Final CFR Reach A, Phase 1 Geomorphology and Vegetation Monitoring Plan

Clark Fork Site

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CFR Reach A Phase 1

Final Geomorphology and Vegetation Monitoring Plan

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1. Introduction

This document describes a Monitoring Plan ("Plan") for evaluating the response of geomorphology and vegetation variables to remedial actions implemented within Reach A, Phase 1 of the Clark Fork Site. Though specific to CFR Reach A, Phase 1, this plan also presents the framework for adaptive management of remedial actions and restoration activities, to be reviewed and updated for each project, as these actions and activities are implemented over the next 10 to 12 years. The Plan sets an initial timeframe for monitoring for up to fifteen years post construction. At a minimum, areas of the Site should be monitored long enough to provide reasonable assurances that Performance Standards have been met. An overview of the design for CFR Reach A, Phase 1 can be found in the draft Phase 1 Preliminary Design (CDM et al., 2011).

The purpose of this Plan is to:

1) Establish and measure interim targets for monitoring vegetation and geomorphology. These adaptive measures will enable the Agencies to assess the effects and evaluate the progress of each particular remedial action and restoration activity towards the goal of attaining all Performance Standards on completion of all construction;

2) Document measures for monitoring remedial performance over time;

3) Describe the sampling and analysis plan for collecting data to evaluate each performance target; and

4) Establish the adaptive management process for periodic review and revision of the Monitoring Plan, interim measures and targets for performance of CFR Reach A, Phase 1, and actions implemented in future project phases based on the analysis of collected data.

This document is organized as follows:

- **Section 2** describes the background of the Clark Fork Site.
- **Section 3** describes the components of the monitoring program.
- **Section 4** describes the monitoring metrics and performance targets that will be used to evaluate effectiveness of project actions on vegetation and geomorphology variables.
- **Section 5** describes the Sampling and Analysis Plan.
- **Section 6** describes how monitoring data will be stored and analyzed.
- **Section 7** describes an adaptive management framework for making decisions using data collected as part of the monitoring program.
- **Appendix A** provides methods and protocols for geomorphology data collection.
- **Appendix B** provides methods and protocols for vegetation data collection.

- **Appendix C** compares vegetation Performance Standards in the Record of Decision (ROD) with performance target values in this Plan.

2. Background

Heavy metals originating from historic mining activities, milling and smelting processes associated with the Anaconda Company operations in Butte and Anaconda have accumulated on the Clark Fork River stream banks and floodplain over a period of at least 100 years. The primary sources of contamination are tailings and contaminated sediments mixed with soils in the stream banks and floodplains, which erode during high flow events and enter the river and other surface waters. In addition to erosion, heavy metals are leached from the contaminated sediments and tailings directly into the groundwater and eventually to surface water. These contaminant transport pathways result in impacts to terrestrial and aquatic life along the Clark Fork River as described in the Record of Decision (ROD) for the site (USEPA/MDEQ, 2004).

Remedial Action Objectives (RAOs) from the ROD are listed by category below.

For overbank tailings and impacted soils, the main RAOs are:

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

For groundwater, the main RAOs are:

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

For surface waters, the main RAOs are:

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

The Clark Fork Site is located within three counties, Deer Lodge, Powell, and Missoula Counties. The upstream boundary of the Site is located at the confluence of the old Silver Bow Creek channel with the reconstructed lower Mill-Willow bypass just downstream of the Warm Springs Ponds. The original channel of the river upstream of this point was obliterated when the Warm Springs Ponds were built. The downstream boundary is the maximum high pool reservoir level (elevation 3265.5, NAVD 88) of the former Milltown Reservoir (eliminated by the removal of the Milltown Dam), just east of Missoula, Montana. The remedial design covers the initial 1.6 river miles of Reach A between the junction with the original channel and the north boundary on land currently owned by the Atlantic Richfield Company. The parties anticipate that this parcel will be transferred to the State of Montana prior to implementation of the Work. This stream segment, which has been designated Phase 1 for Remedial Action purposes, is located within Reach A as shown on Figure 2-1 and Figure 2-2.

The Phase 1 area consists of the river and its floodplain. There is no development on the site and only one road traverses the area. The floodplain contains slickens (barren areas of tailings) and impacted soils which support plant growth to varying degrees. The vegetated areas consist of grasslands, shrub lands (including willows and water birch) and scattered small aspen. In 1990 the Governor's Demonstration Project implemented lime amendment and revegetation techniques in slickens in the Clark Fork River floodplain and reconstructed some eroding banks in the Phase 1 area (Schafer, 1991). The lime amended areas support grassland vegetation, and shrubs are beginning to establish in some of the lower elevation portions of these areas.

DEQ as lead agency will oversee, manage, coordinate, design, and implement the Remedial Action for the Clark Fork Site, in consultation with the Environmental Protection Agency (EPA) (and the National Park Service (NPS) for remedial activities on the Grant-Kohrs Ranch). DEQ will coordinate with the NRDP for the implementation and integration of Restoration components into the Work. DEQ will coordinate with NPS to implement the Federal Restoration Plan at the Grant-Kohrs Ranch. A primary function of consultation and coordination between the agencies is to understand and receive the information to be collected, understand how that information is to be analyzed, provide review and comment, and maximize the use of the resources available for and the environmental benefits to the Clark Fork Site in the successful and cost-effective completion of the Work.

This Plan addresses geomorphology and vegetation variables related to the planned actions. Water quality and biological variables are addressed in a separate monitoring plan (Atkins, 2010).

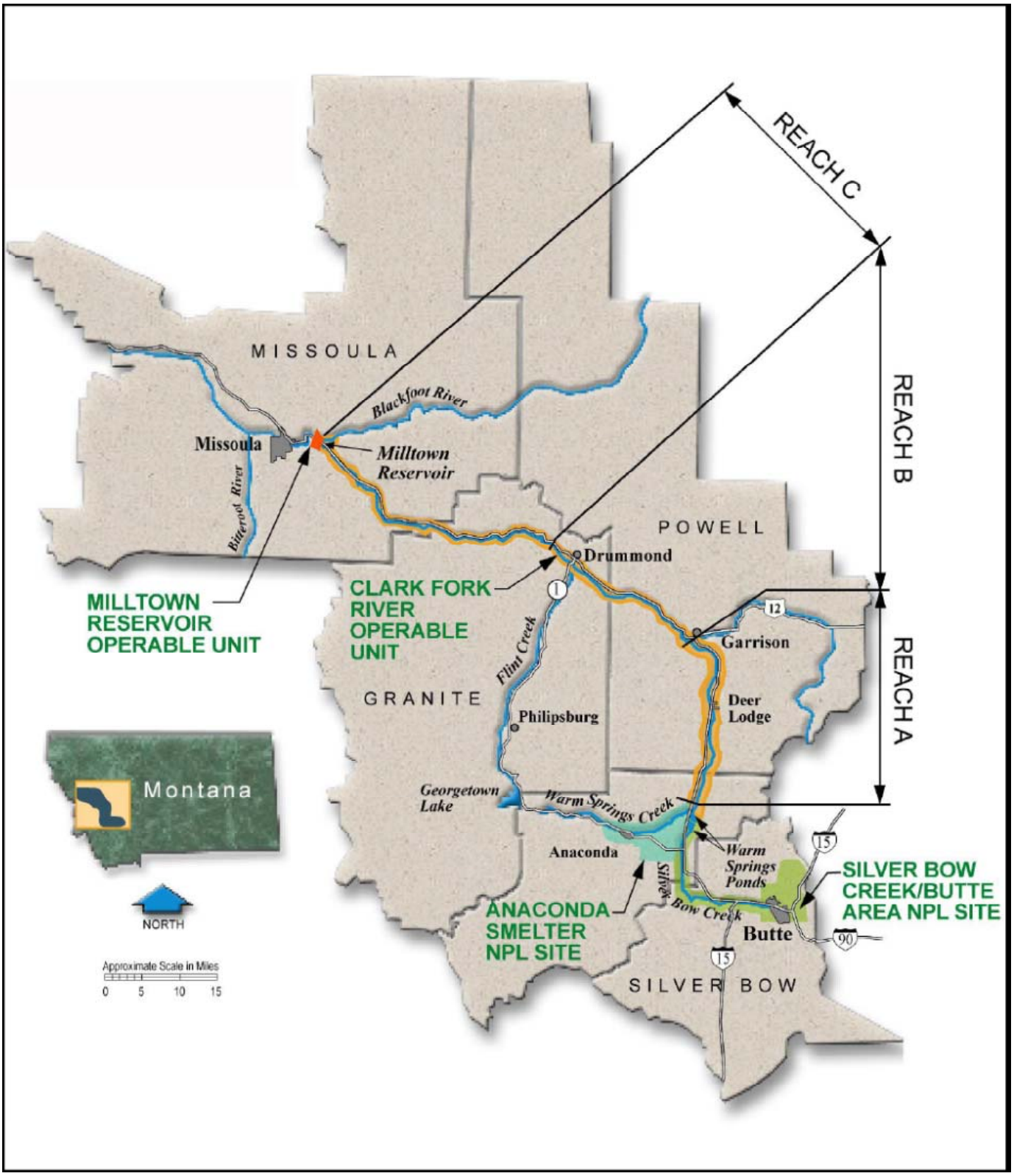

Figure 2-1. Overview of the Clark Fork River Site (USEPA 2009).

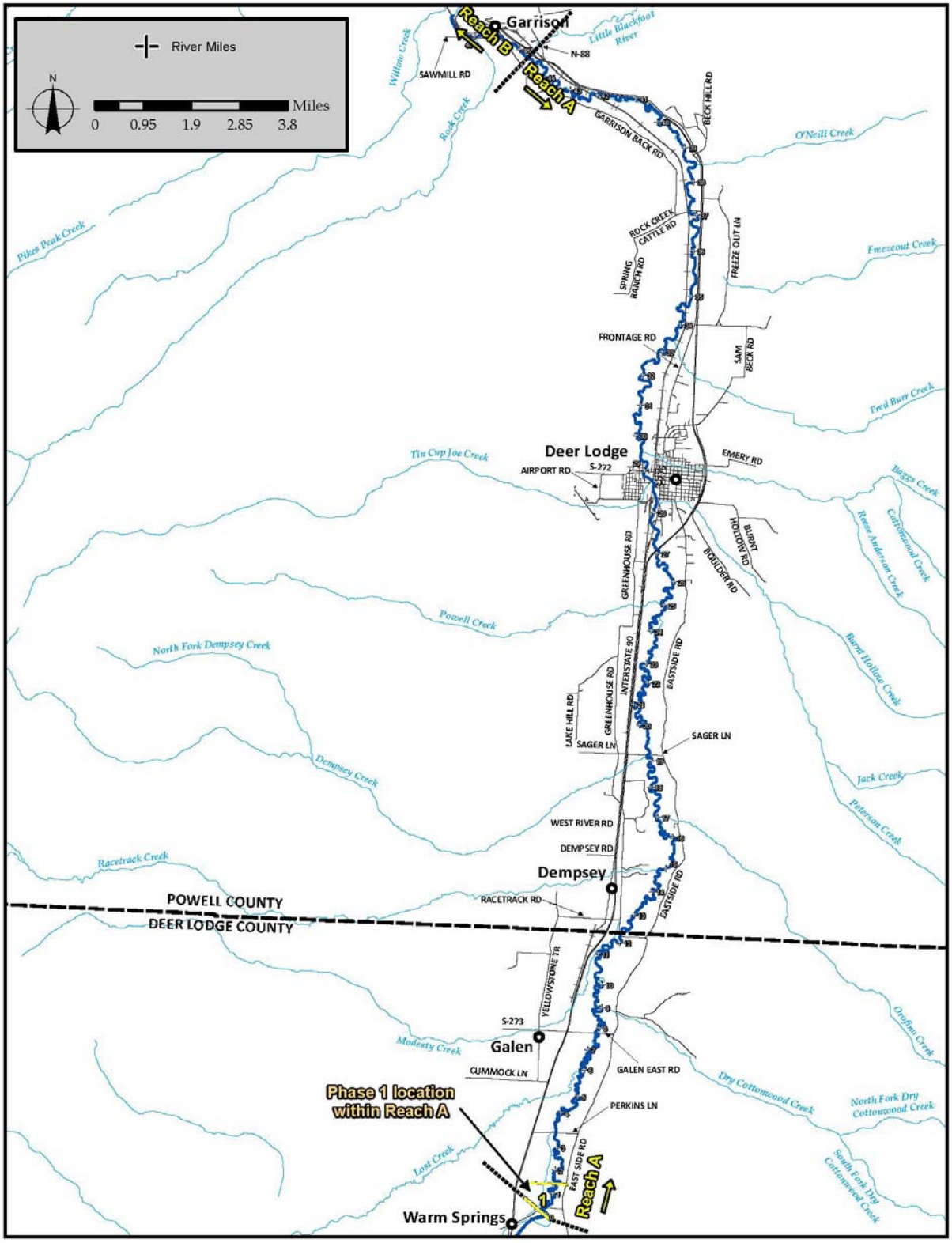

Figure 2-2. Location of Phase 1 within Reach A of the Clark Fork Site.

3. Monitoring Program Components

Three types of monitoring are necessary to establish an integrated monitoring program for the Clark Fork Site. These include: Baseline, Construction, and Effectiveness monitoring. ***Baseline monitoring*** documents the pre-remedy condition. ***Construction monitoring*** describes monitoring requirements during implementation of remedial actions and restoration activities with respect to the floodplain, channel, and revegetation. Construction monitoring with As-Built surveys also documents whether the project was constructed according to the design, and any departures from the design. ***Effectiveness monitoring*** addresses whether project objectives are being met, determines maintenance needs, and provides inputs into adaptive management decision pathways.

3.1 Baseline Monitoring

Baseline data were collected to support the design for CFR Reach A, Phase 1. These data will be used for a post-project comparison where appropriate. Baseline data includes data that were collected to support design and environmental compliance such as topographic surveys, channel cross-sections, wetland delineations and other data that measure morphological and vegetation attributes. In addition, as-built surveys completed as part of Construction Monitoring described below, provide a baseline for comparing morphological and vegetation changes as part of Effectiveness Monitoring.

Baseline data for CFR Reach A are described in other documents:

- Geomorphic, Hydrologic, and Hydraulic Investigation for Phase 1 Remedial Design/Remedial Action (CDM and AGI, 2010).
- State of Floodplain Vegetation within the meander belt of the Clark Fork of the Columbia River (Griffin and Smith, 2002).
- Reach A Vegetation Investigations (Geum, 2010).
- Draft Clark Fork River Operable Unit Milltown Reservoir/Clark Fork River Superfund Site Phase 1 Preliminary Design (CDM et al., 2011).
- Beck Ranch Cover Soil Borrow Investigation CFROU (PBS&J, 2008).
- Draft CFROU Weed Control Plan for the Clark Fork River Operable Unit (DEQ, 2008).
- CFROU Record of Decision (EPA, 2004).
- Analysis of Vegetation Controls on Bank Erosion Rates, Clark Fork of the Columbia River, Deer Lodge Valley, Montana (Griffin and Smith, 2001).

3.2 Construction Monitoring

Construction monitoring includes the monitoring activities during and immediately after project construction. Construction monitoring includes as-built surveys that will be conducted once phases of the project are completed and are ready for inspection. As-

built surveys will document post-construction conditions, and these data will be used as the baseline for Effectiveness Monitoring.

A detailed As-Built survey will be completed to document the completed actions for this Phase of the Project. In creating the As-Built survey, permanent monitoring stations will be established for the purpose of conducting effectiveness monitoring. Section 5 describes preliminary locations for geomorphology and vegetation monitoring within CFR Reach A, Phase 1. The exact location of permanent monitoring stations will be determined after As-Built surveys are completed.

3.3 Effectiveness Monitoring

Effectiveness monitoring is intended to evaluate progress toward achieving project goals and objectives. Effectiveness monitoring will focus on collecting data necessary to calculate the metrics to measure the performance of remedial actions and restoration activities for the project.

4. Monitoring Metrics and PerformanceTargets

4.1 Introduction

This section describes monitoring metrics and performance targets that will be used to evaluate effectiveness of remedial actions and restoration activities and guide long-term management of the project. The following definitions explain how various terms used throughout this section are related to one another:

> ***Goals*** are broad statements that reflect desired outcomes.
>
> ***Objectives*** are specific statements that re-state goals in ways that can be measured.
>
> ***Monitoring metrics*** are used to quantify the objectives. Performance targets are presented in terms of metrics. Monitoring metrics have target ranges or values that are intended to be used to evaluate effectiveness of the project. Metrics help determine whether the project is trending towards or away from project objectives and provide a way to evaluate maintenance needs.
>
> ***Performance targets*** are target values of metrics that indicate the project is accomplishing desired outcomes.

Table 4-1 describes the goals and objectives for the CFR Reach A Phase I project based on the design. See draft Phase 1 Preliminary Design (CDM et al., 2011). Table 4-1 relates the project goals and objectives to project actions, ecosystem function or process related to the project action, performance targets developed to evaluate project goals and objectives and the metrics that will be used to measure performance. Section 4.2 describes the development of the performance measures and targets.

Table 4-1. CFR Reach A, Phase 1 goals and objectives, project actions aimed at achieving goals and objectives, ecosystem function related to project actions, performance targets developed to evaluate project goals and objectives, and monitoring metrics that will be used to measure performance.

Goal	Objectives	Project Actions to Achieve Goals	Ecosystem Function or Process Related to Project Action	Performance Targets to Evaluate Project Goals and Objectives	Monitoring Metrics to Evaluate Performance Targets
GEOMORPHOLOGY					
1) Minimize geomorphic adjustment during period of vegetation re-establishment (15 years) and allow for long-term dynamic equilibrium.	1-1) Cross section adjustments to lowered floodplain condition provide for long-term channel stability and sediment transport equilibrium.	• Tailings removal • Streambank Bioengineering • Floodplain roughness: microtopograhy • Floodplain roughness: woody debris • Secondary channel elevations	• Aquatic habitat diversity • Maintain biodiversity • Floodplain connectivity • Secondary channel access • Support primary productivity	Short-term (0-10 years): Change in average channel cross section area will not exceed 20% of design dimensions. • Cross section area 119ft^2 –179ft^2 • Bankfull width: 44ft – 66ft • Bankfull depth: 2.2ft – 3.2ft • Width/depth ratio: 18-27 Long-term (15+ years): Change in average channel cross section area will not exceed 25% of design conditions. • Cross section area 112ft^2 –186ft^2 • Bankfull width: 41ft – 69ft • Bankfull depth: 2.0ft – 3.4ft • Width/depth ratio: 17-28	Channel dimensions • Cross section area • Bankfull width • Bankfull depth • Width/depth ratio
	1-2) Channel planform and slope adjustments maintain floodplain connectivity at the 2-year flow and support long-term sediment transport equilibrium.	• Tailings removal • Streambank bioengineering • Floodplain roughness	• Aquatic habitat diversity • Maintain biodiversity • Recharge aquifers • Floodplain connectivity • Secondary channel access • Support primary productivity	Short-term (0-15 years): Changes in sinuosity and slope will not exceed 5% of pre-project condition as channel course and profile is maintained and vegetation is established. • Slope: 0.0017– 0.0019 • Sinuosity; 2.20 – 2.44 Long-term (15+ years): Changes in sinuosity and slope may reach 20% as bendway cutoffs or avulsions occur. • Slope: 0.0014 – 0.0022 • Sinuosity: 1.86 – 2.78	Channel planform • Sinuosity • Slope
	1-3) Pool depths and densities are similar to downstream unentrenched channel segments.	• Tailings removal • Floodplain grading (lowering to approximate 2-year flow elevation) • Streambank bioengineering	• Aquatic habitat diversity • Reduce and dissipate energy • Sediment sorting • Recharge aquifers • Maintain biodiversity	Short-term and long-term (0-15+ years): Bedform complexity as measured by pool density and residual pool depth meet or exceed conditions of the downstream unentrenched channel segment. Current unentrenched conditions are 14.3 pools per mile and a 2.4 foot average residual pool depth.	Bedform complexity • Pool density • Residual pool depth
	1-4) Bendway migration rates increase from stabilized condition during vegetative recovery to natural condition for long-term function.	• Tailings removal • Floodplain grading (lower to approximate 2-year flow elevation) • Streambank bioengineering	• Maintain water quality • Aquatic habitat diversity • Floodplain and channel stability	Short-term (0-15 years): Bank erosion will only occur at areas of no streambank treatment. Average rates of movement on untreated banks will reflect typical rates of movement in Reach A which range from 0 to	Bank erosion rate Channel migration rate

				0.8 ft/year. If flows greater than the 10 year recurrence interval occur, average bendway migration rates will not exceed 1.3 ft/yr. Long-term (15+ years): Channel migration rates will reflect typical rates of movement of moderately vegetated banklines (Griffin and Smith 2001). Average bendway migration rates will not exceed 0.6 ft/yr.	
	1-5) The floodplain shall be active at flows greater than the design elevation (2-year flow).	• Tailings removal • Floodplain grading and bank heights at 2-year flow elevation	• Aquatic habitat diversity • Reduce and dissipate energy • Recharge aquifers • Maintain biodiversity • Create primary productivity • Store water and energy • Trap and store sediments	Short-term (0-15 years): Area of inundated floodplain exceeds design criteria or is within 10% of design criteria (28% of inset floodplain area is inundated at the 2-year flow). Long-term (15+ years): None	Primary channel conveyance • Bankfull discharge • Bankfull / bank height ratio • Floodplain inundation extent
	1-6) The floodplain will convey flows without destabilizing or capturing the main channel.	• Tailings removal • Floodplain grading and bank heights at 2-year flow elevation	• Reduce and dissipate energy • Recharge aquifers • Maintain biodiversity • Create primary productivity • Store water and energy • Trap and store sediment	Short-term (0-15 years): Floodplain erosion does not create new continuous channel segments that develop connectivity with main channel at the 2-year flow. Long-term (15+ years): Erosion of floodplain channels is variable and may create continuous threads that are active at all flows.	Floodplain stability • Floodplain channel morphology (cross section area, width depth, slope, continuity)
	1-7) Secondary channels will convey flows without destabilizing or capturing the main channel.	• Tailings removal • Floodplain grading and bank heights at 2-year flow elevation • Secondary channel construction	• Aquatic habitat diversity • Reduce and dissipate energy • Maintain biodiversity • Floodplain connectivity • Support primary productivity	Short-term (0-15 years): At the 2-year flow, secondary channels will convey +/- 20% of design discharge (32-48 cfs upstream of Warm Springs Creek and 47-57 cfs downstream of Warm Springs Creek). Long-term (15+ years): Secondary channel activation flow is variable. Secondary channel morphology adjusts accordingly.	Secondary channel stability • Secondary channel conveyance at 2-year flow
VEGETATION					
2) Provide functional floodplain, Streambank and wetland plant communities.	2-1) Streambank cover is within natural ranges and providing short and long-term channel stability and providing aquatic and terrestrial habitat and food web support.	• Streambank bioengineering • Floodplain grading and bank heights at 2-year flow elevation	• Trap and store sediments • Build and maintain streambanks • Aquatic habitat diversity • Reduce and dissipate energy • Maintain biodiversity • Floodplain connectivity • Filter and buffer water • Create primary productivity	Short-term (0-5 years): 40% canopy cover on treated streambanks by year 5. Mid-term (5-15 years): 60% or greater canopy cover on treated streambanks by year 10. Long-term (15+ years): Canopy cover varies with natural channel migration rates but is greater than 80%.	Canopy cover native woody vegetation on treated streambanks

	2-2) Native floodplain plant communities are distributed according to design cover types and support a wide range of floodplain functions.	• Tailings removal • Floodplain grading to approximate 2-year flow elevation • Floodplain roughness: microtopography and woody debris • Floodplain microsites: swales • Wetlands • Soil depth and texture • Planting: trees and shrubs • Planting: herbaceous • Seeding • Browse protection • Weed control	• Terrestrial and aquatic habitat diversity • Trap and store sediments • Build and maintain streambanks • Store water and energy • Recharge aquifers • Filter and buffer water • Reduce and dissipate energy • Maintain biodiversity • Create primary productivity • Maintain water quality	Short-term (0-5 years): Native species are present in greater than 80% of the project area and greater than 20% total cover by Year 1, 50% by Year 3 and 80% by Year 5. Average canopy cover of woody vegetation in the floodplain is 30% by Year 5. Planted woody species have 80% or greater survival after the first growing season and woody plant density is not decreasing in subsequent years. Mid-term (5-15 years): Native species are present in greater than 80% of the project area and there is greater than 80% total canopy cover of native plant species, allowing for some bare patches of non-contaminated substrate deposition, and open water. Canopy cover of woody vegetation in the floodplain is 50% by Year 10. Long-term (15+ years): The floodplain is composed of a mosaic of native riparian and wetland ecological types, non-contaminated depositional features and open water that provide all of the listed ecological functions and processes.	Canopy cover of herbaceous vegetation Canopy cover of woody vegetation Visual observations of natural recruitment in select design cover types. Proportional abundance of floodplain cover types Survival of planted species Density Browse level
	2-3) Noxious weeds are not compromising designed floodplain function or decreasing species diversity.	• Tailings removal • Floodplain grading to approximate 2-year flow elevation • Floodplain roughness: microtopography and woody debris • Floodplain microsites: swales • Wetlands • Soil depth and texture • Planting: trees and shrubs • Planting: herbaceous • Seeding • Browse protection • Weed control	• Terrestrial and aquatic habitat diversity • Maintain biodiversity	Short, mid and long-term: Less than 5% canopy cover of noxious weeds is present.	Canopy cover noxious weeds Noxious weed distribution
	2-4) Wetlands are present where designed and in other areas where hydrology is appropriate to support wetland development and there is no net loss of wetlands based on EPA wetlands layer.	• Tailings removal • Floodplain grading to approximate 2-year flow elevation • Wetland construction • Soil depth and texture • Planting: trees and shrubs • Planting: herbaceous • Seeding • Browse protection • Weed control	• Terrestrial and aquatic habitat diversity • Maintain biodiversity • Create primary productivity • Reduce and dissipate energy • Trap and store sediments • Maintain water quality • Recharge aquifers • Filter and buffer energy	Short, mid and long-term: There is no net loss of wetlands meeting Army Corps of Engineers criteria from pre-project conditions (0.47 acres in Phase 1). After 5 years, the site meets the reference wetland FEWA score of 2.3 developed for the Clark Fork Site.	Wetland delineation using 1987 COE Manual and Regional Supplements Function Effective Wetland Area (FEWA)

4.2 Development of Performance Targets

Certain monitoring metrics were chosen for their ability to measure whether desired ecological processes and functions are being achieved by proposed actions. In addition, performance targets were selected because they are derived from metrics that can be evaluated consistently and repeatably using a reasonable level of effort as part of an effectiveness monitoring program.

Section 7 describes how monitoring data will be used to evaluate progress towards meeting performance targets and a framework for making decisions related to project actions; project maintenance; and adapting project goals, objectives, monitoring metrics or performance target values.

4.2.2 Geomorphology Monitoring Metrics and Performance Targets

This section includes a discussion about how performance targets were determined for geomorphology for the CFR Reach A, Phase 1 project. Additional supporting information on geomorphology monitoring metrics and performance target development is provided in Appendix A.

The two timeframes used for geomorphology-related performance targets are:

1. Short-term (0-15 years): The short-term time frame for channel and floodplain adjustments during the period of vegetation establishment. The objectives for this timeframe focus on overall channel and floodplain stability.

2. Long-term (>15 years): The long-term time frame reflects natural channel process within a revegetated, lowered floodplain condition that may include a higher level of dynamism typical of unentrenched, unarmored river systems.

Datasets utilized in the development of these performance targets are derived from field measurements of existing conditions within CFR Reach A, Phase 1 and downstream (CDM and AGI, 2010), published data for the area (Griffin and Smith, 2001), and cross sections extracted from a hydraulic model developed for project design.

Channel Dimensions

In Phase 1, the primary modification to channel cross section will be the lowering of banks to the 2-year flow elevation (design bankfull elevation). The only direct modification within the bankfull channel cross section will be on passive margins where the bank will be sloped to reduce entrenchment and to create a low sloping surface that can support riparian vegetation. The channel dimension performance target values reflect anticipated short- and long-term channel response to passive margin sloping and a lowered floodplain condition.

The data used to develop cross section performance targets include fall 2009 survey data (CDM and AGI, 2010). With respect to channel cross section metrics such as mean bankfull depth, it is important to consider whether any flows over the design

bankfull flow may have impacted the entrenched channel prior to or since that survey. In 2009, the maximum instantaneous peak flow measured at the Clark Fork River at Galen gage (USGS 12323800) was 955 cubic feet per second (cfs) on June 1, which is 94 cfs over a 5-year flood event flow (CDM et al., 2011). Thus the survey data were collected shortly after Reach A had experienced flows in excess of the 2-year flow (design bankfull). As channel capacity in subreaches 1 and 2 is relatively high due to entrenchment, the channel may have scoured more deeply during the >5-year flood event flow than it would have in an unentrenched project condition. Furthermore, in 2011 the maximum mean daily flow measured at Galen was 1,390 cfs on June 13. This is almost a 50-year flood event flow (50-year instantaneous peak is 1,415 cfs). The 10-year flood event flow of 1,090 cfs was exceeded for 21 days (mean daily flow) between June 8 and July 2, and the 25-year flood event flow of 1,286 cfs was exceeded 6 days. These high flows may have substantially altered the entrenched channel cross section since the field survey was completed. All of these factors suggest that significant allowance for cross section adjustment should be provided in CFR Reach A, Phase 1 relative to the 2009 survey, which has been used to develop primary performance target values.

Performance target values were developed from a series of 12 cross sections that were selected from the hydraulic model to quantify cross section dimensions under project conditions (Appendix A). These cross sections consist of the 2009 channel that has been modified by lowering banks to the modeled water surface elevation for a 50% exceedance probability event (Q2 or 2-year flow), and by sloping passive margins (inside bends). Based on these data, performance targets were developed with a +/- 20% short-term adjustment allowance from the project condition (Table 4-2). In the longer term, a +/- 25% change is provided to allow for longer term adjustments in channel form due to reduced entrenchment, channel migration, bendway cutoff, or response to altered sediment or hydrologic inputs.

Under existing conditions, CFR Reach A, Phase 1 has relatively high average depths and low width to depth ratios. These depths may be in part due to increased scour at flows greater than 2-year flows in the entrenched channel. Additionally, the relatively high mean channel depths in part reflect the channel entrenchment due to a general lack of bankfull indicators in the survey data.

The design dimensions shown in Table 4-2 reflect conditions extracted from the hydraulic model used for floodplain design. In the event that as-built conditions vary from those dimensions, the performance targets should be modified to reflect those post-implementation channel cross section dimensions.

Table 4-2. CFR Reach A, Phase 1 performance target values for cross section dimensions.

Cross Section Dimensions	Width (feet)	Mean Depth (feet)	Width/Depth Ratio	Area (square feet)
Existing	52.0	3.9	14.3	203
Design	55.2	2.7	22.4	149
Design +20%	66.2	3.2	27	179
Design -20%	44.2	2.2	18	119
Short -term Performance Target	**44-66**	**2.2-3.2**	**18-27**	**119-179**
Design +25%	69.0	3.4	28.0	186
Design -25%	41.4	2.0	16.8	112
Long-term Performance Target	**41-69**	**2.0-3.4**	**17-28**	**112-186**

Slope and Sinuosity

The existing channel planform will not be altered in CFR Reach A, Phase 1 by remedial action and restoration activities. As such, the best data source for slope and sinuosity performance target values is the existing channel. Performance target values for slope include a short-term allowance of +/- 5% and a long-term allowance of +/- 20% relative to the existing condition (Table 4-3). In the short-term, the tolerance for changes in sinuosity and slope will be low as channel course and profile is maintained and vegetation is established. As the Reach A, Phase 1 project is 8,560 feet long, a 5% change in channel slope allows for a change in channel length of approximately 427 feet over the first 15 years after project actions are implemented. In the longer term time frame, reach-scale changes in sinuosity and slope may exceed 20% as planform adjustments (cutoffs) or avulsions occur. If a cutoff were to occur at either station 60+00 or 102+00 (Figure 4-1), the channel would shorten by up to 1,500 feet. A 25% change in slope allows for a change in channel length of 1,730 feet, which would allow one major cutoff in the reach.

Table 4-3. CFR Reach A, Phase 1 performance target values for slope and sinuosity.

Slope and Sinuosity	Bed Slope	Sinuosity
Existing	0.0018	2.32
Existing-5%	0.0017	2.20
Existing +5%	0.0019	2.44
Short-Term Performance Target	**0.0017-0.0019**	**2.20-2.44**
Existing	0.0018	2.32
Existing -20%	0.0014	1.86
Existing+20%	0.0022	2.78
Long-term Performance Target	**0.0014-0.0022**	**1.86-2.78**

Bedform Complexity

Bedform complexity for CFR Reach A, Phase 1 will be measured by pool density and residual pool depth. Because the channel in CFR Reach A, Phase 1 is entrenched, it has a different hydraulic configuration than it will under post-project conditions. The survey data reflect pool conditions several months after a >5-year flood event flow, so scour depths during that event may exceed sustainable pool depths under project conditions, where flows >2-year flow will begin to access the floodplain. To develop more appropriate performance target values for project conditions, pool densities and depths have been derived from a downstream reach were entrenchment is lower, and pool depths are shallower (CDM and AGI, 2010). This reach, which is subreach 4 of Reach A, extends from Station 163+00 to Perkins Lane Bridge (Appendix A). These values have been compared to calculated pool densities as 6 times the performance target for channel width (Thorne, 1997). The measured pool frequency in subreach 4 is within 10% of the calculated frequency based on the maximum channel width performance target value. The adopted pool density performance target for both short-term and long-term is the current condition measured in subreach 4 (Table 4-4). The adopted residual pool depth performance target for both short-term and long-term is the current condition in subreach 4 (Table 4-4).

Table 4-4. CFR Reach A, Phase 1 performance target values for pool frequency and depth.

Bedform Complexity	Pool Frequency (pools/mile)	Mean Residual Pool Depth (feet)
Existing Phase 1	15.7	2.5
Subreach 4 (existing)	14.3	2.4
Calculated value (6 times short-term performance target value for max width)	13.3	N/A
Short-term Performance Target	**>14.3**	**>2.4**
Calculated value (6 times long-term performance target value for max width)	12.8	N/A
Long-term Performance Target	**>14.3**	**>2.4**

Bank Erosion and Channel Migration

The CFR Reach A, Phase 1 actions will include local bank reconstruction. The intent of the bank work is to provide near-term stability while bank and floodplain vegetation establish, but to provide for long-term deformability. The performance target values have been established to maintain a stable bank at flows less than the 10-year flood event flow, consistent with the design criteria for bank toe construction (CDM et al., 2011).

As part of the existing conditions assessment (CDM and AGI, 2010), 1950-2006 migration rates were determined in CFR Reach A, Phase 1 using aerial photography. The results show that migration rates from the Warm Springs Pond outlet to the bottom

of CFR Reach A, Phase 1 range from 0 feet per year (ft/yr) to 0.8 ft/yr. Griffin and Smith (2001) evaluated centerline migration rates for 276 bendways on the Clark Fork River through the Deer Lodge Valley. They measured mean migration rates of 1.3 ft/yr in slickens and 0.3 ft/yr on densely vegetated banks. Their measurements cover the time period of 1989-1997, during which the 10-year flood event flow was exceeded two times (1995 and 1997).

In CFR Reach A, Phase 1, where the bank toe is reconstructed, it will consist of a rock gradation that is sized to be stable up to a 10-year flood event flow to provide short-term stability but allow for longer term deformability. Because of this criterion, performance target values are hydrology dependent (Table 4-5). In the event that no flows in excess of a 10-year flood event flow are experienced for the first 15 years, the performance target value for average bendway migration rate is for no movement (0 ft/yr) on reconstructed banks, and current conditions movement (<0.8 ft/yr) on untreated banks. If a 10-year flood event occurs in the first 15 years of the project, the performance target value is 1.3 ft/year for all banks, which is the migration rate measured by Griffin and Smith (2001) on unvegetated banks. The long-term average migration rate performance target value is 0.6 ft/year, which is the average rate measured by Griffin and Smith (2001) on banks with moderately spaced shrubs.

Table 4-5. CFR Reach A, Phase 1 performance target values for channel migration.

Channel Migration	Average Bendway Migration Rate (feet per year)
Current	0-0.8
Short-term reconstructed bank performance target if no flows exceed 10-year event	0
Short-term untreated bank performance target if no flows exceed 10-year flood	0.8
Short-term performance target for all banks where a 10-year flood discharge is exceeded	1.3
Long-term bank migration performance target for all banks	0.6

Floodplain Connectivity

The extent of floodplain connectivity for CFR Reach A, Phase 1 after remedial action and restoration activities are implemented was derived in the hydraulic model for a range of flow conditions. One threshold for floodplain connectivity is the 2-year flood event flow, which is the point at which flows will begin to access the floodplain after implementation of project actions. Based on hydraulic modeling of the proposed floodplain design, approximately 28% of the inset floodplain is expected to be inundated at a 2-year flow (Figure 4-1). The short-term performance target for floodplain connectivity is for the area inundated at the 2-year flow to be within 10% of that design criteria.

In the long-term, inundated area will equilibrate to endogenic and exogenic influences of system hydrology, sediment inputs, channel complexity, and floodplain roughness. No performance targets have been developed for long-term inundated area at the 2-year flow.

Floodplain Stability

Increasing floodplain access through CFR Reach A, Phase 1 will result in an increased avulsion hazard relative to pre-project conditions. The short-term performance target regarding floodplain stability is that the floodplain remains free of any new channels that develop connectivity with the main channel on both the upstream and downstream ends at the 2-year flow. For the long-term, floodplain channels will be expected to form, as the channel planform adjusts to the lowered floodplain condition. These adjustments may include cutoffs across single bendway cores and perhaps avulsions over longer channel segments.

Secondary Channel Stability

Secondary channels are included in the floodplain design to enhance floodplain function and habitat complexity CFR Reach A, Phase 1. These channels are designed to convey no more than 10% of the flow at a 2-year flow. The performance target for secondary channels in the short-term is to convey +/-20% of the total discharge at the 2-year flow (Table 4-6). No long-term performance target value is included for secondary channels. In the long-term it is desired for secondary channel activation flows to become varied and channels to adjust accordingly.

Table 4-6. CFR Reach A, Phase 1 performance target values for secondary channel conveyance.

Location	Subreach 1: Upstream of Warm Springs Creek	Subreach 2: Downstream Warm Springs Creek
Design Bankfull (2-year flow) (cfs)	396	522
Design secondary channel conveyance at 2-year flow (cfs)	40	52
Short-term performance target at 2-year flow (cfs)	**32-48**	**47-57**

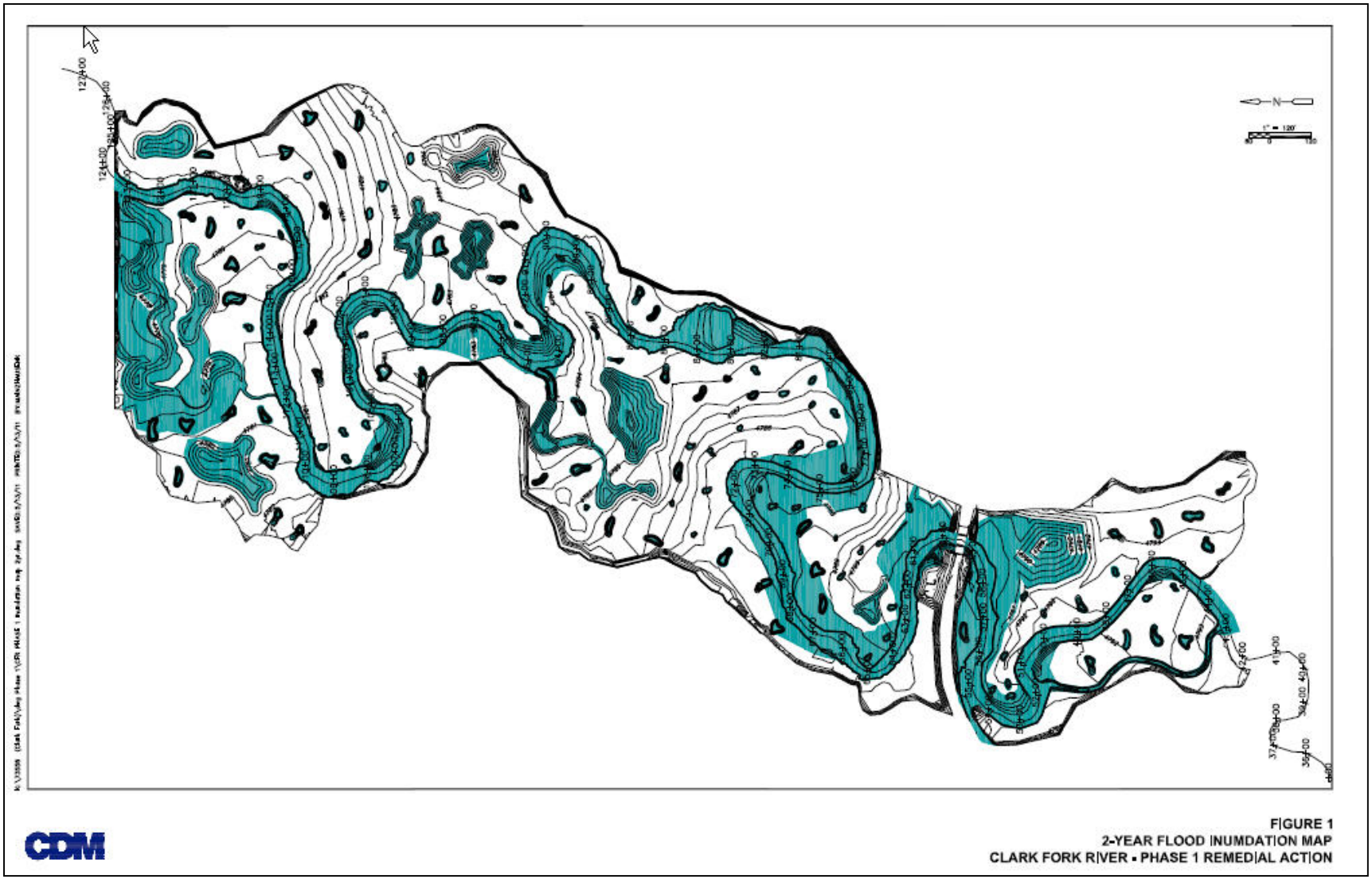

Figure 4-1. Modeled 2-year flow inundation map for CFR Reach A, Phase 1 based on the preliminary design.

Table 4-7 provides a summary of CFR Reach A, Phase 1 geomorphology performance targets.

Table 4-7. Summary of CFR Reach A, Phase 1 geomorphology performance target values.

Metric	Short-term (0-15 years)	Long-term (+15 years)
Channel dimensions	As-built condition +/-20%	As-built condition +/-25%
Slope and sinuosity	Existing condition +/- 5%	Existing condition +/-20%
Bedform complexity	Current condition of subreach 4	Current condition of subreach 4
Bank erosion and channel migration	Treated banks: 0 feet per year Unmodified banks: 0.8 feet per year All banks if 10-year discharge is exceeded: 1.3 feet per year	0.6 feet/year
Floodplain connectivity	10% of design criteria for inundation extent at 2-year flow	N/A
Floodplain stability	No new channels form in the floodplain that have connectivity at upstream and downstream ends at the 2-year flow	N/A
Secondary channel stability	Convey +/-20% of two-year flow (design activation discharge)	N/A

4.2.3 Vegetation Monitoring Metrics and Performance Targets

This section includes a discussion about how vegetation performance targets were determined for CFR Reach A, Phase 1. The discussion is organized by the four vegetation-related objectives: streambank vegetation; floodplain vegetation; noxious weeds; and wetlands (Table 4-1). Additional supporting information on vegetation performance target development is provided in Appendix B.

The timeframes used to evaluate vegetation performance targets are:

1) Short-term (0 to 5 years) is the post-construction period when floodplain vegetation is immature and the site is being colonized by pioneer species.
2) Mid-term (5-15 years) is the period of time when vegetation installed during project implementation has developed functioning root systems such that maintenance irrigation is no longer required. In addition, the site is beginning to be colonized by plants originating from seed or other propagules coming from established plants, either on or off site. Mature vegetation is present but sparsely distributed throughout the site. Vegetation is becoming a primary factor in floodplain stability during this timeframe.
3) Long-term (after 15 years) is the period when areas of mature vegetation are well distributed and self-sustaining on the floodplain and the channel can migrate and change at natural rates without compromising project objectives.

Figure 4-2 illustrates vegetation development in terms of these timeframes for CFR Reach A, Phase 1 based on the draft Phase 1 Preliminary Design.

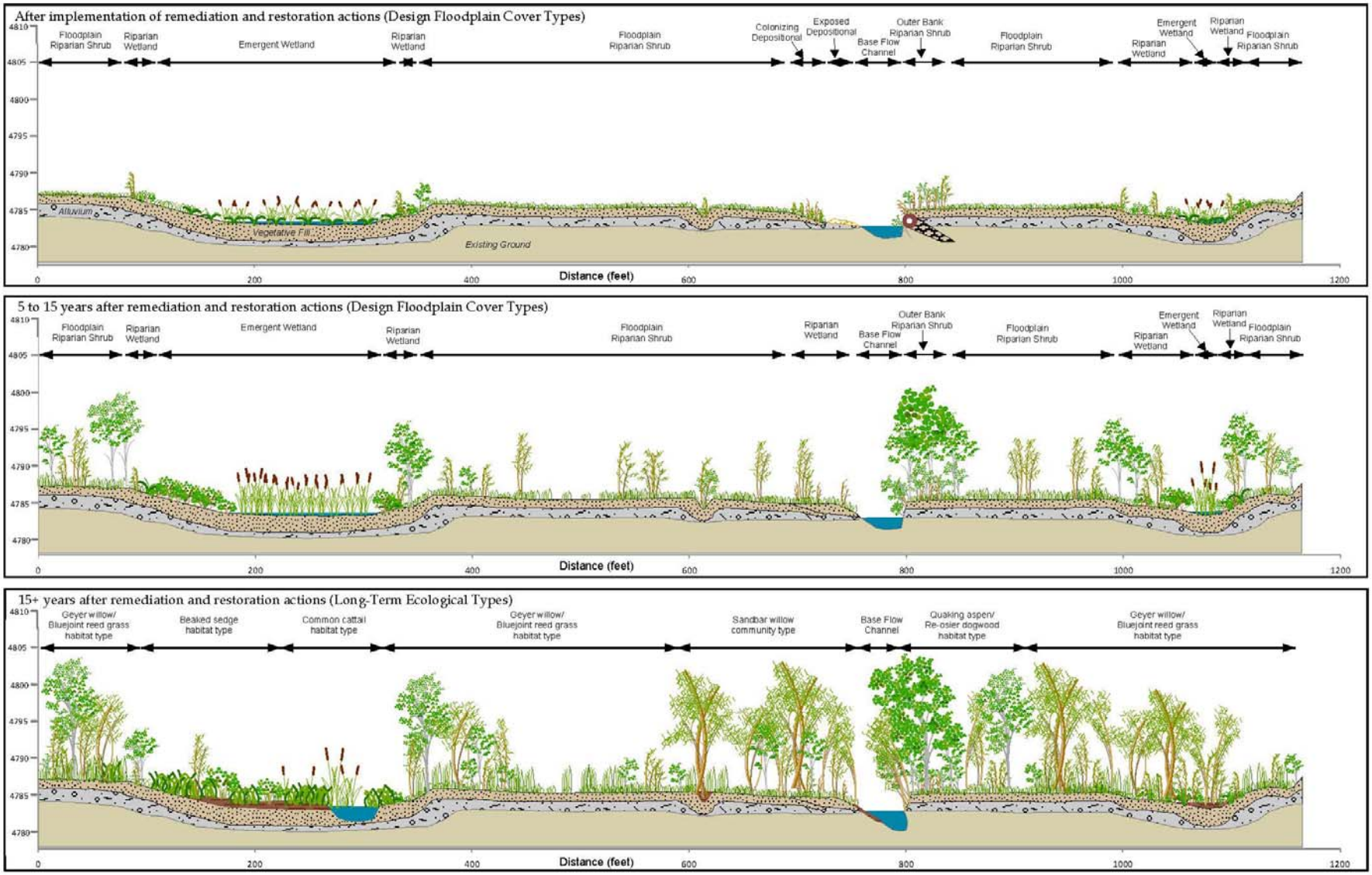

Figure 4-2. Illustration of potential vegetation conditions in the CFR Phase 1, Reach A project area by performance target timeframes of short-term (0-5 years), mid-term (5-15 years) and long-term (15+ years).

Streambank Vegetation

Performance target values for woody vegetation on treated streambanks were developed using canopy cover data collected from several locations, including CFR Reach A, Grave Creek, Jocko River, Mission Creek, Therriault Creek, and the Clark Fork River near Milltown Dam; all of these locations are in western Montana. A total of 169 data points were grouped by age class of streambank vegetation; 0-5 years, 5-15 years and older than 15 years. In some cases, age of vegetation was known because the banks were constructed and revegetated as part of restoration projects. In other cases, particularly for the 5-15 and 15 year plus age classes, the age was estimated based on stem diameter and presence or absence of decadent or dead stems. Figure 4-3 shows an example of each of these age classes.

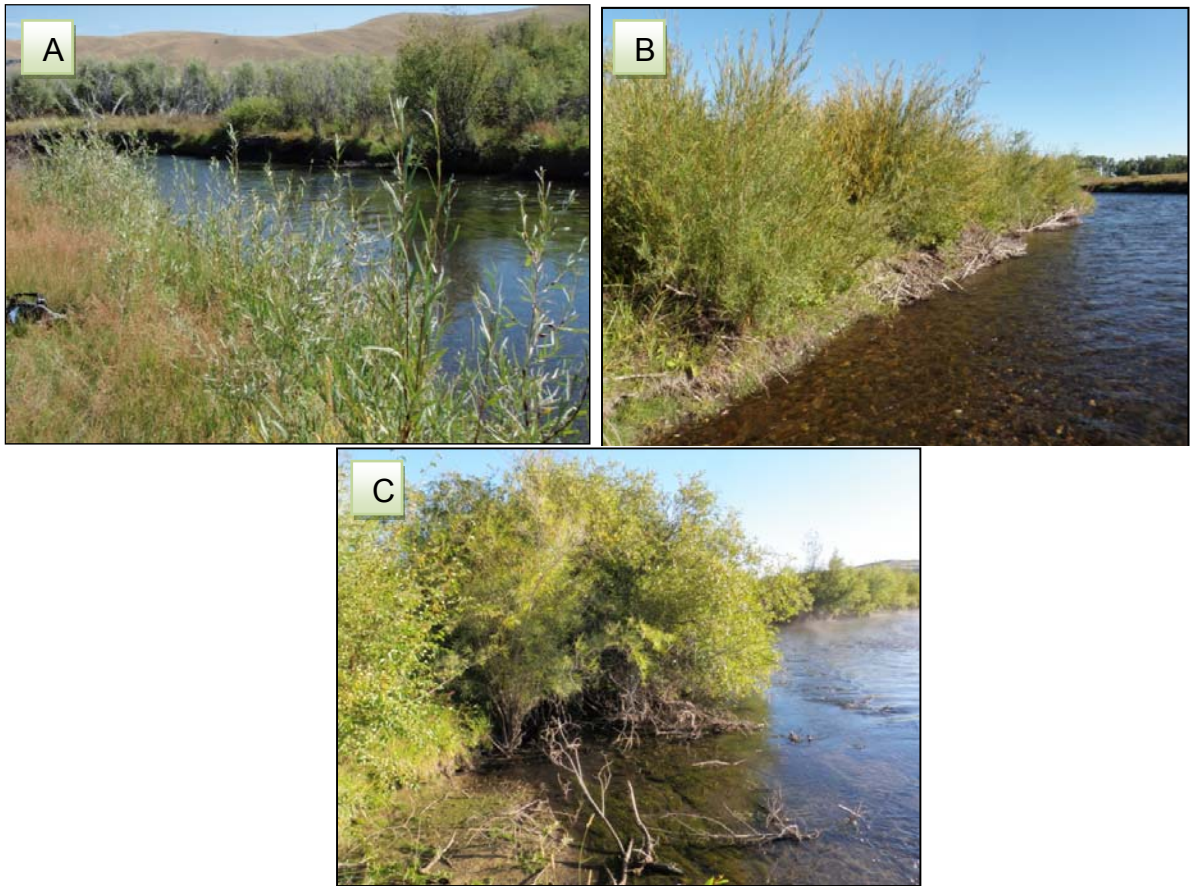

Figure 4-3. Examples of streambanks representing the three age classes used to stratify monitoring data: A) 0-5 year age class where canopy cover = 28.5%; B) 5-15 year age class where canopy cover = 56.3%; and C) 15+ year age class where canopy cover= 87%.

Table 4-8 shows the number of samples, average cover, minimum and maximum values, and other summary statistics for each age class that was evaluated as part of this analysis. These results were evaluated and compared to our knowledge of the sites, and performance targets were developed as follows. Many plots from the 1 to 5 year age class represent the lower age range of that category, and these data also

represent a range of bank construction techniques on different rivers that have been installed in the last eight years. Even though the mean canopy cover for the 1 to 5 year age class is approximately 25 percent, because Phase 1 design incorporates lessons learned from many of the projects used in this analysis, 40 percent cover on constructed streambanks by year 5 is a reasonable target. Similarly, for the 5 to 15 year age class, several of these data points represent banks that are known to be six years old on the Jocko River. Due to those data, and the wider confidence interval for the 5 to 15 age class, a 60% canopy cover target is reasonable for the 5 to 15 year age class. For banks estimated to be older than 15 years, observed canopy cover exceeded 80 percent, so 80 percent is a reasonable target for that age class.

Table 4-8. Summary of percent cover woody vegetation on streambanks data by age class and performance target values for CFR Reach A, Phase 1.

Age of Streambank Vegetation	Number of Plots Sampled (n=169)	Mean Canopy Cover	Min-Max	Standard Deviation	95% Confidence Interval Around Mean	Performance Target
1-5 years	148	25.1%	0-86.7	19.93	+/-3.238	40% canopy cover by year 5
5-15 years	14	44.2%	8.9-79.9	23.13	+/-13.355	60% canopy cover by year 10
>15 years	7	87.7%	82.2-93.3	3.93	+/-3.632	> 80% canopy cover

Floodplain Vegetation

Performance targets for floodplain vegetation are based on woody plant survival, density, woody vegetation canopy cover, and total native plant canopy cover.

Plant survival and density. Containerized plants will be an important component of revegetation within CFR Reach A, Phase 1. Survival data for planted woody vegetation will be used to determine if maintenance, such as irrigation or re-planting, is necessary. Other metrics, such as density and canopy cover, will be used to evaluate progress toward meeting the floodplain vegetation cover objective. Survival data, drawn from 80 sampling plots within 5 restoration projects completed in alluvial river systems in western Montana, were used to determine appropriate targets for survival. Table 4-9 presents a summary of planted woody vegetation survival by growing season after installation. Figure 4-4 shows the results of a least-squares linear regression used to analyze survival data. Appendix B provides additional supporting data for the plant survival metric.

Table 4-9. Summary of survival monitoring data used to develop CFR Reach A, Phase 1 performance target values for containerized plant survival.

Growing Season Post Installation	Number of Plots Sampled	Percent Survival	Standard Deviation	95% Confidence Interval Around Mean	Performance Target*
1	72	89.3%	13%	+/- 3%	80%*
2	32	72.9%	22%	+/- 8%	N/A
3	29	69%	28%	+/- 11%	70%
4	19	52.9%	22%	+/- 11%	N/A
5	15	75.8%	15%	+/- 9%	60%
6	10	78%	7%	+/- 5%	N/A

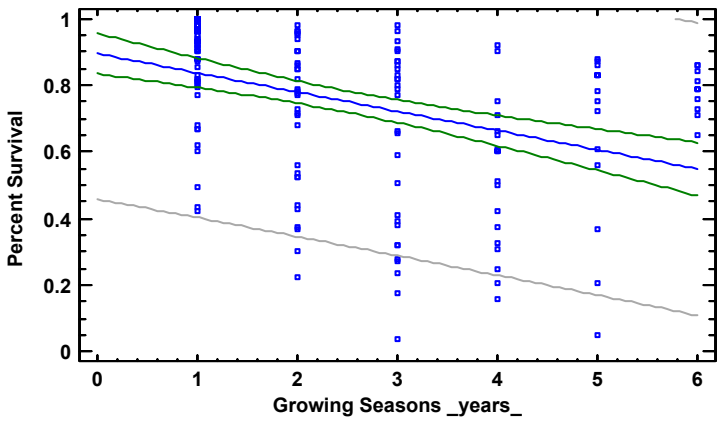

Figure 4-4. Regression of survival data showing relationship between percent survival and year since planting was completed. R-squared = 14.7341%; P=0.0000.

Based on this data set, an appropriate performance target value for survival of planted woody species one growing season after installation is 80%. The 3 and 5 year targets, 70% and 60% respectively, should not be used as performance targets, but should be used as supplemental information to guide decision-making as described in Section 8. Because the project design places a strong emphasis on creating conditions to support natural recruitment, it will become difficult to distinguish between planted and naturally recruited plants after the first growing season. After the first growing season, density of woody plants will be a more appropriate performance target, and the performance target will become no decrease in woody plant density between the end of the first growing season and year 5. This makes sense because if the number of stems remains the same or greater, the area of ground influenced by plants (canopy cover) should be increasing as the plants grow. After year 5, density may decrease as plants become large enough to out-compete each other, and at that point, canopy cover will be the most useful performance target.

Woody vegetation canopy cover. Performance target values for woody vegetation cover in the floodplain were developed using data collected at several floodplain

restoration sites in western Montana, including three sites in the Jocko River watershed, one site on the Clark Fork River floodplain near Milltown Dam, and one site on Therriault Creek near Eureka, Montana. These sites were sampled between one and eight years after planting or other site reclamation actions had occurred. Because the sample size representing each year class was relatively small, data were not analyzed by year class. Instead, all data were analyzed using a least-squares linear regression comparing canopy cover to number of growing seasons (Figure 4-5). Figure 4-5 shows the relationship between canopy cover and year since planting or treatment. Based on this analysis, the performance target for canopy cover of woody vegetation on the floodplain is 30% by Year 5 and 50% by Year 10. After Year 15 (long-term time frame), the performance target shifts to evaluating whether ecological functions are being achieved: the floodplain is composed of a mosaic of native riparian and wetland ecological types, non-contaminated depositional features and open water that provide all of the listed ecological functions and processes.

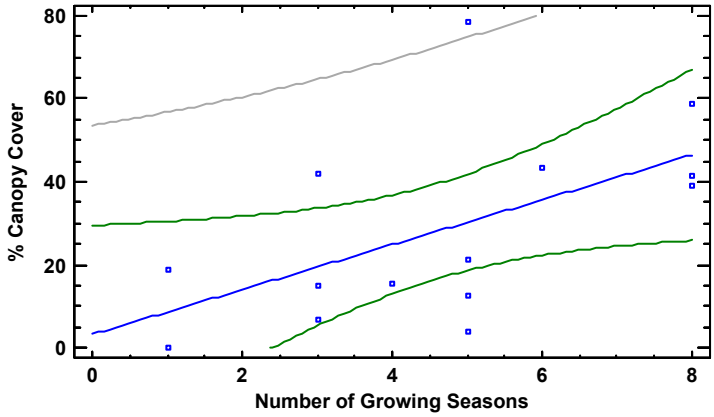

Figure 4-5. Canopy cover of woody vegetation at four alluvial floodplain planting sites by the number of growing seasons post treatment. R-squared=30.8% and P= 0.04.

Total native canopy cover. Short-term performance target values for total native canopy cover in the floodplain were developed using data from the Milltown Dam project site, which implemented similar actions as those proposed for CFR Reach A, Phase 1. These data are summarized in Table 4-10. Based on these data, 20% canopy cover of vegetation in the floodplain after year 1 is used as a performance target. Canopy cover should increase rapidly in subsequent years as grasses and other seeded species mature and as natural colonization and plant reproduction occur. The total canopy cover achievable at the site will depend on a number of factors including site hydrology, weather and natural seed inputs. The performance target value for canopy cover of total native vegetation in the floodplain by Year 3 is 50%; and 80% by Year 5. In addition, 80% of the total floodplain area has native plants present using original design cover type polygons as a unit of measure. These canopy cover values are for vascular plants including both herbaceous and woody life forms.

Table 4-10. Mean (+/- 1 standard error [SE]) canopy cover of all plant species recorded in the Milltown Dam project area in 2010. These data represent one year post implementation of revegetation actions.

Canopy Cover	Mean (%)	Standard Error (%)
All species	28.42	2.00
Seeded species	5.18	0.86
Native herbaceous	13.54	1.11
Native regenerating woody species	0.85	0.25
Exotic species	7.57	0.99
Noxious weed species	1.01	0.23

The mid-term performance target is greater than 80% canopy cover of native plants, and 80% of the total floodplain area has native plants present using original design cover type polygons as a unit of measure. This allows for some floodplain surfaces to continue being occupied by non-contaminated sediment deposits, non-vascular plants, and litter.

The long-term performance target is also greater than 80% canopy cover of native plants, and the site should be evaluated in terms of whether the floodplain is supporting all of the ecological functions and processes shown in Table 4-1. Information used to support the design, such as a regional riparian habitat type classification (Hansen et al. 1995) and a hydrogeomorphic classification (Hauer et al., 2002) that links vegetative cover with riverine geomorphic features can be used to evaluate progress toward developing the desired, long-term mosaic of plant communities and other geomorphic features on the floodplain. Figure 4-6 shows the preliminary design floodplain cover types for Phase 1, which represents a mosaic of plant communities on different geomorphic surfaces, interspersed with water features. Within each of these cover types, several ecological types are expected to develop, and these are shown in Table 4-11 in relation to design cover types. Data collected during monitoring (Section 5) can be used to evaluate progress toward developing these ecological types within the floodplain (proportional abundance of floodplain cover types metric).

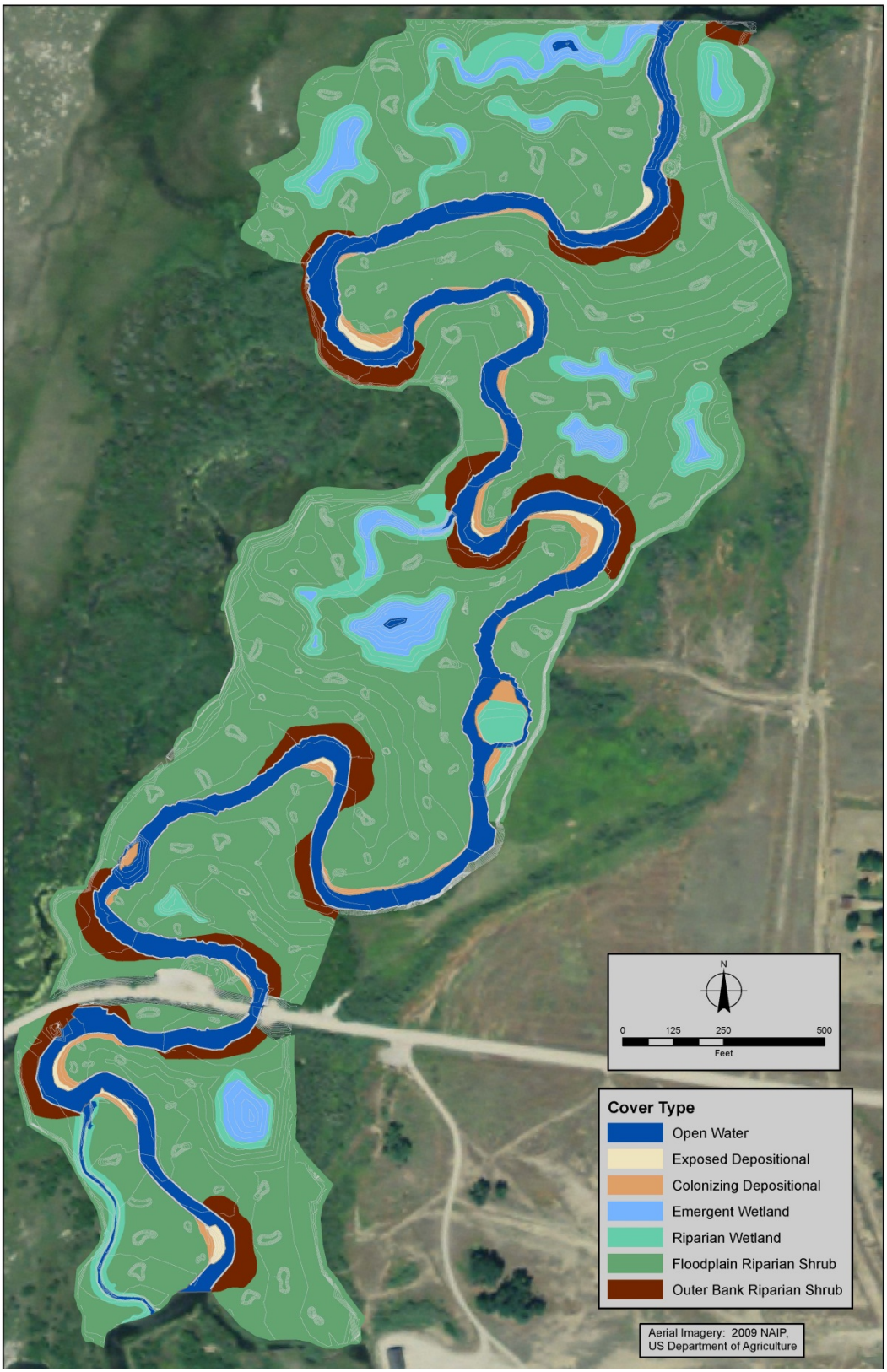

Figure 4-6. Distribution of CFR Reach A, Phase 1 floodplain design cover types.

Table 4-11. CFR Reach A, Phase 1 floodplain design cover types and associated ecological types.

Cover Type	Phase 1 Design Distribution	Associated Ecological Types
Exposed depositional	0.4 acres (0.7%)	No plant communities
Colonizing depositional	1.0 acres (1.7%)	*Salix exigua* Community Type *Carex aquatilis* Habitat Type *Carex utriculata* Habitat Type
Riparian wetland	4.6 acres (8.2%)	*Salix geyeriana/Calamagrostis canadensis* Habitat Type *Salix lutea/Calamagrostis Canadensis* Habitat Type *Salix lutea/Carex rostrata* Habitat Type *Salix geyeriana/Carex utriculata* Habitat Type
Floodplain riparian shrub	44 acres (78.2%)	*Salix geyeriana/Calamagrostis canadensis* Habitat Type *Salix lutea/Calamagrostis Canadensis* Habitat Type *Populus tremuloides*/*Cornus sericea* Habitat Type *Populus tremuloides/Calamagrostis Canadensis* Habitat Type
Outer bank riparian shrub	3.9 acres (9%).	*Salix exigua* (sandbar willow) Community Type *Salix geyeriana/Calamagrostis canadensis* Habitat Type *Salix lutea/Calamagrostis Canadensis* Habitat Type
Emergent wetland	2.2 acres (4%)	*Carex aquatilis* Habitat Type *Carex utriculata* Habitat Type *Calamagrostis Canadensis* Habitat Type *Typha latifolia* Habitat Type *Eleocharis palustris* Habitat Type

Natural recruitment of native vegetation. Natural recruitment of native vegetation, while not a performance target, will be an important component of achieving the desired future conditions and vegetation objectives within CFR Reach A, Phase 1. Natural recruitment will depend on availability of natural seed sources and hydrology to support seedling establishment. Seed sources may be present within the project area, upstream of the project, and in adjacent non-treated floodplain areas. Hydrograph conditions that will effect seedling establishment include timing, duration and extent of flows both during the year of recruitment and in the following year. Because there are so many factors that influence natural recruitment and the density of natural recruited plants will be highly variable and unpredictable (and not something that can be controlled directly by management actions), no natural recruitment performance target is proposed. However, the metric should be evaluated as a way to detect early trends toward achieving long-term objectives and desired ecological functions.

Natural recruitment of desired woody species will be captured through floodplain transects established to monitor canopy cover of vegetation within CFR Reach A, Phase 1. Visual observations of natural recruitment will be made in areas such as on

point bars and in depositional areas where woody species recruitment is expected to occur. These areas correspond with the Colonizing Depositional cover type and areas of Riparian Wetland and Floodplain Riparian Shrub cover types that are adjacent to the channel.

Browse. While browse is not being proposed as a performance target, browse by wildlife can be a significant limiting factor to vegetation goals and objectives. For this reason, the effect of browse on establishing vegetation needs to be monitored. Because browse is a factor influencing other metrics, including percent cover and plant survival, it will indirectly be evaluated through performance targets developed for those metrics. Browse will be monitored within survival monitoring plots.

Noxious weeds. To evaluate the noxious weed objective, the Performance Standard value of 5% indicated by the ROD will be used. At the Milltown Dam project site, one year after construction noxious weeds represented approximately 1% of the total canopy cover. Weeds will be a significant long-term management need in the CFR Reach A, Phase 1 project area due to the extent of soil disturbance that will occur during remediation actions. Noxious weeds are currently present within, adjacent to and upstream of the Phase 1 project area. The first year after construction, weeds will likely be widely distributed in the CFR Reach A, Phase 1 project area but with a relatively low canopy cover. If a long-term integrated weed management plan is in place for the project, it will likely be possible to maintain noxious weed percent cover at 5% or less both short- and long-term.

Wetlands. The wetland objective will be evaluated as specified in the ARARs (ROD, Appendix A). The total area of wetlands will not be less than the pre-project wetland area as mapped by the Environmental Protection Agency (0.47 acres), and a Functional Effective Wetland Area assessment (FEWA) completed at year 5 should show that the functional score for the site meets or exceeds the reference wetland score established for the CFROU of 2.3 (ARCO, 1992).

Table 4-12 provides a summary of CFR Reach A, Phase 1 vegetation performance targets.

Table 4-12. Summary of vegetation performance targets for CFR Reach A, Phase 1.

Metric	Short-term (0-5 years)	Mid-term (5-15 years)	Long-term (15+) years
Cover woody vegetation on streambanks	40% by year 5	60% by year 10	Greater than 80%
Woody vegetation survival by species	80% or higher (year 1)	No performance target	No performance target
Density	No decrease in woody plant density year 1 through 5	No performance target	No performance target
Woody vegetation cover in floodplain	30% (by year 5)	50% (by year 10)	No performance target
Total native vegetation cover in floodplain	Present in greater than 80% of project area 20% (by year 1) 50% (by year 3) 80% (by year 5)	Present in greater than 80% of project area Greater than 80% total canopy cover	No performance target
Proportional abundance floodplain cover types	No performance target	No performance target	No performance target
Natural recruitment	No performance target	No performance target	No performance target
Browse	No performance target	No performance target	No performance target
Cover noxious weeds	<5%	<5%	<5%
Wetlands	No net loss of pre-project wetlands (0.47 acres)	No net loss of pre-project wetlands (0.47 acres) Site achieves FEWA score of 2.3	No net loss of pre-project wetlands (0.47 acres) Site achieves FEWA score of 2.3

5. Sampling and Analysis Plan

This section describes the sampling and analysis plan for collecting adequate data to evaluate the performance targets and other metrics identified in Section 4. This section provides an overview of the sampling design including sampling methods, preliminary monitoring locations within CFR Reach A, Phase 1, sampling effort, frequency and schedule for data collection and quality control and assurance measures. Final monitoring locations and sampling effort will be identified after the as-built surveys for each project phase are completed. Detailed sampling protocols are described in Appendix A and Appendix B.

5.1 Geomorphology

As described in Section 4.0, the following metrics will be used to evaluate CFR Reach A, Phase 1 project performance with respect to geomorphology:

- Cross section dimensions
- Sinuosity
- Slope
- Pool density and residual pool depth
- Bank erosion and channel migration
- Floodplain connectivity
- Floodplain stability
- Secondary channel stability

5.1.1 Monitoring Locations

Table 5-1 lists the locations for monitoring geomorphology metrics in CFR Reach A, Phase 1. Monitoring cross section locations are shown in Figure 5-1.

5.1.2 Monitoring Schedule and Frequency

Geomorphic monitoring will occur after peak spring runoff for all metrics. The monitoring will take place on years 1, 2, 3, 5, 10, and 15 (Table 5-1).

Table 5-1. CFR Reach A, Phase 1 monitoring locations, sampling effort, sampling timing and frequency.

Monitoring Metric	Sampling Locations	Total Samples/ Reach length or Unit Area	Timing	Scheduled Frequency*
GEOMORPHOLOGY				
Cross section dimensions	Distributed throughout Phase 1 including Warm Springs Creek within the Clark Fork River 100-year floodplain	Clark Fork River: 16 total cross sections (1/ ~530 ft) Warm Springs Creek: 2 cross sections (1/200 ft)	After peak runoff	Years 1, 2, 3, 5, 10, 15
Sinuosity	Entire channel in Phase 1 reach (surveyed profile and aerial photo analysis)	Profile: a minimum of 1 sample/100 feet (≥85.6 total samples)	After peak runoff	Years 1, 2, 3, 5, 10, 15
Slope	Entire channel in Phase 1 reach (surveyed profile)	Profile: a minimum of 1 sample/100 feet (≥85.6 total samples)	After peak runoff	Years 1, 2, 3, 5, 10, 15
Pool density and residual pool depth	All pools in Phase 1	Depends on number of pools present at time of monitoring	After peak runoff	Years 1, 2, 3, 5, 10, 15
Bank erosion and channel migration	Distributed throughout Phase 1 including Warm Springs Creek within the Clark Fork River 100-year floodplain (cross section analysis) Entire Phase 1 reach (aerial photo analysis)	Clark Fork River: 16 cross sections (1/~530 ft) Warm Springs Creek: 2 cross sections (1/200 ft) 1	After peak runoff	Years 1, 2, 3, 5, 10, 15
Floodplain connectivity	Entire Phase 1	1	After peak runoff	Years 1, 2, 3, 5, 10, 15
Floodplain stability	Entire Phase 1	1	After peak runoff	Years 1, 2, 3, 5, 10, 15
Secondary channel stability	Entrance to constructed secondary channels	3	After peak runoff	Years 1, 2, 3, 5, 10, 15

Monitoring Metric	Sampling Locations	Total Samples/ Reach length or Unit Area	Timing	Scheduled Frequency*
VEGETATION				
Canopy cover woody vegetation on streambanks	6.5-foot square plots established at 30-foot intervals	Approximately 3,000 linear feet (100 plots)	Growing season	Years 1, 2, 3, 5, 10, 15
Canopy cover floodplain woody vegetation	3-foot square plots established along floodplain wide transects 50-foot x 50-foot plots established in containerized planting units	10 transects/200 plots Measured in survival monitoring plots	Growing season	Years 1, 2, 3, 5, 10, 15
Canopy cover floodplain woody vegetation	3-foot square plots established along floodplain wide transects 50-foot x 50-foot plots established in containerized planting units	10 transects/200 plots Measured in survival monitoring plots	Growing season	Years 1, 2, 3, 5, 10, 15
Canopy cover of herbaceous vegetation	3-foot square plots established along floodplain wide transects	10 transects/200 plots	Growing season	Years 1, 2, 3, 5, 10, 15
Woody vegetation survival	Woody vegetation planting areas: -40% Floodplain Riparian Shrub -30% Outer Bank Riparian Shrub -30% Riparian Wetland	Variable number of plots established to monitor 20% of installed woody plants (estimated to be 2,800 plants split between cover types by percent planted in each)	Growing season	Year 1
Woody vegetation density	Woody vegetation planting areas: -40% Floodplain Riparian	Variable number of plots established to monitor 20% of installed woody plants	Growing season	Years 1, 2, 3, 5

Monitoring Metric	Sampling Locations	Total Samples/ Reach length or Unit Area	Timing	Scheduled Frequency*
	Shrub -30% Outer Bank Riparian Shrub -30% Riparian Wetland	(estimated to be 2,800 plants split between cover types by percent planted in each)		
Proportional abundance of floodplain vegetation cover types	Entire restoration area	1	Growing season	Years 5, 10, 15
Natural recruitment	Colonizing Depositional cover type and portions of Floodplain Riparian Shrub cover type	All	Growing season	Years 1, 2, 3, 5, 10, 15
Woody browse levels	Woody vegetation survival monitoring plots	2,800 plants	Growing season	Years 1, 2, 3, 5
Wetland assessment	Entire Phase 1 project area	1	Growing season	Year 5

5.1.3 Sampling Methods

This section provides general sampling methods for geomorphology monitoring metrics for CFR Reach A, Phase 1. Additional details and field protocols for sampling methods are provided in Appendix A.

Cross Section Dimensions

A total of 16 cross sections will be surveyed within CFR Reach A, Phase 1 at locations shown in Figure 5-1. This equates to an average of one cross section every 530 feet. These cross sections were surveyed in 2009 and will allow direct comparison of the pre-project to post-project cross section morphology. The cross section numbers reference the 2009 survey and 2009 hydraulic model (CDM et al, 2011).

Any vertical adjustment on the Clark Fork River will affect base level of tributaries. To assess the potential impact of such change on tributaries, two cross sections will be surveyed on lower Warm Springs Creek where it flows within the Clark Fork River 100-year floodplain (Figure 5-1).

Slope and Sinuosity

Slope and sinuosity will be measured via the establishment of a longitudinal profile that will include the entire channel within CFR Reach A, Phase 1. The profile shall include consistent measurement of left and right channel bankfull indicators, water surface, and thalweg at intervals not to exceed 100 feet on the profile. Sinuosity will be measured using the longitudinal profile in conjunction with aerial photography.

A longitudinal profile will also extend 300 feet up lower Warm Springs Creek where it lies within the Clark Fork River 100-year floodplain. This profile will be monitored for slope alterations, as any adjustments to this slope will be an indicator of profile adjustment on the Clark Fork River.

Pool Density and Residual Pool Depth

Pools will be mapped and measured in terms of residual pool depth. Estimates of average pool width and pool length will also be made to approximate pool habitat extent through the reach. Each pool will be attributed as to its process of formation (lateral scour, large woody debris, flow convergence, pier scour, etc.). Pools will be mapped as points via GPS to assess pool frequency.

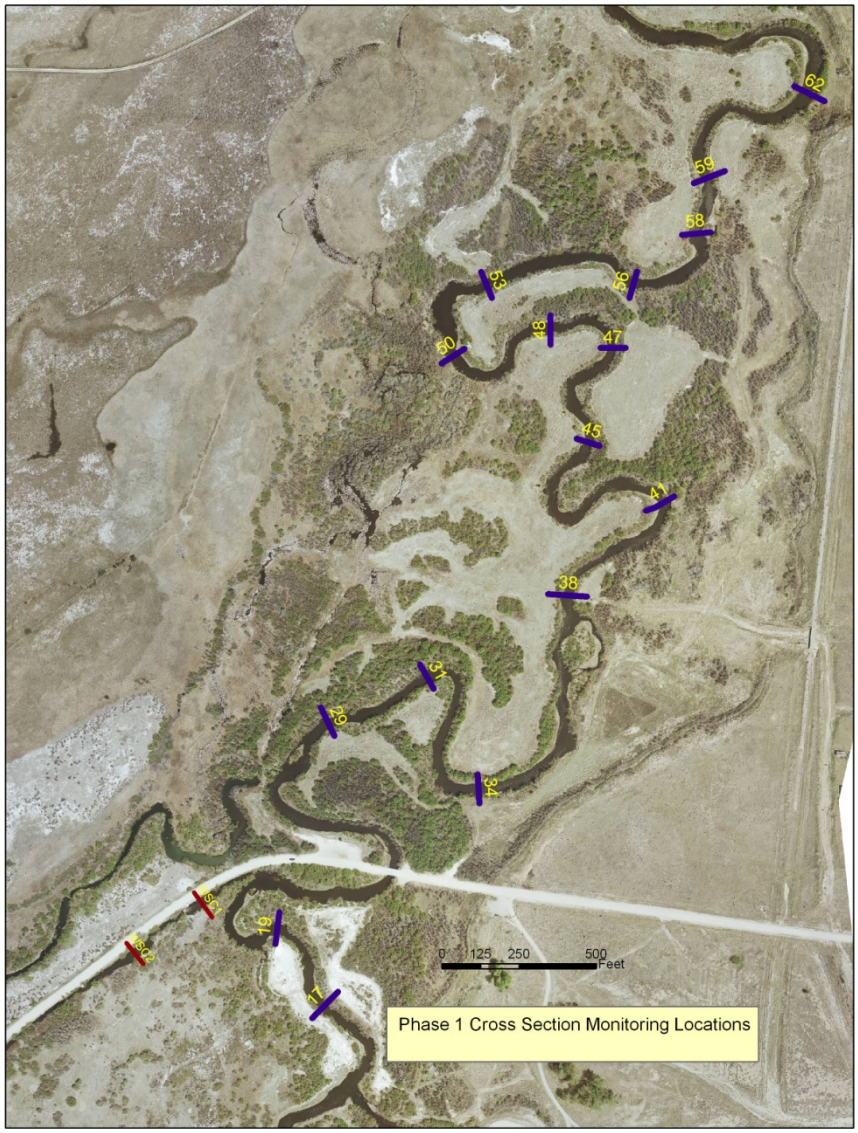

Figure 5-1. CFR Reach A, Phase 1 cross section monitoring locations. Blue lines represent cross sections on the Clark Fork River. Red lines represent cross sections on Warm Springs Creek.

Bank Erosion and Channel Migration Rate

Channel migration will be measured using aerial photography and repeat cross sections. With respect to localized bank erosion, banks that have a reconstructed toe will be surveyed as repeat cross sections. Per the CFR Reach A, Phase 1 draft Preliminary Design, banks that require a reconstructed toe will be identified on-site during construction (CDM et al, 2011). Thus, some cross section locations shown in Figure 5-1 may not include such reconstructed bank area and it will be necessary to relocate some cross sections to capture areas where the bank toe has been re-built. Of the 16 cross sections identified for monitoring, at least 3 should capture at least one bankline where the toe has been reconstructed. If less than three banks require

reconstructed toes, than every site that does have a reconstructed toe should be assigned a monitoring cross section.

Floodplain Connectivity

Floodplain hydrologic connectivity will be evaluated by the assessment of the floodplain surface following spring runoff to estimate the extent of overflows for a given event. The methodology provided by the Corps of Engineers Wetland Delineation Manual can be used to assess inundation depth and extent. (US Army Corps of Engineers Environmental Laboratory 1987). Floodplain connectivity will also be determined analytically using surveyed channel cross sections to determine at what stage the floodplain is accessed.

Floodplain Stability

As the floodplain is assessed in the field in terms of connectivity, any evidence of overflow channelization on the floodplain will be identified. Evidence may include headcut development at points of overflow return, or continuous rill development on the floodplain surface.

Secondary Channel Stability

The stability of secondary channels will include cross section surveys at the head of each secondary channel, and visual inspection of these channels for evidence of enlargement such as systemic widening or local grade imbalances (headcutting).

5.1.4 Quality Control and Assurance

Data quality objectives (DQOs) will be established where applicable for specific monitoring protocols. Quality assurance and quality control are described under each section below. Data quality objectives (DQOs) are the quantitative and qualitative criteria established for a sampling design in order to meet the project's objectives. Data quality indicators (DQIs) are quantitative criteria established for the data acquired within this design to assure it is of sufficient quality for its intended use.

Quality control measures for geomorphology data collection will follow standard procedures as outlined in the field protocols of Appendix B. These procedures relate to sampling methodology and data analysis.

5.2 Vegetation

As described in Section 4, vegetation effectiveness monitoring for CFR Reach A, Phase 1 will consist of collecting data to evaluate the following metrics:

- Canopy cover woody vegetation on streambanks
- Canopy cover of woody vegetation on the floodplain
- Total canopy cover of native vegetation on the floodplain
- Canopy cover of noxious weeds
- Survival of planted woody vegetation
- Density of woody plants

- Proportional abundance of floodplain cover types and associated plant communities
- Natural recruitment and plant reproduction
- Browse
- Wetland delineation and functional assessment

This section describes the sampling and analysis plan for collecting data related to these metrics.

5.2.1 Monitoring Locations

Table 5-1 provides a summary of the monitoring locations for vegetation data collection within CFR Reach A, Phase 1 based on the draft Phase 1 Preliminary Design. Figure 5-2 provides an overview of the sampling design for monitoring vegetation metrics within CFR Reach A. Phase 1. Monitoring locations for collecting vegetation data will be finalized after construction and as-built surveys are complete.

5.2.2 Monitoring Schedule and Frequency

Table 5-1 shows the proposed schedule, locations, frequency, sampling level and sampling timing for monitoring vegetation metrics in CFR Reach A, Phase 1. Vegetation monitoring will occur during the growing season for all metrics. The frequency of monitoring varies by metric.

5.2.3 Sampling Methods

This section describes the sampling design and provides general sampling methods for vegetation effectiveness monitoring metrics for CFR Reach A, Phase 1. Additional details and field protocols for vegetation data collection are provided in Appendix B.

Canopy Cover

Canopy cover is the percentage of ground within a given area covered by a species or life form. Canopy cover is used to determined abundance of individual species (including weeds) and life forms within plant communities. For canopy cover of herbaceous vegetation and establishing woody vegetation (woody vegetation less than 8 inches in height), canopy cover will be recorded in 3-foot square plots established along floodplain wide transects. Floodplain transects will be established to capture the diversity of conditions in CFR Reach A, Phase 1. Figure 5-2 shows the approximate location of floodplain transects and monitoring plots based on the proportional area of design cover types and corresponding vegetation treatments included in the preliminary design. Table 5-2 provides a summary of the number of plots that will be assigned to each design cover type based on the percent of area the cover type occupies within the preliminary design floodplain. Data collected within these plots will also be used to determine the percent cover of noxious weeds within the project area.

For woody vegetation taller than 8 inches, canopy cover will be measured in larger plots (approximately 50 feet x 50 feet or 2,500 square feet) plots. Plots will correspond with survival monitoring plot locations. In the short-term, areas planted with woody vegetation will be the only locations where canopy cover of woody vegetation will be

possible to evaluate. Over the long-term, survival and density metrics will no longer be used and a percent cover metric used instead. Establishing canopy cover plots in the same locations as survival and density monitoring plots will facilitate this transition.

For canopy cover of woody vegetation on treated streambanks, canopy cover will be measured in 6.5-foot square plots established at 30-foot intervals along constructed streambanks. Establishing plots at 30-foot intervals will capture approximately 20% of treated banks.

5.2.4 Quality Control and Assurance

For vegetation data collection, quality control and assurance issues relate to sampling design, data collection and data entry. Quality control measures are built into the sampling design. The sampling design aims at ensuring that the area is sampled to capture variation sufficiently to allow testing for statistically significant differences between measured variables. The sampling density is guided by the Milltown Dam Restoration Site sampling plan where power analysis has been completed using monitoring data collected for one year after completion of restoration actions. The sampling design samples each cover type proportionately in order to accurately capture site response to remedial action and restoration activities completed within CFR Reach A, Phase 1. As-built surveys will be used to lay out the final sampling design on the ground to ensure that all conditions are proportionally represented by the sampling plan.

To ensure consistent quality of data collection, detailed field protocols with built-in quality control measures are used (Appendix B). Detailed field protocols help increase accuracy and reduce bias in sampling. Additional quality control measures are implemented during data entry. All data will be proofed in the office and missing data elements corrected or recollected in the field. All text fields will be spell-checked (including genus and species names).

Table 5-2. CFR Reach A, Phase 1 proportional abundance of design cover types and number of canopy cover plots to be established.

Design Cover Type	Total Design Area (acres)	Percent of area	Number of Plots to establish within cover type (n=200)
Exposed Depositional	0.4	0.7	2
Colonizing Depositional	1.0	1.7	4
Riparian Wetland	4.6	8.2	16
Floodplain Riparian Shrub	44.0	78.2	156
Outer Bank Riparian Shrub	3.9	6.9	14
Emergent Wetland	2.2	4	8

Survival

Woody vegetation survival monitoring will be used to evaluate container plant installation after the first growing season within the short-term time period. Woody vegetation survival will be monitored by establishing permanent monitoring plots within planting units. If possible, these plots will be established along or adjacent to floodplain transects. Three cover types in the preliminary design include containerized woody plants installation as a treatment: Floodplain Riparian Shrub, Outer Bank Riparian Shrub and Riparian Wetland. Approximately 14,000 containerized plants will be installed in CFR Reach A, Phase 1. Twenty percent of installed plants will be monitored (approximately 2,800 plants). Plots will be no larger than 0.1 acre each. Figure 5-2 shows the preliminary sampling design for containerized plant survival monitoring based on this sampling level.

Density

Woody vegetation density will be monitored in survival monitoring plots. Twenty percent of installed plants will be monitored (approximately 2,800 plants). Plots will be no larger than 0.1 acre each. Figure 5-2 shows the preliminary sampling design for containerized plant survival monitoring based on this sampling level.

Proportional Abundance of Floodplain Cover Types

In the short-term, this metric will be evaluated through collection of canopy cover data in plots established along floodplain transects. The data collected in these plots will identify which species occur in which design cover types to determine if desired plant communities are developing.

Over time, as vegetation matures, it will be possible to delineate and map developing floodplain plant communities or ecological types and confirm that the expected range of riparian and floodplain functions is developing on site. Ecological types, described as community types or habitat types, are plant communities described in Hansen et al. (1995). Within this system, community types represent ecological types dependent upon, or created by, disturbance such as floods. Habitat types represent mature (later successional) plant communities that reflect a site's potential give soils, hydrology, climate and landform. Ecological type classification will be used to evaluate progress toward developing a mosaic of native riparian plant communities.

Natural Recruitment of Native Vegetation

Natural recruitment of woody vegetation will be visually observed in all design floodplain cover types. Canopy cover plots and woody plant survival/density plots will capture plant reproduction in all cover types. In addition to cover plots, visual observations of natural recruitment of woody vegetation will be made in cover types where conditions will be present to support natural recruitment.

Browse

The effects of browse on woody vegetation will be evaluated by recording the level of browse on individual plants monitored in survival monitoring plots. A level of browse will be assigned to each monitored plant. The following categories will be used:

0: No browse;
1: Mild browse – less than 50% of current year's growth browsed;
2: Mild browse – greater than 50% of current year's growth browsed;
3: Moderate browse – two to three year old growth exhibits browse;
4: Heavy browse – browse has resulted in arrested growth form or plant mortality.

Wetlands

A wetland delineation will be completed according to the 1987 Manual and any applicable regional supplements (1987 COE, Regional supplement). A wetland delineation will be completed for the entire project area at year 5. In addition, wetland functions will be evaluated using the Functional Effective Wetland Area (FEWA) method (ARCO, 1992).

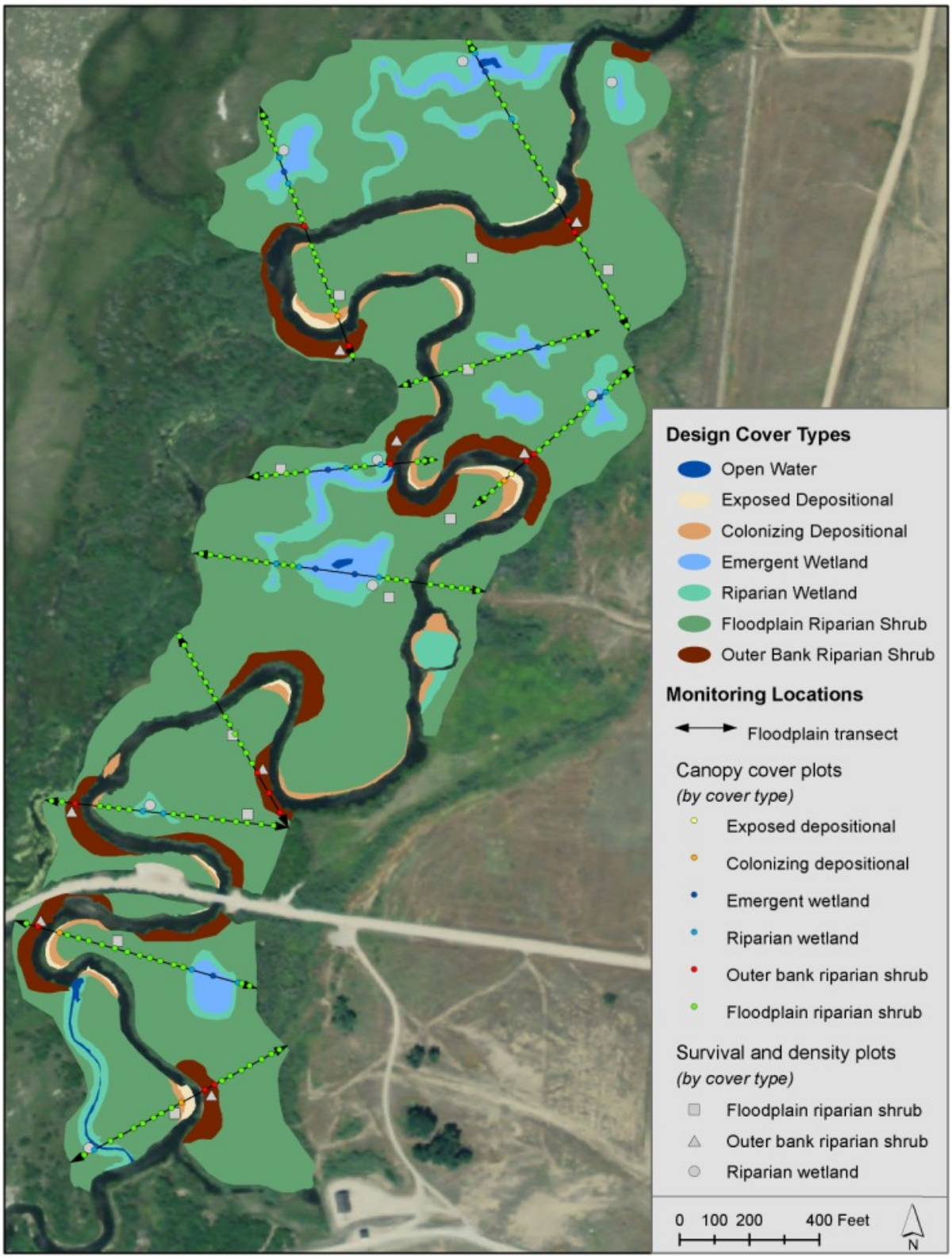

Figure 5-2. Sampling design for vegetation monitoring for CFR Reach A, Phase 1.

6. Data Storage and Analysis

6.1 Data Storage

Monitoring data will be collected in the field according to protocols described in Appendix A and Appendix B, and then entered into a flexible electronic format such as Microsoft Excel workbooks. Contractors collecting data will coordinate with the State to develop appropriate database schema that will support importing data into the State's Oracle database and other data storage formats used for spatial data. Data will be normalized to avoid redundant data structures and to ensure consistent data formats among sampling events. Data will be easily convertible to formats as described above (e.g. as delimited rows and tagged with date of sampling, sampling location code, name of person who collected the data, method used, and other appropriate attributes). Prior to the first sampling event, the monitoring team, including representatives of the State and its contractors as appropriate, will work together to develop consistent data naming conventions and table structures, and address other coordination details that will facilitate data transmission and analysis.

6.2 Data Analysis

Data will be analyzed according to methods associated with metrics as described in Section 5. After each monitoring event, brief monitoring reports will be prepared that include:

- A summary of metrics for which data were collected;
- Methods used to collect data;
- Tabular and graphical summaries of results; and
- Narrative discussions to explain results in the context of project objectives and performance targets.

7. Adaptive Management Framework

Implementing large-scale ecosystem remediation and restoration requires building in mechanisms to address uncertainty that is inherent within natural systems. Sources of uncertainty include spatial and temporal variability in natural conditions such as hydrology and weather, natural variation in plant growth and reproduction, effects of natural predators on plants, and unpredicted changes in the surrounding landscape due to human actions. To address this uncertainty, it is useful to include an adaptive management component as part of large-scale ecosystem remediation and restoration projects.

Adaptive management has been defined as: learning by doing (Walters & Holling, 1990) or experimenting (Marmorek, Robinson, Murray, & Greig, 2006); considering and evaluating several alternative actions (Murray & Marmorek, 2003); experimentation with a feedback loop (Aldridge, Boyce, & Baydack, 2004; Atkinson, et al., 2004); or a way of making decisions and moving forward when faced with uncertainties (Moir, 2001). A more elaborate definition describes adaptive management as "managing according to a plan by which decisions are made and modified as a function of what is known and

learned about the system, including information about the effect of previous management actions" (Parma, 1998).

With such a wide assortment of adaptive management descriptions, some authors have pointed out that there is no one established definition (Bormann, et al., 1999; Doremus, 2001; Morghan, Sheley, & Svejcar, 2006). The definition varies depending on the context of its use and application, such as differences in management goals, available information, funding, and programmatic resources (Doremus, 2001). Additionally, adaptive management is not only a management methodology, but it is also a way of thinking and an attitude. "[I]t is a bold approach to management, which requires creativity, curiosity and a long term commitment to structured learning" (Murray & Marmorek, 2003). With the understanding of adaptive management as a way of thinking, it is important to recognize it is not one step in a multistep process, but it is rather incorporated into almost every step and aspect of a project.

Adaptive management plans can be differentiated as either active or passive. Active adaptive management is an empirical approach which experimentally applies select management actions at a small scale prior to applying an action at the project scale, in order to determine which actions best achieve the objective(s) of the project (PRRIP Attachment 3, 2006; Walters & Holling, 1990). Passive adaptive management involves the conscious and mindful application of one well-evaluated action at the project scale with the flexibility for modifications (Doremus, 2001). It uses literature and experiences from previous studies within or near the general geographic extent of the project area to select a management action to apply at the project-scale.

To accommodate the need to have a mechanism in place to address uncertainty, this section includes an adaptive management decision-making framework that can be used to interpret effectiveness monitoring data and incorporate conceptual models of how the site may respond to unpredictable events such as large floods, ice and debris accumulations, beaver influences, land use changes and other factors that cannot be predicted and which may have a range of associated outcomes that could influence the trajectory of floodplain development and associated processes and functions.

To effectively translate data into reasonable and necessary management actions, evaluate project goals and objectives, inform later project phases, or make the decision to modify performance target values; it will be necessary to identify a decision making team. This core adaptive management team should be available throughout all phases of project work in the Clark Fork Site, and would be responsible for integrating geomorphology and vegetation data with data from other disciplines such as aquatic habitat and water quality to provide a holistic vision of achieving Remedial Action Objectives of the ROD (Figure 7-1).

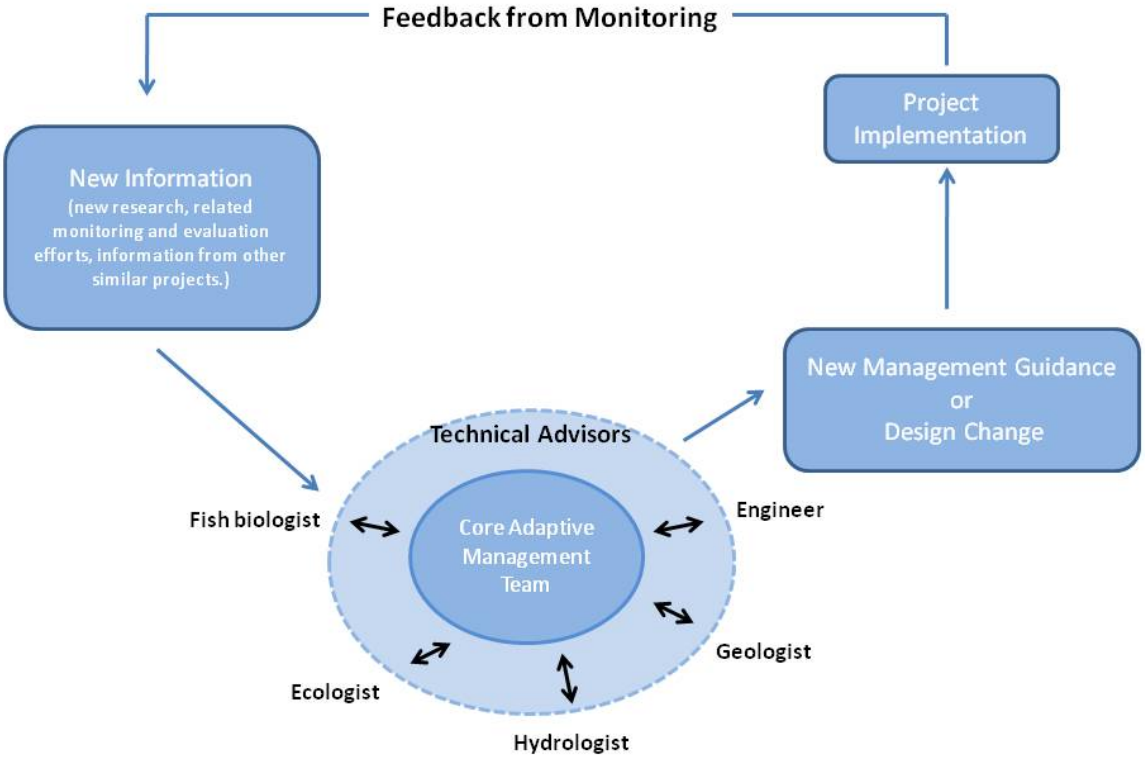

Figure 7-1. Adaptive management framework illustrating the role of the core adaptive management team in integrating monitoring data and new information into the decision-making process.

7.1 Interpreting Monitoring Results for Decision-Making

Interpreting data and determining trends will be an important component of the monitoring program due to the natural variability and various timeframes associated with restoring ecological systems. Trend analysis requires evaluating data collected at specified intervals over a specified period of time in order to determine the magnitude and direction of change. The amount of data needed to conduct a trend analysis will depend on various factors, such as the type of data being collected or the expected response time. For some metrics, such as proportional abundance of plant communities developing in design floodplain cover types, several years of data may be needed to detect trends. Data collected for other metrics, such as bank erosion and migration, may support making management decisions in one year. Trend analysis has the following applications:

- May provide better interpretation of the site specific effects of natural variability (such as occasional herbivory or unusual weather conditions) on the developing floodplain and channel system.

- Due to the long periods of time that may be required to reach some remedial action and restoration activities, detecting data trends will allow early indication of restoration success (e.g. increasing abundance of desired species, hydric soils developing, distribution of desired cover types or plant communities establishing).

At a coarse scale, data generated during monitoring will point toward one of three conclusions related to whether project objectives are being met: (1) project is meeting objectives, (2) project is trending toward meeting objectives, or (3) project is either not meeting objectives or trending toward not meeting objectives (Table 7-1).

Table 7-1. Monitoring program adaptive management decision-making framework.

Conclusion Categories	Possible Decisions and Actions
Conclusion 1. Project is meeting objectives based on values of performance target values.	-Evaluate monitoring program (continue, reduce, eliminate some metrics).
Conclusion 2. Project has not achieved objectives based on performance target values but is trending towards achieving objectives.	-Evaluate monitoring program (continue, reduce, modify, eliminate some metrics). -Evaluate whether rates of progress toward objectives are appropriate. -Evaluate whether trend toward achieving objectives is occurring for reasons unrelated to the restoration and remediation actions.
Conclusion 3. Project is not meeting (or trending away from) objectives based on values of performance targets.	-Evaluate causes of why project is not meeting objectives. -Assess monitoring program to determine if appropriate data are being collected to determine and evaluate causes. -Evaluate whether performance targets are appropriate (i.e. is desired function or unanticipated function being achieved). -Evaluate whether objectives are not being achieved for reasons unrelated to the restoration and remediation actions. -Develop plan to address problems. -Implement plan and monitor results.

Table 7-2 provides examples and guidance on how data collected during effectiveness monitoring may be used to determine trends, which conclusion category may apply and examples of resulting actions. As described above, decision making should be done by an core adaptive management team.

Table 7-2. Examples of monitoring data results and potential decision pathways and corrective actions that may be determined by the Core Adaptive Management Team.

Metric	Example Monitoring Results	Decision Pathway/Trend Determination	Maintenance/ Corrective Action
Floodplain Erosion	Erosion outside of meander cores and no formation of floodplain channels	Continue to monitor (Conclusion 1)	No Action
	Erosion across meander cores or erosion resulting in continuous channel connecting to main channel	Implement maintenance action (Conclusion 3)	Evaluate risk and recovery to determine necessary actions
	Short segments of continuous channels formed in floodplain but not connected to main channel	Trend uncertain (Conclusion 2 or 3)	Treat erosion and re-plant
Percent Survival Woody Plants	Greater than 80% survival first growing season after planting	Continue to monitor (Conclusion 1)	Implement routine maintenance such as scheduled watering
	50-80% survival first growing season after planting	Implement maintenance action (Conclusion 2)	Determine cause of mortality (hydrology, browse, etc.) and recommend ways to achieve project objectives: (1) Increase supplemental irrigation, (2) improve browse protection, (3) increase weed suppression, and/or (4) add additional microsites.
	Less than 50% survival first growing season after planting	Modify remediation and restoration approach (Conclusion 3)	Determine reasons for low survival if possible and modify design for future project phases. Consider re-planting.
Noxious Weed Cover	Less than 5% cover	Continue to monitor (Conclusion 1)	Implement routine weed control measures to continue to meet objective
	Greater than 5% cover	Implement control measures (Conclusion 3)	Evaluate trend and determine if control measures need to be modified or re-evaluate performance target value

7.2 Interpreting Monitoring Results for Routine Maintenance Needs

In addition to monitoring project effectiveness, monitoring data and observations will be used to determine maintenance needs for the project. Some maintenance will need to occur annually regardless of monitoring results and other maintenance will be scheduled as a direct result of interpreting monitoring data or observations made during monitoring data collection. Potential maintenance needs, responses and frequency are summarized in Table 7-3.

Table 7-3. Examples of routine and monitoring induced maintenance needs.

Anticipated Maintenance Needs	Method	Possible Action	Frequency and Duration
Streambank Bioengineering	Visual inspection Monitoring data	Repairs to fabric; supplemental willow cuttings, planting or seeding; additional toe protection	Once per year and as determined by monitoring data for the first 5 years
Floodplain Erosion	Visual inspection Monitoring data	Grade, fill and/or plug channels and revegetate if occurs in high risk areas in the first 5 years	Once per year and as determined by monitoring data for the first 10 years
Irrigation	Visual inspection Monitoring data	Increase frequency of watering	Once monthly in July and August the first three years and as determined by monitoring data after that period
Weeds	Monitoring data	Implement control actions according to weed management plan	Annually, usually 2 passes in the spring and one pass in the fall or more frequently as determined by monitoring data and for minimum of 5 years
Herbivory	Visual inspection Monitoring data	Straighten, replace, re-stake, re-tie or remove herbivory protection	Annually for first 5 years and then as determined by monitoring

7.3 Key Uncertainties

When evaluating monitoring data, it is important to acknowledge that ecosystems are complex and dynamic and that ecosystem response, particularly to extreme or unexpected factors can be unpredictable. The CFR Reach A Phase 1 project goals and objectives, restoration and remediation actions to achieve those goals and objectives, and performance target values to measure success of the project are based on an expected ecosystem response to project actions based on professional knowledge and/or data of similar responses in reference or similar settings. The adaptive management framework described in Section 7.1 is also based on expected ecosystem response to relatively predictable external inputs. However, extreme of unexpected events that fall outside design thresholds may result in unpredictable responses that are not directly related to project actions. This section illustrates how the adaptive management framework may apply to these key uncertainties in site response. Some of the key uncertainties related to ecosystem response for vegetation and geomorphology in CFR Reach A, Phase 1 include:

Vegetation key uncertainties:

- Future land use within and adjacent to the project site:
    - Livestock grazing
    - Land development
    - Fire, for example ditch burning
    - Pesticide or other chemical applications
- New weed sources and invasions of new weed species
- Vegetative fill characteristics
- Beaver influence
- Ungulate browse patterns
- Insect infestations
- Seed sources for natural recruitment of native species
- Weather patterns
- Climate change
- New tailings deposition from upstream sources
- Residual tailings
- Disease
- Recreational impacts

Geomorphic key uncertainties:

- Hydrologic regime
    - Flood magnitude and duration
    - Minimum flows
    - Continued operation of upstream ponds
- Sediment loading
- Woody debris loading
- Ice accumulations and flows
- Tributary dynamics
- Infrastructure stability/influence

- Beaver influence
- Recreational impacts

Table 7-4 provides an example of how the core adaptive management team can use the adaptive management framework for tracking and evaluating extreme events or key uncertainties.

Table 7-4. Example of how the adaptive management framework could be applied to extreme of unexpected events.

Extreme Event/Key Uncertainty: Flood exceeding Q10 occurs prior to Year 5			
Response Category	**Conclusion Category 1 (meeting objectives)**	**Conclusion Category 2 (trending toward meeting objectives)**	**Conclusion Category 3 (failing to meet or trending away from objectives)**
Channel dimensions	**Response:** Channel dimensions post flood meet performance target values for short-term timeframe **Action:** Routine maintenance; integrate new information into adaptive management feedback loop	**Response:** Bank erosion rate exceeds performance target but cross section area is maintained by new deposition on point bars and erosion does not increase risk of scouring intact tailings **Action:** Continue to monitor; integrate new information into adaptive management feedback loop	**Response:** Bed elevation lowered due to channel scour reducing floodplain connectivity that compromises intended function **Action:** Raise channel bed elevation to restore connectivity
Woody vegetation survival, Natural Recruitment, Percent Cover	**Response:** Vegetation metrics meet performance target values for short-term timeframe **Action:** Routine maintenance; integrate new information into adaptive management feedback loop	**Response:** Flood results in significant loss of installed plants but large areas of naturally recruited native woody vegetation present **Action:** Monitor and evaluate survival of natural recruitment in the year following flood and evaluate density and function of surviving recruitment areas	**Response:** Flood results in extensive areas of erosion and deposition with sparse natural recruitment **Action:** Implement supplement revegetation in highest priority areas to support geomorphic stability and functions

Developing simple matrices and conceptual models, such as the example shown in Table 7-4, to anticipate potential site response to events that are either within or outside of design thresholds can provide a useful tool for managing projects so they achieve desired ecological functions. These tools would be developed by the adaptive management team and would allow them to develop a clear picture of how the system is expected to respond to project actions, how that response can be measured, and how the site will likely change over time. In addition, investing in this kind of forethought will allow the adaptive management team to anticipate potential responses of the system to extreme events or unexpected external inputs that may occur. If explanations and alternative actions are defined up front while planning the project, and they are documented in a simple form that can be revised periodically as needed, this will support relatively rapid decision-making when it is necessary to respond quickly to an unexpected event.

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9. Appendix A: Geomorphology Monitoring Protocols and Supporting Data

This section presents definitions and monitoring protocols related to channel cross section, slope, sinuosity, bedform complexity, bank erosion, and floodplain connectivity/stability. Supporting data for performance target development are also provided.

Definitions

Area - Channel cross-section area measured at bankfull conditions.

Bankfull discharge –The maximum discharge that the channel can convey without overflowing onto the floodplain.

Channel migration - Movement of a channel within a floodplain resulting from bank erosion and deposition.

Mean depth - Channel mean depth at bankfull conditions calculated as area divided by width.

Meander wavelength - A measure of channel pattern expressed as the distance between successive meander apexes.

Pools - The deepest channel segments, where the water surface slope at flows below bankfull is near zero.

Riffles - The sections of the bed with the steepest slopes and shallowest depths at flows below bankfull. Riffles typically occur at the cross over locations and have a poorly defined thalweg. Riffles typically have swiftly flowing, turbulent water; some partially exposed substrate, and relatively coarse substrate.

Runs - Runs differ from riffles in that depth of flow is typically greater and the slope of the bed is less than that of riffles. Runs are typically deep and fast with a defined thalweg and little surface agitation.

Sinuosity - A measure of channel pattern expressed as channel length divided by valley length or channel slope divided by valley slope.

Thalweg – The deepest part of a channel cross section.

Width - Channel width measured at bankfull conditions.

Width-depth ratio - A measure of channel shapecalculated by dividing bankfull width by mean bankfull depth.

Data Collection Field Protocols

Sampling protocols for geomorphology-related monitoring metrics are summarized in 9-1.

Table 9-1. Data collection protocols for CFR Reach A, Phase 1 geomorphology metrics.

Metric	Protocol Reference
Channel cross section Width Mean depth Maximum depth Area Bankfull elevation Water surface elevation Side channel cross sections	Harrelson et al., 1994
Channel profile Thalweg elevation Bankfull elevation Water surface elevation Slope	Harrelson, et al. 1994
Channel planform Sinuosity	Thorne, 1997
Bank erosion rate	Harrelson et al., 1994
Residual pool depth	Lisle, 1987

Identifying Bankfull Width and Bankfull Depth

The edge of the bankfull channel typically corresponds to the start of the floodplain (Figure 9-1). The floodplain typically supports perennial plants and trees, whereas within the bankfull channel, repeated flow-related disturbance and inundation does not support mature woody vegetation. The following primary indicators are used to characterize the edge of the bankfull channel and start of the floodplain:

- **Topography** - A berm or other break in slope from the channel bank to a flat valley bottom, terrace or bench;
- **Vegetation** - A change in vegetation from bare surfaces or annual water-tolerant species to perennial water-tolerant or upland species; and
- **Sediment Texture** - A change in the size distribution of surface sediments (e.g., gravel to sand/silt).

Field determination of bankfull stage is further described in a US Army Corps of Engineers Technical Note (Copeland, Biedenharn, and Fischenich, 2000) and Harrelson et al (1994).

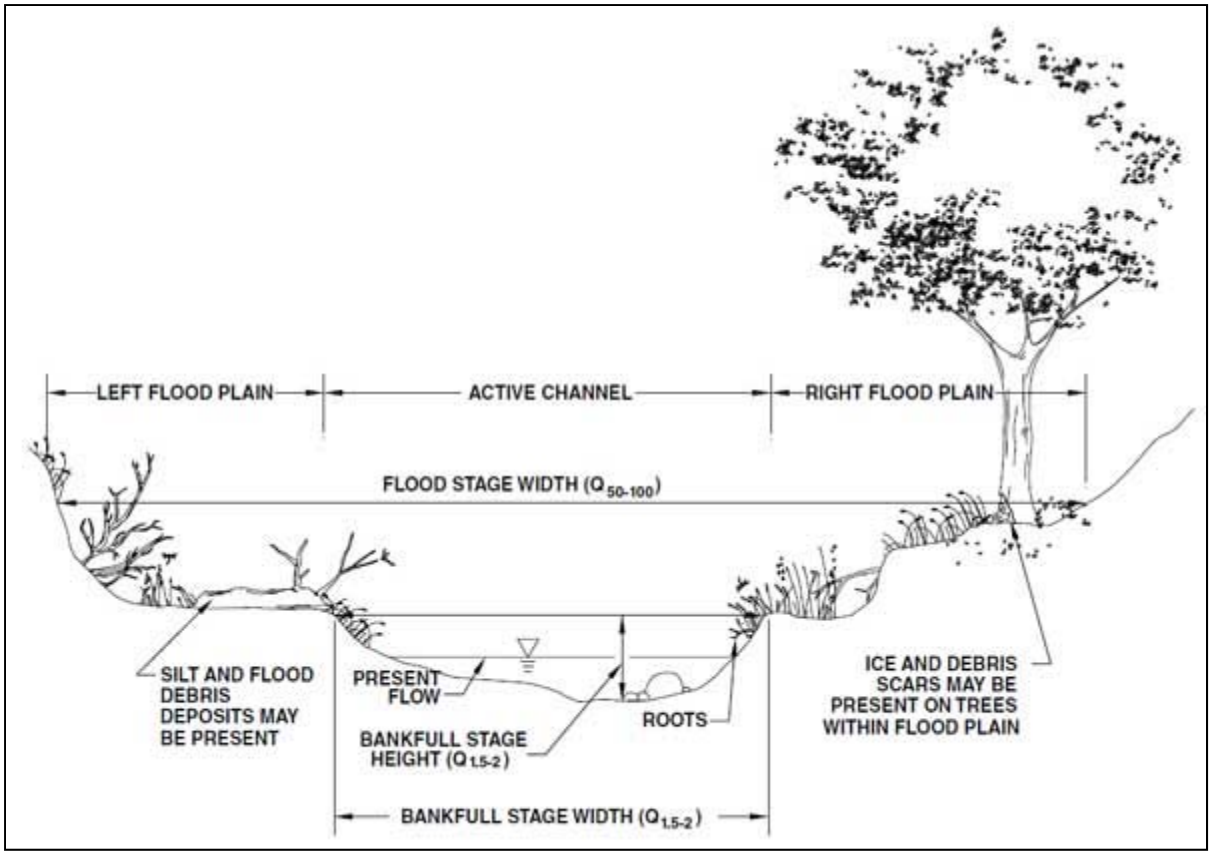

Figure 9-1. Schematic channel cross section (Groenier and Gubernick, 2012).

Channel Cross Sections

Cross sections will be surveyed using standard methods (Harrelson, 1994), and data will be collected either via a Total Station or survey grade GPS. Latitude/longitude should be recorded at either end of each cross section. Measurements will be collected from river left to river right (facing downstream), and measurements should be recorded to at least tenth of a foot. At least 10 points will be collected within the bankfull channel, including water edge, thalweg, and all significant slope inflection points. Photographs shall be collected of each cross section, with view upstream through section, view downstream through section, and from cross section mid-point of each bank.

Channel Profile

A longitudinal profile will be established for Phase 1. Data will be collected either via Total Station or survey grade GPS. The profile will include measurement of identifiable left and right channel bankfull indicators, thalweg, and water surface elevations. The channel flagging procedure as described in Harrelson et al. (1994) is not necessary, and survey points can be identified by stationing rather than pacing. Points will be collected on at least 100-foot spacing, with a higher density collected where necessary to document channel curvature.

Channel Planform

Both field survey and available aerial photography will be used to assess sinuosity. Channel length will be defined by the profile, and valley length will be assessed with aerial photography. Sinuosity will be calculated as the ratio of channel length to valley length.

Residual Pool Depth

Maximum pool depth will be measured as water depth at the time of data collection. Residual pool depth is the maximum water depth in the pool minus the depth at the hydraulic control (Figure 9-2) (Lisle, 1987). The hydraulic control is the point where the last trickle of water would flow out of the pool if inflows ceased, and this is typically at the crest of the downstream riffle. All pools will be attributed by locations via GPS. Data collected will include maximum water depth and water depth at hydraulic control. Pool length and average width will be visually estimated and recorded for documentation of approximate pool habitat area. Pools will be attributed in terms of process of scour including lateral scour, woody debris scour, pier scour, beaver dam, convergent channels, etc.

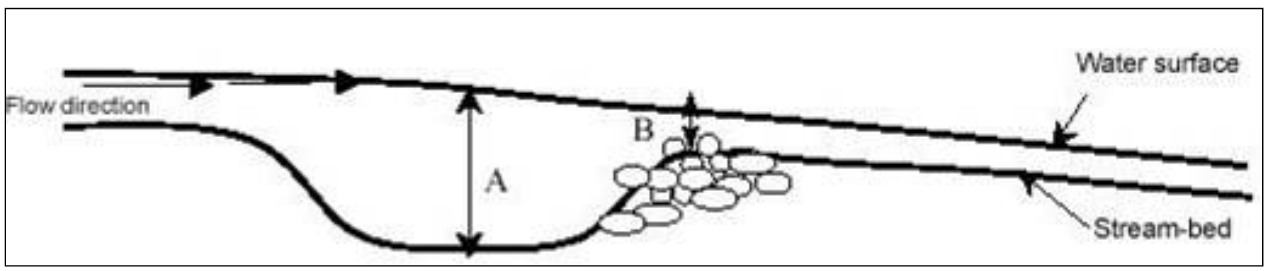

Figure 9-2. Profile schematic showing how residual pool depth is measured as A-B (VANR, 2004).

Bank Erosion

Bank erosion will be assessed at cross section locations via direct comparison of repeat sections (Harrelson et al., 1994). Sections will be overlain to identify extents and vertical locations of bank retreat through time. Where erosion is evident, it will be characterized in terms of materials and height above bank toe. Undercutting of bank toe will be documented as such.

Supporting Data for Performance Target Values

Channel Cross Section

Performance targets were developed from a series of 12 cross sections that were extracted from the floodplain design hydraulic model to quantify cross section dimensions under project conditions (Table 9-2). In the existing condition, width to depth ratios are notably low due to the entrenched channel condition and lack of bankfull identifiers in the cross section survey. Existing and design cross section overlay is approximate.

Table 9-2. Cross section data for CFR Reach A, Phase 1 extracted from 2009 survey (existing) and hydraulic model (design) to assess cross section morphology.

Parameter	***Cross Section***												
	19	***29***	***31***	***33***	***34***	***39***	***42***	***45***	***47***	***48***	***53***	***56***	***Mean***
Width (existing)	50.2	48.2	60.1	46.9	57.5	47.3	52.1	49.5	41.2	51.9	64.6	54.8	52.0
Width (design)	74.8	49.8	67.5	38.4	61.1	34.4	67.5	51.0	71.0	47.4	53.0	46.1	55.2
Depth (existing)	3.5	3.7	4.0	3.9	3.8	4.3	4.0	4.6	3.7	4.2	3.1	3.8	3.7
Depth (design)	3.2	2.8	2.0	2.0	1.7	3.6	2.2	3.1	2.5	2.7	2.2	3.8	2.7
W/D (existing)	14.4	12.9	14.9	11.9	15.3	11.1	13.1	10.7	11.2	12.2	20.8	14.3	13.6
W/D (design)	23.2	17.7	33.5	18.7	36.8	9.6	31.2	16.7	28.0	17.4	23.8	12.0	22.4

Channel Slope

Performance target values for channel slope are based on the existing channel slope, which was derived from the 2009 channel survey of Phase 1 (CDM and AGI, 2010) (Figure 9-3).

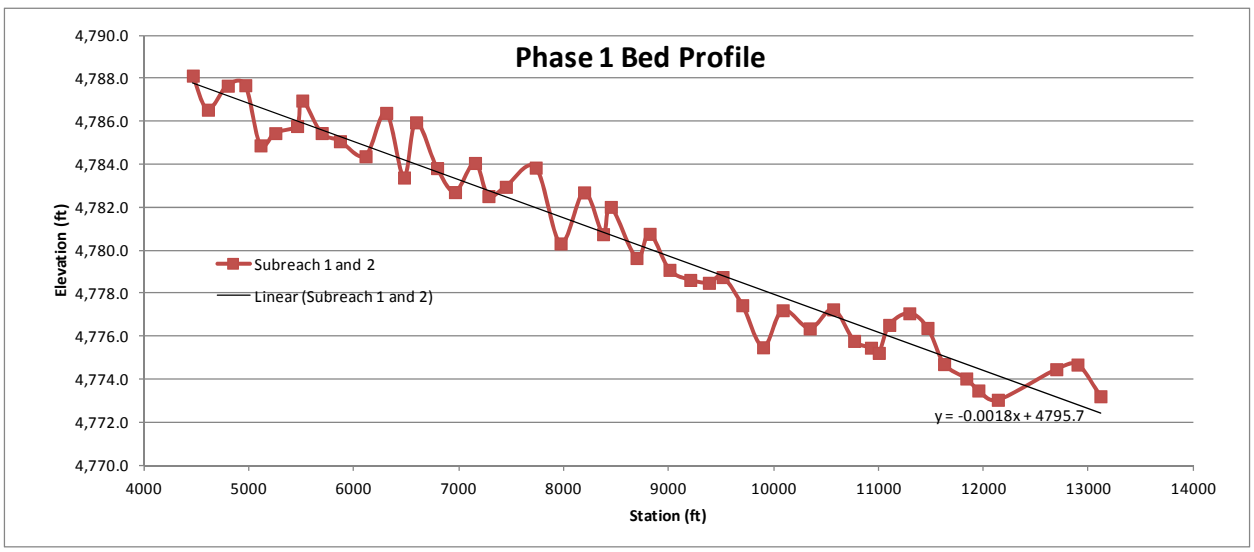

Figure 9-3. Channel profile for CFR Reach A, Phase 1.

Pool Density and Residual Pool Depth

Performance target values related to pool frequency and residual depths are derived in part from current conditions in subreach 4, which is a less-entrenched channel segment downstream from Phase 1 (Figure 9-6). Residual pool depth data derived from the 2009 survey for all subreaches are shown in Figure 9-4 (CDM and AGI, 2010). Pool frequency data derived from the 2009 survey for all subreaches are shown in Figure 9-5 (CDM and AGI, 2010).

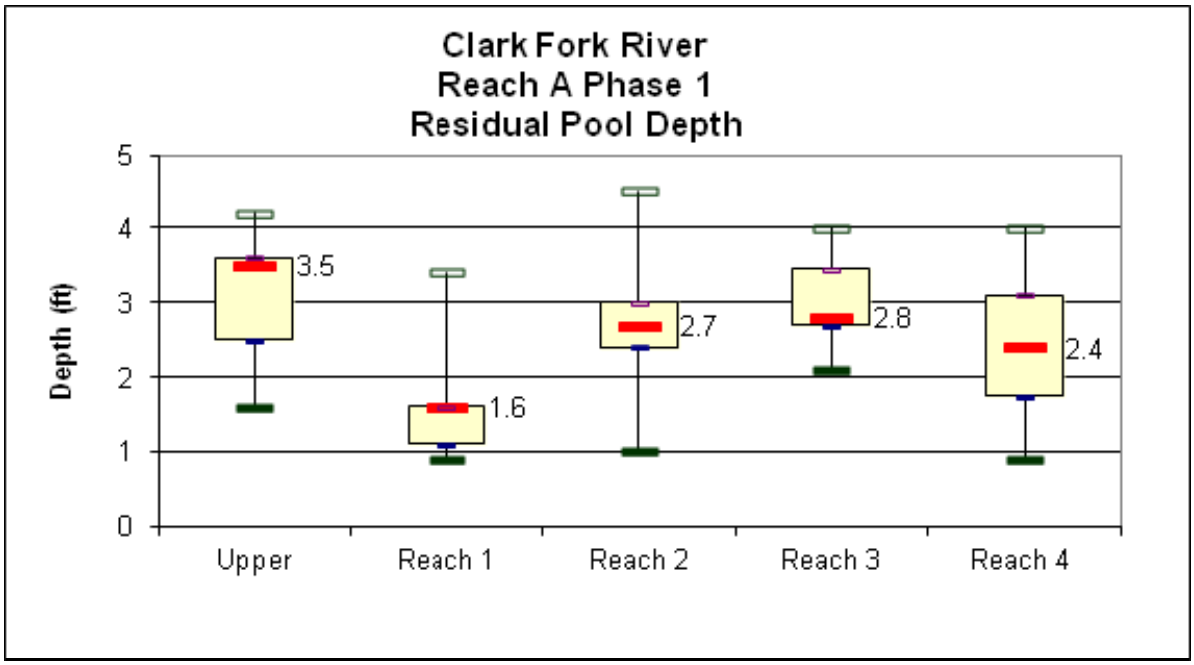

Figure 9-4. Residual pool depth measurements for Reach A, subreaches 1-4 (CDM and AGI, 2010).

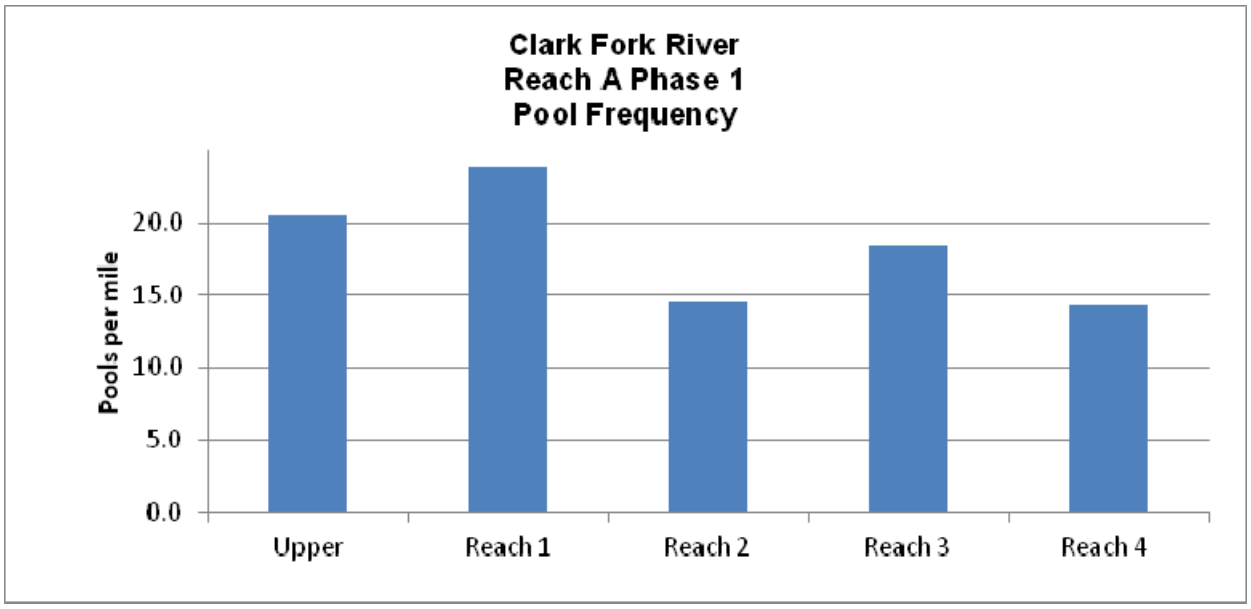

Figure 9-5. Pool frequency values in Reach A, Phase 1 (CDM and AGI, 2010).

Figure 9-6. CFR Reach A, Phase 1 geomorphic subreaches.

Appendix A References

CDM and AGI, 2010. Clark Fork Operable Unit Milltown Reservoir/Clark Fork River NPL Site Powell, Deer Lodge, and Granite Counties, Montana Part 2: Geomorphic, hydrologic and Hydraulic Investigation for Phase 1 Remedial Design/Remedial Action: Report prepared for Montana Department of Environmental Quality, Remediation Division, Helena, MT.

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10. Appendix B: Vegetation Monitoring Field Protocols

This appendix includes field monitoring protocols for vegetation metrics included Plan. Table 10-1 provides a definition of each vegetation related monitoring metric. The following sections provide field protocols for methods for collecting data for each metric.

Table 10-1. CFR Reach A, Phase 1 vegetation monitoring metric definitions and sampling methods.

Metric	Definition and Method
Canopy cover woody vegetation	Canopy cover woody vegetation is the percentage of the ground within a given area covered by woody species. Canopy cover of woody vegetation will be recorded in established plots to monitor plant community development. Standardized forms will be used to record canopy cover of woody vegetation less than 24 inches and greater than 24 inches.
Canopy cover herbaceous vegetation	Canopy cover herbaceous vegetation is the percentage of the ground within a given area covered by herbaceous species. Canopy cover of herbaceous species will be used to evaluate erosion control functions and development of plant communities. Canopy cover of herbaceous vegetation will be recorded in plots established along floodplain transects. Standardized forms will be used to record canopy cover.
Canopy cover noxious weeds	Canopy cover noxious weed species is the percentage of the ground within a given area covered by noxious weed species. Canopy cover of herbaceous vegetation will be recorded in plots established along floodplain transects. Standardized forms will be used to record canopy cover.
Canopy cover woody vegetation on streambanks	Canopy cover woody vegetation on streambanks is the percentage of the streambank within a given area covered by woody species. Canopy cover of woody vegetation will be recorded in plots established along treated streambanks. Standardized forms will be used to record cover.
Woody vegetation survival by species	Woody vegetation survival monitoring will be used to evaluate container plant installation in the short-term. Woody vegetation survival will be monitored by establishing permanent plots within planted areas.
Density	Density is the number of plants per unit area. Density will be measured in survival monitoring plots.
Proportional abundance floodplain cover types	Floodplain cover types are modified from Hauer and others (2002). These integrate vegetation, substrate, hydrology and geomorphic features, and represent a functioning floodplain when distributed proportionately. Floodplain cover types are described in detail in the Phase 1 preliminary design document. Short-term, the development of floodplain cover types will be evaluated using data collected in

	floodplain canopy cover monitoring plots. Long-term, floodplain cover types will be evaluated using a combination of aerial photograph interpretation and on-the-ground data collection. Standardized forms will be used to record data within monitoring plots to determine which ecological type or plant community is developing. Once floodplain cover type data are evaluated, the proportional abundance of established and developing cover types will be compared with desired cover type distributions.
Browse	The level of browse on woody vegetation will be evaluated by recording the category of browse observed on each plant monitored in woody vegetation survival plots.
Natural recruitment	Natural recruitment of desired woody species will be recorded in cover plots established along transects within the floodplain. Observations of natural recruitment will also be made in cover types where it is expected to occur.
Wetland delineation and function	Wetland areas will be delineated using the 1987 Army Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987). Based on this method, wetlands are defined as those areas having wetland vegetation, soils and hydrology. Standardized data forms and paired data points will be used to delineate wetland areas. Wetland functions will be evaluated using the Functional Effective Wetland Area method.

Data Collection Field Protocols

Canopy Cover Herbaceous and Small Woody Vegetation

Reference Forms: *Transect Survey* form and *Canopy Cover* data collection form, transect location overview figures, treatment conditions spreadsheets

Two field forms apply to establishing and monitoring canopy cover along floodplain transects:

- Form A: Transect survey Information
- Form B: Cover of substrates and herbaceous plants and cover of small woody plants

Transect and Plot Establishment (FORM A: TRANSECT SURVEY INFORMATION):

Equipment: clipboard; site maps; azimuth and geographic coordinates for each transect to be sampled (four coordinates per transect: start point, left side of main channel, right side of main channel, end point); resource grade GPS (with transect start and end points uploaded); 3-ft rebar (50 pieces/transect); 3-ft PVC pipe (25

pieces/transect); 4-ft rebar (4 pieces per transect); 4-lb sledge hammer; rebar caps (24 per transect); 200-ft tape; 100-ft tape; compass; digital camera; tripod; photo-reference pole marked in 6-inch increments; white board; black white-board marker; sequentially numbered aluminum tags; engravable aluminum tags; landscape staples, black permanent markers

Transect establishment:
Transect locations will be determined prior to establishing transects in the field. Upload transect coordinates to a resource grade GPS unit. Use the GPS to locate the mapped start point of each transect (coordinates obtained from GIS). Install a permanent monument at the start point using a 4-ft piece of capped rebar. The mapped start point will always be on the left side of the river (looking downstream). After installing the monument at the transect start, locate the point where the transect hits the left bank of the main channel using the GPS or by establishing an azimuth at the start point. Establish another monument at this location using a 4-ft piece of capped rebar. Clip a 200-ft tape to the rebar at the transect start point and run the tape out toward the main channel along the designated transect azimuth. Extend the 200-ft tape along the transect, with the zero end of the tape clamped on the rebar monument installed at the start point. Keep the tape as straight and as low to the ground as possible. At the location of the first cover sampling plot, drive a 3-ft piece of rebar 2/3rd into the ground. Record the location of the first plot by distance in feet along the transect and with the GPS. Continue along the 200-ft tape, establishing plots in designated locations as you proceed until all plots on the left side of the main channel are established.

After the transect and plots are established on the left side of the main channel, establish the transect and plots on the right side of the main channel starting at the right streambank along the same azimuth established on the left side of the channel. Monument the right bank start point using a 4-ft piece of capped rebar and continue with transect establishment using the method outlined above. Record the point on the right bank of the main channel as 0-ft. GPS the transect start and end points and all plot locations.

Install an engraved rectangular aluminum tag identifying on each of the four monuments with the transect id and position (left start, left channel, right channel, right end).

Plot establishment:
Each transect will have approximately 20 plots (see sampling design Figure 10-1). Plots will be stratified by floodplain design cover type and revegetation treatments. Transect and plot locations will be determined based on as-built conditions prior to establishing transect and plot locations in the field.

Once the position of a plot has been located along a transect, insert a 3-foot rebar 2/3rd of the way into the ground. This point, where the plot intersects the main transect line, is the “0-ft mark” for the plot. Record on the data form the side of the river on which the plot is located (left or right) and the distance in feet (1-inch resolution) from the start point of the transect.

At each plot location a 3-ft by 15-ft belt transect will be established. Establish the belt transect by running a 100-foot tape 15 feet from the 0-ft mark rebar along the transect azimuth plus 90^0. While setting up the sampling plot belt transect line, walk carefully along the south side of the transect line (and as far from the line as possible) to minimize damage to the vegetation. Any damage to plants adjacent to or along the line may influence vegetation measurements. At 15 feet, insert a 3-ft piece of rebar 2/3rd of the way into the ground.

After data has been collected for each plot (see Canopy Cover Data Collection below), install a sequentially numbered round aluminum tag at the rebar monuments at the 0-ft and 15-ft marks using staples or wire. Cover each piece of rebar with a 3-foot PVC tube and pound the PVC tube 1/3rd of the way into the ground. Write the transect # and plot # on the PVC tube using a pre-determined naming convention. Record the tag numbers on the data collection form.

Record the coordinates of the rebar monuments installed at the 0-ft and 15-ft marks for each transect using the GPS.

Photographs:
At each plot, take one photograph using a minimum 5 megapixel camera. Set the camera on a tripod that is positioned directly over the 0-ft rebar at the maximum height that the tripod can achieve while remaining level. Position the lens in portrait orientation with the 2-foot point on the tape (that runs along the belt-transect line) at the bottom of the frame and the 15-foot mark rebar at the top of the frame. Make sure the camera is zoomed out all the way.

Prior to taking a picture, write the plot ID in block letters on the white board using a black white-board marker. Plot IDs should be written according to a pre-determined naming convention. Below the Plot ID on the bottom right hand side of the white board, write the date (mm/dd/yyyy). Insert the photo reference pole into the ground 6 inches and prop the white board up against the bottom of the pole.

Comments on survey information:
For each plot, there is space to write comments on plot locations and survey information. Use this space to note any aspects of the plot that might affect plant establishment (e.g., if the plot is located on a compacted area, or if there is a log that crosses the line-intercept transect or falls within the subplot [see rules for including these]) or if substrates are particularly rocky, and any information that might help with plot relocation.

Canopy Cover Data Collection (FORM B: COVER OF SUBSTRATES, HERBACEOUS PLANTS, and SMALL WOODY PLANTS)

Equipment: clipboard; 2, 100-ft tapes; ruler; hammer; 4 spring clamps; 3-ft x 3-ft sampling frame; hand lens; black permanent markers; as-built plant lists; plant identification reference books; one-gallon zip loc bags; Forest Service Region One list of plant names and codes

Subplot location:
At each plot location, two 3-ft by 3-ft sub-lots will be established along the belt transect (Figure 10-1). For each plot, ground substrates, herbaceous plant cover, and cover of small woody plants (≤ 8 inches tall) will be sampled (Figure 10-1). The subplots will be located between 5 and 8 feet (subplot A) from the 0-ft mark along the belt transect and between 12 and 15 feet (subplot B).

For subplot A, position the subplot frame such that one edge is located along the belt transect line between 5 and 8 feet from the 0-ft mark. For subplot B, position the subplot frame such that one edge is located along the belt transect line between 12 and 15 feet from the 0-ft mark. If greater than 10% of the area of any subplot is covered by an obstruction to vegetation growth (tree bole, log, rock) larger than 6 inches in any dimension, offset the frame by 2 feet along the belt transect toward the 15-ft mark (e.g., position the subplot from 7 to 10 feet rather than 5 to 8 feet). Subplot A and B cannot be in the same location. Subplot A should always be closer to the 0-ft mark than subplot B. The two subplots can be adjacent (i.e. directly next to each other along the belt transect or established directly adjacent to the left and right of the belt transect).

Record on the data form the distance along the belt transect from the 0-ft rebar to the start of the A and B subplots.

Cover resolution:
Cover resolution are as follows: round values between 0 and 1% to the nearest 0.1%; between 1 and 10% to the nearest 1%; and those >10% to the nearest 5%. Cover equivalents are as follows: 1 x 1 cm = 0.01% cover; 1 x 10 cm = 0.1% cover; and 10 x 10 cm = 1% cover.

Cover of substrates:
Record total cover of substrates, using the following ground-surface-condition codes:

- BARE = Bare ground that is not covered by plant canopy (e.g., a falling raindrop would hit), including mineral soil, small rocks or gravel (< 6 inches in the narrowest dimension)
- LITTER = Ground that is covered by accumulated plant material (< 6 inches in the narrowest dimension)
- LOG = Logs, snags, or natural stumps (> 6 inches in narrowest dimension).
- TREEBASE = Base, buttress, or exposed roots of a live tree or shrub (> 6 inches diameter at the intersection with the ground).
- STONE = Stone (≥ 6 inches in narrowest dimension).
- NON-VASCULAR PLANTS = Bryophytes or algae

If LOG, TREEBASE, or STONE is covered by > 2 inches of mineral soil or litter, record as BARE not as the underlying substrate.

Cover of herbaceous plants and of woody plants ≤ 8-inches tall:

Individual species' cover will be recorded for 1) herbaceous species (including ferns and their allies, graminoids, forbs, subshrubs) and for 2) woody plants (shrubs and trees) less than or equal to 8-inches tall. List each species separately on the data collection form by full scientific name (Species Name) and the six character acronym in (Species Code) and the cover in the appropriate plot column. Record cover for all foliage that falls within the subplot, even if the plant is rooted outside of the plot.

Unknown plants:
Code any species that cannot be identified at the time of sampling as a unique unknown and describe the plant in detail on the field sheet. Collect a sample from outside of the subplot (include roots/rhizome, stem, leaves, and flowers/fruits if possible) and place in a one-gallon zip-loc bag for subsequent identification. Use black permanent marker, and record the following information either on the collection bag or on an index card placed inside the collection bag: the collector's last name, the date, location (project name, transect id, plot, and subplot where the specimen was found), and a description of the plant and/or habitat. Record the unique unknown code for each plant on the data collection form. Once the plant is identified, the unknown code on the data forms will be replaced with the species name.

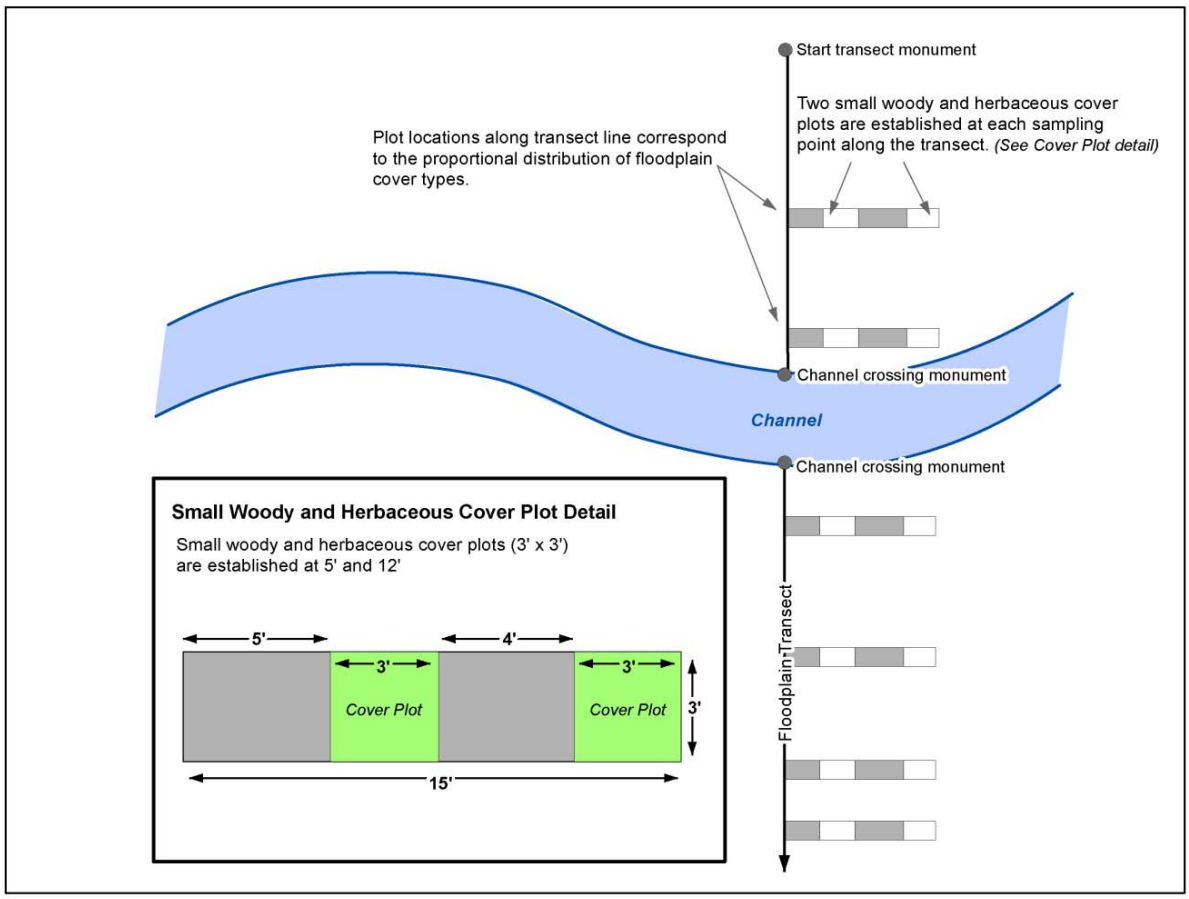

Figure 10-1. Sampling design for floodplain transects showing approximate locations of small woody and herbaceous cover subplots.

Canopy Cover Large Woody Vegetation

Reference forms: *Canopy Cover* data collection form, plot location overview figures.

Equipment: Resource-grade GPS (with plot locations uploaded), digital camera, clipboard, sufficient copies of data forms, two 200-foot fiberglass tape measures, 6-foot measuring stick partitioned into 6-inch increments, pencils

Plot establishment and monitoring setup:
Use the canopy cover plot location overview figures and GPS to locate each plot. Note whether the plot will be a 30-foot or 50-foot plot. The example below is described for a 50 foot plot. For a 30 foot plot, measurements and increments will need to be adjusted and are described after the 50 foot plot instructions.

Create your plot perimeter by starting at a selected point A and securing the end of the 200-foot tape (Figure 10-2). Extend the 200-foot tape 50 feet to point B and secure the tape again. Turn at a 90 degree angle and extended another 50 feet to point C and secure the tape again, turn at a 90 degree angle and extended another 50 feet to point D and secure the tape again and finally turn at a 90 degree angle and extended another 50 feet, returning to point A and secure the tape. At each corner before securing the tape, make sure the tape is as low to the ground as feasible and remove any slack in the tape (Figure 10-3).

Recording woody vegetation cover:
Hold the stick vertically at Point A (Figure 10-2), which is the zero mark on the tape. If the stick contacts any part of a woody plant, record this point as a hit. Repeat this measurement along the AB line in five foot increments, finishing at the 50-foot mark for a total of 11 points along the perimeter line. Repeat this process for transects 2 through 11 as shown on Figure 10-2. This will result in a total of 121 observations within a 50-foot x 50-foot plot, so the canopy cover in the plot should be calculated as the number of hits divided by 121.

In some instances, the floodplain geomorphology and river channel may not allow for a 50-foot plot size. In this case, a 30 foot plot size can be used. The process described above will be the same; however, transects should be spaced only 3 feet apart and presence or absence of woody plants should be assessed in 3 foot increments along the transects.

Photographs:
Take one photograph looking into the plot from each of the four corners for a total of four photos.

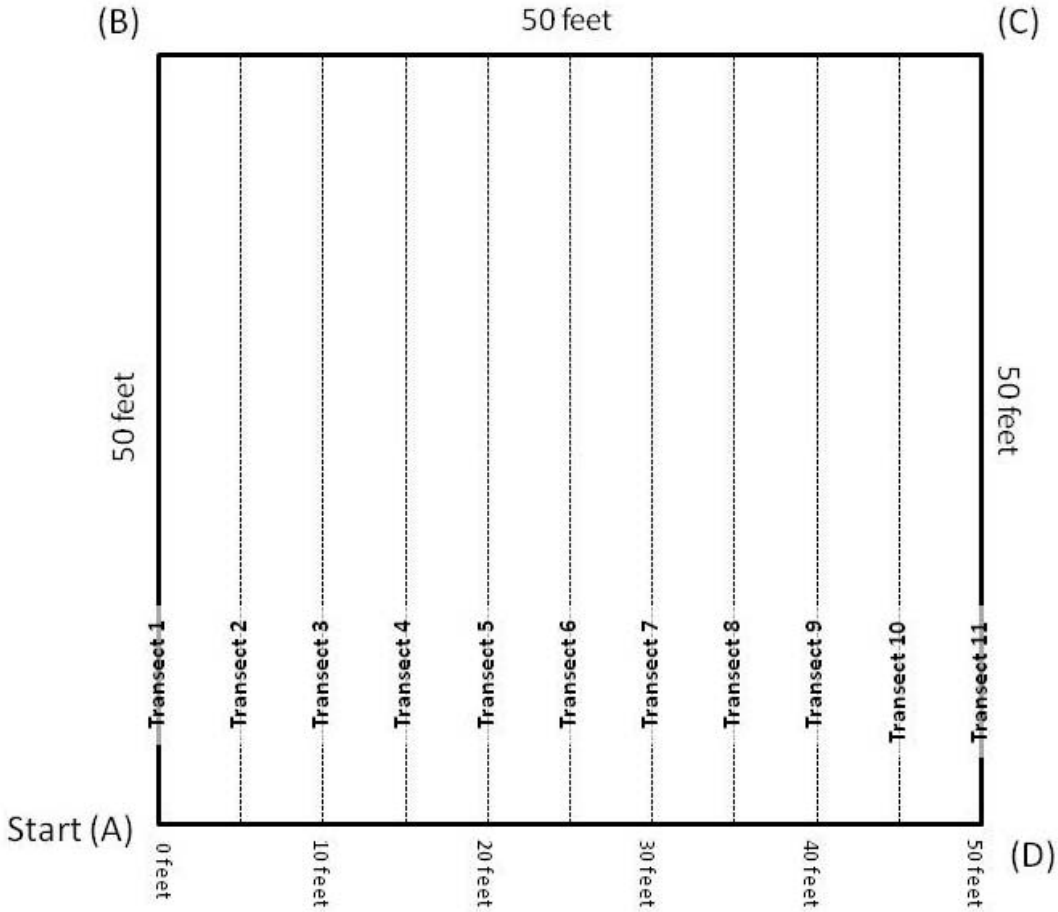

Figure 10-2. Schematic of floodplain canopy cover plot, showing 11 transects. Canopy cover assessments will be performed at five foot increments along these transects starting at 0 feet for a total of 121 sampling points.

Figure 10-3. Canopy Cover plot perimeter. Photo from Clark Fork River Milltown site showing perimeter measuring tape.

Canopy Cover Woody Vegetation on Streambanks

Reference forms: *Streambank Canopy Cover* data collection form, streambank structure location overview figures for each reach, plant lists with 6-letter species codes

Equipment: clipboard; resource grade GPS (with structure locations and origin points uploaded); digital camera; tripod; sufficient hard copies of data forms; 300-foot tape; two measuring sticks with 6-inch increments marked; sufficient 12-inch x ½-inch pieces of rebar; flat ½-inch rebar caps for length of structure being monitored; 4-lb sledge hammer; spring clamps; white board; black white board markers; pencils; compass

Plot establishment and monitoring setup:
All treated streambanks within the project area will be given a unique identifier and an as-built figure identifying streambanks by id will be developed after as-built surveys are completed. Use the treated streambank as-built overview figure to locate streambanks to be monitored for the first time. Use the structure location overview figures and GPS to locate the upstream origin of each structure. Install a 12-inch piece of rebar with flat rebar cap on the top surface of the structure, approximately 12 to 18 inches behind the front edge of the structure/river bank line. This monument will serve as a permanent origin point for the establishment of monitoring plots along the length of the structure. GPS the rebar location using a pre-determined nomenclature such as: structure id and US origin.

Secure the 300-foot tape to the origin rebar using a spring clamp and ensuring that the 0-foot mark is flush with the rebar. Place tape as close as possible to the front of the structure, but ensure that installed cuttings will not interfere with the tape laying flush on the structure surface. Extend the tape along the structure until either the end of the structure is reached or the tape is exhausted (structure is greater than 300 feet in length). Install additional rebar monuments at 50-foot intervals along the structure in the same manner as the origin rebar. These monuments will serve as distance benchmarks for repeating monitoring. If the structure length exceeds 300 feet, repeat this process from the 300-ft rebar monument after monitoring of the initial 300-ft length is complete. Leave the tape lying on the surface of the lift as monitoring is performed. This will allow the observer to identify the location of each monitoring plot at the prescribed distance interval along the structure.

Measuring from the origin rebar, establish a 6.5-foot by 3-foot plot at the 30-foot mark along the tape. Each plot should extend 6.5 feet along the structure face as measured from an even 30-foot interval (e.g. Plot #1 extends from 30-ft to 36.5-ft, Plot #2 extends from 60-ft to 66.5-ft). Figure 10-4 shows the orientation of the 6.5-foot by 3-foot plots on each bioengineering structure. Each 6.5-foot plot will extend 3 feet from the origin of willows on the top of each structure (Figure 10-4). Plot dimensions can be established using the 300-foot tape as a linear reference and the two measuring sticks as the perpendicular reference for toward-channel plot boundaries (Figure 10-5).

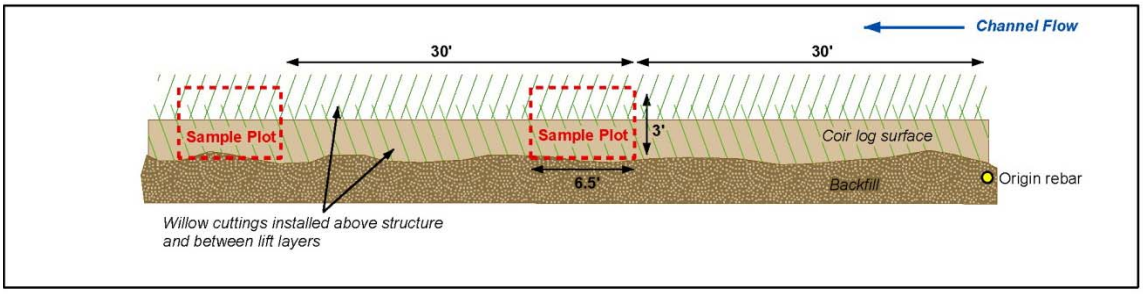

Figure 10-4. An overview of monitoring plot establishment on vegetated soil lift structures.

Figure 10-5. Photograph showing the use of two partitioned measuring sticks to delineate a monitoring plot on the face of a vegetated soil lift.

Recording woody vegetation cover:
Record the distance at which the 6.5-foot by 3-foot plot was established along the 300-ft interval in the 'Distance' column on the *Streambank Canopy Cover* data collection form. Within each 6.5-ft by 3-ft plot, record percent cover of woody vegetation using the *Streambank Canopy Cover* data collection form.

To record percent cover of woody species within each 6.5-ft x 3-ft plot, stand on the top surface of the structure. Establish a visual plane that corresponds to the 6.5-ft x 3-ft plot dimensions. Within this plane, assess the cover of leafy material growing from woody species (do not include cover provided by woody stems). Record cover according to the following resolution: for cover less than 10%, use 1% resolution; for cover greater than or equal to 10%, use 10% resolution.

Other non-woody species: Record a list of all herbaceous species found within the 6.5-ft x 3-ft plot in the 'Other non-woody species' field using the appropriate six-letter species code.

Photographs:
Prior to taking the pictures, write the structure ID in block letters on the white board using a black white board marker. Structure IDs should be written according to a pre-

determined naming convention such as: Structure ID/Bank/Photo Orientation. Below the Plot ID on the bottom right hand side of the white board, write the date (mm/dd/yyyy). Position the white board so that it is oriented at the bottom center of the photograph.

Two sets of two photographs should be taken of each structure. Each set should consist of a portrait oriented photo and a landscape oriented photo. Take the first set of photographs at the upstream end of the structure looking downstream. Set up a tripod so that the camera is positioned directly over the origin rebar at a height of 4 feet. Position the lens to capture as much of the structure length as possible, looking directly down the front edge of the structure.

Take the second set of photographs at the downstream end of the structure looking upstream. Set up a tripod so that the camera is positioned directly over the downstream terminus of the structure at a distance from the front edge of the structure equivalent to the upstream origin rebar location. Position the lens to capture as much of the structure length as possible, looking directly up the front edge of the structure.

Take additional photographs to document conditions of the streambank or individual plots, or to provide photo-documentation of recorded data. To document cover in a specific plot, position the camera on the tripod on the face of the structure so that the field of view roughly corresponds to the plot dimensions. Position the partitioned measuring stick along one edge of the plot boundary as a reference for the plot location and dimensions in the photo. For any supplemental photos taken, record a photo number and description in the 'Notes' section at the bottom of the *Streambank Canopy Cover* data collection form.

Woody Plant Survival and Density

Reference forms: *Survival Plot* data collection form, plot location overview figures and data for repeat monitoring, planting unit overview figures for establishing new plots, as-built plant species and quantities for establishing new plots, plant lists with 6-letter species codes

Equipment: clipboard; resource grade GPS (with plot corner points uploaded if navigating to established monitoring plots); digital camera; sufficient hard copies of data forms; 100-ft tape; sufficient 18-inch x ½-inch pieces of rebar; ½-inch large mushroom rebar caps for number of plots being established; 4-lb sledge hammer; black permanent markers; white board; black white board markers; sufficient sequentially numbered id tags for number of plants being monitored; pencils; compass; measuring stick with 6-inch increments marked; plant identification reference books; one-gallon zip loc bags

Plot establishment and monitoring setup:
All planting units within the project area will be given a unique identifier and an as-built figure showing units by this ID will be developed after as-built surveys are completed. Use the as-built planting unit overview figure to locate planting units to be monitored for the first time. Once plots are established, a GIS layer will be developed with monitoring

plot locations. For repeat sampling, a plot location overview figure will be developed and used to locate established monitoring plots along with uploaded GPS coordinates.

Locate each planting unit to monitor and determine the monitoring plot location within the planting unit. The plot size for each unit will be based on sampling a specified number of plants and will be determined prior to sampling.

Monument plot corners for each monitoring plot. For planting swales in which all installed plants will be monitored, use the swale boundary as a visual guideline for monumenting monitoring plot corners. Establish rebar monuments at the upstream and downstream extents of the swale monitoring plot (Figure 10-6). Monuments should consist of 18-inch rebar and a large rebar cap. Write the identification of each corner on the rebar cap. Record each monument location using the Trimble GPS. Record the same identification in the GPS unit as written on the corner monument.

For planting units in which only a portion of installed plants will be monitored, it is necessary to define the extents of the survival monitoring plot within the larger planting unit prior to monumenting plot corners (Figure 10-6). Visually estimate an area that includes approximately the number of plants to be monitored and temporarily cordon off this area. With the approximate area defined (using either the 100-foot tape, string, or spray-paint markings on the ground) count the exact number of plants within the defined boundary. Redefine the plot extents as necessary in order to capture the prescribed number of plants to be monitored and install corner monuments.

Recording survival:
Record every planted plant that occurs within the monitoring plot using the *Survival Plot* data collection form. Record the plant species encountered using the appropriate six-letter code in the 'Species' column of the form. Tag each plant with a pre-numbered tag. Record the number on the tag in one of the 'Plant ID' fields for that species. Record survival data for the plant in the 'Survival' field next to 'Plant ID' using the numeric code for alive or dead (1 = alive, 0 = dead).

Continue to record individual plants of each species in additional field next to the 'Species' column. Add additional species to the 'species' column as they are encountered and record data for and tag each individual plant of that species as described above.

Record a list of dominant herbaceous species present in the plot in the 'Notes' section at the bottom of each form. Include all noxious weeds observed.

Record any additional notes on the monitoring plot in the 'Notes' section at the bottom of each form. Record any information or details relating to revegetation trends, hydrologic function, and indicators of animal presence that may be influencing plant survival in the plot or other plant community development trends.

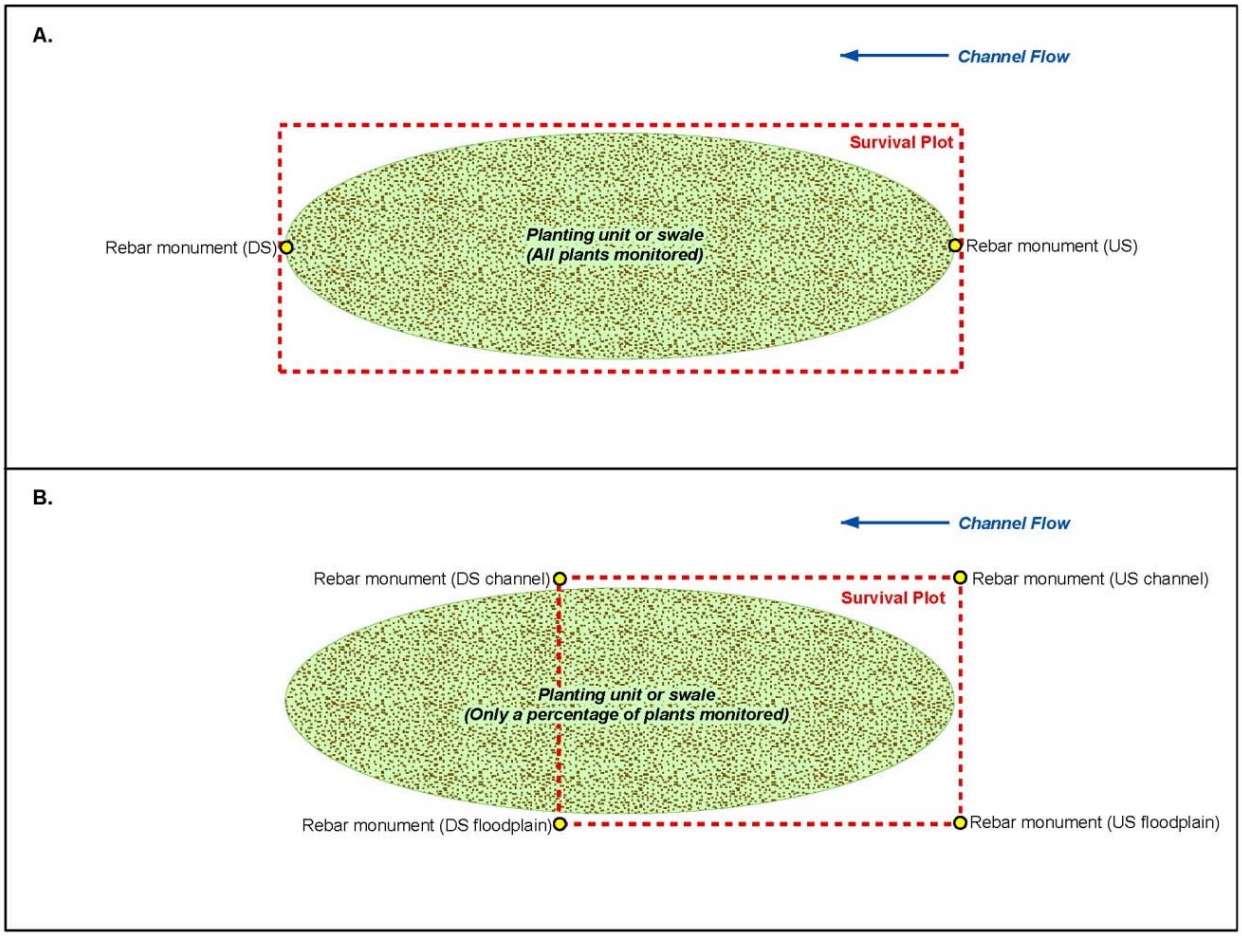

Figure 10-6. Example of survival monitoring plots in A) swales for which all plants will be monitored, and; B) planting units for which only a portion of plants will be monitored.

Recording Density:
The total number of woody plants (trees and shrubs) should be tallied in survival monitoring plots. All species present should be recorded using the full species name and the six-letter character species acronym. Presence is determined not by canopy cover but by rooting position (i.e. where the tree or shrub base enters the litter layer).

Photographs:
Take photographs at all monumented plot corners. Orient photos toward opposing monumented plot corners if possible to capture the entirety of the plot. Photographs should be taken from opposing monumented corners in order to catch the greatest field of view within the plot. Take two photos at each location – one with portrait orientation, and one with landscape orientation. If additional photo points are necessary to capture the entire plot, monument the points using rebar similar to plot corners.

Prior to taking a picture, write the Plot Corner ID in block letters on the white board using a black white board marker. Below the Plot ID write the date (mm/dd/yyyy) the photograph is taken. Record the azimuth for the photo below the date. Insert the partitioned measuring stick into the ground immediately adjacent to the plot corner

monument. Place the white board so that it leans against the partitioned measuring stick. Measure a distance of 5 feet from the plot corner moving away from the plot to take the photograph so the whiteboard is oriented directly at the bottom center of the picture frame. Record the Plot Corner ID in the 'Photo Point ID' field on the form. Record the photo azimuth and any additional notes in the fields following 'Photo Point ID'.

Take additional photographs as necessary to record conditions within each monitoring plot. For example, photos of browse severity, animal use, plant health concerns, plant vigor, evidence of deposition or scour, colonization by desirable plants, or maintenance needs could be photographed. These additional photos should be noted on the form for in the 'Notes' section at the bottom of the form. Use the partitioned measuring stick within the photo frame where plant height or other size references are appropriate.

Floodplain Cover Types

Short-term, floodplain cover types will be evaluated using data collected in floodplain transect cover plots (see Cover Herbaceous and Small Woody Vegetation field protocols) and woody vegetation survival, density and cover monitoring plots (see Woody Vegetation Survival, Density and Large Woody Vegetation Cover). Long-term, as plant communities mature, GPS surveys and aerial photographs will be used to delineate plant communities that have developed within the Phase 1 project area.

Natural Recruitment

This metric will be evaluated using data collected in transect cover plots (see Cover Herbaceous and Small Woody Vegetation).

Browse

Record the observed level of browse for the plant in the 'Browse' field of the *Survival Plot* data collection form using the following browse level codes:

0: No browse;
1: Mild browse – less than 50% of current year's growth browsed;
2: Mild browse – greater than 50% of current year's growth browsed;
3: Moderate browse – two to three year old growth exhibits browse;
4: Heavy browse – browse has resulted in arrested growth form or plant mortality

Take photographs as necessary to record conditions of browse severity. Use the partitioned measuring stick within the photo frame where plant height or other size references are appropriate.

Wetland Delineation and Functional Assessment

Wetland areas will be delineated using the 1987 Army Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987). Wetland functions will be evaluated using the Functional Effective Wetland Area (FEWA) method (ARCO 1992).

Appendix B References

ARCO. 1992. Atlantic Richfield Company Evaluation Form for Determining Wetland Functional Value and Effective Wetland Areas in Upper Clark Fork River Superfund Sites. August, 1992.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual, Technical Report Y-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Hauer, F.R., Cook, B.J., Gilbert, M.C. 2002. A regional guidebook for applying the Hydrogeomorphic Approach to Assessing Wetlands Functions of Riverine Floodplains in the northern Rocky Mountains, ERDC/EL TR-02-21, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

11. Appendix C: Summary of Existing Performance Standards

This appendix provides supporting data for development of the CFR Reach A, Phase 1 vegetation performance target values and compares differences in performance targets included in this Plan with certain Performance Standards included in the Clark Fork River Operable Unit (CFROU) Record of Decision (ROD) (USEPA 2004).

As specified in Section 13.11.1.2 of the ROD, vegetation Performance Standards may include, but will not be limited to, the following variables:

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

Table 11-1 indicates if Performance Standard values for these variables are included in the ROD and how this monitoring plan addresses those variables. The ROD specifies interim survival rate targets for planted woody plants, canopy cover of preferred woody species, and total canopy cover of non-weed perennial vegetation (woody and herbaceous together) for areas within the Riparian Buffer Zone (within 50 feet of main channel) and outside the Streambank Riparian Buffer Zone but within the historic 100 year floodplain. The ROD also includes Performance Standards for the non-riparian vegetation areas (outside of the historic 100-year floodplain) but those are not addressed specifically in this monitoring plan.

Table 11-1. Comparison between Performance Standards specified in the ROD for streambank riparian buffer zone and performance targets included in the CFR Reach A, Phase 1 Monitoring Plan.

ROD Performance Standard Category	ROD Specified Value: Streambank Riparian Buffer Zone (50 feet from channel)	ROD Specified Value: Outside the Streambank Riparian Buffer Zone but within the historic 100-year floodplain	Monitoring Plan Performance Target
Woody browse levels	No value specified. Livestock grazing may be allowed 5 years after implementation of remedial treatment when the RipES polygon has exceeded all minimum canopy cover vegetation standards and in compliance with ranch management plan language.	Grazing may resume after 2 years if non-weed perennial vegetation reaches at least 98% and in compliance with the management plan written for the property.	Browse will be measured in containerized planting areas but no performance target value is assigned.
Completeness of the canopy within the streambank buffer	80% cover of preferred species of woody plants as quickly as practicable to control streambank erosion. 50% preferred woody species by year 5, 60% by year 7 and 80% by year 10.	No	40% cover of preferred woody species by Year 5. 60% cover of preferred woody species by Year 10. 80% cover of preferred woody species by Year 15.
Vegetation Cover	Achieving and maintaining an essentially complete (98%) canopy cover of combined woody and herbaceous perennial vegetation to prevent invasion of weeds. 90-98% cover of non-weed perennial vegetation by year 1, 95-98% by year 2, 98% for years 4, 5, 7 and 10. 98% canopy cover of combined woody and herbaceous perennial vegetation to prevent invasion of weeds. Herbaceous vegetation must have 98% cover byyear 1 through year 10.	90-98% cover of non-weed perennial vegetation by year 1, 95-98% by year 2, 98% for years 3 and 5. 98% canopy cover of combined woody and herbaceous perennial vegetation to prevent invasion of weeds. Herbaceous vegetation must have 98% cover by year 1 through year 10. Upland areas: 45% Ag Upland grazing: 45%, Ag Crop: no standard, but production is equivalent to county average. Recreational: 45% in upland areas,	Native species present in greater than 80% of restoration area and greater than 20% total cover by Year 1, 50% by Year 3 and 80% by Year 5. Average canopy cover of woody vegetation in the floodplain is 30% by Year 5 and 50% by Year 10.

ROD Performance Standard Category	ROD Specified Value: Streambank Riparian Buffer Zone (50 feet from channel)	ROD Specified Value: Outside the Streambank Riparian Buffer Zone but within the historic 100-year floodplain	Monitoring Plan Performance Target
	Cover by species (noxious weeds count 0, undesirable weeds count a maximum of 5% toward live cover.	100% in riparian areas, Residential/Parks: 45% in upland areas, 100% in riparian areas, Cover by species (noxious weeds count 0, undesirable weeds count a maximum of 5% toward live cover.	Noxious weeds <5% cover
Production	No	No	No
Species Richness (Each species must account for greater than or equal to 1 percent of the live plant canopy cover. Invasive species and undesirable weedy species do not count.)	No	Open space and wildlife habitat: N/A, Upland areas: 5species/100 sq. meters Ag Upland grazing: 5species/100 sq. meters Ag Crop: N/A Recreational: 5species/100 sq. meters for upland species, Residential/Parks: appropriate for type of residence or park.	No
Structural diversity	No	No	No
Maturation periods	No	No	No
Plant reproduction	No	No	Metric will be measured but no performance target value assigned.
Evidence of successional processes	No	No	Metric (development of ecological types) will be evaluated but no performance target value assigned.

Comparison between ROD Performance Standards and Monitoring Plan Performance Target Values

This section compares Performance Standards specified in the 2004 ROD with performance target values specified in this Plan. Table 11-2 compares canopy cover of vegetation Performance Standard in the ROD with the performance targets included in this Plan.

Table 11-2. Comparison of canopy cover Performance Standards specified in the ROD and the performance targets in the CFR Reach A, Phase 1 Monitoring Plan.

After Year Number	ROD: Percent Total Canopy Cover of Non Weed Perennial Vegetation[1]	Monitoring Plan: Percent Total Native Canopy Cover[2]	Monitoring Plan: Percent Woody Vegetation Canopy Cover[2]	ROD: Percent Canopy Cover of Preferred Woody Vegetation in Streambank Bufffer Zone	Monitoring Plan: Percent Preferred Woody Species Canopy Cover Along Streambanks
1	90-98	20	N/A	N/A	N/A
2	95-98	N/A	N/A	N/A	N/A
3	98	50	N/A	N/A	N/A
5	98	80	30	50	40
7	N/A	N/A	N/A	60	N/A
10	N/A	N/A	50	80	60
15	N/A	N/A	N/A	N/A	80

[1] Values are for Streambank Riparian Buffer Zone and Outside Streambank Riparian Buffer Zone but within 100-year Floodplain

[2] These values apply to the entire CFROU Reach A Phase 1 floodplain which extends beyond the 50 feet buffer indicated in the ROD. The riparian buffer values are more applicable to this area

The ROD includes a percent total cover of non-weed perennial vegetation Performance Standard value of 90-98% for year 1, 95-98% for year 2 and 98% for years 3 and 5. No values are specified beyond year 5. For total native canopy cover, this Plan includes a performance target value of 20% cover at year 1, 50% at year 3 and 80% at year 5. No values are specified beyond year 5. Justification for these values is provided in Section 4.

The ROD includes a cover of preferred woody vegetation in the streambank buffer zone Performance Standard value of 50% at year 5, 60% at year 7 and 80% at year 10. The ROD values apply to preferred woody vegetation cover in the Streambank Riparian Zone which includes 50 feet along the channel. This Plan includes a performance target value for cover of preferred woody species along treated streambanks of 40% at year 5, 60% at year 10 and 80% at year 15. This value applies to the treated streambank only. Outside of the streambank, this Plan includes a value of 30% cover at year 5 and 50% cover at year 10 for cover of woody vegetation in the floodplain.

Table 11-3 compares the Performance Standard values for percent planted woody species survival in the ROD with the performance target values included in this Plan. In year 1, the ROD indicates survival of planted woody species will be 90%. The ROD also includes 90% survival for year 2, and does not specify a value for years 3 through 5. This Plan uses a value of 80% survival after the first growing season (year 1) and does not include a percent survival value for any subsequent years. Between years 1 and 5, this Plan uses woody plant density to evaluate planted tree and shrubs. Beyond year 5, both the ROD and this Plan switch from using survival to canopy cover to evaluate planted shrubs and trees.

Table 11-3. Comparison of woody species survival Performance Standards specified in the ROD and the performance targets in the CFR Reach A, Phase 1 Monitoring Plan.

After Year Number	ROD: Percent Planted Woody Species Survival	Monitoring Plan: Percent Planted Woody Species Survival
1	90	80
2	90	Density does not decrease
3	N/A	Density does not decrease
4	N/A	Density does not decrease
5	50% canopy cover of preferred woody species.	Density does not decrease 30% canopy cover of native woody vegetation
7	60% canopy cover of preferred woody species.	N/A
10	80% canopy cover of preferred woody species	50% canopy cover of preferred woody vegetation

Appendix C References

U.S. Environmental Protection Agency. 2004. Record of Decision, Clark Fork River Operable Unit of the Milltown Reservoir/Clark Fork River Superfund Site. U.S. EPA Region 8. April, 2004.