover, and pools that support populations of westslope cutthroat trout and other aquatic organisms.						
Construct a stream channel that is connected to the floodplain and interacts with the floodplain in terms of surface flow and sediment exchange.	✓	✓	✓	✓	✓	✓
Maximize riparian and floodplain habitats and functions.	✓	✓	✓	✓	✓	✓
Minimize sediment inputs to the channel resulting from upland and/or instream source areas.	✓	✓	✓	✓	✓	✓
Improve existing and future proposed stream crossings to provide for fish passage and transport flows, sediment and debris.	✓	✓		✓	✓	
Incorporate, to the greatest extent practical, historical (buried) floodplain and terrace surfaces and associated features including stumps and other roughness elements.		✓	✓	✓	✓	✓
Relocate access roads outside of the channel migration zone and where possible, remove all unnecessary infrastructures.	✓				✓	✓

1.3 Preliminary Restoration Strategies

The Montana Department of Environmental Quality (MT DEQ) is currently in the process of implementing remedial actions in the UBMC project area. To ensure ongoing remedial actions support the desired restoration outcome, and do not preclude implementation of a range of potential restoration alternatives, preliminary restoration strategies were developed during the conceptual design phase. Table 1-2 summarizes the preliminary strategies by reach. These strategies will set the stage for developing quantitative design parameters that will be developed as part of future phases of this project.

For purposes of this document, restoration strategies are defined as general approaches to achieve restoration objectives. Once more information becomes available as a result of remedial project components being completed, it will be possible to re-state these strategies in more specific, quantitative terms such as the conceptual design parameters presented in Tables 2-1 to 2-6 in Section 2 of this document.

Table 1-2. Summary of preliminary restoration strategies for UBMC project reaches.

Strategies	UBMC Project Reach					
	1	2	3	4	5	6
Design primary channel to convey the effective or bankfull discharge and a connected floodplain to accommodate larger flood events.	✓	✓	✓	✓	✓	✓
Provide for sediment transport continuity and sufficient capacity to transport the available sediment load.	✓	✓	✓	✓	✓	✓
Construct a low sinuosity, highly entrenched, confined stream channel with step-pool morphology developed within a narrow, well-	✓					

Table 1-2. Summary of preliminary restoration strategies for UBMC project reaches.

vegetated riparian corridor.						
Construct a low sinuosity, moderately entrenched stream channel with step-pool morphology and interspersed riffles and rapids, developed within a well-vegetated riparian corridor.		✓	✓	✓		
Construct a moderately sinuous, moderately entrenched riffle-pool stream channel with broad a broad, well-vegetated floodplain.					✓	
Construct a moderately entrenched, step-pool channel with interspersed riffles and rapids transitioning to a slightly entrenched, meandering channel with riffle-pool bedforms and a well-developed floodplain.						✓
Create a complex and narrow vegetated floodplain that functions to filter sediment and other chemical inputs from adjacent uplands, legacy mining and reclamation-related infrastructure, and residual metals.	✓					
Develop a narrow riparian area and floodplain that will occupy the full valley bottom width transitioning to an upland conifer forest.		✓	✓	✓		
Create a complex, broad vegetated floodplain with side channel habitats that supports a mosaic of conifers, cottonwoods, aspen and riparian shrubs.					✓	✓
Relocate access roads and other unnecessary infrastructure outside of the channel migration zone and provide for fish passage at existing and future proposed stream crossings.	✓	✓	✓	✓	✓	✓
Maintain a stable channel in the vicinity of the water treatment plant that can pass a >100 year flood without damaging the plant				✓		

1.4 Project Area Description

The UBMC project area includes the site of Mike Horse Dam, the Mike Horse Tailings Impoundment, the Upper Blackfoot River and tributaries. Figure 1-1 shows an overview of the UBMC project area. The UBMC project area has legacy impacts from mining activities that include Mike Horse Dam, waste repositories, and mine tailings.

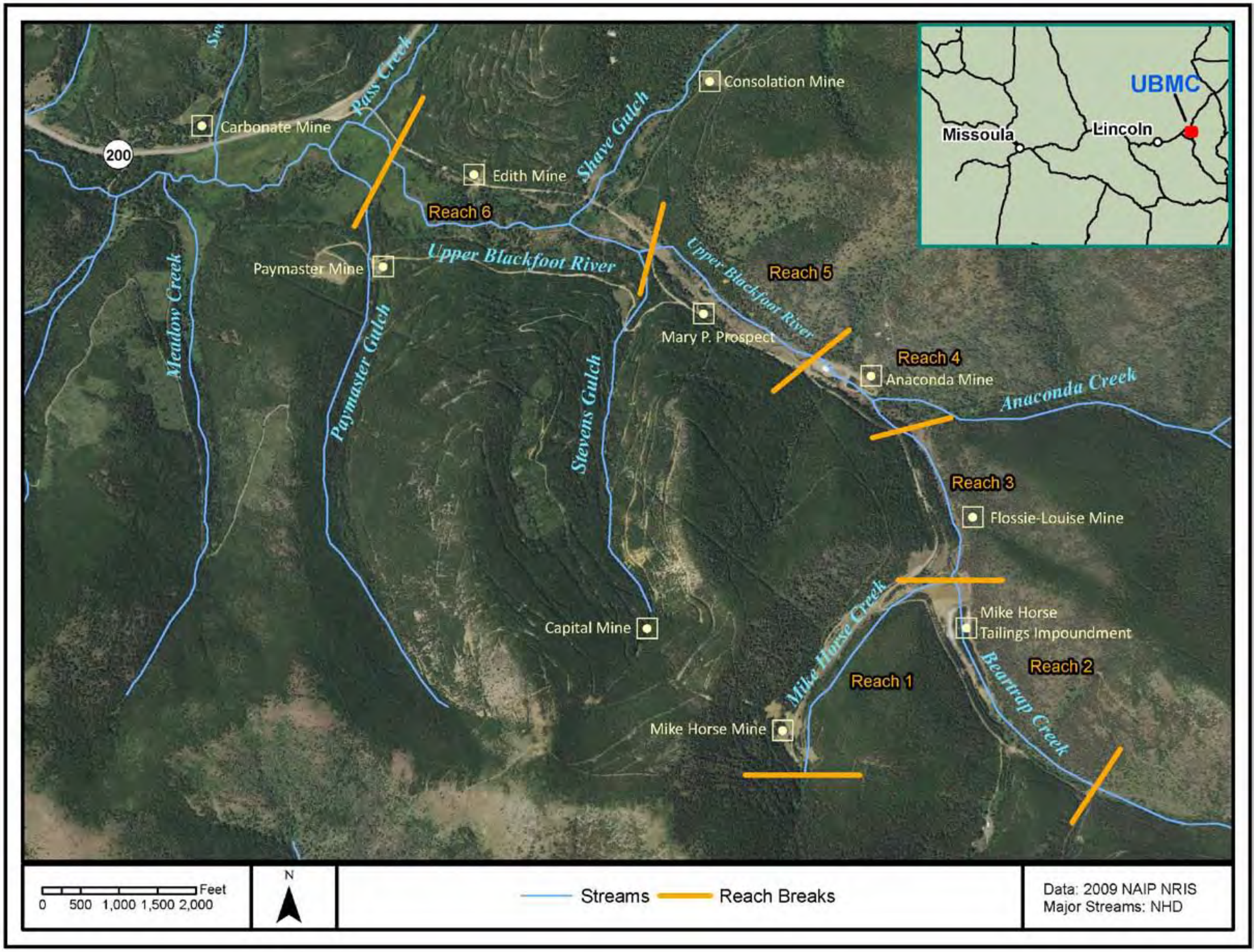


Figure 1-1. Overview of the UBMC project area showing project reaches and infrastructure locations.

1.4.1 Reach Delineations

For the purposes of this document, the UBMC project area was delineated into stream reaches based on several attributes including dominant valley and stream types, stream order and tributary confluences, major infrastructure, and vegetation characteristics. Stream reach delineations are shown in Figure 1-1 and described generally in the following section. Additional details for each project reach are included in Section 2 of this document.

Reach 1 Mike Horse Creek

Reach 1 Mike Horse Creek is situated in the upper headwaters of the UBMC project area and includes approximately 0.6 miles of channel from the Upper Mike Horse waste piles downstream to the confluence with Beartrap Creek. Significant geographic features in Reach 1 include the Mike Horse Mine, waste repository and associated infrastructure.

Reach 2 Upper Beartrap Creek

Reach 2 Upper Beartrap Creek includes approximately 0.7 miles of channel from the primary diversion located at the head of the Mike Horse Tailings Impoundment downstream to the confluence with Reach 1 Mike Horse Creek. The primary geographic feature in Reach 2 includes the Mike Horse Dam and Tailings Impoundment. Constructed in 1941, the earthen embankment was constructed across Beartrap Creek just upstream of the confluence with Reach 1 Mike Horse Creek to serve as an impoundment for tailings from the Mike Horse Mine flotation mill (Tetra Tech 2008). Reach 2 encompasses approximately 18 acres of potential riparian and floodplain area that is presently impacted by the tailings impoundment.

Reach 3 Lower Beartrap Creek

Lower Beartrap Creek forms at the confluence of Reach 1 Mike Horse Creek and Reach 2 Upper Beartrap Creek and extends 0.5 miles downstream to the confluence with Anaconda Creek. Encompassing approximately nine acres of valley bottom, the Flossie-Louise Mine and associated mine waste piles are the dominant geographic features in Reach 3.

Reach 4 Transition Reach

The confluence of Reach 3 Lower Beartrap Creek and Anaconda Creek denotes the start of the Upper Blackfoot River and Reach 4 of the UBMC restoration project area. Reach 4 extends downstream to the water treatment facility. In operation since 1996, the facility treats drainage from the Mike Horse Adit and the combined discharges from an adit and shaft located at the Anaconda Mine near the confluence of the Blackfoot River and Anaconda Creek. Reach 4 includes 0.3 miles of the Upper Blackfoot River and approximately eight acres of riparian and floodplain area.

Reach 5 Upper Blackfoot River

Reach 5 in the UBMC project area includes the Upper Blackfoot River from the water treatment facility downstream to the main crossing of Mike Horse Road, 0.2 miles upstream of the confluence with Shave Creek. Reach 5 includes approximately 0.5

miles of channel and 13 acres of riparian and floodplain area. Primary infrastructure in Reach 5 includes two stream crossings, Mike Horse Road that parallels the south side of the river corridor, and the Mary P. Mine and waste pile.

Reach 6 Upper Blackfoot River Wetlands

Reach 6 includes the lower 0.7 miles of the Upper Blackfoot River, starting at the Mike Horse Road crossing at the lower end of Reach 5, and terminating at the large wetland complex associated with the confluence of Pass Creek. Approximately 36 acres of riparian and floodplain area are encompassed in Reach 6. Shave Gulch and Stevens Gulch join the Upper Blackfoot River in Reach 6 of the project area. Additional geographic features include the Edith Mine and waste piles.

1.5 Watershed Overview

The UBMC project area is located in Lewis and Clark County, Montana, approximately 15 miles east of Lincoln, Montana at the headwaters of the Blackfoot River. The Blackfoot River is one of the three major streams in the Helena National Forest (Sirucek 2001). The project area and the surrounding watershed is steep and forested with elevations ranging from 7,500 feet above mean sea level at the headwaters in the continental divide to 5,200 feet above mean sea level below the UBMC project area at the confluence of Pass Creek and the Upper Blackfoot River (Stratus Consulting 2007 and Hydrometrics 2007).

1.5.1 Climate

Pacific Ocean air masses that distribute rain in the western Montana mountain ranges influence climate in the Helena National Forest (Sirucek 2001). The National Oceanographic and Atmospheric Administration (NOAA) maintains two weather stations at Rogers Pass, approximately two miles northeast of the UBMC, and at the Lincoln Ranger Station, approximately fourteen miles west of the UBMC project area. Both weather stations show similar weather data that indicates relatively consistent climatic patterns throughout the Blackfoot River watershed. Based on temperatures recorded at the Roger's Pass Station; January has the lowest average monthly minimum temperature at 13.4°F and July has the highest average monthly maximum temperature at 81.5°F. The record low is -70°F set on January 20, 1954 (Hydrometrics 2007). The area has average minimum temperatures near or below freezing from October to April (Stratus Consulting 2007). In the valley, summers are warm and receive high intensity, short duration thunderstorms. Wind speeds are highest in the spring (Sirucek 2001).

Average monthly precipitation ranges from 0.65 inches in February to 3.10 inches in June, with an average total annual precipitation of 17.99 inches with a record high of 31.4 inches in 1975 (Tetra Tech 2008). Table 1-1 below shows average monthly precipitation data from Rogers Pass. The lowest annual precipitation occurred in 1988 with only 13.9 inches (Hydrometrics 2007).

Table 1-2. Average monthly precipitation data recorded at Rogers Pass (Source: http://www.wrcc.dri.edu/cgi-bin/cliMONtrpre.pl?mtroge).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Precipitation (inches)	0.84	0.64	1.27	1.79	2.91	3.10	1.33	1.68	1.69	1.12	0.70	0.91

1.5.2 Vegetation

Vegetation varies within the UBMC project area, but is typical of Rocky Mountain flora. The current flora in the UBMC project area has been altered from its original state by the presence of mining and timber harvesting activities (Hydrometrics 2007). Vegetation communities present in the UBMC project area are primarily riparian and wetland communities along the Upper Blackfoot River and its tributaries consisting of forested, shrub-dominated or meadow vegetation communities. Forested wetland communities may have either coniferous trees such as Engelmann spruce (*Picea engelmannii*) or subalpine fir (*Abies lasiocarpa*), or deciduous trees such as quaking aspen (*Populus tremuloides*) (Sirucek 2001). Willows (*Salix spp.*), alders (*Alnus spp.*), and bog birch (*Betula glandulosa*) are some of the main species found in shrub-dominated wetlands (Stratus Consulting 2007 and Hydrometrics 2007). Vegetation in wet meadows generally consists of sedges (*Carex spp.*) (Sirucek 2001). A marsh area occurs at the downstream end of the project area (Reach 6) at the confluence of Pass Creek and Swamp Gulch with the Upper Blackfoot River (Stratus Consulting 2007 and Hydrometrics 2007). These riparian and wetland vegetation communities are described in more detail below.

Adjacent to and surrounding the UBMC project area, plant communities on lower and drier slopes consist of mountain big sagebrush (*Artemisia tridentata spp.*)and fescue grassland, while the higher more mesic slopes include lodgepole pine (*Pinus contorta*), Engelmann spruce and Douglas-fir (*Pseudotsuga menziesii*) (Stratus Consulting 2007 and Hydrometrics 2007). South facing slopes generally consist of open, mixed Douglas-fir and lodgepole pine forest with an understory dominated by Idaho fescue (*Festuca idahoensis*), elk sedge (*Carex geyeri*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). North facing slopes also generally consist of lodgepole pine and some Douglas-fir, as well as Engelmann spruce and subalpine fir. Understory species on north-facing slopes include beargrass (*Xerophyllum spp.*), elk sedge and huckleberry (*Vaccinium spp.*) (Sirucek 2001).

Classification Systems Used to Describe Plant Communities

Plant communities, as referenced in this discussion, are relatively homogeneous assemblages of plant species, the distribution of which is determined by landform position, hydrology, soils, wildlife use and movement, and the presence of other plant communities and species. Their distribution may also reflect their age relative to a specific disturbance. In western Montana, *Classification and Management of Montana's Riparian and Wetland Sites* (Hansen and others 1995) is the standard habitat-typing manual used to describe plant communities occupying the near-bank area, active floodplain zone, older floodplain terraces, and other wet areas. Plant communities described in Hansen and others (1995) are discussed in terms of their relationship to plant community succession and their response to natural and human-induced disturbance processes. Riparian and wetland plant communities observed in the UBMC project area, or that have the potential to be present in the project area are described below. Each plant community is named according to Hansen and others (1995) and a general description of the plant community follows.

The Montana Natural Heritage Program (2010) maintains a plant community database focusing on plant communities that are significant from a conservation perspective. Information from this database is included to supplement information from Hansen and others (1995).

Black Cottonwood/Red-osier Dogwood (*Populus trichocarpa/ Cornus stolonifera*) Community Type

Black cottonwood (synonym *Populus balsamifera ssp. trichocarpa*) is the dominant native cottonwood in Montana west of the continental divide. The Black Cottonwood/ Red-osier Dogwood Community Type typically occupies portions of the active floodplain and adjacent alluvial terraces at elevations ranging from 2,000 feet to 6,600 feet (Hansen et al. 1995). The Montana Natural Heritage Program (2010) summarizes the type as follows:

> This association has been documented from Washington south to northern California and eastward to Idaho and all of Montana west of the Continental Divide, as well as central Montana. In Montana alone it occurs over a broad elevation range of 610-2010 m (2000-6600 feet) where *Populus balsamifera ssp. trichocarpa* is the dominant cottonwood at elevations considered relatively low- to mid-gradient; in Idaho it ranges to 2135 m (7000 feet). This forest type occupies alluvial terraces of major rivers and streams, point bars, side bars, mid-channel bars, delta bars, an occasional lake or pond margin, and even creeps onto footslopes and lower subirrigated slopes of hilly or mountainous terrain. Many of these sites are flooded in the spring and dry deeply by summer's end; capillary action keeps upper portions of soil profile moist. Other sites are merely subirrigated. *Populus balsamifera ssp. trichocarpa* dominates the overstory with cover values ranging from approximately 12-90%, though the modal range, at least in Montana is 40-60%. *Populus angustifolia* is a subordinate canopy species in the eastern portion of the range, and *Populus tremuloides* and *Betula papyrifera* occur as subordinates in the western portion. The shrub layer comprises at least 25% cover with *Cornus sericea* diagnostic for the type and having anywhere from 1-90% cover; other shrub taxa with high constancy include *Symphoricarpos* spp., *Rosa* spp., *Salix* spp., *Crataegus* spp., *Amelanchier alnifolia*, and *Alnus incana*. There are no graminoids exhibiting high constancy, though any one of a number of disturbance-associated exotics can manifest high coverages. *Maianthemum stellatum, Galium triflorum, Solidago canadensis*, and *Equisetum* spp. are the only forbs that exhibit even relatively high constancy across the range of the type. This is a successional community that colonizes moist, newly deposited alluvium exposed to full sunlight; in the absence of fluvial

disturbance it is capable of developing into conifer-dominated communities belonging to alliances as diverse as *Thuja plicata, Picea* spp. and *Juniperus scopulorum*. Adjacent wetter sites are dominated by a suite of wetland *Salix* spp., *Alnus incana*, wetland-associated *Carex* spp. often including *Carex utriculata, Carex aquatilis* and *Carex buxbaumii* or *Typha latifolia*-dominated communities. Adjacent drier sites are dominated by *Populus balsamifera ssp. trichocarpa* or *Populus tremuloides* types or any of a vast array of conifer-dominated types that are capable of growing within the elevational zone occupied by the *Populus balsamifera ssp. trichocarpa / Cornus sericea* Forest (MNHP 2010).

Quaking Aspen/Red-osier Dogwood (*Populus tremuloides/Cornus stolonifera*) Habitat Type

This habitat type usually occurs on alluvial terraces adjacent to rivers and streams, or near springs and seeps at elevations ranging from 2,400 feet to 6,900 feet. An overstory of quaking aspen typically dominates an understory of willows and other shrubs. Black cottonwood and scattered conifers may also be present. Dominant mid-story shrubs include red-osier dogwood (synonym *Cornus sericea* spp. *sericea*), mountain alder (*Alnus incana*), Woods' rose (*Rosa woodsii*), red raspberry (*Rubus idaeus*), and several species of willow. Other shrubs such as, Rocky Mountain maple (*Acer glabrum*), water or bog birch (*Betula occidentalis* or *B. glandulosa*), twinberry (*Lonicera involucrata*), chokecherry (*Prunus virginiana*), current (*Ribes* s*pp*.), western serviceberry (*Amelanchier alnifolia*), and smaller shrubs such as creeping barberry (*Mahonia repens*) and bunchberry (*Cornus canadensis*) may also be present. Understory species composition varies widely depending upon soil moisture (Hansen et al. 1995).

Soils within this habitat type are typically Mollisols. Adjacent to streams the soils are often shallow Fluvents overlying river cobble, as a result of recently deposited alluvium. Soil textures can vary from silt loam to sand.

Spruce/Red-osier Dogwood (*Picea/Cornus stolonifera*) Habitat Type

This habitat type is typically found at low to mid elevation (2,700feet to 5,300 feet) on moist sites that are gently undulating or flat alluvial benches and terraces along streams. It may also occur on moist toe slopes. The relatively closed overstory consists of mature spruce *(Picea spp*.). Western larch (*Larix occidentalis*), lodgepole pine, and Douglas-fir are also present and can be a major component. Subalpine fir occurs in limited amounts in the upper elevation limits of this habitat type. Black cottonwood can also be a component in this habitat type in certain locations. They are typically widely scattered when they do occur. The mid-story consists of a thick cover of shrub species dominated by red-osier dogwood, common snowberry (*Symphoricarpus albus*), and western serviceberry. Other shrubs that may be present include various willows, mountain alder, and twinberry. Cover of the herbaceous layer varies where species richness is high but cover and constancy is usually low for most species. The following species have been documented as having high constancy in the herbaceous layer of this habitat type: starry false Solomon's seal (*Maianthemum stellatum*), Virginia strawberry (*Fragaria virginiana*), sweetscented bedstraw (*Galium triflorum*), mountain sweet-cicely (*Osmorhiza chilensis*), and western meadowrue (*Thalictrum occidentalis*) (Hansen et al. 1995).

The habitat type may be temporarily flooded in the spring, and due to its location in riparian zones, the water table is usually within one meter of the surface throughout the growing season. Soils are generally Inceptisols, Mollisols, or Entisols. Parent material is usually alluvium. The soils often have Histic or Aquic characteristics such as, high organic matter accumulation, gleyed soil, mottling, and high water tables. Soil textures vary between clay loam and silt loam with coarse fragments throughout (Hansen et al. 1995).

Subalpine Fir (*Abies lasiocarpa)* Habitat Types

A number of the subalpine fir habitat types described by Hansen and others (1995) represent potential communities that may have been present in UBMC project area and that have potential to be present with the implementation of proposed restoration actions. These potential habitat types include: Subalpine Fir/ Baneberry (*Abies lasiocarpa/ Actea rubra*) Habitat Type, Subalpine Fir/ Clasping Twisted Stalk (*Abies lasiocarpa/ Streptopus amplexifolius*) Habitat Type, and Subalpine Fir/ Sweetscented Bedstraw (*Abies lasiocarpa/ Galium trifolium*) Habitat Type. Vegetation within these three habitat types is similar but varies depending on elevation, hydrology, and aspect. The baneberry habitat type tends to be located on moist but drained alluvial terraces, lower slopes, and sometimes old landslides whereas the other two habitat types tend to occupy wetter locations. A description of the clasping twisted stalk habitat type is provided below as an example of the environment in which the subalpine fir habitat types are found and the typical vegetation and soils found within these habitat types (Hansen et al 1995).

Subalpine Fir/ Clasping Twisted Stalk (*Abies lasiocarpa/ Streptopus amplexifolius)* Habitat Type

This habitat type occurs at mid elevations (4,100 feet to 8,800 feet) along slopes with seeps and sub-irrigated alluvial terraces. It also occurs along small streams (Hansen et al 1995). The Montana Natural Heritage Program (2010) summarizes the type as follows:

> The *Abies lasiocarpa/Streptopus amplexifolius* association occurs predominantly as a small patch community type with a broad geographic distribution, found in nearly all mountainous terrain from the inland Pacific Northwest to the Southern Rocky Mountains. This association is strongly associated with high water tables, being saturated for extensive periods during the growing season and in some years and for some landscape positions it is seasonally flooded. Not uncommonly small rivulets will course across stands early in the growing season only to desiccate completely by mid-summer. It occurs in the lower to middle portions of the subalpine zone, with actual elevation parameters being associated with geographical context. The canopy is usually relatively open and

dominated by *Picea engelmannii* as a long-lived seral species with a subordinate layer of *Abies lasiocarpa* that is projected to be the dominant of long-term stable stands; the critical recognition feature is that *Abies lasiocarpa* be successfully reproducing. With the exception of *Pinus contorta*, a minor seral associate, other tree species are only incidentally present. The undergrowth is typified by a diverse assemblage of tall, moist- to wet-site forbs; depending on the region from which the type is cited it may be recognized by the mere presence of *Streptopus amplexifolius* or by a whole host of forbs considered ecological analogues (MNHP 2010).

Douglas-fir/ Red-osier Dogwood (Pseudotsuga menziesii/ Cornus sericea) Habitat Type

This habitat type occurs at low to mid elevations, ranging from 3,600 feet to 6,300 feet, on well drained alluvial benches or terraces of major streams and rivers as well as along smaller streams and creeks. The dominant overstory vegetation consists of Douglas-fir. This habitat type may contain a scattering of ponderosa pine or lodgepole pine as well as a few black cottonwood or quaking aspen. The understory shrub layer generally consists of a dense cover of Woods' rose, red-osier dogwood, chokecherry, and western serviceberry. The herbaceous layer consists of a variety of species including forbs such as baneberry and starry false Solomon's seal (Hansen et al. 1995).

Seral stands are dominated by lodgepole pine, black cottonwood, or quaking aspen community types, but Douglas-fir will be present and successfully reproducing. Different understory species dominate depending on the degree of disturbance. In moderately disturbed sites the understory is dominated by Woods' rose and common snowberry. Severe or prolonged disturbance can result in a non-native herbaceous understory (Hansen et al. 1995).

1.5.3 Geology

The UBMC project area lies within the Northern Rocky Mountain physiographic province (Fenneman and Johnson 1946) with mountain ranges and valleys trending in a general northwest to southeast direction (Sirucek 2001). Landforms within the Helena National Forest are a result of water and ice deposition as well as erosion. Glacial influences in some areas have left U-shaped valleys, cirques, steep sided mountain peaks and rolling glacial moraines. In areas such as the UBMC project area, streams have eroded V-shaped mountain valleys, terraces and floodplains (Sirucek 2001). The mountain ranges in the Helena National Forest are folded and faulted metasedimentary rocks and limestone. The three main bedrock units found in the UBMC are 1) the Belt Series Spokane Formation, 2) a diorite sill, and 3) a series of igneous intrusive bodies from the Tertiary-age.

The steeper drier mountain slopes, close to the river are composed of volcanic material, while the wetter higher slopes are part of the Spokane Belt Series and composed of metasediment. The floodplain is a sandy to clayey course alluvial material with rounded rock fragments (Hydrometrics 2007 and Sirucek 2001). Breaklands (steep, high relief slope areas) that consist of rock outcrops and deliver high volumes of sediment are located within a mile of the southern portion of the Blackfoot River on both the east and west sides of the river. The breaks follow along the eastern side of the river but increase in distance from the river in the northerly sections (Sirucek 2001).

In the western area of the Helena National Forest where the UBMC project area is located, granite rocks intrude limestone and metasedimentary rocks (Sirucek 2001). The metasedimentary rocks of the Spokane Formation are often weakly weathered and moderately to highly fractured (Sirucek 2001). Weathering of this material creates angular rock fragments ranging in size from moderately course to moderately fine texture material. Soil resulting from this material is at a slight hazard for erosion (Sirucek 2001).

In the center of the watershed, igneous intrusive stocks composed of quartz Tertiary monzonite porphyry are found within the Spokane argillite and diorite sill. Dikes formed radially from the main center stock along faults and fractures. These radial dikes were the original target for mining in the area (Hydrometrics 2007). Mineralization related to this Tertiary-age intrusive complex imposes natural constraints on remediation and restoration that will need to be considered as specific project objectives are developed during later design phases.

Granitic rock intrusions such as those distributed throughout the UBMC project area are weakly to moderately jointed and weathered. When only weakly weathered, the hardness of this bedrock can limit excavation indicating underlying stability. Underlying geomorphology influences stream channel locations and slope gradients and shape depending on the hardness and orientation of bedrock. Erosion hazard is severe in soil derived from granites (Sirucek 2001).

1.5.4. Soils

Three main soil map units are present in the UBMC project area: 1) Aquolls, 2) Typic Cryoboralf, and 3) Typic Ustochrepts-Typic Cryochrepts complex. Volcanic material is also found in the UBMC project area as deposits from the eruption of Mount Mazama, Oregon about 6,700 years ago. Soils following the river channel are Aquolls, found on floodplains and terraces and formed in alluvium or glacial outwash. The soil is usually characterized by an organic layer 2 to 16 inches thick with substratum layer that includes a cobbly sandy clay loam for up to 60 inches or more. Water tables in these soils are near or at the surface during the spring and the beginning of summer, while spring snowmelt can cause short flooding periods. Underlying valley fill material is characterized by stratified alluvial deposits and glacial outwash (Sirucek 2001).

The north-facing, mountainous slopes along the south side of the Upper Blackfoot River channel are Typic Cryoboralf soils. The soil is medium to moderately fine textured and covers the bedrock with 40 to more than 60 inches. Subsoils contain 40 to 60 percent angular rock fragments. The bedrock consists of argillites, siltites and quartzites with dikes and sills of andesites. Andesites are often associated with landslides and practices causing erosion are discouraged. This form of weathered bedrock forms loamy material (Sirucek 2001).

On the south-facing mountainous slopes along the north side of the Upper Blackfoot River channel the soils are Typic Ustochrepts-Typic Cryochrepts complex. The surface layer of these soils has a medium texture reaching 20 to 40 inches deep above the bedrock. Because they are southerly facing, these soils are warm and dry as opposed to the cool and moist soil of northerly facing soils. Beneath the soils lies bedrock of argillites, siltites and quartzites. Some sandstones and shales also exist. When weathered, the sandstones and shales also produce a loamy material. These soils are not highly susceptible to erosion, but can be difficult to revegetate because of a lack of water holding capacity (Sirucek 2001).

Although not in direct contact with the Upper Blackfoot River, Typic Cryoboralfs-Typic Cryochrepts complex soils are found on the north facing slopes of Anaconda Creek, a tributary to the Upper Blackfoot River flowing west. These soils have surface layers two to seven inches thick that formed in loess (accumulations of wind-blown fine textured silts or sediment) influenced by volcanic ash with a medium texture. Subsoils have 40 to 60 percent angular rock fragments and the volume of clay in the soil increases on lower portions of the slope. Underlying bedrock is the same as that of the soils on the south facing slopes, Typic Ustochrepts-Typic Cryochrepts complex and erosion is not prominent (Sirucek 2001).

1.5.5 Watershed Hydrology

The UBMC project area is located in the headwaters of the Blackfoot River where numerous perennial and intermittent streams contribute to the combined flow of the Upper Blackfoot River. Major tributaries in the project area include Beartrap Creek, Mike Horse Creek, Anaconda Creek, Stevens Gulch, Shave Gulch, Paymaster Creek, and Pass Creek. The mainstem of the Upper Blackfoot River forms at the confluence of Beartrap Creek and Anaconda Creek in the middle portion of the UBMC project area.

Similar to headwater systems located in intermediate to high elevation regions of the northern Rocky Mountains, tributaries draining the UBMC project area are subject to rain-on-snow driven storm events that can produce flood peaks of significant magnitude. Snowmelt and spring storm events recharge the local groundwater aquifers which in turn sustain baseflows in the project area streams.

TerraGraphics (2009) performed a detailed flood series analysis for tributaries and stream reaches in the UBMC project area. Since all of the streams in the project area are ungaged, USGS regional equations were applied to estimate peak flows for various recurrence interval discharges including the 2, 5, 10, 25, 50, and 100 year. A summary of annual peak discharge estimates for the eight primary sub-watersheds of the UBMC project area is provided in Table 1-2. Bankfull and effective discharge estimates for the UBMC project area tributaries have not been developed and will be performed under subsequent phases of this project.

Table 1-3. Average recurrence interval discharge for selected reaches and tributaries in the UBMC project area. Average recurrence interval discharges are from findings reported by TerraGraphics (2009).

Reach	Average Recurrence Interval Discharge in Cubic Feet per Second (cfs)					
	Q2	Q5	Q10	Q25	Q50	Q100
Reach 1 Mike Horse Creek	4 (3-5)	11 (8-14)	18 (12-23)	33 (22-44)	55 (38-72)	91 (66-115)
Reach 2 Upper Beartrap Creek	12 (8-17)	32 (23-41)	51 (35-66)	89 (58-120)	140 (96-184)	224 (162-286)
Reach 3 Lower Beartrap Creek	17 (11-23)	43 (31-55)	133 (45-88)	117 (75-158)	179 (122-236)	284 (205-363)
Anaconda Creek	17 (16-33)	59 (42-76)	91 (61-121)	157 (99-214)	236 (161-311)	371 (267-475)
Reach 4 Transition Reach	42 (27-57)	97 (68-126)	147 (96-197)	243 (153-343)	360 (244-476)	562 (400-724)
Reach 5 Upper Blackfoot River	42 (27-57)	97 (68-126)	147 (96-197)	243 (153-343)	360 (244-476)	562 (400-724)
Reach 6 Upper Blackfoot River Wetlands	44 (28-59)	102 (71-132)	153 (100-205)	258 (159-357)	373 (253-493)	582 (414-750)
Shave Gulch	NA	NA	NA	NA	NA	NA

"QT = the annual peak discharge, in cubic feet per second (cfs), for a recurrence interval T, in years.
The recurrence interval, which is the reciprocal of annual exceedance frequency, represents the average length of time between exceedances of a particular annual peak discharge. For example, an annual peak discharge with a recurrence interval of 5 years (Q5) is a flood that, on average, is exceeded once every 5 years and has 20% (1/5) probability of occurring in any year" (from TerraGraphics 2009).

1.5.6 Water Quality and Beneficial Use Designation

All surface waters within the UBMC project area are classified as B-1 waters (ARM 17.30.607) with the following identified beneficial uses (MT DEQ 2003): 1) growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; 2) contact recreation; 3) agriculture water supply, 4) industry water supply, and 5) drinking, culinary and food purposes after conventional treatment (Tetra Tech 2008).

The Upper Blackfoot River (above Landers Fork), Beartrap Creek, and Mike Horse Creek are listed on MT DEQ's 303(d) list as having impaired beneficial uses for aquatic life, cold water fish, and drinking water supply. Beneficial uses are identified as impaired due to the following pollutants of concern for the Upper Blackfoot River and Beartrap Creek: cadmium, copper, iron, lead, manganese, and zinc; with the addition of aluminum for Mike Horse Creek. These pollutants are released from areas of historical mine activities and may be related, in part, to natural background conditions (Tetra Tech 2008).

1.5.7 Valley and Channel Morphology

Floodplain and riverine ecosystems are dynamic mosaics that adjust over time to local and watershed-level changes in discharge, sediment supply, debris inputs, and riparian vegetation conditions. Valley morphology influences channel and floodplain conditions according to valley bottom width, slope, and valley wall interaction with the channel. Narrow valley bottoms constrict the floodplain-river environment, while broader valley bottoms permit floodplain building and lateral channel migration. Defining the historical or pre-disturbance morphology of UBMC tributaries and stream reaches is necessary to predict the potential state and morphology of the channel and floodplain ecosystem in the project area. A hierarchical classification system developed by Rosgen (1996) was employed to predict the most probable form, or desired future condition, of the channels and floodplain ecosystem within the UBMC project area.

Descriptions of the major valley and stream type associated are provided in the following section. Table 1-3 provides a summary of the dominant valley types and historical and existing stream types in the UBMC project area.

Table 1-4. A summary of valley types, historical stream types, and existing stream types in the UBMC project area.

Reach	Valley Types	Historical Stream Types	Existing Stream Types
Reach 1 Mike Horse Creek	I	A1 A2	G3 F3
Reach 2 Upper Beartrap Creek	I II	B2 B3	Reservoir
Reach 3 Lower Beartrap Creek	II	B2 B3	D3 D4
Anaconda Creek	II	B3 B4	D3 D4
Reach 4 Transition Reach	II	B4	F4, D4
Reach 5 Upper Blackfoot River	II VIII	B4 C4b	D4b
Reach 6 Upper Blackfoot River Wetlands	II VIII	B4c C4	F4 B4, D4
Shave Gulch	II	B4	F4

Prior to mining activities and other related disturbances, the upper headwaters of the UBMC including Reach 1 Mike Horse Creek and Reach 2 Upper Beartrap Creek were characterized by very confined, structurally controlled drainages (Valley Type I). High relief, steep slopes, and coarse bed material influenced channel morphology, resulting in high gradient, deeply entrenched, slightly meandering step-pool systems (A and B stream types). Due to the inherent structural stability of the channels, sediment supply was likely extremely low in the absence of watershed disturbances.

Downstream of the confluence of Reach 1 and Reach 2, the Upper Beartrap Creek valley widens and flattens, exhibiting a down-valley slope of four to five percent, and widths ranging from 80 feet at the upstream end of the reach to 200 feet near the confluence with Anaconda Creek in Reach 3 of the project area (Valley Type II). Prior to the failure of the Mike Horse Dam embankment, the valley in Reach 3 Lower Beartrap Creek was likely characterized by forested terraces positioned laterally along the toe of the valley floor. Associated stream types included higher gradient B types that were characterized by moderate entrenchment (narrow floodplain), irregularly spaced scour pools with higher gradient rapids, and cobble and boulder dominated substrate. Coarse valley fill material and the steep energy gradient of the reach limited lateral channel migration. This likely resulted in a stream corridor that was very stable with low sediment supply and well-vegetated floodplain and terrace surfaces. Presently, due to mining disturbances and accumulated sediments deposited in Reach 3 related to the Mike Horse Dam breach, the channel morphology is generally unstable with high bank erodibility, braided channels, and poor riparian and floodplain vegetation conditions due to the frequent scour of raw, unstable depositional surfaces.

The middle and lower reaches of the UBMC project area (Reach 5 Upper Blackfoot River and Reach 6 Upper Blackfoot River Wetlands) represents a zone of valley expansion. Moderate valley slopes, glacial moraines, and multiple river terraces characterize the valley morphology (Valley Type VIII). Alluvial terraces and expansive, highly disturbed floodplain surfaces in Reach 5 result in a primarily braided channel regime (D stream type). The D stream type is characterized by multiple channels, high sediment supply, extreme bank erosion, degraded aquatic habitat conditions, and altered hydraulic and sediment transport characteristics. In Reach 6 Upper Blackfoot River Wetlands, floodplain disturbances are less pronounced, and the channel oscillates between a slightly entrenched, meandering, riffle-pool type developed within a broad, vegetated floodplain corridor (B4 stream type), and aggrading, multi-channel D4 stream type conditions at the downstream end of Reach 6 near the Pass Creek confluence. The depositional regime and unstable channel morphology in Reach 6 are attributed to multiple factors and are further described in Section 2 of this report.

Downstream of Reach 6, the Upper Blackfoot River joins Pass Creek and enters a very low relief, broad, alluvial floodplain developed within an expansive wetland complex. The dominant stream types vary from stable single-threaded to multiple channel configurations characterized by a highly sinuous channel planform, extensive shrub vegetation, cohesive banks, and low bank erosion rates. Beaver complexes influence the morphology by creating localized backwater effects and ponding.

In summary, valley and stream channel morphology varies in the UBMC project area, ranging from steep, confined step-pool and bedrock dominated reaches to terraced valleys characterized by lower gradient, slightly sinuous, unconfined riffle-pool stream types. This broad level characterization was used determine the desired future condition of the channel and floodplain in the UBMC, and to describe how the existing system has departed from its potential reference condition.

1.5.8 Fisheries and Aquatic Habitat

The integrity of aquatic communities plays an essential role in support ecological function in the upper Blackfoot watershed. . Functions of the aquatic biota include: 1) primary and secondary productivity, 2) nutrient cycling and transport of energy/food to organisms downstream, 3) food for fish, birds and higher food-chain animals, 3) security cover for birds and their supporting ecosystems, 4) indicators of a functioning ecosystem, 5) biodiversity, and 6) recreational and cultural services (Stratus Consulting 2007). Due primarily to mining-related contamination, the ecological integrity of biotic communities within the upper Blackfoot River environment has been greatly compromised within and downstream of the UBMC (Ingman et al. 1990, Moore et al. 1991, Stratus Consulting 2007). The Upper Blackfoot River and Beartrap Creek are 303(d) listed streams for a variety of impairments including: tailings, resource extraction, habitat modifications, and bank and shoreline modifications/destabilization (Blackfoot Challenge and others 2005). The failure of the Mike Horse Mine Dam in 1975 specifically led to 1) the local collapse of the westslope cutthroat trout population (Spence 1975), 2) the contamination of the valley bottom and 3) the downstream transfer of heavy metals and the uptake of heavy metals into the aquatic food web (Ingman et al. 1990, Moore et al. 1991, Stratus 2007). Thirty years after the Mike Horse Dam failure, mining contamination and related disturbance continue to impede cutthroat trout from re-establishing in the upper Blackfoot River environment (Stratus Consulting 2007, Pierce et al. 2008). Westslope cutthroat trout is a *Species of Special Concern* in Montana and the focus of recovery actions in other areas of the Blackfoot basin over the last 20 years. Compared to other species, westslope cutthroat trout appear to hold the highest potential for recovery within disturbed areas through successful removal of contaminants and the restoration of essential stream and riparian habitats.

Where not directly affected by past mining, streams both up- and downstream of the UBMC area continue to support communities of resident westslope cutthroat trout (*Oncorhynchus clarki lewisi*) and sculpin (*Cottus* spp.). These species inhabit small headwater streams like Anaconda Creek and Shave Gulch. In these and other headwater streams of the upper Blackfoot River, westslope cutthroat trout maintain a high level of genetic purity (Pierce et al. 2008). Westslope cutthroat trout also inhabit and reproduce in the mainstem of the upper Blackfoot River downstream of the UBMC, although the abundance of westslope cutthroat trout has declined since the collapse of the Mike Horse tailings dam (Stratus Consulting 2007). Westslope cutthroat trout in the upper Blackfoot River still possess a migratory component to the population (Pierce et al. 2007, 2008). The migratory fish move downstream as juveniles, mature in the larger streams and rivers and then return as adults to spawn in their natal streams. Adult spawners are known to migrate distances of up to 40 river miles up the Blackfoot River to spawn. Because the upper Blackfoot River supports both resident and migratory fish, it is crucial to maintain passage and restore suitable habitats in order to recover and maintain westslope cutthroat trout populations and life history variation affected by past mining activities.

In addition, native bull trout (*Salvelinus confluentus*) and mountain whitefish (*Prosopium williamsoni*) also occupy the upper Blackfoot River downstream of the UBMC in low abundance (Status 2007, Pierce et al. 2008). Bull trout are a *Montana Species of Concern* and a listed threatened species under the Federal Endangered Species Act. The portion of the Upper Blackfoot River below the UBMC project area is regarded as a recovery area for bull trout and was designated critical habitat for bull trout by the U.S. Fish and Wildlife Service (FWS) in September 2010 (USFWS 2010). Habitat requirements, or primary constituent elements (PCEs), necessary to recover critical habitat included:

- Springs, seeps, groundwater sources, and subsurface water connectivity to contribute to water quality and quantity and provide thermal refugia.
- Migratory habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats.
- An abundant food base.
- Complex river, stream and aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities and structure.
- Water temperatures ranging from 2 to 15 ˚C (36 to 59 ˚F).
- Substrates of sufficient amount, size and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival.
- A natural hydrograph, including peak, high, low and base flows within historic and seasonal ranges.
- Sufficient water quality and quantity.
- Few or nonnative predatory or competitive species present.

Montana Fish, Wildlife and Parks (MFWP) rely on the "*wild trout"* philosophy to manage stream dwelling salmonids in Montana. High quality spawning and rearing habitat and stream connectivity all serve as the basis of this management philosophy. MFWP generally defines quality stream habitat as streams with sufficient water quantity and quality and an arrangement of physical channel features that provide food, cover and space that allow a population to thrive. Cold, clean and connected and the natural complexity of stream channels are all essential to allow fish movement among streams or reaches to access the variety of habitats required to complete their life-cycle (Pierce 2010).

Non-native fish are also present in the Blackfoot River. Though uncommon in the Upper Blackfoot River and the UBMC project area, brown trout (*Salmo trutta*) and rainbow trout (*O. mykiss*) are common in middle and lower reaches of the Blackfoot River below the UBMC project area. In the high-gradient tributaries to the Blackfoot River non-native brook trout (*Salvelinus fontinalis*) are abundant (Stratus Consulting 2007).

Macroinvertebrates found in the UBMC project area include stoneflies, mayflies, caddisflies. Example macroinvertebrates inhabiting the UBMC project area include *Perlidae*, *Hydropsychidae*, *Brachycentridae*, and *Limnophilidae.* Like fish, macroinvertebrates require passage from headwaters to tributaries. Sufficient densities and species richness within these waters are necessary for the viability of downstream species (Stratus Consulting 2007).

MFWP in conjunction with the Blackfoot Challenge and other partners developed *A Basin-Wide Restoration Action Plan for the Blackfoot Watershed* (Action Plan) in 2005. The Action Plan integrates all the stream and native fish restoration efforts in the Blackfoot River watershed and provides a comprehensive, native fish-based, priority-driven template for restoration projects. Further, the Action Plan expands upon the gains of the existing Blackfoot River Restoration Program (Blackfoot Challenge and others 2005). The basin-wide strategy focuses on tributary restoration as a means to restore the watershed on a comprehensive level as wild trout depend on the connectivity of the mainstem and its tributaries to complete their life histories. With an emphasis on improving tributary conditions, native trout of the Blackfoot River have shown consistent population size increases since native fish recovery efforts began in 1990 (Blackfoot Challenge and others 2005).

Although Mike Horse Creek, Beartrap Creek, and Anaconda Creek are not covered in the Action Plan, the Upper Blackfoot River is considered a High Priority for the pursuit of native fish restoration activities (Pierce et al. 2008). The classification is based on the presence of migratory native bull trout and cutthroat trout and the potential of the upper Blackfoot River to provide for downstream fisheries improvements through restoration activities. At this time, the UBMC also lacks the riparian vegetation and physical channel conditions necessary to provide and maintain native trout habitat. Successful remedial activities combined with the reconstruction of natural channels, complex habitat features, and full vegetative recovery will be necessary to recover of coldwater fisheries from mining disturbance.

Section 2 Restoration Concepts by Reach

2.1 Reach 1 Mike Horse Creek

2.1.1 Existing Conditions, Limiting Factors and Constraints

Reach 1 Mike Horse Creek originates in the headwaters of the Upper Blackfoot River watershed and encompasses approximately 0.6 miles of channel. The stream is formed in a narrow, confined and structurally controlled valley type (Valley Type I). Hillslopes adjacent to the channel are generally steep and composed of bedrock with overlying unconsolidated glacial till. Existing stream morphology is characterized by stable, deeply entrenched, highly confined, A stream types with step-pool bedforms, to unstable, G stream types with high bank erodibility conditions. Bank erosion and hillslope failures are most prevalent in areas where the channel interacts with mine waste piles in the Mike Horse Creek floodplain.

Upstream of the main crossing of Mike Horse Road in Reach 1, the channel has been highly manipulated by past channel stabilization efforts that included lining the channel with angular cobble-size material and installing rock check dams. Bank erosion, fine sediment deposition, and pool filling are common characteristics due to the increased supply of sediment and altered channel morphology. Throughout Reach 1, past mining activities have resulted in loss of riparian and streambank vegetation and hillslope surface erosion. Downstream of the Mike Horse Road crossing to the confluence with Reach 2 Upper Beartrap Creek, Mike Horse Creek is deeply incised with frequent hillslope failures, unstable channel obstructions, and high bank erodibility conditions. Figure 2-1 depicts the existing conditions of the channel and valley in Reach 1.

The riparian plant community along Mike Horse Creek within Reach 1 is largely absent, although remants of the subalpine fir (*Abies lasiocarpa*) and spruce (*Picea spp.*) series of habitat types (Hansen and others 1995) occur along the margins of areas disturbed by mining and reclamation activities. Scattered riparian shrubs such as alder grow along the channel margins, and lower gradient reaches include some herbaceous wetland plants species where floodplain soil is present.

Figure 2-1. Existing valley and channel conditions in Reach 1 Mike Horse Creek. The upper reach (left photo) has been extensively armored and stabilized with rock. Downstream of Mike Horse Road, the channel is highly unstable and characterized by mass wasting features that contribute large volumes of sediment to the channel network (right photo).

Water quality related impacts from past mining and ongoing remedial activities are a significant concern in Reach 1 Mike Horse Creek. In the upper reaches, a large waste rock area and ore body remain exposed and are treated by a groundwater treatment system. An inactive water treatment facility is present along the west side of the valley; infrastructure within the facility includes two detention basins, buildings, and an access road that encroaches on the channel and floodplain corridor. Surface water from the upper headwaters of Reach 1 is captured into a system of pipes that convey the clean water around the existing waste piles and exposed ore body to limit the amount of contaminants mobilized by surface water. The history of mining and residual contaminants, combined with the presence of permanent infrastructure, impose several constraints and limiting factors on restoration opportunities. Limiting factors and constraints include:

- Surface runoff from existing roads, other exposed soils and mine waste material, mobilizes and delivers contaminated sediments to the narrow floodplain and stream channel.
- Adit drains are a perpetual source of acid mine drainage.
- Access must be preserved to maintain adit drains for the purpose of limiting their impacts on water quality.
- Existing infrastructure and roads constrain the valley width, limit riparian and stream function, and are a sediment source.
- Remediation activities that result in removal of materials will leave a raw, exposed surface with little structure or complexity to maintain a stable stream morphology.

2.1.2 Desired Future Condition

In the upper reaches of Mike Horse Creek, the most probable condition, in the absence of disturbance, would include a highly entrenched and confined stream channel with step-pool morphology developed within a narrow, well-vegetated riparian corridor (A2 stream type). Bedforms would consist primarily of step-pool features formed by large roughness elements such as wood and boulders. The channel bed, streambanks and hillslopes would be generally stable and contribute minimal sediment to the channel network. Downstream of the water treatment facility and in the vicinity of the historical confluence with Beartrap Creek, channel morphology would transition to a moderately entrenched, cobble and small boulder dominated stream type with step-pool sequences (B3 stream type). B stream types are moderately steep, with rapids and riffles and irregularly spaced scour pools. Pools are commonly pocket pools rather than more expansive pools typically associated with outside stream meanders. These stream types are moderately entrenched, with moderate width-to-depth ratios and low sinuosity. Vegetation has a moderate influence in determining channel stability in B stream reaches and fish habitat is often associated with large woody debris that contributes to scour pool formation and cover (Rosgen 1996). Table 2-1 summarizes preliminary restoration criteria for Reach 1 Mike Horse Creek.

Table 2-1. Preliminary restoration design parameters for Reach 1 Mike Horse Creek. Average values and ranges presented.

Stream Type	Channel Width (feet)	Mean Depth (feet)	Slope (%)	Floodprone Width (feet)	Sinuosity
A2	5 (3-7)	0.6 (0.5-0.8)	12 (10-14)	10 (8-12)	1.1-1.2
B2	8 (6-10)	0.7 (0.6-0.8)	6 (4-8)	12 (10-12)	1.1-1.2

A narrow riparian area and floodplain would occupy the full valley bottom width and transition to an upland conifer forest with little exposed soil. The riparian plant community would be dominated by conifers, including subalpine fir, Douglas-fir and lodgepole pine. A narrow band of riparian shrubs would be present along the streambanks. Figure 2-2 illustrates this desired condition.

Figure 2-2. Desired valley and channel conditions in Reach 1 Upper Mike Horse Creek. Well-vegetated, narrow riparian areas are dominated by conifers with some shrubs in the understory.

Working within the constraints of the existing infrastructure, a well-vegetated riparian buffer would be capable of filtering sediment inputs from access roads and other exposed surfaces, and would provide instream shade, food web support, and habitat. The desired future condition for uplands adjacent to the Mike Horse Creek riparian area is typical of vegetation conditions that are common along moderate elevation headwater streams and valleys along the Continental Divide in western Montana. Dense stands of mature conifers with an understory dominated by native forbs and grasses with inclusions of native shrubs such as grouse whortleberry (*Vaccinium scoparium*), dwarf huckleberry (*Gaylussacia dumosa*) and white spirea (*Spiraea betulifolia*) are currently present in less disturbed portions of the project area, and were likely more common in this area prior to mining disturbance. A mosaic of structurally diverse plant communities was likely present throughout these forests as natural disturbances such as fire, wind, landslides or avalanches created patches of early and later successional vegetation communities. Potential to maintain or restore conifer forests in upland areas within the watershed may be limited by mountain pine beetle infestations that are currently causing high mortality among conifers in this area.

2.1.3 Objectives

Based on limiting factors and constraints described above, and the desired future condition for Mike Horse Creek, the following restoration objectives have been identified:

- Produce clean water consistent with supporting aquatic life.
- Construct a stream channel that is connected to the floodplain and interacts with the floodplain in terms of surface flow and sediment exchange.
- Maximize riparian and floodplain habitats and functions.
- Minimize sediment inputs to the channel resulting from upland and/or instream source areas.
- Improve existing and future proposed stream crossings to provide for fish passage and transport flows, sediment and debris.
- Relocate access roads outside of the channel migration zone and where possible, remove all unnecessary infrastructure.

During later design phases, described in Section 5, these objectives will be refined. In order to achieve these objectives, restoration strategies described in the next section will be implemented.

2.1.4 Restoration Strategies and Treatments

The following restoration strategies are proposed for Reach 1:

- Construct a low sinuosity, step-pool dominated, A stream type where the channel bed and grade controls are composed of medium size boulders in combination with large wood elements.
- Create a complex, vegetated narrow floodplain that functions to filter sediment and other chemical inputs from adjacent uplands, legacy mining and reclamation-related infrastructure, and residual metals that are periodically mobilized.
- Relocate access roads away from the Mike Horse Creek channel where possible, and remove all unnecessary infrastructure including detention basins, buildings, access roads and pipes in cooperation with the remediation effort.

- While Reach 1 does not presently support westslope cutthroat trout, restoration strategies should be designed so future potential colonization by westslope cutthroat trout is not constrained.

Because the average channel gradient through this reach is approximately 12 percent, the restoration strategy in Reach 1 does not emphasize restoring habitat or channel connectivity for westslope cutthroat trout and bull trout. However, step-pool structures will be constructed, as feasible, in a manner that does not limit the potential for fish to occupy this reach. Similarly, the riparian area and floodplain will be capable of providing cover and habitat for migratory and resident fish.

Because some soil and substrate within the Mike Horse Creek drainage will likely be removed as part of remediation activities, it may be necessary to import substrate to form a channel bed, channel banks and floodplain surface that matches historical topography and grades to existing uplands that would not be disturbed by remedial activities. As part of later design phases, a grading plan will be developed that specifies the shape of this surface, volume of material to import, and whether existing surfaces would need to be re-graded.

Due to the steep, confined morphology of Mike Horse Creek, the channel shape would be maintained by natural structural components including boulders, bedrock, and embedded wood. As part of floodplain and channel construction and grading, rock and wood would be incorporated with imported substrate.

Step-pool structures would be placed along the stream length at distances between approximately 1 and 1.5 times the stream's bankfull width (8 to 12 foot spacing). These structures would be constructed of medium size boulders and may include some wood. Channel and floodplain restoration treatments are described in more detail in Section 3.

Three revegetation zones would be included within Reach 1 (Figure 2-3): 1) a riparian shrub zone, 2) a riparian conifer zone, and 3) an upland conifer zone. The riparian shrub zone would occupy approximately a narrow band along the length of each bank at elevations between bankfull and approximately one foot above bankfull. While over the long-term this area would ultimately be colonized by conifers, a disturbed site with high available light and nutrients would typically be initially colonized by shrubs. A riparian conifer zone would occupy the next band further from the stream, between approximately one to four feet above bankfull. An upland conifer zone would occupy higher elevation areas where the floodplain ties into existing upland vegetation. The upland conifer zone may include areas where infrastructure such as roads and portions of the inactive water treatment facility are removed. These revegetation zones are described in more detail in Section 3.

Reach 1 - Mike Horse Creek

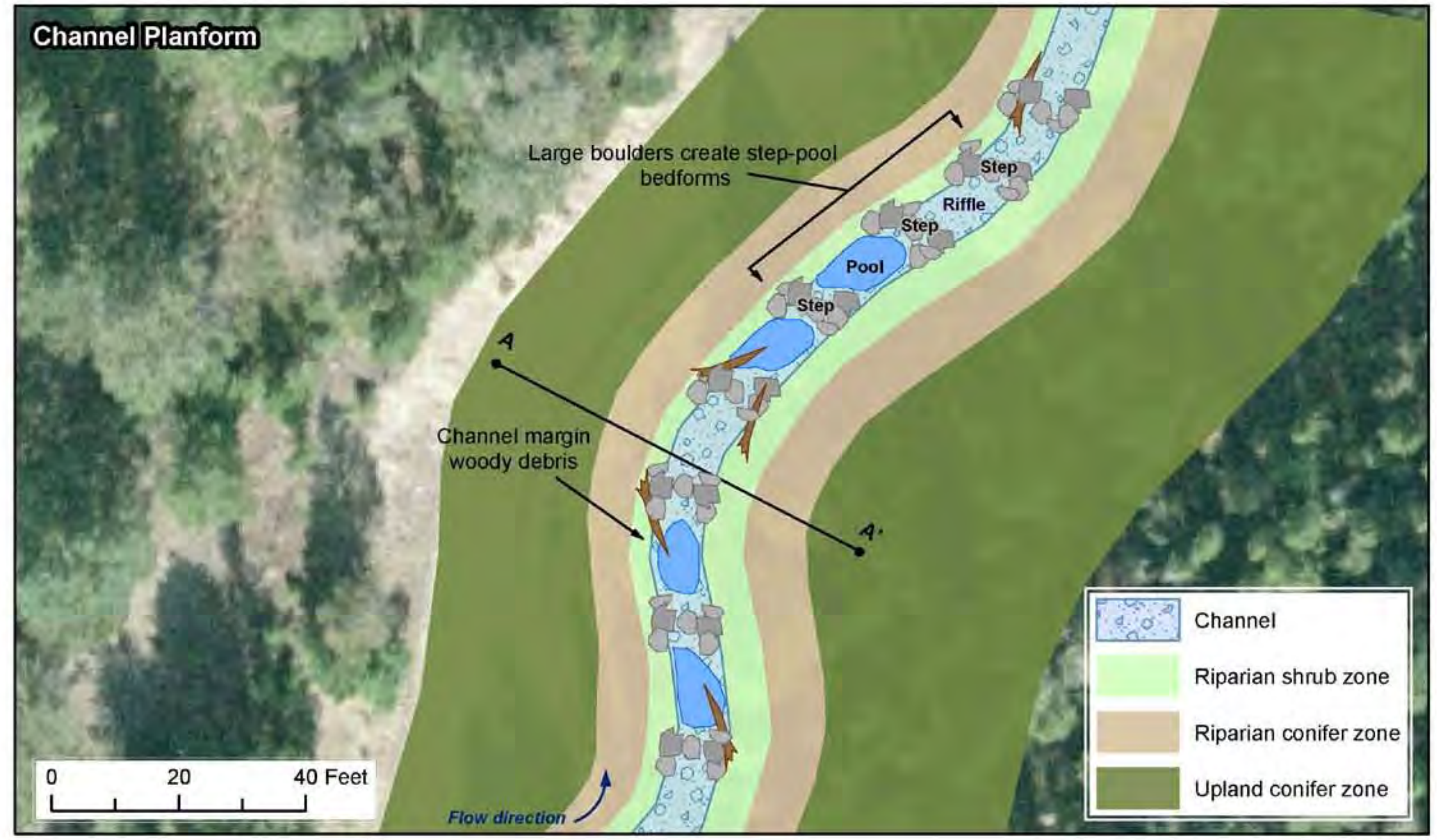
Reach 1, Mike Horse Creek, is formed in a narrow, structurally controlled valley type. The desired future condition of the channel corridor is characterized by a stable, deeply entrenched, confined, boulder dominated A2 stream type. The channel width would average 5 ft and include step-pool features constructed of large boulders and wood. A well vegetated riparian buffer would be established to filter sediment and provide instream shade, food web support, and habitat.

The primary restoration objective in Reach 1 is to produce clean water consistent with supporting downstream westslope cutthroat habitat by maximizing riparian habitat and natural channel function. The vegetated floodplain would reduce erosion and limit the amount of sediment inputs from existing infrastructure including access roads and disturbed hillslopes.

A.

B.

The Reach 1 existing condition (A), and desired future condition (B).



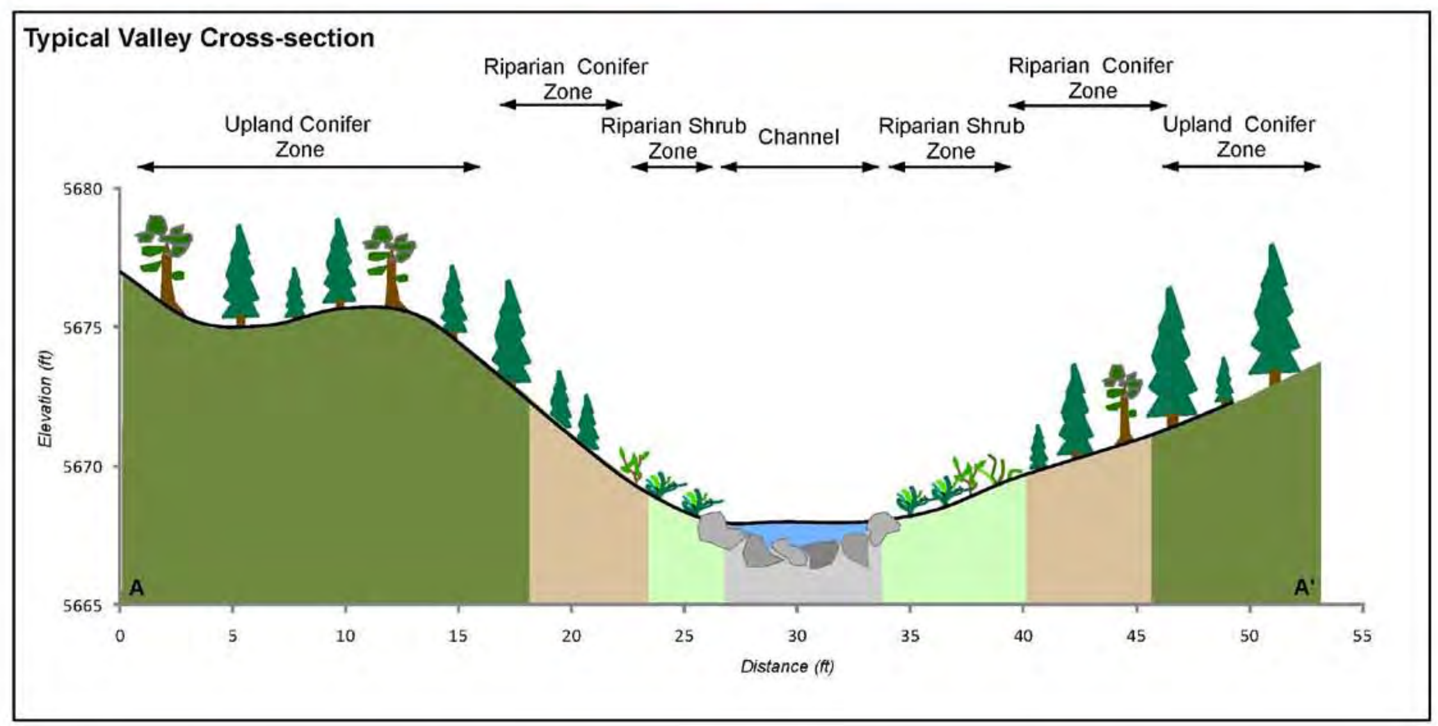


Figure 2-3. Example restoration treatments that may be applicable to Reach 1.

2.2 Reach 2 Upper Beartrap Creek

2.2.1 Existing Conditions, Limiting Factors, and Constraints

Reach 2, Upper Beartrap Creek, has been directly impacted by the Mike Horse Tailings Impoundment. Presently, surface water is routed into a lined diversion canal at the transition from the natural Beartrap Creek channel to the impoundment reservoir. Flow is routed through a collection facility and discharged to Beartrap Creek through a 36-inch pipe at the toe of the embankment. Upstream of the impoundment and reservoir influence, Beartrap Creek is characterized as a gravel and small cobble dominated B stream type with moderate entrenchment, riffle-pool bedforms, and a relatively narrow, forested riparian zone comprised of willow, alder, spruce and cottonwood. Similar to Reach 1, the stream is formed in a narrow, structurally controlled valley. Glacial terraces bracket the channel and limit floodplain development (Figure 2-4).

The riparian plant community along Upper Beartrap Creek above Mike Horse Dam and the impoundment is a combination of subalpine fir (*Abies lasiocarpa*) and spruce (*Picea spp.*) series of habitat types (Hansen and others 1995). Riparian shrubs such as alder, willow and dogwood grow along the channel margins. The width of the shrub zone varies from several feet along the channel margins to over 30 feet.

Figure 2-4. The Mike Horse Tailings Impoundment and associated mining activities have altered the natural landscape and valley morphology of Upper Beartrap Creek (left photo). Upstream of the impoundment, Beartrap Creek has a stable, riffle-pool channel with stable streambanks and a well-vegetated floodplain and riparian corridor.

One unimproved road crossing is located approximately 0.2 miles upstream of the tailings impoundment and consists of a perched, 24-inch corrugated metal pipe. The culvert constricts the channel and forms an upstream backwater condition. Although fish do not presently occupy Upper Beartrap Creek, restoring westslope cutthroat trout and bull trout habitat has been identified as a restoration objective for Reach 2. Evaluating options for restoring fluvial connectivity at the existing crossing is recommended during subsequent assessment and design phases.

Similar to Reach 1, legacy effects of historical mining activities impose several constraints and limiting factors on restoration opportunities. Limiting factors and constraints include:

- The level of disturbance is significant and the pre-disturbance morphology of the valley and floodplain topography is uncertain at this time.

- Remediation activities that result in removal of materials will leave a raw, exposed surface with little structure or complexity to maintain a stable stream morphology.
- Elevated risk of post-dam removal erosion is likely in the short-term until vegetation becomes established and provides long-term stability to the channel and floodplain.

2.2.2 Desired Future Condition

The desired future condition within Reach 2 Upper Beartrap Creek, is similar to the lower reach of Mike Horse Creek. The most probable state of the channel would be one that is typical of a boulder and large cobble dominated B stream type formed in a narrow valley with moderate to steep, forested hillslopes. Channel slope would average three percent with frequent step-pool features and interspersed riffles and rapids. Large wood would be a primary component of the system and would provide stability and aquatic habitat complexity to the channel and floodplain. Table 2-2 summarizes preliminary restoration criteria for Reach 2 Upper Beartrap Creek.

Table 2-2. Preliminary restoration design parameters for Reach 2 Upper Beartrap Creek. Average values and ranges presented.

Stream Type	Channel Width (feet)	Mean Depth (feet)	Slope (%)	Floodprone Width (feet)	Sinuosity
B2 – B3	9 (8-10)	0.7 (0.6-0.8)	3 (2-4)	16 (14-18)	1.2-1.3

The confluence of Mike Horse Creek and Upper Beartrap Creek would be located downstream of the existing impoundment and approximately 1,300 feet upstream of the Flossie-Louise Mine. Downstream from the confluence in Reach 3 Lower Beartrap Creek, both stream reaches transition into a Type II valley characterized by moderate relief and an expanding floodplain with terraces positioned laterally along the margins of the existing valley floor. Similar to upstream characteristics, the channel would emulate a riffle-pool channel with large cobble and boulder substrate forming frequent steps in the channel profile.

Dense stands of conifers would populate the streambanks and transition from wetter riparian species to drier species adapted to the aspect and topography of the steep hillslopes. The understory would be dominated by native forbs, sedges and grasses, with a minor shrub component consisting of dwarf huckleberry, grouse whortleberry, and white spirea. Aspect, elevation and topography will determine which conifer species are dominant but conifer species such as subalpine fir, spruce, lodgepole pine, and Douglas-fir were likely common prior to the anthropogenic disturbances. The existing condition described above is likely a good model for Upper Beartrap Creek within the project area. Riparian shrubs would include early successional, higher elevation riparian species such as alder, red osier dogwood and willows. The fully vegetated floodplain would reduce erosion and limit sediment inputs from the surrounding hillslopes or any infrastructure, such as roads, that may be left in place.

In contrast to Reach 1 Upper Mike Horse Creek, restoring fluvial connectivity and habitat for native westslope cutthroat trout, bull trout and other aquatic organisms have been identified as important restoration objectives in Reach 2. Figure 2-5 shows desired conditions and examples of restoration treatments that may be applied within Reach 2.

2.2.3 Objectives

Based on limiting factors and constraints described above, and the desired future condition for Reach 2 Upper Beartrap Creek, the following restoration objectives have been identified by the project team:

- Produce clean water consistent with supporting aquatic life and westslope cutthroat trout and bull trout habitat.
- Create complex aquatic habitat components such as depth, velocity, substrate, cover, and pools that support populations of native westslope cutthroat trout, bull trout and other aquatic organisms.
- Construct a stream channel that is connected to the floodplain and interacts with the floodplain in terms of surface flow and sediment exchange.
- Maximize riparian and floodplain habitats and functions.
- Minimize sediment inputs to the channel resulting from upland and/or instream source areas.
- Improve existing and future proposed stream crossings to provide for fish passage and transport flows, sediment and debris.
- Incorporate, to the greatest extent practical, historical (buried) floodplain and terrace surfaces and associated features including stumps and other roughness elements.
- Remove access roads outside of the channel migration zone and where possible, remove all unnecessary infrastructures.

Project and reach-scale objectives will be further refined in subsequent phases of this project.

Reach 2 - Upper Beartrap Creek

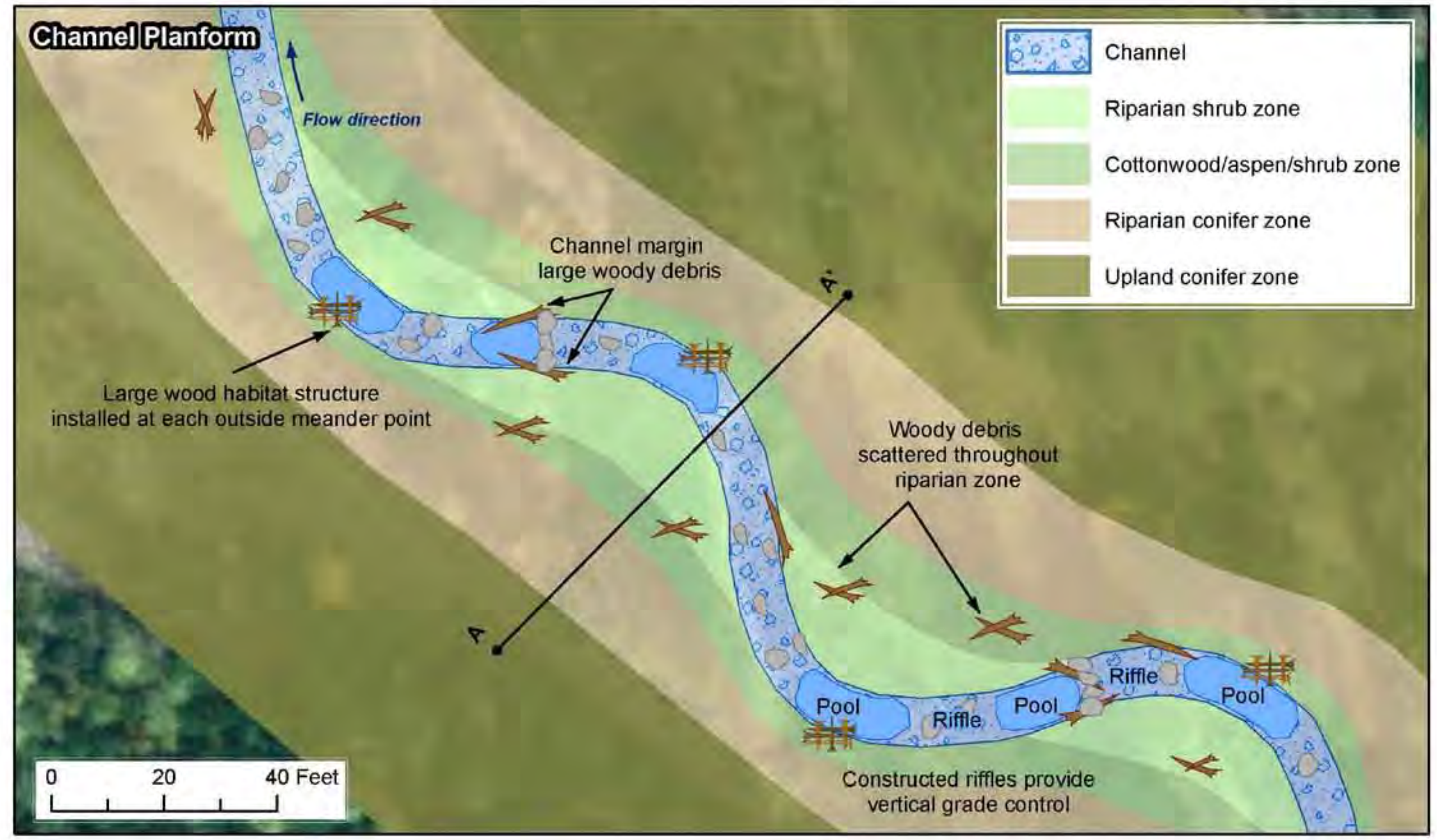
Reach, 2 Upper Beartrap Creek, is formed in a moderately narrow valley with steep, forested hillslopes. The desired future condition of the channel corridor would include a moderately entrenched, step-pool channel with interspersed riffles and rapids (B2 and B3 stream types). Channel width would average 9 ft with an associated floodprone width of 16 ft. Dense stands of conifers would populate the streambanks and transition from wetter riparian species to drier species adapted to the aspect and topography of the restored and existing hillslopes. The vegetated floodplain corridor would reduce erosion and limit the amount of sediment inputs from the surrounding hillslopes and any infrastructures that may be left in place.

A primary objective in Reach 2 would be to create complex aquatic habitat components such as depth, velocity, substrate, cover and pools that support populations of native westslope cutthroat trout and other aquatic organisms. Large wood aquatic habitat structures and constructed riffles would be the primary restoration techniques. Bank treatments would be required to stabilize newly constructed streambanks and encourage establishment of riparian vegetation.

A.

B.

Reach 2 existing condition (A), and desired future condition (B).



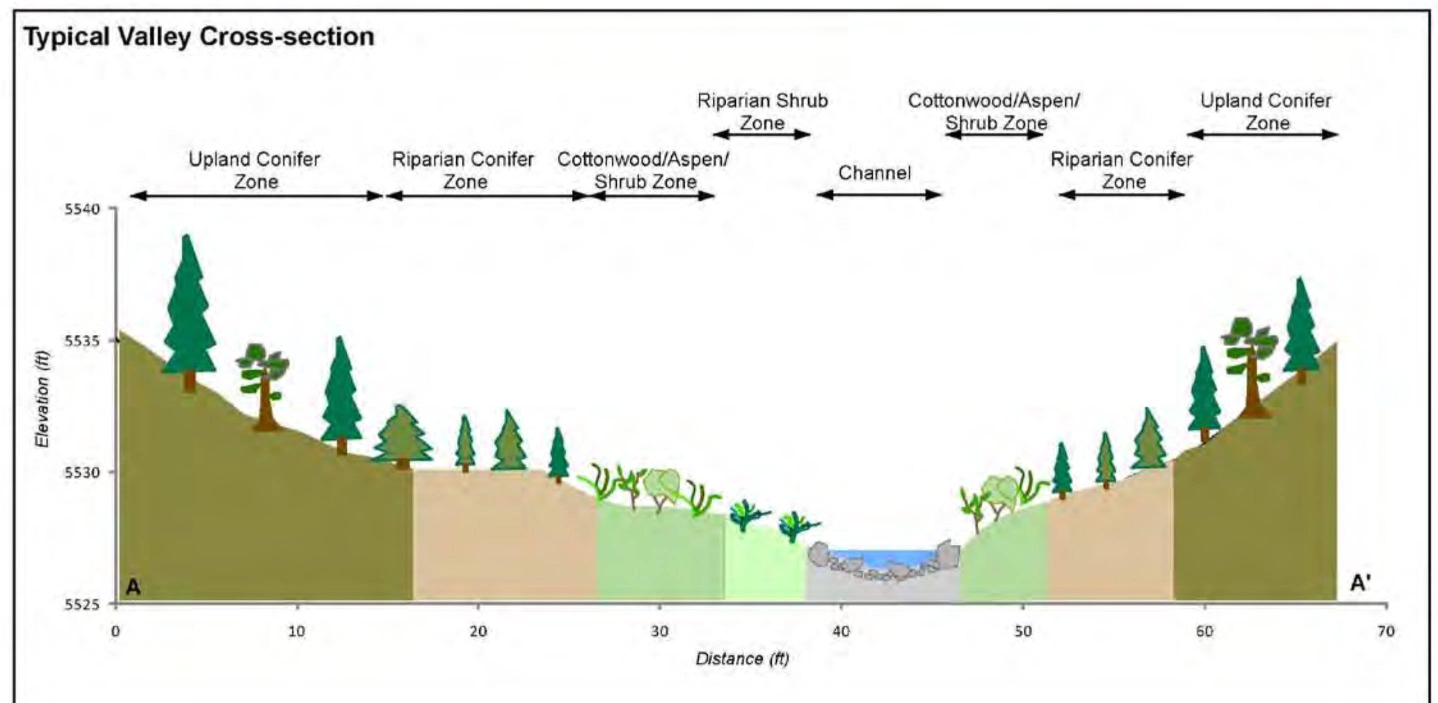


Figure 2-5. Example restoration treatments that may be applicable to Reach 2.

2.2.4 Restoration Strategies and Treatments

Restoration strategies for Reach 2 address the limiting factors and reach specific objectives identified for Upper Beartrap Creek. The valley would be restored in a manner that supports the development of a moderately steep channel and narrow, well-vegetated floodplain corridor. Similar to undisturbed stream reaches located upstream of the tailings impoundment, vegetation would transition from a riparian shrub zone associated with the active floodplain, to riparian and upland conifer zones associated with the adjacent terraces and hillslopes.

Restoration strategies specific to Reach 2, Upper Beartrap Creek include the following:

- Construct a low sinuosity, step-pool, B stream type with interspersed riffles and rapids. Channel bed material would be comprised of graded alluvium with primary grade control features composed of medium size boulders and large wood.
- Create a complex and narrow vegetated floodplain that functions to filter sediment and other chemical inputs from adjacent uplands, legacy mining and reclamation-related infrastructure, and residual metals.
- Replace the existing crossing of Mike Horse Road and Upper Beartrap Creek upstream of the existing impoundment with a bottomless arch pipe or equivalent structure that will simulate natural streambed hydraulic conditions.

Due to the lower gradient of Upper Beartrap Creek and anecdotal information that indicates the drainage once supported westslope cutthroat trout, restoring fluvial connectivity and aquatic habitat conditions will be prioritized in Reach 2. Channel bedform features including step-pool features and riffles will be designed in a manner that does not interfere with fish passage and simulates natural sediment transport and hydraulic characteristics. The riparian area and floodplain will provide cover, shade, and complexity which will in turn, provide long-term stability of the restored channel corridor. Restoration treatments that may be applied within Reach 2 Upper Beartrap Creek, are described below.

Because a significant volume of material is expected to be removed as part of remediation activities, it will likely be necessary to import substrate to form a channel bed, channel banks and floodplain surface that matches historical topography and grades to existing uplands that would not be disturbed by remedial activities. As part of later design phases, a grading plan would be developed that specifies the shape of this surface, volume of material to import, and whether residual floodplain surfaces are present, and whether they would need to be re-shaped.

Due to the degree of remedial disturbance and increased energy environment associated with the new channel, it will be necessary to incorporate natural structural components to ensure the channel remains connected with the floodplain. Structural elements would be comprised of native alluvium, embedded wood, and boulders. Similarly, native alluvium and large wood would be incorporated in the floodplain and along channel margins to encourage natural plant propagation to stabilize raw, newly constructed surfaces.

Step-pool structures would be placed along the stream length at distances ranging from 20 to 30 feet. These structures would be constructed of medium boulders and large wood elements.

Four revegetation zones would be included within the riparian area: 1) a riparian shrub zone, 2) a cottonwood/aspen shrub zone, 3) a riparian conifer zone, and 4) an upland conifer zone. These revegetation zones are described in more detail in Section 3. A riparian shrub zone would occupy low elevation areas within the floodplain adjacent to the channel. The cottonwood/aspen shrub zone would occupy areas within the bankfull floodplain outside of the riparian shrub zone, and would function as a transition zone between shrubs and conifers. Over time, this zone would likely be occupied by riparian conifers. The riparian conifer zone would occupy higher positions in the floodplain such as low terrace features. The upland conifer zone would occupy higher elevation areas where the floodplain ties into existing upland vegetation. Within Reach 2, this zone may be more extensive than in other reaches because valley slopes currently buried under tailings will likely support upland vegetation once tailings are removed. Examples of restoration treatments are described in more detail in Section 3.

2.3 Reach 3 Lower Beartrap Creek

2.3.1 Existing Conditions, Limiting Factors, and Constraints

Reach 3 Lower Beartrap Creek begins at the confluence of Reach 1 and Reach 2 and extends approximately 0.5 miles downstream to the confluence with Anaconda Creek. Similar to the upper watershed, the reach is formed in a narrow, moderately confined drainage with forested hillslopes. Relict, undisturbed terrace and floodplain surfaces occur in Reach 3, but are spatially limited due to past and ongoing disturbances. The existing unstable stream corridor conditions signify the magnitude of the Mike Horse Dam embankment failure. Due to the extensive valley aggradation that occurred following the failure of the embankment, and subsequent disturbances including floods, the present channel is vertically and laterally unstable, resulting in the seasonal erosion and delivery of contaminated floodplain sediments and mine waste to the channel. The annual contribution of coarse sediment from streambank erosion and channel scour appears to exceed the sediment transport capacity of Lower Beartrap Creek, resulting in frequent scour and redistribution of materials. The prevalence of raw, smooth alluvial deposits and lack of mature streambank and floodplain vegetation reflects this frequent disturbance regime.

The present morphology of the channel is typical of a braided, D stream type with in-channel sediment deposition forming transverse and mid-channel bars. Sediment deposition results in the disproportionate distribution of stress to the near-bank region of the channel, which further compounds streambank erosion and channel widening. Figure 2-6 depicts the existing conditions of the channel, floodplain and valley morphology in Reach 3.

Existing vegetation is limited by erosion and sediment inputs into the stream. Accumulations of coarse material promote colonization by lodgepole pine, although pockets of riparian shrubs and herbaceous wetland plants are present in some areas.

At the downstream end of this reach, where the valley widens near the confluence with Anaconda Creek, cottonwoods and aspen are present in the floodplain.

Figure 2-6. Existing valley and channel conditions in Reach 3, Lower Beartrap Creek. This reach is affected by large quantities of sediment transporting through the system, in addition to erosion from adjacent hillslopes.

Water quality related impacts from past mining activities exist in Reach 3. As described in the Engineering Evaluation/Cost Analysis (Hydrometrics 2007), mine waste within Beartrap Creek occurs in three general forms: 1) relatively small isolated surficial deposits of highly concentrated, oxidized mine tailings, 2) tailings intermixed with native sediments, and 3) a discrete mine waste pile located on the Flossie-Louise Mine claims. While a significant portion of the metals load in Beartrap Creek is derived from upstream sources, past investigations have noted an increase in metals loading through Reach 3 of Beartrap Creek (Hydrometrics 2007). In summary, the history of mining and residual contaminants presents some constraints and limiting factors on restoration opportunities in Reach 3. These include:

- Adit drains associated with the Flossie-Louise Mine may serve as a perpetual source of acid mine drainage.
- The historical floodplain surface and soil surface horizons are not present due to the 1975 failure of the Mike Horse Dam embankment.
- Large amounts of sediment are transporting through the system. Sediment is derived from both from upstream sources and adjacent hillslopes.

2.3.2 Desired Future Conditions

Encompassing approximately nine acres, the valley in Reach 3 was likely characterized by forested terraces that resulted in a low sinuosity, moderately entrenched, and confined stream type with coarse cobble and small boulder substrate. Longitudinal profile characteristics likely consisted of step-pool features with interspersed riffles and rapids. The structurally controlled nature of the valley and parent material resulted in a very stable channel and floodplain with a limited tendency to migrate laterally.

The desired future condition within Reach 3 is similar to Reach 2; however, as the valley transitions and becomes wider and lower gradient in the vicinity of the confluence with Anaconda Creek (Reach 4), channel sinuosity would increase slightly resulting in a flatter gradient, riffle-pool, cobble dominated B3 stream type with a more expansive meander belt width relative to more confined upstream reaches. The floodplain would be characterized by a more diverse mosaic of shrubs and trees of varying age classes. Geomorphic and other disturbance processes would affect the development of the riparian and floodplain ecosystem, ultimately determining the spatial pattern and successional development of riparian vegetation. A mosaic of riparian conifer forest, cottonwoods, aspen and riparian shrubs would be present within the floodplain depending on topography, disturbance patterns, and morphology. Exposed depositional surfaces would become more common in the vicinity of Anaconda Creek as the valley widens and the stream amplitude increases. These depositional surfaces would support natural recruitment of early successional species such as cottonwoods and willows and provide substrate for native plant species recruitment and colonization.

Table 2-3 includes preliminary design criteria for Reach 3 Lower Beartrap Creek.

Table 2-3. Preliminary restoration design parameters for Reach 3 Lower Beartrap Creek. Average values and ranges presented.

Stream Type	Channel Width (feet)	Mean Depth (feet)	Slope (%)	Floodprone Width (feet)	Sinuosity
B2 - B3	11 (10-12)	0.8 (0.7-0.9)	3.6 (3-4)	18 (16-20)	1.2-1.3

The desired condition of Reach 3 would include complex aquatic habitat conditions that would support populations of westslope cutthroat trout and other aquatic organisms. Figure 2-7 illustrates the desired future condition for Reach 3 Lower Beartrap Creek.

2.3.3 Objectives

Based on limiting factors and constraints described above, and the desired future condition for Reach 3 Lower Beartrap Creek, the following restoration objectives have been identified:

- Produce clean water consistent with supporting aquatic life and westslope cutthroat trout and bull trout habitat.
- Create complex aquatic habitat components such as depth, velocity substrate, cover, and pools that support populations of native westslope cutthroat trout, bull trout and other aquatic organisms.
- Construct a stream channel that is connected to the floodplain and interacts with the floodplain in terms of surface flow and sediment exchange.
- Maximize riparian and floodplain habitats and functions.
- Minimize sediment inputs to the channel resulting from upland and/or instream source areas.
- Incorporate, to the greatest extent practical, historical (buried) floodplain and terrace surfaces and associated features including stumps and roughness elements.

- Relocate access roads outside of the channel migration zone and where possible, remove all unnecessary infrastructures. Future proposed stream crossings should provide for fish passage and transport flows, sediment and debris.

Reach 3 - Lower Beartrap Creek

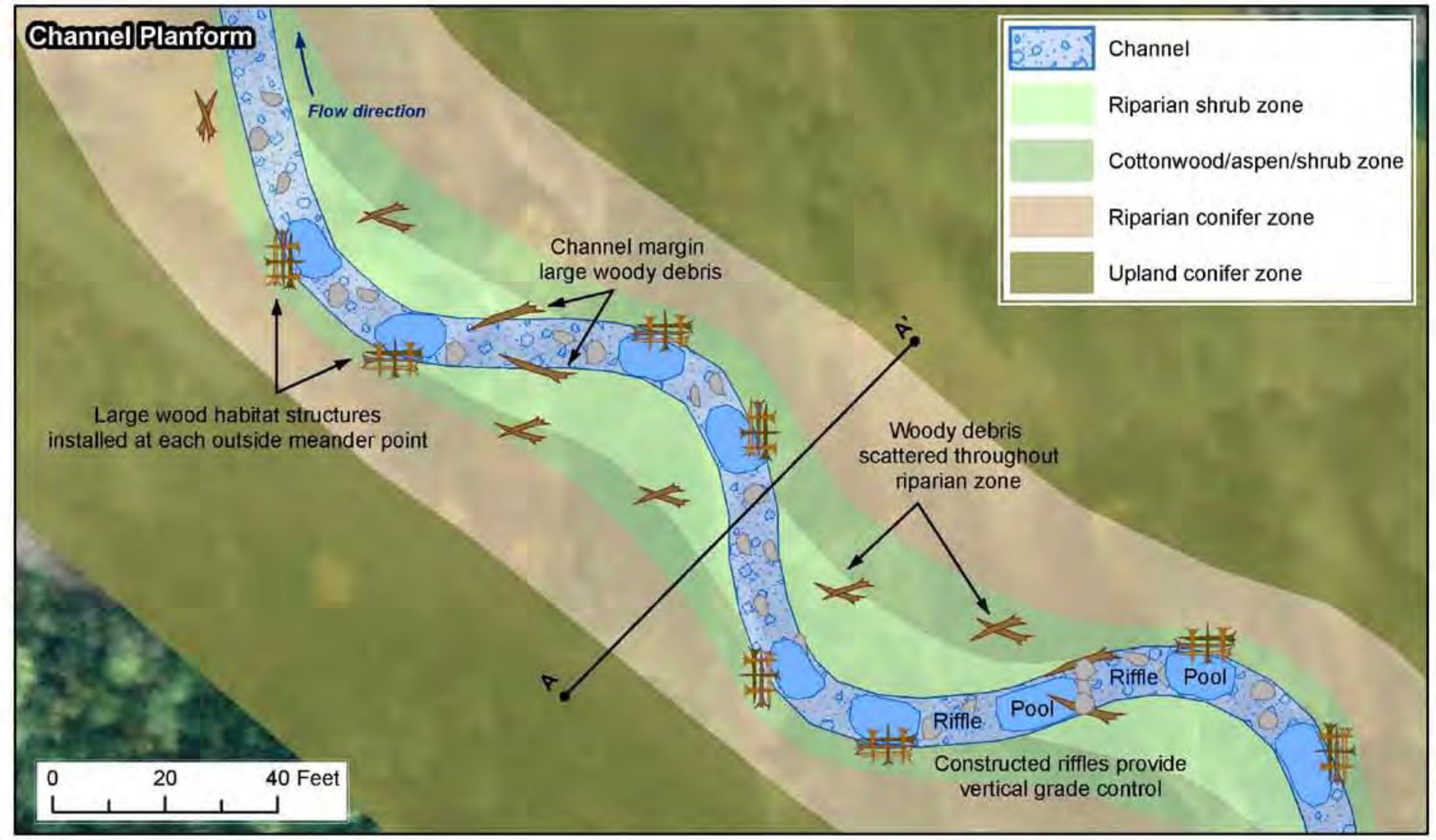
The Lower Beartrap Creek valley would be restored to a condition characterized by forested terraces and a low sinuosity, moderately entrenched, riffle-pool B3 stream type. The channel width would average 11 ft and consist of riffle-pool bedforms formed of coarse cobble substrate. The floodplain would average 25 ft in width and support a diverse mosaic of shrubs and trees of varying age classes. Exposed depositional surfaces would be more common in the vicinity of the confluence with Anaconda Creek as the valley widens and the stream amplitude increases.

A primary objective in Reach 3 would be to create complex aquatic habitat components such as depth, velocity, substrate, cover and pools that support populations of native westslope cutthroat trout and other aquatic organisms. Large wood aquatic habitat structures and constructed riffles would be the primary restoration techniques. Bank treatments would be required to stabilize newly constructed streambanks and encourage establishment of riparian vegetation.

A.

B.

Reach 3 existing condition (A), and desired future condition (B).



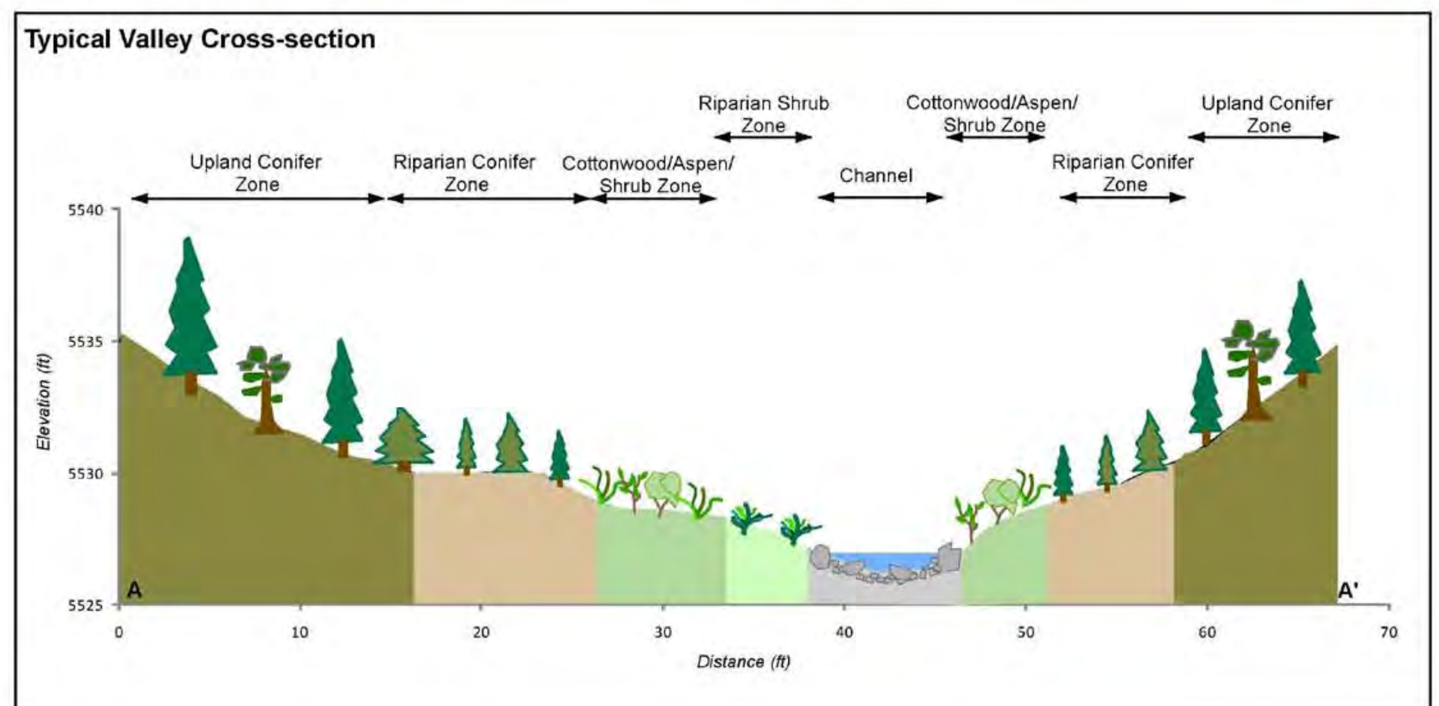


Figure 2-7. Example restoration treatments that may be applicable to Reach 3.

3.4 Restoration Strategies and Treatments

Restoration strategies and treatments in Reach 3 would be similar to Reach 2 and include restoring the valley in a manner that supports the development of a moderately steep, riffle-pool channel and narrow, well-vegetated floodplain corridor. As described above, channel and valley morphology would transition to a slightly flatter gradient stream type with a wider floodplain in the vicinity of the confluence with Anaconda Creek in Reach 4 of the project area.

Due to uncertainty related to the depth of tailings removal, it is not possible to estimate the depth of the post-remedial surface, the width of the restored floodplain, or how the constructed surfaces would transition to the existing, forested hillslopes. A grading plan would be developed that specifies the shape of the valley cross-section and down-valley attributes including floodplain and terrace surfaces. Similar to Reach 2, a low sinuosity, step-pool channel with interspersed riffles and rapids would be constructed. Channel bed material would be comprised of graded alluvium with primary grade control features composed of medium boulders and wood.

Restoration strategies and treatments specific to Reach 3 are summarized below.

- Construct a low sinuosity, step-pool, B stream type with interspersed riffles and rapids. Channel bed material would be comprised of graded alluvium with primary grade control features composed of medium boulders and large wood.
- Create a complex and narrow vegetated floodplain that functions to filter sediment and other chemical inputs from adjacent uplands, legacy mining and reclamation-related infrastructure, and residual metals.
- Gradually expand the floodplain width in a down-valley direction, and slightly increase channel sinuosity and amplitude approaching the confluence with Anaconda Creek.
- Maximize floodplain function of water storage through development of off-channel wetlands that would be permanently inundated to keep tailings in a reduced state, where possible.

Due to the degree of disturbance that will occur during remediation, and the increased energy environment associated with the new channel, it will be necessary to incorporate natural structural components to ensure the channel remains connected with the floodplain. Structural elements would be comprised of native alluvium, embedded wood, and boulders. Similarly, native alluvium and large wood would be incorporated in the floodplain and along channel margins to encourage natural plant propagation and to stabilize raw, newly constructed surfaces.

Step-pool structures would be placed along the stream length at distances between 20 and 30 feet. These structures would be constructed of medium boulders and large wood elements. Riffle and pool features would comprise approximately 70 percent and 30 percent of the available habitat, respectively.

Five revegetation zones would be included within the riparian area: 1) a riparian shrub zone, 2) a cottonwood/aspen shrub zone, 3) a riparian conifer zone, 4) an upland conifer zone, and 5) a natural recruitment zone. These revegetation zones are described in more detail in Section 3. A riparian shrub zone would occupy low elevation areas within the floodplain adjacent to the channel. The cottonwood/aspen shrub zone would occupy areas within the bankfull floodplain outside of the riparian shrub zone, and would function as a transition zone between shrubs and conifers. Over time, this zone would likely be occupied by riparian conifers. The riparian conifer zone would occupy higher positions in the floodplain such as low terrace features. The upland conifer zone in Reach 3 would be a narrow zone between the floodplain and existing upland vegetation. At the downstream end of Reach 3, a natural recruitment zone would be left as exposed alluvial material (sand, gravel and cobble) where willows, cottonwoods, and other native plants would be able to naturally colonize the floodplain.

2.4 Reach 4 Transition Reach

2.4.1 Existing Conditions, Limiting Factors, and Constraints

The Upper Blackfoot River forms at the confluence of Anaconda Creek and Lower Beartrap Creek in Reach 4 of the project area. Reach 4 represents a distinct change in the character and morphology of the Upper Blackfoot River valley. Transitioning downstream, the stream types and bed forms change, the valley bottom width increases, and valley gradient decreases from 4.3 percent in Reach 3, to 3.1 percent in Reach 4. Similar to Reach 3, highly disturbed channel and floodplain conditions result from past disturbance cycles in the watershed, including the failure of the Mike Horse Dam embankment in 1975, subsequent floods, and other direct impacts including construction of the water treatment facility and associated infrastructure. Presently, the morphology of the Upper Blackfoot River in Reach 4 is characterized by incised and entrenched channel conditions with a disconnected floodplain and high streambank erodibility. Channel headcuts are present upstream of the water treatment facility and have initiated floodplain headcutting and erosion. Existing channel morphology is predominantly characterized by gravel and small cobble dominated, deeply incised G4 stream types, and over-widened, high width-to-depth ratio F4 stream types. While the cause of channel down-cutting is not clearly understood, a headcut may have propagated upstream as the channel and floodplain were straightened and bermed in the vicinity of the water treatment facility. Bank and terrace erosion is significant in Reach 4, resulting in the contribution of contaminated sediments to the channel.

Riparian vegetation is sparse through this reach due to the highly disturbed conditions. Terraces immediately adjacent to the stream support conifers in the upper portion of the reach. Downstream portions of the reach do not support vegetation due to the proximity to roads and the water treatment infrastructure.

Figure 2-8 includes existing site conditions in Reach 4.

Figure 2-8. Existing valley and channel conditions in Reach 4 Transition Reach. This reach is influenced by large quantities of sediment moving through the system, in addition to erosion from adjacent hillslopes.

Anaconda Creek joins Lower Beartrap Creek and forms the Upper Blackfoot River approximately 100 feet upstream of the water treatment facility. The historical confluence of Anaconda Creek and Lower Beartrap Creek was located approximately 500 feet upstream of the present juncture. The confluence is now located at the north side of the valley along the toe of the forested hillslope. Floodplain disturbances in the lower 0.25 miles of Anaconda Creek result in varied stream morphology including braided, multi-channel conditions with high bank erodibility and frequent shifts in the location of the primary channel. The diffuse flow network that has formed in aggraded sections of the channel may impede fish passage to the upper reaches of Anaconda Creek. Anaconda Creek has been identified as critical habitat for the reintroduction of westslope cutthroat trout to the UBMC project area.

Downstream of the confluence, the Upper Blackfoot River is affected by infrastructure including the water treatment facility, roads, armored fill slopes, and undersized stream crossings. The identified infrastructure impairs the form and function of the channel and floodplain. A majority of the channel adjacent to the water treatment cells is armored with riprap and occurs as an entrenched, high width-to-depth ratio, gravel dominated, F4 stream type with limited floodplain connectivity. The main access road crossing to the water treatment facility consists of a 48 inch concrete pipe that is significantly undersized relative to the predicted flood series of the Upper Blackfoot River. Coarse sediment is deposited in mid-channel bars at the culvert inlet due to backwater conditions and reduced hydraulic capacity of the culvert. Evaluating options for restoring fluvial connectivity and fish passage at the crossing is recommended during subsequent assessment and design phases.

Similar to Reach 1, historical mining activities and the presence of permanent infrastructure impose several constraints and limiting factors on restoration opportunities in Reach 4 and lower Anaconda Creek. Limiting factors and constraints include:

- Existing water treatment facility infrastructure constrains the valley width, limits riparian and stream function, and is a cause of channel instability.
- Reach 4 is a confluence reach. Restoration will need to accommodate more complex sediment and debris transport processes associated with this type of dynamic geomorphic setting.

- The historical floodplain is likely not present and a floodplain will need to be constructed following removal of contaminated sediments.

2.4.2 Desired Future Conditions

The desired future condition for Reach 4 Transition Reach and lower Anaconda Creek, assumes that the existing water treatment facility and a majority of the associated infrastructure will remain in place following remedial and restoration activities. Given these identified limiting factors and constraints, the most probable condition of the Upper Blackfoot River channel and floodplain would include a low sinuosity, moderately entrenched, and confined stream type with coarse gravel and small cobble substrate. The channel bed morphology would include riffle-pool morphology with irregularly spaced scour pools. Pools would be formed and maintained by large wood structures associated with outside meander bends, vegetation, and boulders. Table 2-4 summarizes preliminary restoration design criteria for Reach 4. The proposed stream type and floodplain-channel morphology would create and maintain aquatic habitat conditions that support westslope cutthroat trout, bull trout and other aquatic organisms.

Table 2-4. Preliminary restoration design parameters for Reach 4 Transition Reach. Average values and ranges presented.

Stream Type	Channel Width (feet)	Mean Depth (feet)	Slope (%)	Floodprone Width (feet)	Sinuosity
B3-B4	12 (11-13)	1.0 (0.9-1.1)	2.5 (2-3)	18 (16-20)	1.3-1.5

The water treatment facility would limit the potential width of the restored floodplain resulting in a channel and valley gradient that would be slightly steeper than expected for the valley type. Similar to Reach 3, the likely condition of the valley would include forested terraces positioned laterally along the toe of the existing forested hillslopes, with a relatively narrow inset floodplain adjacent to the active channel.

Vegetation communities in this reach will be constrained by infrastructure, so the emphasis of the revegetation approach would be to maximizing riparian function within a narrow vegetated corridor that separates the stream from adjacent roads and other infrastructure. Upstream of the water treatment facility, vegetation would be a mosaic of riparian shrubs, cottonwoods, and riparian conifers. Figure 2-9 and Figure 2-10 show desired conditions and examples of restoration treatments that may be applied within Reach 4.

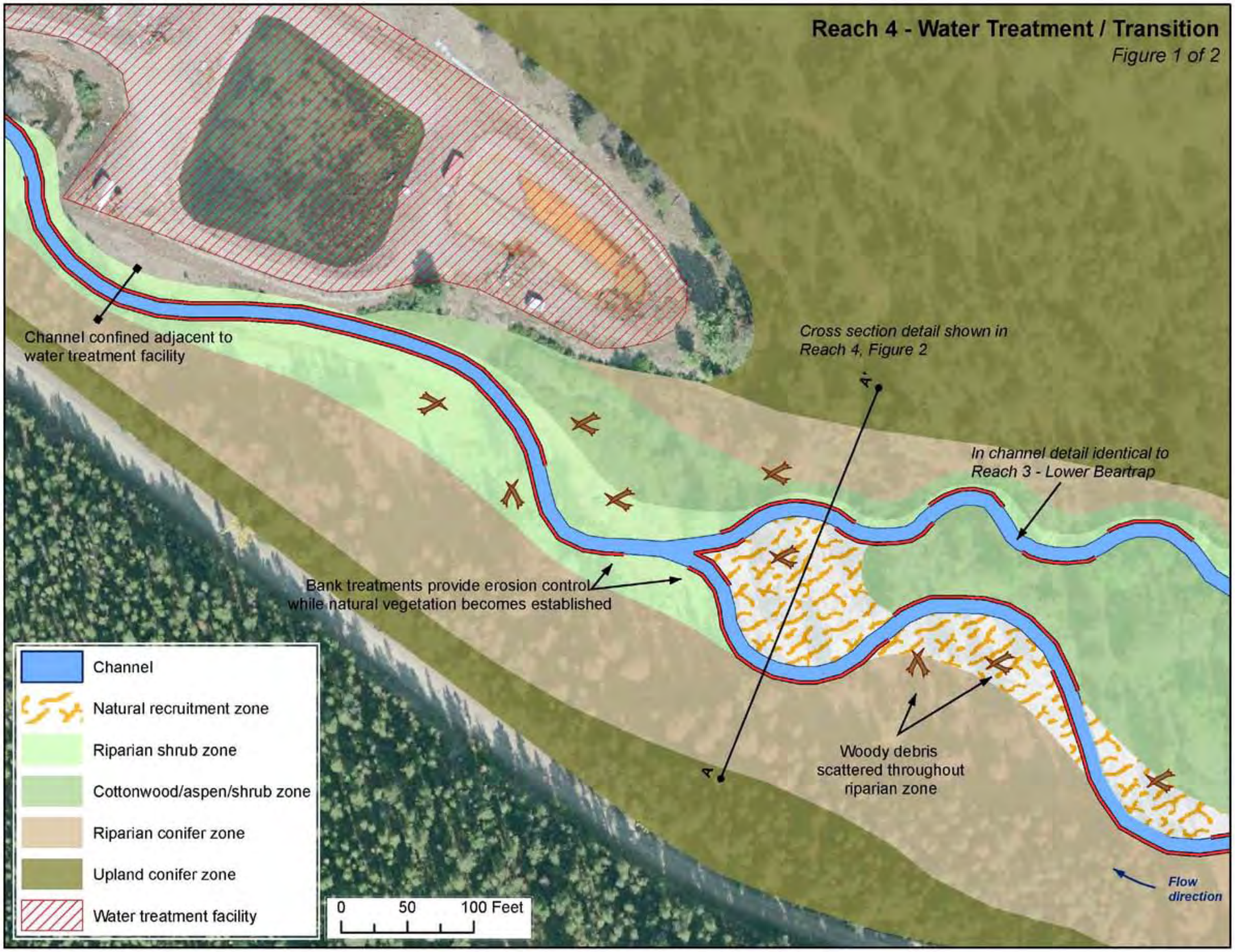


Figure 2-9. Example restoration treatments that may be applicable to Reach 4.

Reach 4 - Water Treatment / Transition *(Figure 2 of 2)*

The desired future condition of Reach 4 is based on the existing water treatment facility and related infrastructure remaining in place following remedial and restoration activities. The most probable state of the Upper Blackfoot River would include a low to moderate sinuosity, moderately entrenched, confined B4 stream type with coarse gravel and small cobble substrate. The channel bed morphology would be characterized by riffles and rapids with irregularly spaced scour pools. The floodplain width would be constrained by existing infrastructure and average 45 feet. A diverse mosaic of shrubs and trees of varying age classes would characterize the riparian zone.

A primary objective in Reach 4 would be to create complex aquatic habitat components such as depth, velocity, substrate, cover and pools that support populations of native westslope cutthroat trout and other aquatic organisms. Large wood aquatic habitat structures and constructed riffles would be the primary restoration techniques. Bank treatments would be required to stabilize newly constructed streambanks and encourage establishment of riparian vegetation.

A.

B.

Reach 4 existing condition (A), and desired future condition (B).

Typical Valley Cross-section

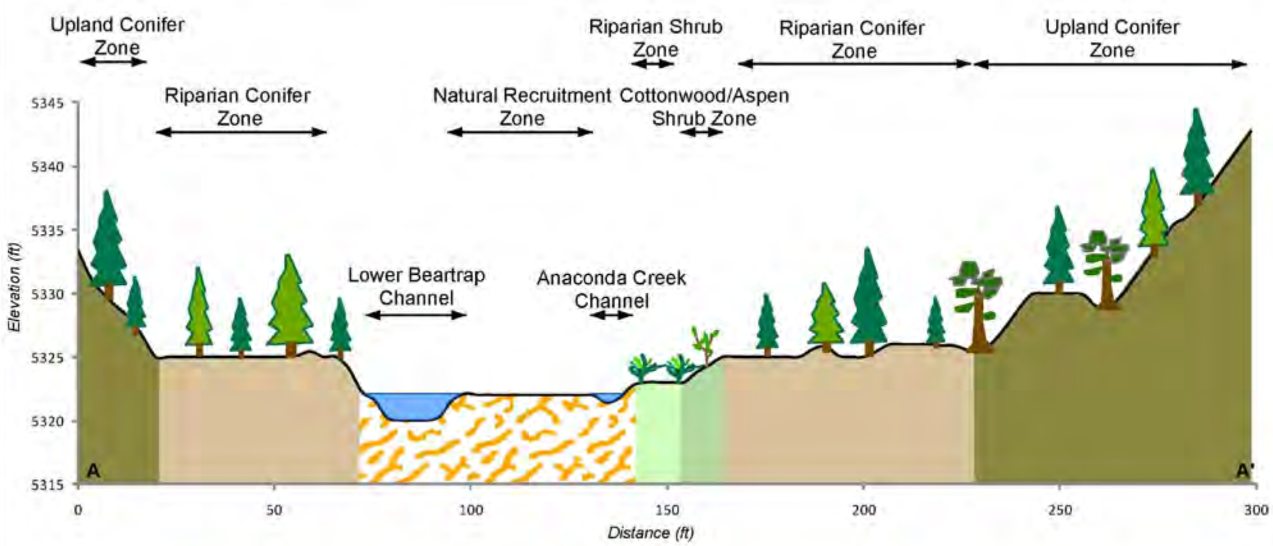


Figure 2-10. Example restoration treatments that may be applicable to Reach 4.

2.4.3 Objectives

Based on limiting factors and constraints described above, and the desired future condition for Reach 4 Transition Reach, the following restoration objectives have been identified:

- Produce clean water consistent with supporting aquatic life and westslope cutthroat trout and bull trout habitat.
- Create complex aquatic habitat components such as depth, velocity substrate, cover, and pools that support populations of native westslope cutthroat trout, bull trout and other aquatic organisms.
- Construct a stream channel that is connected to the floodplain and interacts with the floodplain in terms of surface flow and sediment exchange.
- Maximize riparian and floodplain habitats and functions.
- Minimize sediment inputs to the channel resulting from upland and/or instream source areas.
- Incorporate, to the greatest extent practical, historical (buried) floodplain and terrace surfaces and associated features including stumps and other roughness elements.
- Relocate access roads outside of the channel migration zone and where possible, remove all unnecessary infrastructure. Future proposed stream crossings should provide for fish passage and transport flows, sediment and debris.
- Connect potential westslope cutthroat trout habitat in Anaconda Creek through reconstruction of lower Anaconda Creek and the confluence with Lower Beartrap Creek.

2.4.4 Restoration Strategies and Treatments

Restoration strategies and treatments in Reach 4 address the limiting factors and constraints identified for the Upper Blackfoot River. In order to transition the channel and floodplain down-valley, it will be necessary to relocate non-critical infrastructure on the south side of the valley, including the existing equipment staging areas. A minimum meander belt width of 40 feet to 50 feet is recommended to ensure adequate channel and floodplain hydraulic capacity is provided to convey flood flow discharges without compromising stability. Since permanent infrastructure will limit the width of the river corridor, it may be necessary to identify additional channel and floodplain restoration strategies and treatments to ensure the channel and floodplain remain stable.

The historical confluence of Anaconda Creek and Lower Beartrap Creek/Upper Blackfoot River will be re-established approximately 500 feet upstream of the present location. In addition, active channel and floodplain restoration would include approximately 0.25 miles of lower Anaconda Creek, from the confluence with the Upper Blackfoot River, upstream to a geomorphically stable point in the valley.

Restoration strategies in Reach 4 Transition Reach include the following:

- Construct a moderately sinuous, riffle-pool, B stream type with connected floodplain. Channel bed and bank materials would be comprised of graded alluvium with interspersed boulders and large wood complexes, respectively.
- Gradually widen the floodplain in the vicinity of Anaconda Creek and establish a stable confluence with Lower Beartrap Creek.
- Downstream of the confluence with Anaconda Creek, gradually decrease the width of the floodplain in the vicinity of the water treatment facility. The more confined stream morphology would require step-pool bedforms with interspersed rapids and riffles comprised of graded alluvium and boulder grade control structures to account for the increase in channel slope and stream energy. The stream near the water treatment plant would be capable of passing a >100 year flood while protecting the water treatment plant infrastructure.
- Incorporate vegetated floodplain and low terrace surfaces along armored road and embankment fill slopes associated with the water treatment facility.
- Replace the existing crossing of the Upper Blackfoot River and the water treatment facility access road with a bottomless arch pipe or equivalent structure that will simulate natural streambed hydraulic conditions.

Up to five revegetation zones would be included within the riparian area: 1) a riparian shrub zone, 2) a cottonwood/aspen shrub zone, 3) a riparian conifer zone, 4) an upland conifer zone, and 5) a natural recruitment zone. These are described in more detail in Section 3. A riparian shrub zone would occupy low elevation areas within the floodplain adjacent to the channel. The cottonwood/aspen shrub zone would occupy areas within the bankfull floodplain outside of the riparian shrub zone, and would function as a transition zone between shrubs and conifers. Both the riparian shrub and cottonwood/aspen shrub zones would function to filter sediments and chemicals that might move toward the stream from nearby infrastructure. The riparian conifer zone would occupy higher positions in the floodplain such as low terrace features. The upland conifer zone in Reach 4 may not be necessary as mature upland conifers are present to the toe of adjacent hillslopes. At the upstream end of Reach 4, a natural recruitment zone would be left as exposed alluvial material (sand, gravel and cobble) where willows, cottonwoods, and other native plants would be able to naturally colonize the floodplain.

2.5 Reach 5 Upper Blackfoot River

2.5.1 Existing Conditions, Limiting Factors, and Constraints

Reach 5 includes the Upper Blackfoot River from the water treatment facility downstream to the main Mike Horse Road crossing. Within Reach 5, the morphology transitions from a laterally and structurally confined valley type (Valley Type II) to a broader, flatter and wider valley characterized by well-developed floodplain and terrace surfaces (Valley Type VIII). The valley gradient decreases from approximately 2.8 percent at the upstream end of the reach to approximately 2.4 percent at the downstream end of the reach. Figure 2-11 reflects the existing valley and channel conditions in Reach 5.

Figure 2-11. Existing valley and channel conditions in Reach 5 Upper Blackfoot River.

Channel, floodplain and vegetation characteristics in Reach 5 have been significantly altered by mining, flooding associated with the Mike Horse Dam embankment failure, and other infrastructure including the Mike Horse Road located on the southwest side of the valley. The existing stream morphology transitions from a gravel dominated, high width-to-depth ratio, D4 braided channel regime to a predominantly single-threaded, highly entrenched F4 stream types characterized by severe bank and terrace erosion. Channel and floodplain stability varies through the reach reflecting the local direct disturbances and indirect impacts associated with past land management activities. In summary, high bank erosion and associated sediment supply result in reach-scale channel instability.

Due to the reduction in slope and stream energy in Reach 5, a depositional sediment regime is present throughout a majority of the reach. Channel bed materials fine from cobble and small boulder-dominated substrates in the upper reaches of the UBMC project area to a bimodal distribution consisting of gravels and finer sands and silts. The depositional channel regime has reduced the channel area and sediment transport capacity and competency within the reach, resulting in the formation of mid-channel bars, transverse bars, and high near-bank stress distribution. Given the lack of mature, stabilizing vegetation on the channel margins, floodplain, and terrace surfaces, the contribution of sediment from these source areas is considerable and compounds instability in Reach 5 as well as downstream reaches.

Figure 2-12 includes a typical channel cross-section from Reach 5. The cross-section reflects the entrenched F4 stream type condition characterized by vertically, eroding streambanks and terraces and the lack of channel-floodplain connectivity in the downstream portion of the reach.

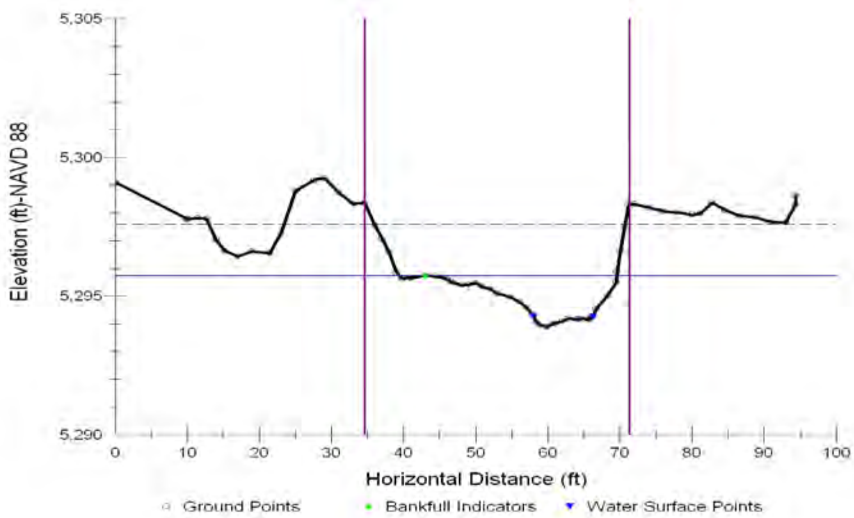


Figure 2-12. Typical channel cross-section in Reach 5 of the project area. The solid, horizontal line represents the bankfull elevation and the dashed line represents the elevation and width of the floodprone area (data provided by MFWP).

The Mike Horse Road crossing on the Upper Blackfoot River in the lower portion of Reach 5 poses a concern for fish passage and channel and floodplain stability. The existing crossing consists of a 48 inch concrete round pipe. Past efforts to direct flows into the pipe have included berming the right floodplain and streambank with angular rock. The crossing structure is not compatible with the predicted flood series and morphology of the Upper Blackfoot River.

Vegetation in Reach 5 includes mostly young age class cottonwoods, willows, lodgepole pine, and Douglas-fir. Frequent mobilization of floodplain sediments likely scours vegetation frequently, so plants do not typically survive for more than a few years.

Based on the above mentioned existing conditions, limiting factors and constraints in Reach 5 include:

- The level of disturbance is significant and the pre-disturbance morphology of the valley and floodplain morphology is uncertain at this time.
- Water treatment infrastructure at upstream end of this reach limits the width of floodplain available for restoration.
- Remediation activities that result in removal of materials will leave a raw, exposed surface with little structure or complexity to maintain a stable stream morphology.

2.5.2 Desired Future Conditions

Despite the high degree of disturbance in Reach 5, there is a high potential for recovery with active restoration that involves complete channel and floodplain restoration integrated with a comprehensive revegetation strategy for the streambanks, floodplain and terrace surfaces. As the valley widens and flattens in Reach 5, the step-pool morphology of the higher gradient B channel would transition to riffle-pool morphology as the channel increases its sinuosity and belt width. Channel bed materials would be composed of a combination of colluvium and alluvium. The most probable stream types for Reach 5, based on the valley morphology and parent material, would include a moderately entrenched, step-pool channel with interspersed riffles and rapids (B4 stream type) transitioning to a C4b stream type characterized by a slightly entrenched, meandering, gravel-dominated channel with riffle-pool bedforms and a well developed floodplain.

Table 2-5 includes draft restoration design criteria for Reach 5.

Table 2-5. Preliminary restoration design parameters for Reach 5 Upper Blackfoot River. Average values and ranges presented.

Stream Type	Channel Width (feet)	Mean Depth (feet)	Slope (%)	Floodprone Width (feet)	Sinuosity
B4	14 (12-16)	0.9 (0.8-1.0)	2.1 (2.0-2.2)	20 (18-22)	1.3 (1.2-1.4)
C4b	16 (14-18)	1.0 (0.9-1.1)	2.0 (1.9-2.1)	22 (20-24)	1.4 (1.3-1.5)

Potential vegetation communities within Reach 5 include the black cottonwood/ red-osier dogwood community type, which would be followed in terms of succession by the Douglas-fir/ red-osier dogwood habitat type and/or a spruce habitat type as described by Hansen and others (1995). Following restoration, occasional sediment deposition on the floodplain would likely occur, and the channel would likely change location on the floodplain over time. This will result in a changing mosaic of conifers, cottonwoods, aspen, and riparian shrubs with side channels and off-channel wetland features occupying the locations of former channels.

2.5.3 Objectives

Based on limiting factors and constraints described above, and the desired future condition for Reach 5 Upper Blackfoot River, the following restoration objectives have been identified by the project team:

- Produce clean water consistent with supporting aquatic life and westslope cutthroat trout and bull trout habitat.
- Create complex aquatic habitat components such as depth, velocity, substrate, cover, and pools that support populations of native westslope cutthroat trout, bull trout and other aquatic organisms.
- Construct a stream channel that is connected to the floodplain and interacts with the floodplain both in terms of surface flow and sediment.
- Maximize riparian and floodplain habitats and functions.
- Minimize sediment inputs to the channel resulting from upland and/or instream source areas.

- Relocate Mike Horse Road on the south side of the floodplain outside of the channel migration zone below the junction with Paymaster Road, and where possible, remove all unnecessary infrastructures.
- Improve existing and future proposed stream crossings to provide for fish passage and transport flows, sediment and debris.

Project and reach-scale objectives will be further refined in subsequent assessment and design phases of this project.

2.5.4 Restoration Strategies and Treatments

Restoration strategies and treatments in Reach 5 would focus on restoring the valley in a manner that supports the development of a riffle-pool channel and a broad (relative to upstream reaches), well-vegetated floodplain corridor. Channel and valley morphologies would transition to a flatter gradient stream type with a wider floodplain throughout this reach. Restoration strategies and treatments specific to Reach 5 are listed and described below.

- Construct a moderately entrenched, step-pool channel with interspersed riffles and rapids (B4 stream type) transitioning to a C4b stream type characterized by a slightly entrenched, meandering, gravel-dominated channel with riffle-pool bedforms and a well-developed floodplain;
- Create a complex, broad (compared to upstream reaches) vegetated floodplain with side channel habitats that supports a mosaic of conifers, cottonwoods, aspen, and riparian shrubs. The floodplain would filter sediment and other inputs from upstream reaches, adjacent uplands, legacy mining and reclamation-related infrastructure, and residual metals.
- Replace the lower crossing of Mike Horse Road with a bottomless arch pipe or equivalent structure that will simulate natural streambed hydraulic conditions.

Following the removal of tailings and the existing berm located on the northeast side of the valley bottom, a floodplain width of approximately 200 feet will be established for restoration activities. A grading plan would be developed that specifies the shape of the floodplain and terraces, and depressions that would function as off-channel wetlands. The channel bed would be comprised of graded alluvium with primary grade control features composed of small boulders and wood. Vegetative controls on channel morphology would be more important in this reach than in upstream reaches. Due to the degree of remedial disturbance and lack of vegetation after the new channel is constructed, it will be necessary to incorporate natural structural components to ensure the channel remains connected with the floodplain. Structural elements would be comprised of native alluvium, embedded wood, and streambank bioengineering structures. Similarly, native alluvium and large wood would be incorporated throughout the floodplain and along channel margins to encourage natural plant recruitment and to stabilize raw, newly constructed surfaces.

Engineered log jams would be placed along the stream length at outer meanders, resulting in compound pools at each meander bend. Riffle and pool features would comprise approximately 70 percent and 30 percent of the available habitat, respectively.

Four revegetation zones would be included within the riparian area: a natural recruitment zone, a cottonwood/aspen shrub zone, a riparian conifer zone, and an upland conifer zone. These revegetation zones are described in more detail in Section 3 below. A natural recruitment zone would be left as exposed alluvial material (sand, gravel and cobble) on floodplain surfaces on the inside of meander bends. The cottonwood/aspen shrub zone would occupy areas within the bankfull floodplain outside of the natural recruitment zone, and would function as a transition zone between depositional surfaces and the riparian conifer zone. The riparian conifer zone would occupy higher positions in the floodplain such as low terrace features. The upland conifer zone would occur on higher ground such as where the berm is removed, or along road fill slopes. Figure 2-13 demonstrates the desired future condition of Reach 5 following restoration activities in the UMBC project area.

Reach 5 - Upper Blackfoot

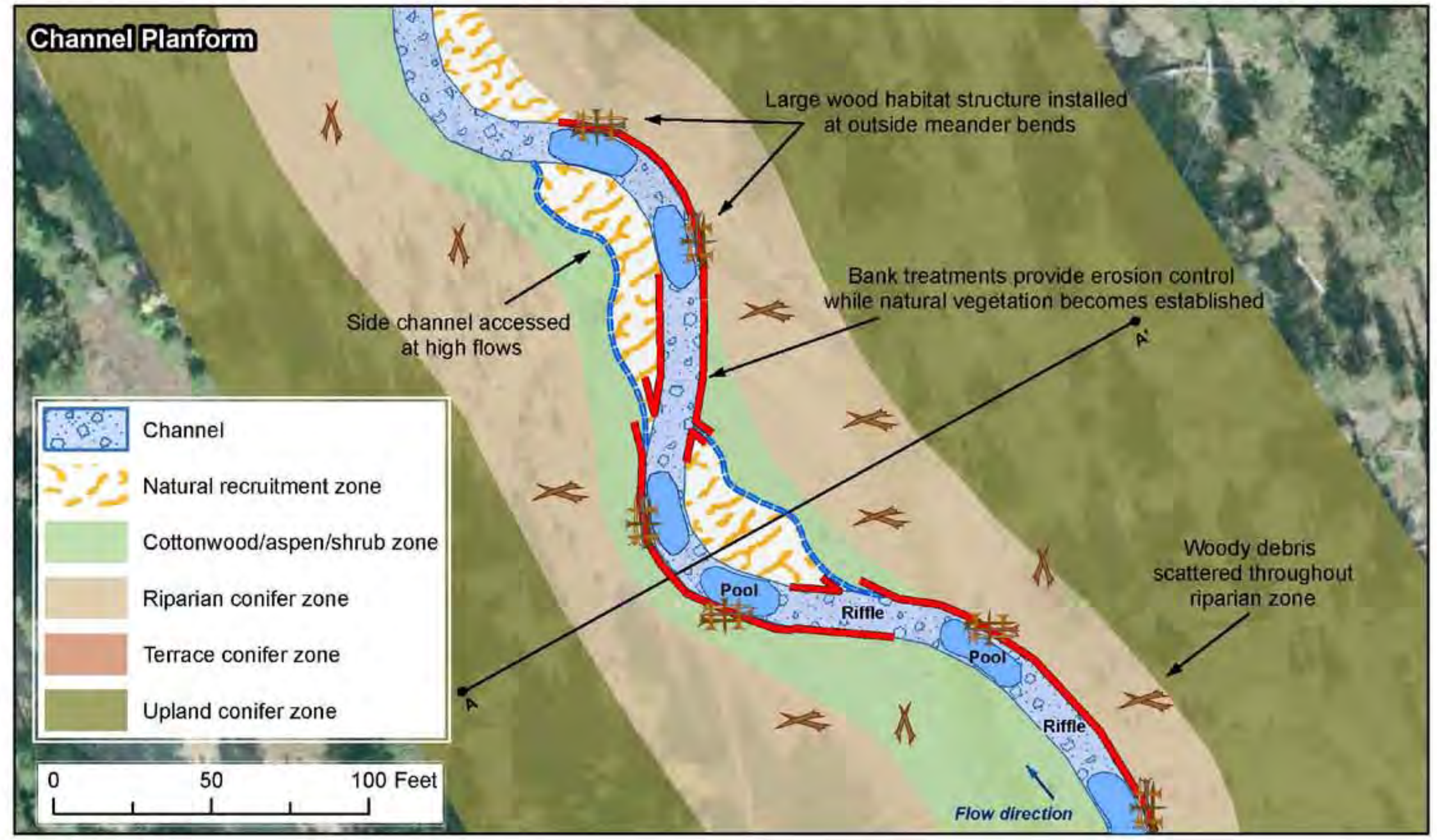
The desired future condition for Reach 5 is a moderately sinuous, slightly entrenched, B4 stream type with coarse gravel and small cobble substrate. The channel bed morphology would be characterized by riffles and rapids with irregularly spaced scour pools. The floodplain width would be constrained by existing infrastructure and average 125 feet. A diverse mosaic of shrubs and trees of varying age classes would characterize the riparian zone.

A primary objective in Reach 5 would be to create complex aquatic habitat components such as depth, velocity, substrate, cover and pools that support populations of native westslope cutthroat trout and other aquatic organism. Large wood aquatic habitat structures and constructed riffles would be the primary restoration techniques. Bank treatments would be required to stabilize newly constructed streambanks and encourage establishment of riparian vegetation.

A.

B.

Reach 5 existing condition (A), and desired future condition (B).



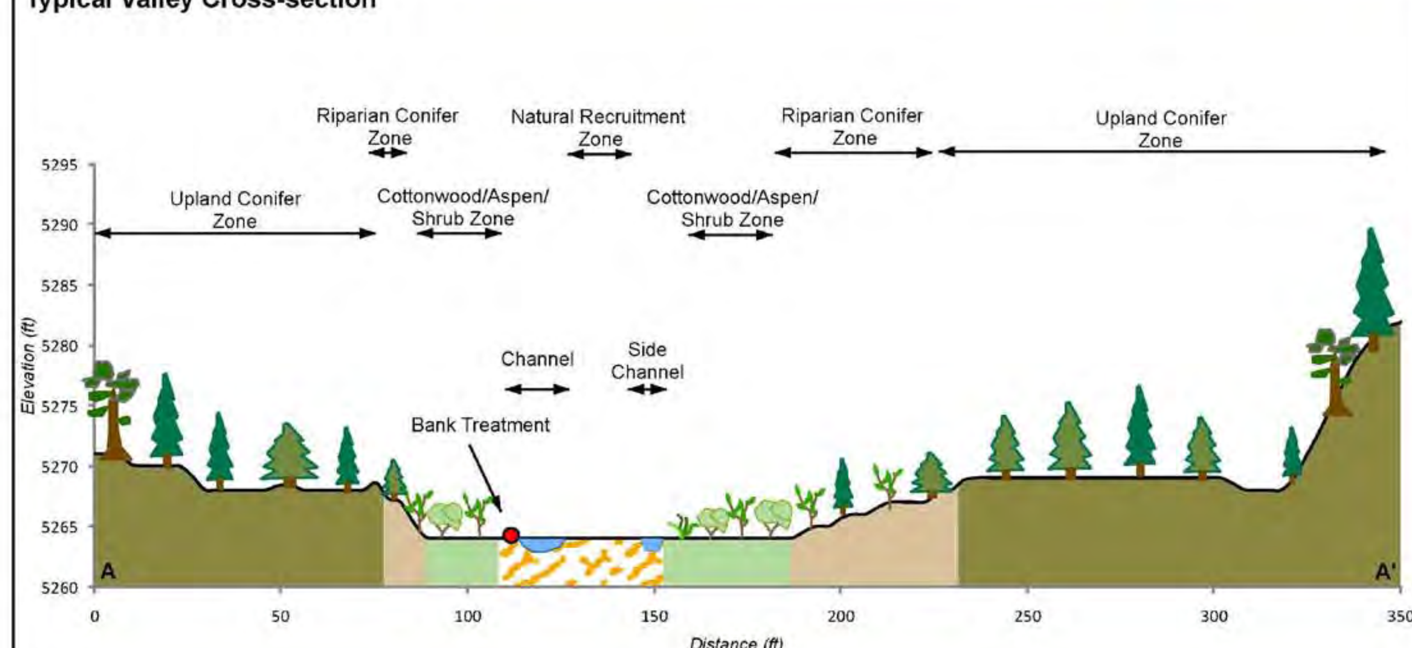


Figure 2-13. Example restoration treatments that may be applicable to Reach 5.

2.6 Reach 6 Upper Blackfoot River Wetlands

2.6.1 Existing Conditions, Limiting Factors, and Constraints

Reach 6 Upper Blackfoot River Wetlands, includes the area in the vicinity of Shave Gulch, and the Upper Blackfoot River downstream from the current access road to Mike Horse Dam. As described for Reach 5, the Upper Blackfoot River valley gradually transitions from a semi-confined system to a lower gradient, more sinuous and unconfined morphology typical of B4c and C4 stream types. The existing stream morphology varies longitudinally based on the degree of floodplain disturbance and valley aggradation that occurred following the failure of the Mike Horse Dam embankment. Downstream of the Mike Horse Road crossing, the reach is highly incised and entrenched relative to the adjacent terrace surface and characterized by severe bank erosion (F4 stream type). Channel incision has initiated floodplain headcuts that contribute contaminated floodplain sediments to the channel.

Downstream of the confluence of Shave Gulch and the Upper Blackfoot River, channel morphology transitions to a more sinuous channel developed with a forested floodplain corridor. Alternating pool and riffle bedforms typical of a C4 stream type occur and the channel is controlled laterally by large wood complexes and mature trees that confine the channel to a relatively broad, terraced floodplain. The most prominent effects of upstream mining and land use activities in Reach 6 include the significant supply of coarse sediment that has deposited in the channel due to reduced sediment transport capacity and competency. Coarse sediment deposition and channel aggradation impairs aquatic habitat conditions by creating extremely high width-to-depth ratio channel conditions and diffuse flow patterns. Sediment deposition reduces the hydraulic capacity of the channel and likely encourages floodplain activation during flows less than bankfull or effective discharge.

Figure 2-14. Existing valley and channel conditions in Reach 6 Upper Blackfoot River Wetlands.

Shave Gulch enters the project area and joins the Upper Blackfoot River in the upper portion of Reach 6. Similar to Anaconda Creek, the channel has been channelized and is hydrologically disconnected from the historical floodplain surface by floodplain berms. Downstream of Mike Horse Road, Shave Gulch has incised in response to a lowering of the base elevation of the Upper Blackfoot River. High streambank erodibility conditions, simplified aquatic habitat conditions, and channel entrenchment characterize the existing conditions of Shave Gulch downstream of Mike Horse Road in Reach 6.

Vegetation in Reach 6 is more diverse than in upper reaches. Along the stream channel, spruce, Douglas-fir and lodgepole pine are the dominant conifers. Because the floodplain is relatively wide and the valley gradient is low in places, wetlands are present within this reach. Immediately downstream from the access road (at the upstream end of Reach 6), tailings deposits are present along the stream channel and in former wetlands. Within these wetlands, it appears that willows initially died, and then re-sprouted through the tailings from their original roots. This resulted in a higher floodplain elevation with substrate that is coarse relative to typical wetland soils. Because of this, lodgepole pine now colonize the higher surfaces. At the downstream end of Reach 6, tailings are either less thick or are not present, resulting in a great floodplain wetland expanse.

Limiting factors and constraints that are present within Reach 6 include:

- Wetlands and streambanks in the upper portions of the reach have accumulated tailings.
- A road and culvert are present at upstream end of the reach; however, this road crossing can be upgraded or removed as long-term access may be provided through the Paymaster site.
- The existing supply of sediment to Reach 6 overwhelms the system and impairs the ability of the channel to effectively transport the available supply. Restoration success in Reach 6 will be determined, in part, on the ability to reduce sediment loading derived from upstream source areas in Reaches 1 through 5.

2.6.2 Desired Future Conditions

The desired future condition of the stream corridor in Reach 6 includes a moderately entrenched, riffle-pool channel (B4c stream type) with inclusions of slightly entrenched, meandering, gravel-dominated systems characterized by riffle-pool bedforms and a well developed floodplain (C4 stream type). The potential stream type and valley morphology would encourage development of a complex floodplain ecosystem with connected side channels and wetlands. Side channel habitats would be hydrologically connected to the channel during moderate to high flow events and provide aquatic habitat refugia and nutrient inputs to the channel. Table 2-6 summarizes preliminary restoration design criteria for Reach 6.

Table 2-6. Preliminary restoration design parameters for Reach 6 Upper Blackfoot River Wetlands. Average values and ranges presented.

Stream Type	Channel Width (feet)	Mean Depth (feet)	Slope (%)	Floodprone Width (feet)	Sinuosity
B4c	18 (16-20)	1.0 (0.9-1.1)	1.2 (1.1-1.3)	30 (28-32)	1.4 (1.3-1.5)
C4	22 (18-22)	1.2 (1.1-1.3)	1.0 (0.9-1.1)	110 (100-120)	1.7 (1.6-1.8)

The desired condition for much of Reach 6 would be a riparian conifer forest (dominated by spruce) with inclusions of cottonwoods, aspen, riparian shrubs and wetlands. The natural wetland immediately downstream from this reach, near the confluence with Pass Creek, serves as a reference for the desired future condition of portions of Reach 6. The desired future condition for Reach 6 would also include a dense and diverse willow complex driven by disturbance processes, such as beaver activity, and fluvial processes, such as scour and deposition. Conifer species would be present along the older sections of the floodplain that are created as beaver activity shifts the alignment of side channels and meanders. This type of system would be resilient to the natural disturbance processes that are necessary for balanced ecosystem function. It would be necessary to remove tailings that have been deposited in former wetlands to achieve this desired condition.

2.6.3 Objectives

Based on limiting factors and constraints described above, and the desired future condition for Reach 6 Upper Blackfoot River Wetlands, the following restoration objectives have been identified:

- Produce clean water consistent with supporting aquatic life and westslope cutthroat habitat.
- Create complex aquatic habitat components such as depth, velocity, substrate, cover, and pools that support populations of native westslope cutthroat trout, bull trout and other aquatic organisms.
- Construct a stream channel that is connected to the floodplain and interacts with the floodplain both in terms of surface flow and sediment exchange.
- Maximize riparian and floodplain habitats and functions, and more specifically, pursue options for enhancing existing and developing additional off-channel wetlands.
- Connect westslope cutthroat trout potential habitat in the Shave Gulch through reconstruction of lower Shave Gulch and the confluence with the Upper Blackfoot River.
- Relocate Mike Horse Road on the south side of the floodplain outside of the channel migration zone below the junction with Paymaster Road, and where possible, remove all unnecessary infrastructures.
- Incorporate, to the greatest extent practical, historical (buried) floodplain and terrace surfaces and associated features including stumps and other roughness elements.
- Improve existing and future proposed stream crossings to provide for fish passage and transport flows, sediment and debris.

2.6.4 Restoration Strategies and Treatments

Restoration strategies and treatments in Reach 6, and specific to Shave Gulch, would focus on restoring the river and floodplain to a diverse riverine ecosystem with multiple channel types, vegetation communities, off-channel wetlands and side channels. Channel and valley morphology would transition from a B channel type, include sections of C channel, and merge with the E channel morphology present in the wetland complex that marks the downstream end of this reach.

Restoration strategies and treatments specific to Reach 6 are summarized below.

- Construct a moderately entrenched, step-pool channel with interspersed riffles and rapids (B4 stream type) with C4 stream type inclusions characterized by a slightly entrenched, meandering, gravel-dominated channel with riffle-pool bedforms and a well developed floodplain.
- Create a complex, broad (compared to upstream reaches) vegetated floodplain with side channel habitats that supports a mosaic of conifers, cottonwoods, aspen, and riparian shrubs. The floodplain would filter sediment and other inputs from upstream reaches, adjacent uplands, legacy mining and reclamation-related infrastructure, and residual metals.
- Replace the Mike Horse Road crossing at Shave Gulch with a bottomless arch pipe or equivalent structure that will simulate natural streambed hydraulic conditions.
- Remove tailings on wetland surfaces to restore wetlands and minimize surface water contamination.

Tailings extents and depths need to be assessed and mapped, and results of the analysis would be incorporated as part of a floodplain grading plan. The grading plan would specify the shape of the floodplain and terraces, as well as side channels and depressions that would function as off-channel wetlands. Channel bed material would be comprised of graded alluvium with primary grade control features composed of native alluvium, small boulders and wood.

The floodplain and channel bed and banks would be constructed using native alluvium, embedded wood, and streambank bioengineering structures. Similarly, native alluvium and large wood would be incorporated throughout the floodplain and along channel margins to encourage natural plant recruitment and stabilize raw, newly constructed surfaces.

Engineered log jams would be placed along the stream length at outer meanders, resulting in compound pools at each meander bend. Riffle and pool features would comprise approximately 70 percent and 30 percent of the available habitat, respectively.

Five revegetation zones would be included within the riparian area: 1) a natural recruitment zone, 2) a riparian shrub zone, 3) a cottonwood/aspen shrub zone, 4) a riparian conifer zone, and 5) an upland conifer zone. These zones are described in more detail in Section 3. A natural recruitment zone would be left as exposed alluvial material (sand, gravel and cobble) on some floodplain surfaces on the inside of meander bends. A riparian shrub zone would occur adjacent to the stream within the bankfull floodplain, and this zone would also be present within wetland areas. The cottonwood/aspen shrub zone would occupy areas within the bankfull floodplain outside of the natural recruitment and riparian shrub zones. The riparian conifer zone would occupy higher positions in the floodplain such as low terrace features. The upland conifer zone would occur on higher ground and would tie in with existing upland vegetation. Figure 2-15 shows desired conditions and examples of restoration treatments that may be applied within Reach 6. Figure 2-15 includes an exhibit of activities proposed for Shave Gulch.

Reach 6 - Lower Blackfoot

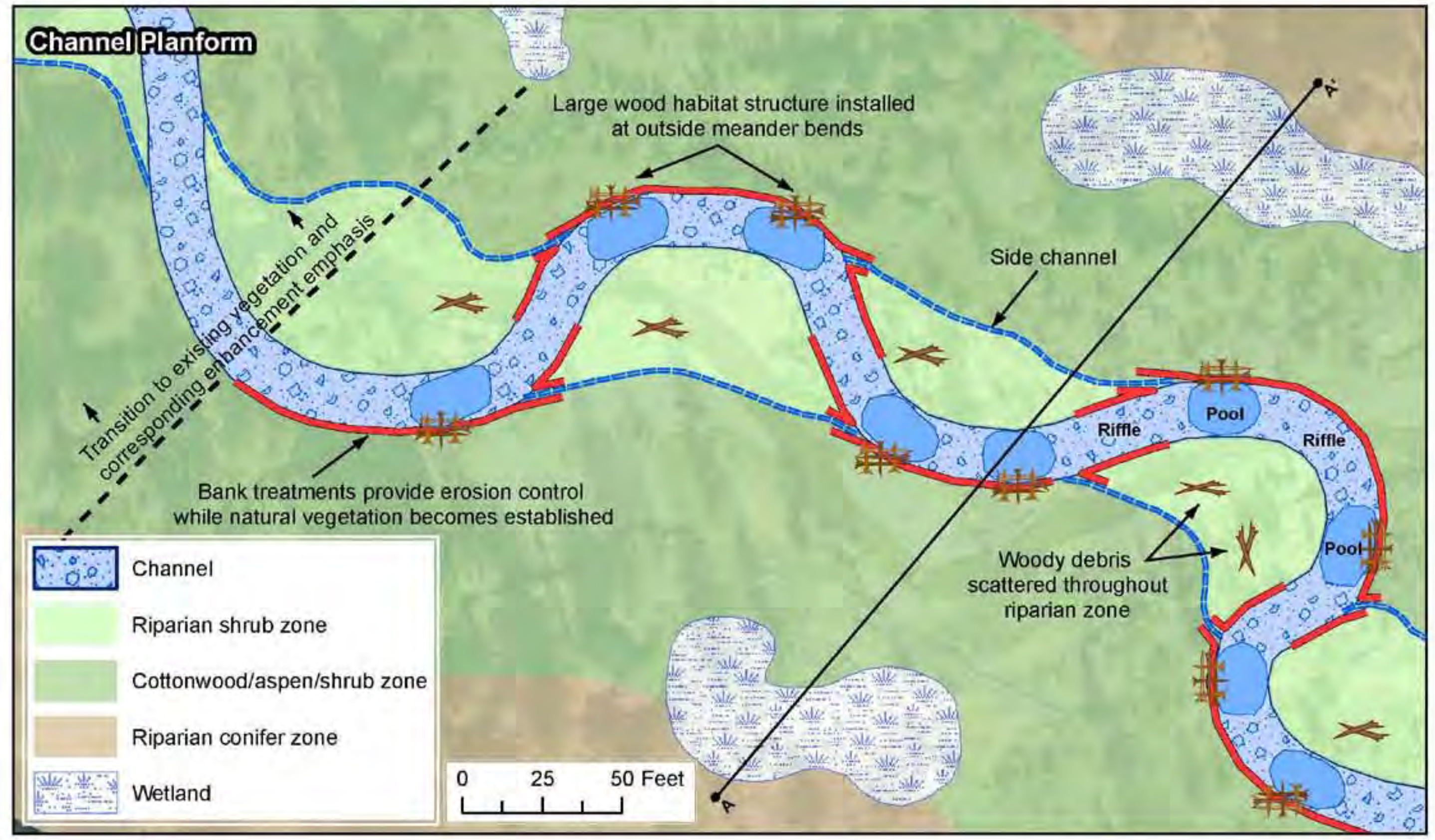
The desired future condition for Reach 6 is a moderately entrenched, riffle-pool channel (B4c stream type) with inclusions of slightly entrenched, meandering, gravel-dominated channels characterized by riffle-pool bedforms and well developed floodplains (C4 stream type). The potential stream type and valley morphology would encourage development of a complex floodplain ecosystem with connected side channels and wetlands. Side channel habitats would be hydrologically connected to the channel during moderate to high flow events and provide aquatic habitat refugia and nutrient inputs to the channel. The desired condition for much of Reach 6 would be a riparian conifer forest (dominated by spruce) with inclusions of cottonwoods, aspen, riparian shrubs and wetlands.

Collectively, restoration objectives in Reach 6 would seek to maximize floodplain and channel complexity. Aquatic habitat would consist of varied depths, velocity gradients, substrate composition, and cover that supports populations of native westslope cutthroat trout and other aquatic organisms. Large wood aquatic habitat structures and constructed riffles would be the primary restoration techniques. Bank treatments would be required to stabilize newly constructed streambanks and encourage establishment of riparian vegetation.

A.

B.

Reach 6 existing condition (A), and desired future condition (B).



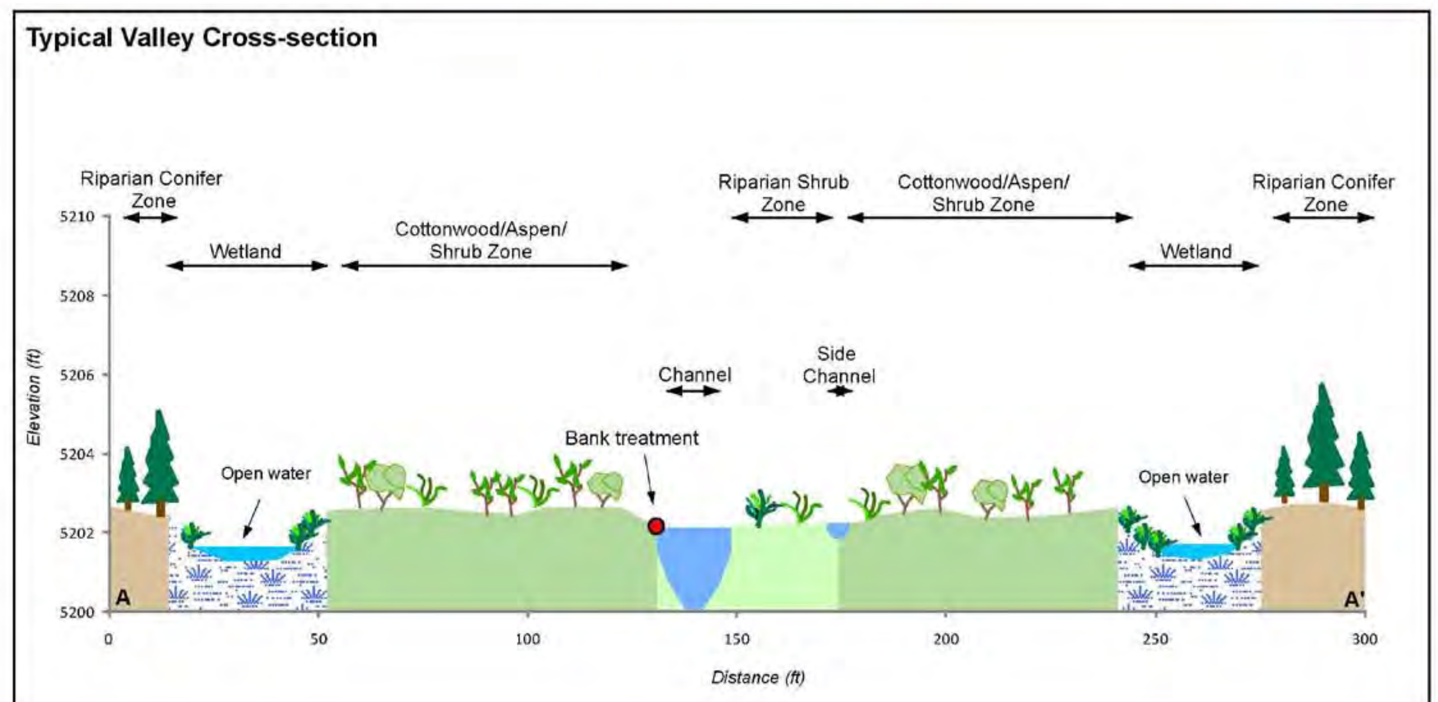


Figure 2-15. Example restoration treatments that may be applicable to Reach 6.

Shave Gulch

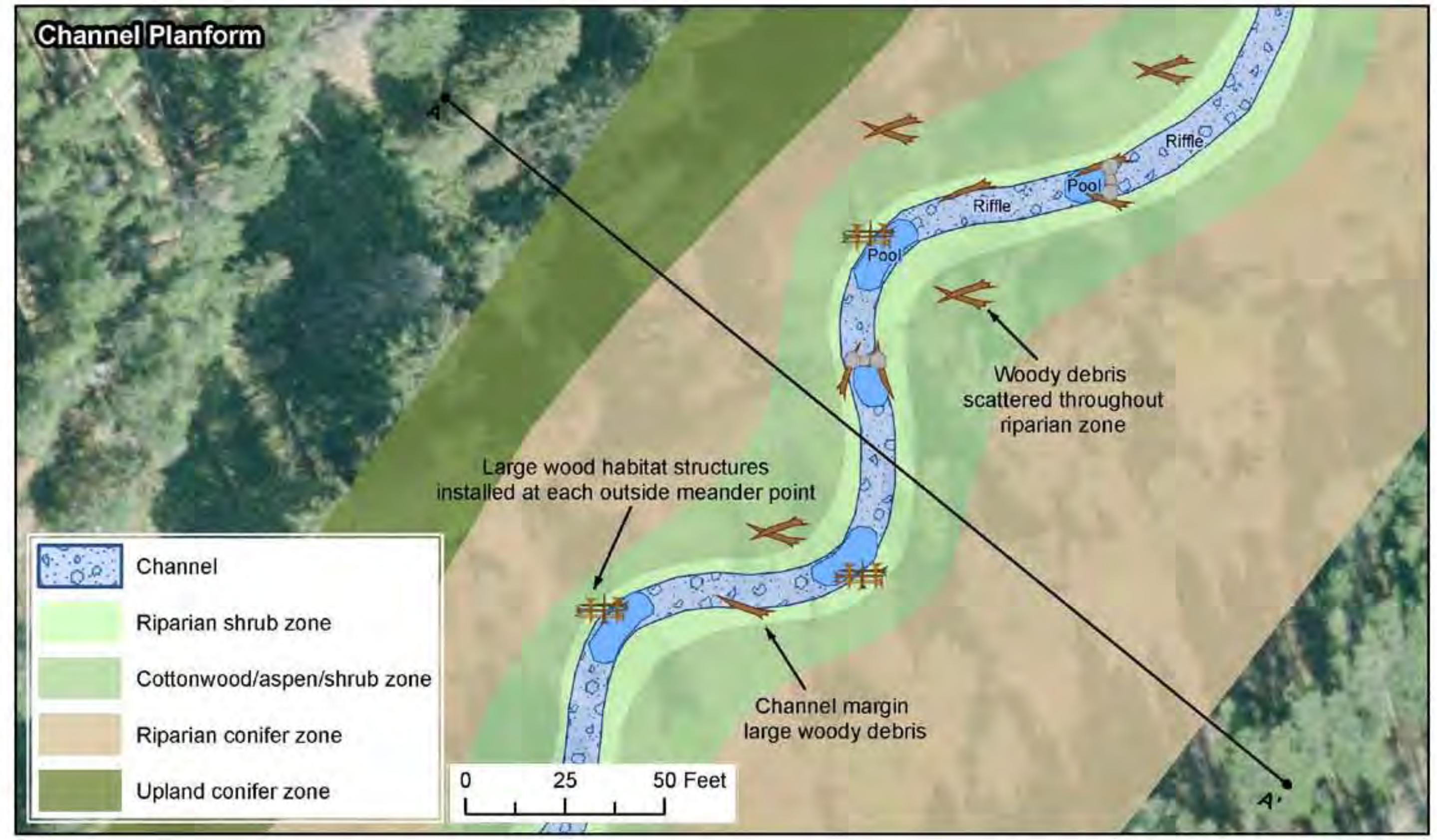
The channel and floodplain in the lower reaches of Shave Gulch, would be restored from the confluence with the Upper Blackfoot River to approximately 0.25 miles upstream of the Mike Horse Road. The primary goals of restoration would be to restore channel-floodplain connectivity, improve aquatic habitat complexity for westslope cutthroat trout and other aquatic organisms, and create a stable confluence with the Upper Blackfoot River in Reach 6 of the UBMC project area. The desired future condition of the channel and floodplain includes a moderately entrenched, riffle-pool channel with a narrow, well-vegetated floodplain corridor that would support a diverse mosaic of shrubs and trees of varying age classes. Exposed depositional surfaces would be more common in the vicinity of the confluence with the Upper Blackfoot River as the floodplain width increases in a down-valley direction.

Creating complex aquatic habitat components such as depth, velocity, substrate, cover and pools that support populations of westslope cutthroat trout and other aquatic organisms would be a primary objective in lower Shave Gulch. Large wood aquatic habitat structures and constructed riffle and pool sequences would be the primary restoration techniques, in addition to bioengineering treatments to stabilize newly constructed streambanks and encourage establishment of riparian vegetation.

A.

B.

Shave Gulch existing floodplain (A), and desired future condition (B).



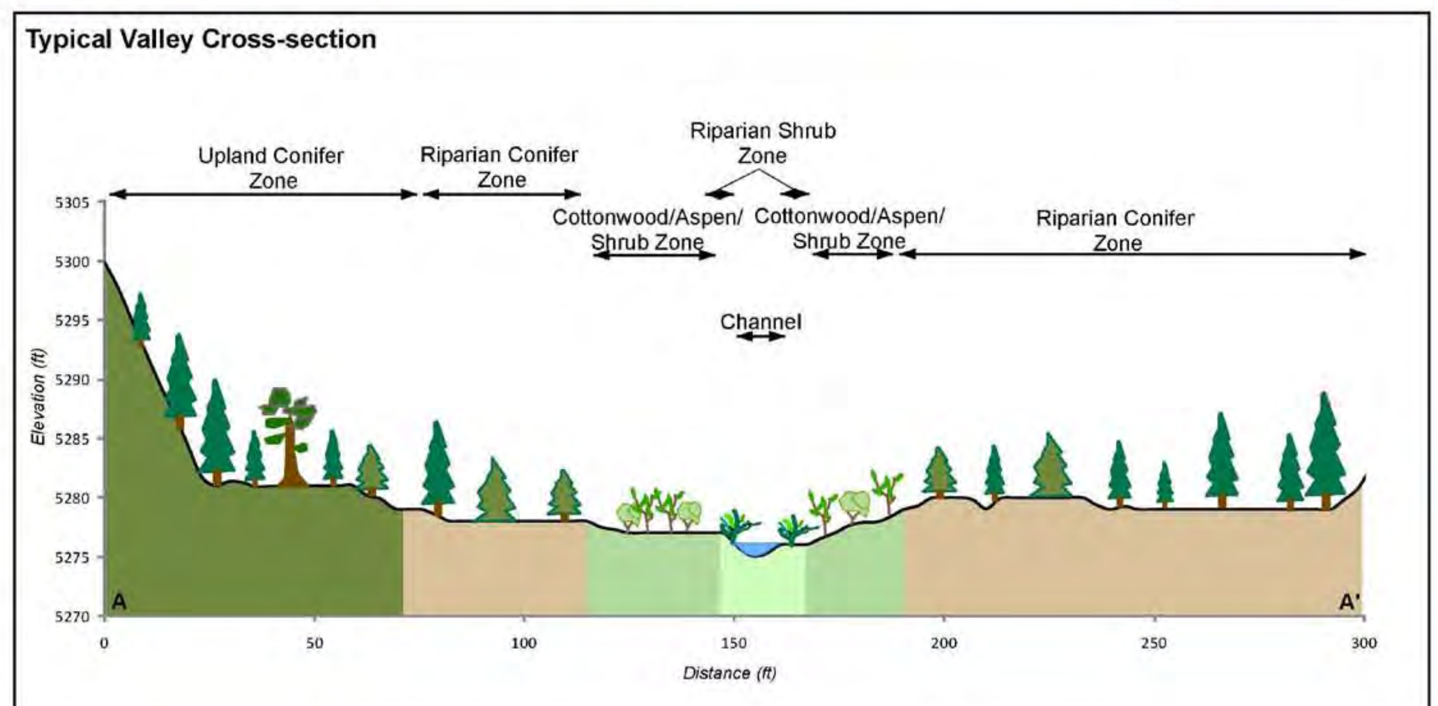


Figure 2-16. Example restoration treatments that may be applicable to Shave Gulch.

Section 3 Restoration Treatments

3.1 Channel Construction

Stream channels within the UBMC project area would be designed and constructed using natural channel design techniques. In general, the active channels would be designed to convey the estimated bankfull or effective discharge, with a connected floodplain to accommodate flood events. This design concept is essential for the streams to maintain stability and provide high quality, complex aquatic habitat. Re-establishing the proper channel geometry and sediment transport capacity of the streams would improve the capability of UBMC reaches to maintain perennial flow during base flow conditions. Floodplains, as described below in Section 3.2, would be designed to activate at the approximate 1.5 year recurrence interval discharge, and would provide essential functions such as energy dissipation and sediment storage.

Channel construction and associated channel gradients would vary longitudinally at both the watershed and reach scales. In general, channel morphology for streams in upstream, steeper tributaries would be controlled by substrate such as boulders, in addition to embedded wood. Eventually, tree and shrub roots would provide additional controls on channel form. Channel form in the middle reaches of the UBMC project area would be controlled to some degree by substrate, but wood and vegetation would be more significant controlling factors. In downstream reaches such as Reaches 5 and Reach 6, vegetation would be the primary control on channel form. The increasing importance of vegetation in controlling channel morphology is reflected by increasing use of streambank bioengineering in downstream portions of the UBMC project area.

At the reach scale, the channel would be designed with an undulating bed profile with stream gradients generally shallower in the meanders associated with pools, and steeper in the straight riffles. This undulating bed profile would function to dissipate stream energy and maintain the vertical stability of the channel profile, as well as provide a variety of habitat requirements for westslope cutthroat trout and other aquatic organisms. While natural stream systems can maintain vertical grade control through natural processes, reconstructed channels require some degree of vertical grade control structure to ensure the channel remains hydrologically connected to the constructed floodplain. In the upper watershed including Reach 1 Mike Horse Creek, Reach 2 Upper Beartrap Creek, Reach 3 Lower Beartrap Creek, and Reach 4 Upper Blackfoot River, including Anaconda Creek and Shave Creek, grade controls to balance stream energy would be created in the form of step-pool sequences and constructed riffles. Slightly lower gradient reaches, including Reach 5 Upper Blackfoot River and Reach 6 Upper Blackfoot River Wetlands would include riffle and pool sequences in addition to channel planform modifications to balance stream energy.

Constructed channels and riffles typically involve importing suitable graded alluvium placed within a framework of larger material (e.g. boulders) to counteract scour of the finer gradation matrix. Hydraulic effects of the alluvium placement include spawning material retention and deposition along the glide face or pool tailout. For higher gradient stream reaches, boulders will be incorporated in the bed material to dissipate stream energy, create velocity gradients, and consolidate base flows for fish passage. Collectively, constructed channels and riffles will replicate natural stream conditions. Figure 3-1 includes examples of constructed channels that include a variety of bedform features including riffles, runs, pools and glides.

Figure 3-1. Example constructed channels incorporating graded alluvium and boulder placement for grade control and aquatic habitat diversity.

Channel restoration in the UBMC project area would increase the amount of habitat to support various life stages of westslope cutthroat trout (and potentially bull trout) with an emphasis on restoring connectivity to high quality tributaries such as Anaconda Creek, maximize connection between the channel and floodplain, and sustain balanced sediment transport and hydraulic characteristics of the restored stream reaches.

3.2 Floodplain Construction

Floodplains would be constructed of native alluvial material with an overlying horizon of soil of varied textures depending on the revegetation zone (described below). Woody debris and micro-topography in the form of swales would be incorporated within floodplain surfaces. Woody debris and micro-topography function as sediment traps and microsites; they can increase sediment storage, flood storage, and debris retention; create stable points for vegetation development; promote topographic diversity on floodplain surfaces; and add habitat complexity. Figure 3-2 shows examples of restoration techniques that result in a complex floodplain surface.

Figure 3-2. Floodplain woody debris and microtopography treatments are shown in the left photo. The right photo shows willows growing from buried cuttings combined with coir logs to sustain rooting zone moisture.

3.3 Streambank Treatments

Streambank treatments act to maintain lateral channel stability, within an acceptable range of natural variability, while vegetation becomes established and provides long-term stability to the stream system. In addition, streambank treatments also add aquatic habitat complexity and mimic the functions of large wood that is naturally recruited into the stream system. Examples of streambank treatments that may be used within the UBMC project area include engineered log jams, vegetated soils lifts, and coir log fascines. These streambank treatments are described in more detail below.

3.3.1 Engineered Log Jams

Engineered log jams are engineered wood structures that intercept flow and reduce near-bank velocities, protect new floodplain surfaces, promote pool scour and maintenance, and provide habitat along the land-water interface. These structures span from the anticipated depth of the channel to over the bankfull channel elevation, and tie into existing stable bank vegetation where available. Engineered log jams are constructed of logs, whole trees with attached root wads, and either large anchor rocks or tree members for ballast and structural support. Engineered log jams are used in combination with streambank bioengineering structures. They create stable tie-in points for the streambank structures and provide aquatic habitat by encouraging scour along outside streambanks and meander bends. Figure 3-3 includes examples of engineered log jams used in conjunction with streambank bioengineering structures.

Figure 3-3. Photographs demonstrating the use of engineered log jams used in conjunction with streambank bioengineering structures and submerged wood to form a stable, vegetated land-water interface and create complex aquatic habitat along the channel margins.

3.3.2 Streambank Bioengineering

Streambank bioengineering consists of using live plant material in conjunction with biodegradable coconut fiber fabrics (coir) to create a streambank that is stable in the short term until native vegetation can become established. Streambank bioengineering treatments are used to encourage woody vegetation establishment in areas such as at the land-water interface along outer meander bends. Because streambank bioengineering is a revegetation technique rather than a streambank stabilization technique, engineered log jams would also be constructed at these sites to provide more stability to the bioengineering structure while also providing in-stream habitat.

Vegetated Soil Lifts

Vegetated soil lifts are a revegetation and bank construction technique that combines layers of dormant willow cuttings with fabric-wrapped soil to revegetate and stabilize stream banks. Soil is wrapped within two layers of biodegradable coir fabric to hold the soil in place while vegetation becomes established in the relatively high stress land-water interface. The purpose of this treatment is to provide site conditions directly along the channel that are suitable for growing riparian vegetation. While vegetated soils lifts provide some degree of bank stabilization, they are primarily a revegetation technique. These structures reduce bank erosion rates, but they must be located within a sequence of other bank stabilization and grade control structures that provide bank stability. Over a five to seven year period, the fabric will decompose and be replaced by dense, woody vegetation that will provide rooting strength sufficient to maintain low bank erosion rates. Figure 3-4 below shows vegetated soil lifts used as a stand-alone treatment and in combination with other streambank treatments including engineered log jams.

Figure 3-4. Vegetated soil lifts used in conjunction with engineered log jams (left) and as a stand-alone treatment (right).

Coir Log Fascines

Coir log fascines are a revegetation and bank stabilization treatment that involves the placement of coir logs, combined with dormant willow cuttings, at the toe of streambanks along outer meander bends or areas with relatively high stress at the land-water interface. The purpose of this treatment is to establish woody vegetation along the channel in areas where scour is compromising the toe of banks and causing bank erosion and channel widening. Coir logs are constructed of high-density coir bales contained within coir fiber netting. Coir is used for bioengineering because it stores water for long periods, and its durable fibers trap sediment and mimic soil matrices formed by living roots. Coir fibers biodegrade over approximately five to seven years, and provide a stable growing medium while native riparian plants establish. The coir log fascine provides streambank toe stability to limit bank erosion due to scouring, allowing time for woody vegetation to establish and stabilize the bank over the long-term. Figure 3-5 below shows a cross-section view of a typical coir log installation.

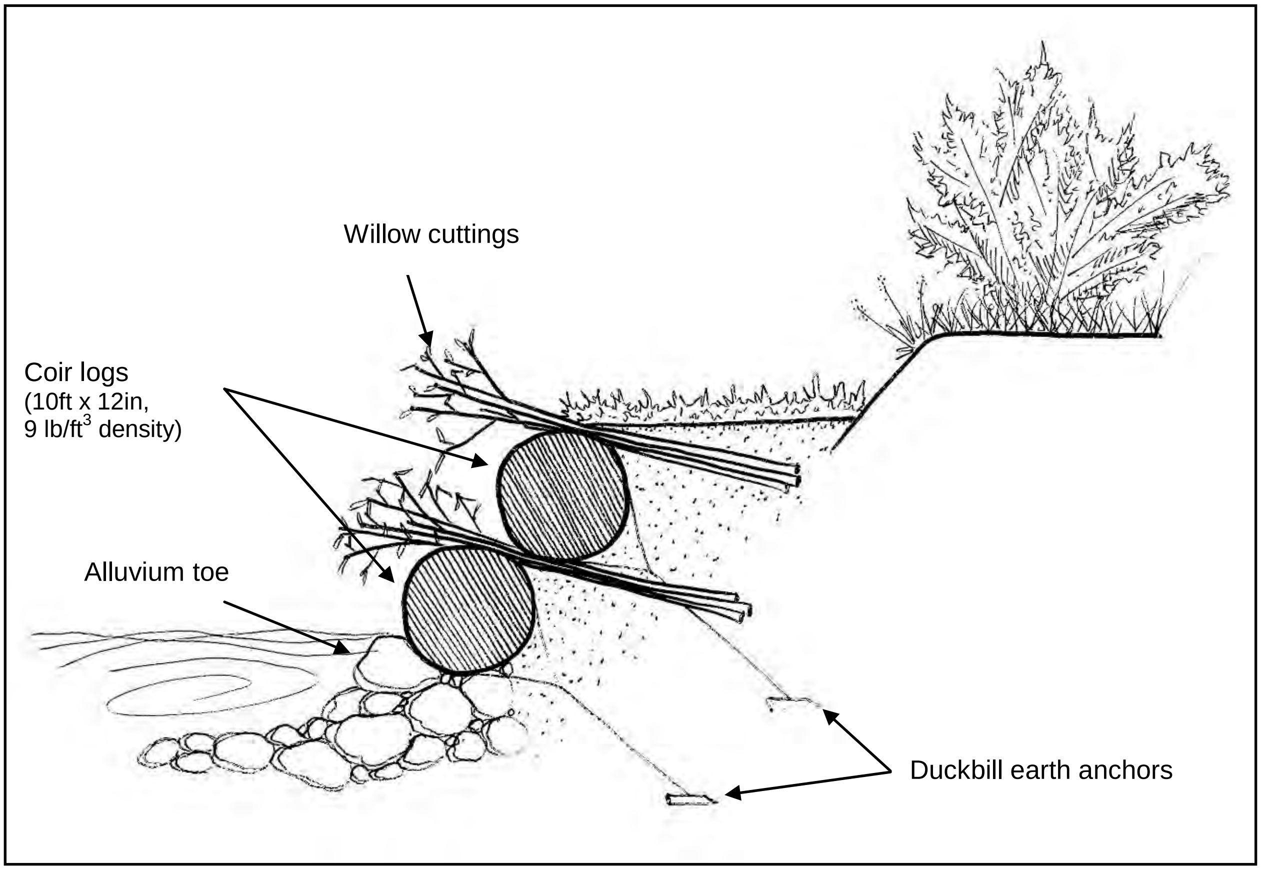


Figure 3-5. Typical cross-section of a coir log fascine streambank bioengineering treatment.

3.4 Revegetation Zones

The revegetation approach within the UBMC project area is organized according to five revegetation zones that represent different geomorphic surfaces and hydrologic regimes. These revegetation zones include: riparian shrub; cottonwood/aspen shrub; riparian conifer; upland conifer and natural recruitment zones. Specific plant species mixes will be developed for each zone during later design phases, but species composition and other attributes of each zone are described below.

3.4.1 Riparian Shrub Zone

The riparian shrub zone occurs immediately adjacent to streambanks, at or below the elevation of the bankfull floodplain (approximate 1.5 to 2 year return flow). This zone is present in all project reaches and, in most cases, represents an early successional phase of one of the tree-dominated habitat types described above. Within the riparian shrub zone, roots of planted shrubs would integrate with structural materials (rock, wood, or fabric-wrapped soil) to provide dense, rooting stability and function as a vegetative control on channel morphology. In upper, steeper reaches, structural materials would include larger cobbles and boulders that form the channel bed and banks. In middle reaches, structural controls would include a combination of native rock and embedded wood; and in downstream (lower gradient, smaller substrate) reaches, structural controls would be mainly wood and fabric-wrapped banks. Shrubs that establish along streambanks would also provide overhanging bank cover, shade, and food web inputs into the stream channels.

Shrub species that may be planted include various willows (*Salix* spp.), red-osier dogwood (*Cornus sericea*), alder species (both *Alnus sitchensis* and *A*. *incana*), and other near-bank riparian shrubs that would be selected as part of later design phases. Particularly in upper reaches, drier shrub species such as chokecherry (*Prunus virginiana*), western serviceberry (*Amelanchier alnifolia*), Rocky Mountain maple (*Acer glabrum*) and others may be appropriate along stream margins where streambank and bed materials are very coarse textured and well-drained.

Several revegetation techniques would apply within the riparian shrub zone. These techniques include: salvage and transplant; planting containerized species either by hand or with heavy equipment support; installation of vegetative cuttings within fabric-wrapped banks (vegetated soils lifts); or natural recruitment driven by appropriately sized and graded substrate. These techniques are described below. In many cases, revegetation within the riparian shrub zone would be closely integrated with bank structures and floodplain construction as described above.

3.4.2 Cottonwood/Aspen Shrub Zone

The cottonwood/aspen shrub zone occurs outside of the riparian shrub zone, at elevations ranging from at or below the bankfull floodplain to the low terrace (approximately one foot above bankfull). This zone is present in all project reaches except for Reach 1 and represents an early successional phase of one of the tree-dominated conifer habitat types described above. Within this zone, a mixture of cottonwoods, aspens and riparian shrubs will occupy the floodplain surface and function to trap sediment (thereby building the floodplain), provide roughness to moderate flood flows, and stabilize floodplain soils. Within this zone, large wood and microtopography would be incorporated as part of floodplain construction. Over time, relatively short-lived cottonwoods and aspens would be sources for large wood inputs into the stream, and would help sustain aquatic habitat complexity.

Tree and shrub species that may be planted include black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), quaking aspen (*Populus tremuloides*), various willows, red-osier dogwood, alder species, and other near-bank riparian shrubs that would be selected as part of later design phases. Conifer species such as lodgepole pine (*Pinus contorta*) and Douglas-fir (*Pseudotsuga menziesii*) may also be included as part of this zone.

Several revegetation techniques would be used within the cottonwood/aspen shrub zone. These techniques include: salvage and transplant; planting containerized species either by hand or with heavy equipment support; installation of buried willow or cottonwood fascines (bundles of vegetative cuttings), or natural recruitment driven by appropriately sized and graded substrate. These techniques are described below. Revegetation within this zone would be closely integrated with floodplain grading.

3.4.3 Riparian Conifer Zone

The riparian conifer zone occurs on the low terrace, which ranges from approximately one foot above the bankfull floodplain elevation to an upper elevation extent that is determined either by transition to a higher terrace position, or in some cases by aspect (for example, this zone may extend higher on north facing slopes). Riparian conifers such as spruce (*Picea spp.*), subalpine fir (*Abies lasiocarpa*), and Douglas-fir represent the long-term potential natural community for most riparian areas within the UBMC project area. As noted above, shrubs, cottonwoods and aspen would naturally colonize near-banks areas either before, or alongside, conifers, so short-term revegetation goals focus on those species near the streambanks and on the bankfull floodplain. However, on drier terraces, natural recruitment processes would favor conifers, so initial revegetation would include a significant conifer planting component on terrace features. The riparian conifer zone is present in all project reaches and represents a moderate to late successional phase of one of the tree-dominated conifer habitat types described above. Within this zone, a mixture of conifers and shrubs would occupy the terrace surface and function to stabilize soils (limiting erosion potential), provide habitat for terrestrial wildlife and birds that use riparian corridors, and provide long-term large wood inputs onto the floodplain and into the stream, sustaining riparian and aquatic habitat complexity. Within this zone, large wood and microtopography would be incorporated as part of floodplain construction.

Tree and shrub species that may be planted include lodgepole pine, Douglas-fir, quaking aspen, chokecherry, western serviceberry, Rocky Mountain maple, and others species that would be selected as part of later design phases. Later successional species like subalpine fir and spruce may not be planted directly; rather, terrace and floodplain grading would include incorporating microsites that would allow these species to recruit naturally from readily available on-site seed sources adjacent to the stream channels.

Within the riparian conifer zone, the primary revegetation technique would be planting of containerized nursery stock. Where available, some upland shrubs may be salvaged and transplanted into these areas.

3.4.4 Upland Conifer Zone

The upland conifer zone is present in all project reaches to varying degrees and represents an early to late successional phase of several upland conifer habitat types that are present on the site. Where significant upland areas will be exposed when tailings are removed (for example, Reach 2), or where upland areas will be otherwise reclaimed such as when roads are removed, restoration of these areas will follow typical reforestation practices such as tree planting. In cases where upland restoration occurs along a narrow band that links restored riparian areas with existing upland conifer forest, restoration treatments might focus more on erosion control and increasing understory plant species diversity.

Within this zone, a mixture of conifers and shrubs would occupy high terraces and slopes and function to stabilize soils (limiting erosion potential). Tree and shrub species that may be planted include lodgepole pine, Douglas-fir, common juniper, white spirea, western serviceberry, Rocky Mountain maple, and other species that would be selected as part of later design phases.

Within the riparian conifer zone, the primary revegetation techniques would be planting of containerized nursery stock and seeding. Erosion control measures such as placing contour logs and other techniques may also be applied.

3.4.5 Natural Recruitment Zone

Within portions of Reaches 4, 5 and 6, a natural recruitment zone is identified. This zone represents areas that would likely develop into the cottonwood/aspen shrub zone, but these areas would be constructed so the final graded surface is composed of alluvial sand, gravel and cobble with microtopography and wood incorporated into the floodplain surface. Elevations within this zone would be at or below the bankfull floodplain elevation. The natural recruitment zone would be located within low stress areas of the floodplain, such as the inside of meanders, where dominant floodplain sediment processes would likely be depositional. Riparian tree and shrub species such as cottonwoods and willows are able to establish from seed on surfaces that are composed of sand, gravel and cobble and where moisture is present during late spring and early summer coincident with the hydrograph's peak. Because seed sources of a variety of native riparian trees and shrubs are present within the UBMC project area, this zone is intended to take advantage of natural processes to establish native riparian plant communities in areas where risk of either erosion or channel avulsion is low.

3.5 Revegetation Treatments

Several revegetation treatments are described in general terms in the following sections. These revegetation treatments have been applied on other river and floodplain restoration projects in western Montana. In addition to specific limiting factors and constraints described in Section 2 above, western Montana riparian ecosystems typically have short growing seasons, extreme seasonal temperature shifts, short seed viability windows, wide variations in rooting zone hydrology, invasive plant species that compete with native species, and browse impacts from wildlife. Each of these factors should be considered during the restoration design process, and the following revegetation treatments are intended to support and sustain natural ecosystem processes in western Montana riparian ecosystems.

3.5.1 Plant Salvage and Transplant

As part of both remediation and restoration activities, native plants should be salvaged where it is feasible and where plants are not rooted in contaminated substrate that must be removed. Salvaging plants and sod can be a relatively inexpensive method for obtaining large, native, site-adapted planting stock to transplant in floodplains and along streambanks. During final design, potential shrub, tree, and sod salvage areas should be identified. In addition, holding areas should be identified, and a maintenance plan should be developed that addresses duration of salvaged material storage, timing related to other construction activities, weeding, and watering. Where it is not possible to keep plant material alive, or where roots are in contaminated substrate, woody plant material should still be stockpiled so it can be incorporated in constructed floodplain surfaces to create micro-sites.

3.5.2 Floodplain Grading, Substrate and Woody Debris

Floodplain grading should result in varied elevations aimed at creating micro-topographic relief and a variety of habitat niches. As part of final grading plans, substrate should be specified and linked to geomorphic features that would be constructed as part of restoration work. For example, substrate in the natural recruitment zone would be composed of sand, gravel and cobble, while substrate on terrace features should include at least six inches of soil (sandy loam or other textures determined during final design) on top of general fill. In general, substrate should consist of uncontaminated native material originating from within or near the UBMC project area. Because the UBMC project area is within a forested ecosystem, woody debris will be an important component of streambanks, floodplain surfaces and other surfaces that require revegetation. Functions of woody debris that benefit restoration include: providing microsites where plants and seeds can grow in a protected environment; adding organic matter to the soil, and promoting microbial activity to support soil development; retaining moisture during drier parts of the growing season; and providing physical structure to floodplains and streambanks that resists erosion and helps control channel plan form as vegetation becomes established. Restoration designs should include detailed specifications related to floodplain grading, substrate and woody debris placement.

3.5.3 Weed Management

Weed management should be incorporated as part of remediation and restoration activities. Most weed species have broader substrate and moisture tolerances than many of the native plant species, and they are very tolerant of disturbance; therefore, weed management on a construction site is important. If possible, weeds should be mapped as part of feasibility work being completed for remedial work, and a weed management plan should be developed that applies to both remediation and restoration work. The weed management plan should address issues including:

- Avoid spreading weeds during construction by cleaning equipment and removing weed concentrations.
- Seed stockpiles and exposed soils that will remain exposed during the growing season to occupy available niches for weeds.
- Actively manage vegetation by consistently controlling weeds and maintaining newly seeded and planted areas.

3.5.4 Seeding

As part of the design process, different seed mixes should be developed for wetlands, floodplains and upland areas, and these seed mixes should consist of both grass and forb species (wetland species such as sedges, rushes and bulrushes may be included in the wetland and floodplain mixes). Using a mix of grasses and forbs will result in a wider range of microsites and soil strata being occupied and help to reduce availability of open sites for weedy species to germinate and become established. In addition to these restoration seed mixes, a reclamation seed mix should be developed that consists of a short-lived, sterile grass such as triticale or annual rye. The reclamation seed mix would be applied to stockpiles and exposed soils to limit weed colonization and provide short term erosion control.

Seed quantities should be specified in terms of pure live seed (PLS) pounds per acre. Depending upon seeding method and species, seed may need to be provided as mixes of similar sized seed.

3.5.5 Plant Materials for Restoration

Trees and shrubs planted at the UBMC site should be containerized native plants with an established root system. Woody plants should be grown in pot sizes ranging from 1/3 gallon (for example, 3-inch diameter by 14-inch cylinders) to 16 gallon root balls (for example, 16 gallon grow bags). Herbaceous species would be grown in smaller containers (for example, 10 cubic inch tubes). Dormant cuttings would be limited to native willow, dogwood and cottonwood species harvested from within the Blackfoot River watershed, preferably upstream from Lincoln, Montana. The length and diameter of willow cuttings will vary depending on how they are being used.

3.5.6 Planting Methods

As part of later design phases, specific planting methods should be identified for groups of plant species. For example, willow and rose family plants can be planted with stems partially buried. Most other species must be planted so that the root crown is even with the soil surface. Detailed planting specifications should be developed as part of final design to ensure that air pockets are eliminated during planting, plants are installed at the correct depth for each species, and plants are installed within the proper hydrologic zone for each species.

Examples of plant methods include: auger attachment on a rubber-tracked skid-steer; excavator-mounted hydraulic stinger attachment; hand planting by crews using hoedads; or excavating planting holes for larger plants or salvaged plants using an excavator bucket. Regardless of the planting method, all plants should be watered immediately after planting to improve soil contact around roots and to limit air pockets in the planting holes.

3.5.7 Browse Protectors

Browse protectors should be installed around shrubs and trees, in protected areas of the floodplain, to prevent browse by wildlife. Browse protectors should be four feet tall and between one and two feet in diameter, and they should be constructed using a rigid mesh material that will resist wear and not rapidly photo-degrade. Alternatively, eight to ten foot tall browse exclosures can be constructed around plants where they are grouped in such a way that exclosures are efficient to construct and maintain.

3.5.8 Soil Amendments

Revegetation strategies in this plan include techniques for varying topography and substrate to mimic how natural processes create a complex matrix of substrate. Soil amendments, in the context of native plant revegetation, are typically aimed at either adding nutrients or changing the texture or organic matter composition of soil surfaces. Nutrient additions may not be necessary in the UBMC project area as long as the channel and floodplain are hydrologically connected, allowing nutrient inputs and exports as part of normal water movement through the system. In addition, because native plants are generally adapted to lower levels of available nutrients than non-native plant species, adding nutrients might give invasive plants a competitive edge.

It may be necessary to import organic matter in the form of compost depending on the organic matter content of material that is used to construct floodplain and terrace surfaces.

3.6 Monitoring and Adaptive Management

A restoration monitoring plan determines the effectiveness of restoration activities, supports recommendations for future restoration treatments, and determines whether the project has achieved project objectives and is trending towards the desired future condition. In addition, regular data collection related to monitoring can help identify maintenance needs.

To achieve project objectives over time, it will be necessary to observe how the restoration strategies and treatments applied on the ground influence ecological processes and habitat in the UBMC project area. For example, by observing and documenting stream channel morphology, floodplain development, natural vegetation recruitment, invasive species colonization and any shifts in plant species composition that reflect changes in hydrology and soil nutrient regimes, it will be possible to determine if each reach is progressing towards the desired future condition.

Monitoring is generally conducted in three phases: Baseline, Implementation and Effectiveness. Baseline monitoring documents the pre-restoration condition, and includes information in this report and in other reports completed to support remediation at the UBMC project area; implementation monitoring documents the restoration project as completed; and effectiveness monitoring addresses whether project objectives are being met. A comprehensive monitoring plan will be developed as part of later design phases. The monitoring plan will include decision-making criteria so the project can be modified if necessary using an adaptive management framework.

Section 4 Integration with Remedial Actions

4.1 Integration Schedule

The proposed schedule for remediation and restoration activities at the UBMC project area (as of September 2010) is shown in Table 1. The schedule is dependent on the successful siting of a repository in time for design and construction in 2011.

Beginning in 2012, assuming the repository can be prepared in 2011, material from the Mike Horse Dam and the impoundment will be removed and taken to the repository. The removal of the dam and impoundment, with the exception of the existing Beartrap Creek diversion, may take up to three construction seasons, depending on weather and hauling conditions. The Beartrap Creek (Reach 2) floodplain and channel will be constructed according to the final restoration plan for this reach. This construction will occur as soon after removal as possible. Once the new Reach 2 Beartrap Creek channel has been completed, water will be diverted into the channel and the diversion portion of the impoundment will be removed.

In subsequent years, working within an approximately 90 day construction season work window, projects will be constructed in the following order: Reach 1, Mike Horse Creek; Reach 3, Lower Beartrap Creek; Reach 4, Transition Reach; Reach 5, Upper Blackfoot River; and Reach 6, Lower Blackfoot River. Throughout the sequence, restoration work will be closely integrated with the remediation schedule.

Table 4-1. Proposed remediation and restoration schedule for the UBMC project area as of spring 2010. The schedule is organized into four quarters including spring, summer, fall and winter.

	2010				2011				2012				2013				2014 - 2016			
TASK	S	S	F	W	S	S	F	W	S	S	F	W	S	S	F	W	S	S	F	W
Access Road Construction to Water Treatment Plant																				
Repository Citing and Investigation																				
GW investigation and dewatering																				
Repository Construction																				
Road Construction to Dam																				

Table 4-1. Proposed remediation and restoration schedule for the UBMC project area as of spring 2010. The schedule is organized into four quarters including spring, summer, fall and winter.

	2010				2011				2012				2013				2014 - 2016			
TASK	S	S	F	W	S	S	F	W	S	S	F	W	S	S	F	W	S	S	F	W
Install Infrastructure																				
GW investigation and dewatering																				
Remove tailings from impoundment																				
Complete Tailings removal[1]																				
Restore Beartrap Creek																				
Remove tailings from Mike Horse and Beartrap Creek to Anaconda Creek																				
Restore Mike Horse and Beartrap creek to Anaconda																				
Remove tailings from Blackfoot River from Anaconda Creek to End																				
Restore Blackfoot River from Anaconda Creek downstream to end of project area																				

[1]The removal of tailings from the impoundment is scheduled to take one year (2012); however, factors outside of the State's control may affect the schedule, such as precipitation, snowpack, fire restrictions, and groundwater elevations.

4.2 Integration Issues

Several components of the project implementation schedule would need to be coordinated closely between remediation and restoration. These components include:

1. Road building and removal
    a. Ensure permanent crossings are fish passable and transport flows, sediment, and debris.
    b. Ensure temporary access roads are available for restoration prior to decommission.
    c. Ensure resident access is maintained.
    d. Minimize new road infrastructure and remove where possible.

2. Stream crossing engineering
    a. Ensure engineered stream crossings are consistent with the channel and floodplain morphology and provide fish passage.

3. Staging sites
    a. Determine if proposed locations may postpone or interfere with restoration.
    b. Determine if staging areas can be used by both remediation and restoration either concurrently or sequentially.

4. Temporary storage sites
    a. Restoration would need sites to stockpile materials, including soil and wood.

5. Consideration for use of native material for remediation.
    a. Is material available from the repository site?

Section 5 Next Steps

The following section describes an overview of the planned next steps for the UBMC restoration project. This chapter presents a summary of the general tasks scheduled for upcoming phases of this project including: 1) project management and planning 2) additional data needs to support restoration feasibility analysis, and 3) data needs to support preliminary design and final design phases. Additional next steps not described in this chapter, but likely to be included in future planning phases, include environmental compliance and construction implementation coordination between remedial and restoration actions.

5.1 Project Planning, Coordination and Outreach

Project tasks described in the following section will require project planning, coordination and outreach tasks to ensure the remediation actions support a desired restoration outcome, and to identify specific integration issues to ensure remediation and restoration can be done in an efficient and compatible manner. Examples of specific tasks include the following:

- Coordinate with federal, state and local agencies to identify and confirm environmental compliance approach, identify cooperating agencies, confirm timelines, and initiate appropriate permitting activities.
- Consultation with The Confederated Salish and Kootenai Tribes on cultural resources issues.
- Convene meetings with involved stakeholders, including federal, state, and local agencies, to discuss, identify, and prioritize immediate short-term remediation and restoration integration needs.
- Conduct ongoing community outreach to keep local communities and stakeholders apprised of project progress. For example, the U.S. Forest Service has an outreach and education team, The Montana Discovery Foundation, as well as a cooperative partnership with the Blackfoot Challenge Education Coordinator that can support community outreach efforts.
- Convene the interdisciplinary teams to initiate development of a project Adaptive Management and Monitoring program. This will include refining the project goals and objectives and developing a program that defines measurable objectives.
- If necessary, coordinate technical peer review(s) and value engineering review(s) of the preliminary and final design deliverables.

5.2 Additional Data Needs to Support Restoration Feasibility Analysis and Design

A significant level of investigation has been conducted to support remedial activities in the UBMC project area. In contrast, information used to support restoration planning is ongoing. To date, information used to develop this conceptual design included:

- Discussions with MT DEQ staff and contractors;

- Discussions with MFWP staff and other local community stakeholders;
- Consultation with U.S. Forest Service and U.S. Fish and Wildlife Service staff;
- Documents developed in support of remediation and tailings removal (Hydrometrics 2007; Stratus Consulting 2007; MT DEQ 2010); and
- Information collected on stream type, valley type, and vegetation communities during fall 2009.

Additional data and information will need to be collected, compiled and analyzed to support feasibility analysis and restoration alternatives development. These additional data needs include:

- High resolution topography (LiDAR) of projected post-remediation surfaces;
- Depth and extent of tailings in Reach 6;
- Streamflow and sediment data to develop bankfull discharge estimates and hydrographs for each reach identified in this plan;
- Identification of geomorphic reference reach analogs suitable for developing preliminary and final channel and floodplain design dimensions;
- Locations and size of potential borrow sites for floodplain fill (alluvium and general fill) and topsoil/growth media;
- Delineation of existing wetlands and aquatic resources in the project area;
- Growing season assessment and mapping of existing plant communities sufficient to develop detailed planting and seeding mixes;
- Sources of salvageable plant material. Distinguishing salvageable versus non-salvageable areas will help determine plant material and other related material quantities needed to implement revegetation components of the restoration plan;
- Assessment of existing wetlands and riparian areas within the project area for enhancement opportunities; and
- Identify sources for seed and willow cuttings collection in and near the project area.

5.3 Restoration Alternatives Analysis and Preliminary Design

This stage will include a comparative analysis of restoration alternatives, development of detailed design concepts to 60 percent completion, peer review, identification of real estate acquisition or lease and access needs, definition of project-specific environmental compliance requirements, cost estimate refinement, identification of funding sources, and development of materials necessary to support permitting. Restoration alternatives will be analyzed considering all appropriate factors, including the factors described in the Department of Interior natural resource damage regulations (43CFR Section 11.82(d)). To support preliminary design, feasibility analysis steps may include:

- Channel construction tie-in analysis;

- Infrastructure inventory and mitigation;
- Cost/benefit analysis of alternative treatment approaches;
- Constructability analysis (step-by-step construction steps and equipment/materials for each restoration treatment);
- Refine project hydrology and prepare flood frequency analysis;
- Preliminary channel and floodplain hydraulic modeling; and
- Refine channel dimensions using models and reference reach data.

The preliminary design phase will continue to evaluate project feasibility. A series of documents may be developed to address data gaps, reduce uncertainty, and summarize collected data and analysis efforts.

5.4 Final Design

The project final design will include producing the following components to a level of detail sufficient to support developing bid documents for construction.

- Channel and floodplain grading plan.
- Hydraulic and sediment transport modeling.
- Infrastructure mitigation.
- Revegetation plan.
- Wetland plans.
- Land acquisition and access plan, legal descriptions.
- Detailed treatment drawings.
- Construction specifications.
- Construction access, infrastructure plan, and clearwater diversions.
- Cost estimates.
- Materials quantities and specifications.

5.5 Summary

The Montana Department of Justice Natural Resource Damage Program and involved stakeholders commissioned this plan to develop an overall concept for restoring the ecological integrity of the UBMC project area. The plan identifies an overall vision that will set the stream and floodplain system on a trajectory of self sustaining ecological processes that support maintaining clean water and providing both high quality, complex aquatic and terrestrial habitat over the long-term. As summarized in the document, specific elements of the restoration vision include restoring stream channel and floodplain function, creating riparian conditions that exchange nutrients and other materials with the aquatic environment, and providing high quality habitat for westslope cutthroat trout and other aquatic and terrestrial organisms. Throughout the life of this project, continued coordination with stakeholders, including MT DEQ, USFS, and MFWP, will be critical to achieving restoration goals at the site. This document serves as a working document, and the first of several documents, that will culminate in a final restoration plan for the UBMC project area.

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