Kootenai River Habitat Restoration Project

Braided Reach, Phase 1 Monitoring Plan

November, 2011

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1 Overview of Adaptive Management and Monitoring Plan for Phase 1 Projects

This document describes the adaptive management and monitoring approach for the Braided Reach, Phase 1 projects. The overall adaptive management framework and approach is described in more detail in the *Kootenai River Habitat Restoration Master Plan* (Master Plan, KTOI 2009) and the *Kootenai River Habitat Restoration Project Braided Reach, Phase 1 Feasibility Analysis and Preliminary Design* (Preliminary Design Report, KTOI 2010). This document focuses on specific monitoring metrics, protocols, responsibilities and schedule for the Phase 1a and 1b projects.

Adaptive Management incorporates the scientific method into a management framework to resolve a specific problem or problems. In large-scale projects, such as the Kootenai River Habitat Restoration Project, adaptive management considers, and is a part of, the multiple stages of restoration such as planning and design, implementation, monitoring and maintenance. Decision-making is supported by new information that is generated by project-specific effectiveness monitoring, in addition to related research, monitoring and evaluation programs that focus on various components of the Kootenai River ecosystem. The primary purpose of adaptive management is to reduce the uncertainty inherent in managing natural systems so decisions about future project phases are informed by information from earlier project phases and targeted experiments. Effectiveness monitoring from Phase 1 projects will support future management of those projects, and help guide design efforts for future projects.

An Adaptive Management Team made up of a core group of individuals who represent the co-management agencies and design team, will use new information generated by the Phase 1a and 1b projects, and other existing information to adaptively manage Phase 1 projects and subsequent phases of the project. This adaptive management framework will incorporate an iterative process where decisions and metrics are modified in later project phases if objectives are not met, or if new information becomes available (see Master Plan 5.2 for conceptual figure). The Adaptive Management Team core group will be supported by a number of technical advisors with expertise in specific aspects of the restoration project (Figure 1-1).

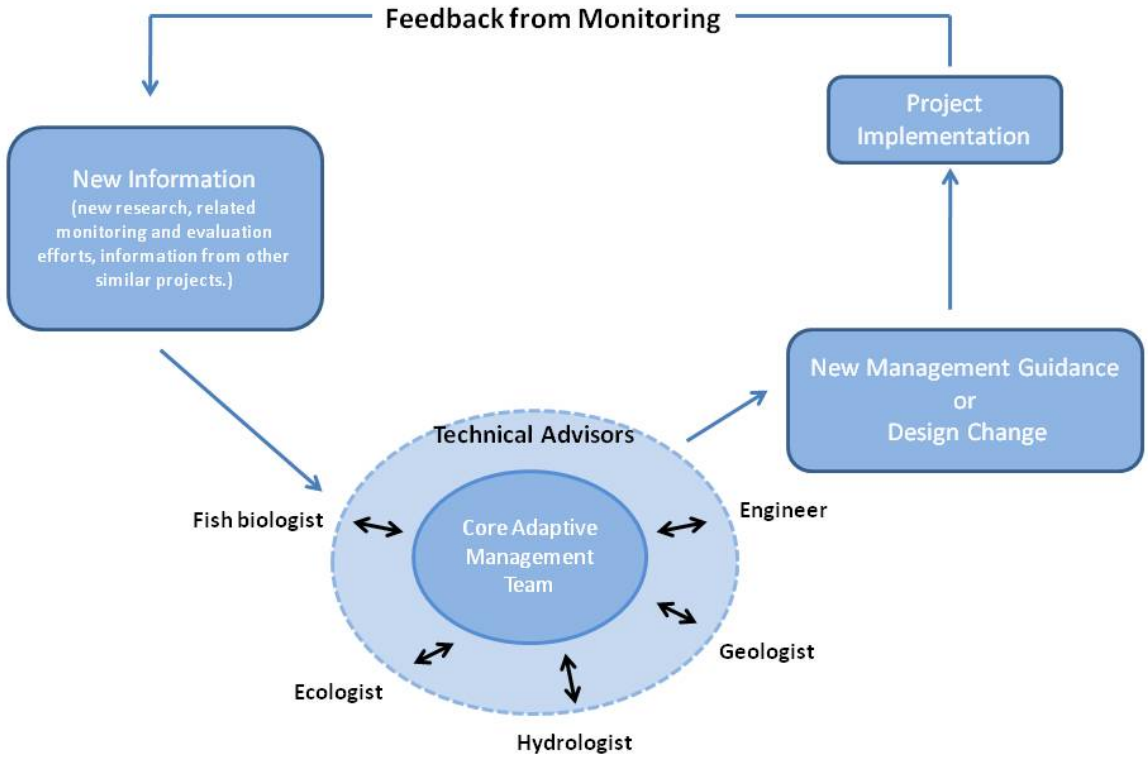

Figure 1-1. Adaptive Management Framework/Flowchart.

The purpose of this document is to describe how the adaptive management framework outlined in the Master Plan and Preliminary Design Report will be applied to the Braided Reach 1, Phase 1 restoration projects.

This document is organized as follows:

- Relationship among limiting factors, objectives and metrics.
- Monitoring program components
- Monitoring schedule and responsible parties.
- Success indicators for both short-term and long-term time frames.
- The adaptive management decision-making process relative to Phase 1 projects.
- Opportunities to link information from other related research, monitoring and evaluation projects.

2 Relationship among Limiting Factors, Objectives and Metrics

The Master Plan provides a framework for developing measurable objectives that are linked to habitat limiting factors. To determine whether objectives are being met, a set of metrics must be identified that can be measured and observed as part of an effectiveness monitoring program. Some metrics are specific to a particular objective, and some metrics are appropriate for evaluating several objectives. In addition, different metrics are suitable for measuring the same objective over different time frames; for example, integrity of wood structures is an appropriate metric for evaluating aquatic habitat complexity in the short term, while pool spacing may be a more appropriate metric for evaluating the same factor in the long term. Table 2-1 describes metrics in relation to objectives and limiting factors. Recognizing these relationships allows for development of more concrete and quantifiable correlations between restoration actions and tangible achievement of these objectives. Table 4-1 provides success indicators (in terms of metrics) for both short- and long-term time frames.

Limiting factors are conditions that limit ecosystem resilience and habitat for focal species. The limiting factors in Table 2-1 represent only of a few of the limiting factors identified in the Master Plan and have been selected because they are specifically addressed by the Phase 1 projects. **A restoration treatment** is a practical concept for implementing a restoration strategy and corresponds to the limiting factor in the table to be addressed. **Objectives** are statements that express the goals of the restoration project in measurable terms and **monitoring metrics** describe what data will be used to determine if the habitat objects are being met. Monitoring metrics are all reflective of changes in habitat that result from restoration treatments, rather than reflective of species populations. This allows monitoring to focus on observable responses rather than being dependent on species' preferred environments at a specific point in time or a specific life stage of that species.

Table 2-1. Relationship of Limiting factors to Metrics

Limiting factor	Restoration treatment	Objectives	Monitoring Metrics
Floodplain grazing	Install livestock exclosure fencing to create a non-grazed riparian pasture	Grazing is eliminated, riparian buffer will be created, and riparian vegetation will have a chance to colonize banks and floodplain.	• Woody vegetation browse • Observed livestock use • Landowner agreement in place and in compliance
Lack of outer bank vegetation and bank erosion	Re-grade and seed banks	Bank erosion rates will be low and will be similar to other densely vegetated banks on the river. Banks will be able to support riparian vegetation communities, planted shrubs and trees will begin to colonize surfaces and provide seed sources for long-term plant community establishment.	• Containerized plant survival • Noxious weed cover • Streambank canopy cover
	Plant willow cuttings and containerized plants		
	Add microtopography and wood to create more complex niches for plant establishment		• Bank erosion rates • Structural integrity and observed function of bioengineering structures
Lack of surfaces that support riparian recruitment	Install LWD structures on bank margins	Increase roughness on bank margins with LWD to promote floodplain accretion on existing features and provide protection for colonizing vegetation. Floodplain hydraulics (velocity and shear stress) support deposition of sand and silt	• Hydrologic connectivity (topography/elevation of constructed floodplain surfaces relative to ecologically significant flows), hydrology indicators • Floodplain substrate
	Construct floodplain surfaces with excavated fill from re-graded banks		• Woody seedling recruitment • Area and stability of depositional surfaces
River and floodplain response to altered flow and sediment regimes	Install structures to manage flow into side channels	Right side channel is connected at all flow levels and does not significantly alter mainstem sediment transport	• Structural integrity and observed function of bioengineering structures (side channel inlet structures)
		Left side channel is maintained primarily as a backwater habitat and is connected to mainstem at flows greater than 20,000 cfs.	• Side channel flow capacity • Area and stability of depositional surfaces
Lack of aquatic habitat complexity	Enhance side channel habitat	Increase pool availability, pool-riffle hydraulic complexity and near-bank cover with LWD, bank vegetation, and bioengineering structures.	• Hydraulic complexity (side channel geometry) • Structural integrity and observed function of bioengineering structures • Particle size distribution • Pool/riffle habitat length • Pool spacing • Species population / Proportional distribution
	Plant stream bank vegetation and promote natural plant colonization.		• Containerized plant survival • Streambank canopy cover

3 Monitoring Program Components

This section describes the integrated monitoring program for the project. The purpose of this section is to describe how monitoring data will be used to collect the necessary information to evaluate whether the project is trending toward meeting objectives.

Three types of monitoring are necessary to establish the integrated monitoring program. These include: baseline, construction, and effectiveness monitoring. ***Baseline monitoring*** documents the pre-restoration condition. ***Construction monitoring*** describes monitoring requirements during floodplain, channel, and revegetation implementation and documents whether the restoration project was constructed according to the design, and any departures from design. ***Effectiveness monitoring*** addresses whether project objectives are being met, determines maintenance needs, and provides inputs into decision pathways.

3.1 Baseline Monitoring

Baseline data will be collected to support restoration designs for each project phase. 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, vegetation and habitat attributes. Other baseline monitoring includes pre-project fixed photo points taken from locations that will not be disturbed by project activities. In addition, as-built surveys completed as part of construction monitoring described below, provide a baseline for comparing morphological, vegetation and habitat changes as part of project effectiveness monitoring.

3.2 Construction and As-built Monitoring

Construction monitoring includes the monitoring requirements during and immediately after project construction. Construction monitoring includes as-built surveys that will be completed as soon as sections of the project have been 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 restoration project. During the as-built survey, permanent monitoring stations will be established for the purpose of conducting effectiveness monitoring. The exact location of permanent monitoring stations will be determined as construction proceeds. Similar to construction, as-built documentation will occur in phases following completion of each project reach.

The following information and data were collected as part of the as-built documentation:

- Terrestrial and bathymetric topographic surveys of the channel and floodplain for use as base maps for project monitoring.
- Aerial photographs of the project reach.
- Longitudinal profile and channel cross sections with as-built stationing.

- Resource-grade GPS surveys to create maps documenting revegetation treatment areas and vegetation cover type extents.
- Resource-grade GPS surveys to create as-built wetland maps.

3.3 Effectiveness Monitoring

Effectiveness monitoring is intended to evaluate progress toward achieving project goals and objectives as measured by success indicators and to determine maintenance needs. This monitoring effort will focus on collecting data necessary to calculate the monitoring metrics established as performance criteria for the project. The following section describes how the effectiveness monitoring plan will be implemented including: monitoring methods, monitoring locations, level of effort, and monitoring schedule and frequency. Final monitoring locations will be identified during the as-built survey. Specific monitoring methods are included in Appendix A.

4 Monitoring Schedule

Monitoring data will be used to determine if objectives are being met or whether trends indicate objectives are likely to be achieved in the future. If data suggest objectives are not being met or trends toward objectives are not apparent, either objectives or metrics are not appropriate for the corresponding objective. In this case, the adaptive management framework calls for a management response. For example, if hydrologic connectivity metrics are not being met and floodplains are not accessed at flows greater than 20,000 CFS, this could indicate that floodplain surfaces were not established at the proper elevations, hydrologic models are not calibrated accurately, or there has been an unanticipated geomorphic response. Thus, alternative actions to restore floodplain connectivity need to be considered and executed.

The monitoring schedule (Table 4-1) specifies details of data collection for each metric. Appendix A includes data collection and analysis methods.

Table 4-1. Phase 1 Project potential monitoring sampling locations, effort, timing and frequency.							
Metrics	**Monitoring Methods**[1]	**Sampling Locations**	**Total Samples / Sampling Event**	**Timing**	**Est. 1st Sampling**	**Responsible Party**	**Scheduled Frequency***
Morphology							
Area and stability of depositional surfaces	Channel cross section; Topographic survey	Entire area	TBD	Post-runoff	Oct 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Cover type distribution	Cover type mapping; Topographic survey	Entire area	TBD	Post-runoff	July 2012	Geum (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Bank erosion rates	Channel cross section	Entire area	TBD	Post-runoff	Oct 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Hydrologic connectivity	Longitudinal profile	Entire area	Two	Post-runoff at ecologically significant flows	June 2012	RDG/Geum (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Side channel flow capacity	Channel cross section; Longitudinal profile	Inlets	One per side channel	Post-runoff	Oct 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Floodplain Substrate	Floodplain substrate monitoring	Entire area	TBD	Post-runoff	Oct 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Structural integrity and observed function	Bioengineering structure monitoring	All installed bioengineering structures	TBD	Post-runoff	Oct 2012	Geum/RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Riparian Vegetation							
Woody seedling recruitment	Floodplain vegetation cover monitoring	Observation in natural recruitment zone	Incidental to other monitoring	Growing season	July 2012	Geum (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Woody shrub canopy cover	Floodplain vegetation cover monitoring	Sampling plots	One sample per cycle within survival plots	Growing season	July 2012	Geum (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.

Table 4-1. Phase 1 Project potential monitoring sampling locations, effort, timing and frequency.							
Metrics	**Monitoring Methods[1]**	**Sampling Locations**	**Total Samples / Sampling Event**	**Timing**	**Est. 1st Sampling**	**Responsible Party**	**Scheduled Frequency***
Hydrologic connectivity	Longitudinal profile	Entire area	One/Sampling Event	Growing season	July 2012	Geum (or TBD)	Years 1, , 3, 5, 10, 15, etc.
Survival	Survival monitoring	All containerized planting and transplant locations	40% of plants installed	Growing season	July 2012	Geum (or TBD)	Years 1, 3, 5, 10, 15, etc.
Weed cover and distribution	Noxious weed mapping	Throughout project area	Note locations throughout project area	Growing season	July 2012	Geum (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Aquatic Habitat							
Hydraulic complexity (side channel geometry)	Bioengineering structure monitoring	All structures		Post-runoff	October 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Species population/ Proportional distribution		Entire restoration area	Per related M&E efforts	Per existing protocols	September 2012	KTOI / IDFG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Channel particle size distribution	Channel substrate monitoring	At cross-sections	Depends on Reach Length	After peak runoff	October 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Pool/riffle habitat length	Channel long profile	Entire length of longitudinal profile	Depends on Reach Length	After peak runoff	October 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Pool spacing	Longitudinal profile		Depends on Reach Length		October 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Streambank Canopy Cover	Floodplain vegetation cover monitoring	Streambanks	5 locations along bank	Growing Season	July 2012	Geum (or TBD)	Years 3, 10, 15, etc.
Structural integrity and observed function	Bioengineering structure monitoring	All structures	Once per sampling event	Growing season	July 2012	RDG (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
River stewardship							
Woody vegetation browse	Browse evaluation	Containerized planting units,	40% of plants installed	Growing season	July 2012	Geum (or TBD)	Years 1, 3, 5, 10, 15, etc.

Table 4-1. Phase 1 Project potential monitoring sampling locations, effort, timing and frequency.							
Metrics	**Monitoring Methods[1]**	**Sampling Locations**	**Total Samples / Sampling Event**	**Timing**	**Est. 1st Sampling**	**Responsible Party**	**Scheduled Frequency***
		willow cutting installation sites					
Observed livestock use/ Misc. disturbance	Disturbance observation	Planting units; constructed streambanks and floodplains	Note locations throughout project area	Ongoing	July 2012	Geum (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Landowner agreement in place and in compliance	Land owner management	Entire project area	Once per year	Ongoing	July 2012	Geum (or TBD)	Ongoing
Other							
Visual inspections	Multiple	Entire project area	Once per monitoring cycle	When appropriate	August 2011	All (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.
Greenline photos	Photo Monitoring	Entire project area	Once per year	Growing season	August 2011	Geum (or TBD)	Years 1, 2, 3, 5, 10, 15, etc.

* Significant floods and other disturbances may trigger additional monitoring events (e.g., drought, ice jams, and seasonal flow events exceeding bankfull). Related Monitoring and Evaluation (M&E) programs will be referenced as part of project-specific monitoring plans.

[1] Appendix A provides detailed descriptions of monitoring methods.

5 Restoration Indicators

The above monitoring metrics can be stated in terms of success indicators related to restoration actions in the context of both short-term and long-term time frames. The differences between short- and long-term indicators can be a change in numeric thresholds (e.g., increasing percent plant cover over time), or a change in project perspective (e.g., considering responses at a larger scale over time). The following Table 5-1 presents success indicators for Phase 1 project adaptive management in the context of short- and long-term time frames.

Table 5-1. Conceptual success indicators for Phase 1 project adaptive management in the context of short-term and long-term time frames.

Metrics	Short-term indicators (0-15 years)	Long-term indicators (15+ years)
Morphology		
Cover type distribution	Shows trend toward CS, RS or CF cover types	CS, RS or CF cover types are present in desired proportional distributions
Area and stability of depositional surfaces	80% or greater of depositional surfaces correspond to ecologically significant flows (between elevations 1771 and 1773 for Phase 1a and between elevations 1764 and 1767 for Phase 1b.)	Surfaces are able to support design plant communities
LWD Counts	Number of pieces of LWD is at least 80% of as-built quantity	Vegetated surfaces contribute LWD to the system
Bank erosion rates	Average bank erosion rates are less than 0.1 ft per year	Average bank erosion rates are less than 0.1 ft per year.
Hydrologic connectivity	80% of modeled water surface elevations for ecologically significant flows (16,000cfs to 24,000 cfs) are between elevations 1771 and 1773 for Phase 1a and between 1764 and 1767 for Phase 1b.	Constructed floodplain surfaces support desired distribution of cover types
Side channel flow capacity	Right side channel conveys 5 to 10% of total flow in the mainstem.	Right channel conveys 5 to 10% of total flow in the mainstem.
	Left side channel is active at flows greater than 20,000 cfs.	Left side channel accretes and develops into a floodplain surface.
Floodplain substrate	Substrate is within range for design cover types	Constructed floodplain surfaces support desired distribution of cover types
Structural integrity and observed function	Structures control bank stability	Structures decompose
Riparian vegetation		
Hydrologic connectivity	Primary surface hydrology indicators used for wetland delineations are present in cover types	Cover types are developing in expected proportions and hydrology indicators continue to be present.
Survival	80% of woody containerized plants in first five years	Cover types are developing in expected proportions
Woody shrub canopy cover	Canopy cover shows increasing trend years 5 to 15	Shows trend toward CS, RS or CF cover types[1]
Woody seedling recruitment	Willow and cottonwood seedling recruitment is observed in natural recruitment zone	Shows trend toward CS, RS or CF cover types[1]

Table 5-1. Conceptual success indicators for Phase 1 project adaptive management in the context of short-term and long-term time frames.		
Metrics	**Short-term indicators (0-15 years)**	**Long-term indicators (15+ years)**
Weed cover and distribution	< 10% cover of noxious weeds	Cover types are developing in expected proportions (weeds are not inhibiting their development)
Aquatic habitat		
Hydraulic complexity (side channel geometry)	Side channel geometry is within 20% of design criteria	Side channel geometry is within 30% of design criteria
Species population / Proportional distribution	Per related monitoring and evaluation program	Per related monitoring and evaluation program
Channel particle size distribution	60-80% gravel/cobble bed	60-80% gravel/cobble bed
Pool/riffle habitat length	30-40% Pool 60-70% Riffle	30-40% Pool 60-70% Riffle
Pool spacing	Pool spacing = 5 to 7 bankfull widths	Pool spacing = 5 to 7 bankfull widths
Streambank canopy cover	30 to 50% cover	>50% cover
Structural integrity and observed function of LWD	Pool habitat is maintained by structures.	Pool spacing = 5 to 7 bankfull widths; Pool habitat is maintained by natural processes such as LWD recruitment and lateral scour from meander migration
River stewardship		
Woody vegetation browse	< 20% browse of woody plants by wildlife	Wildlife browse not limiting vegetation establishment
Observed livestock use (ex. Hoof prints, trails)	No livestock use within exclosure	Livestock use not causing bank erosion
Landowner agreement in place and in compliance	Confirm yes/no	In compliance

[1]Cover Type Abbreviations: EXD – Exposed depositional, CD – Colonizing depositional, CS – Cottonwood shrub, RS – Riparian shrub, CF – Cottonwood forest, MCF- Mixed conifer forest, EM – Emergent wetland (Appendix B) Desired proportional distributions to be determined based on as-built conditions.

6 Adaptive Management Decision-Making Process

The adaptive management decision pathway illustrated in Figure 5.2 of the Master Plan presents a general iterative framework for making decisions and evaluating whether project objectives are being achieved. When applying this pathway more specifically to Phase 1 projects this framework will be used to determine if the individual objectives in Table 2-1 are being met in light of the limiting factors addressed by Phase 1 projects:

- Floodplain grazing;
- Lack of outer bank vegetation and bank erosion;
- Lack of surfaces that support riparian vegetation recruitment;
- Altered sediment transport, and;

- Reduced aquatic habitat complexity

Several functional groups will guide and support the adaptive management decision-making process. These groups and their roles are broadly illustrated in Figure 1-1. The Core Adaptive Management Team (Core Team) will act as a primary filter for new information. New information includes data collected as part of recent research, related monitoring and evaluation efforts, and information from other similar projects in the Kootenai watershed or elsewhere. The Core Team is composed of technical representatives with appropriate background and access to critical data from: the Army Corps of Engineers, Bonneville Power Administration, Idaho Fish and Game, Montana Fish Wildlife & Parks, British Columbia Ministry of Forests Land Natural Resource Operations (formerly the British Columbia Ministry of Environment), the Kootenai Tribe of Idaho, and the U.S. Fish and Wildlife Service.

In addition to the Core Team, a group of Adaptive Management Team Technical Advisors (Technical Advisors) representing a range of technical expertise will be on call to provide review, additional interpretation, and advice to the Core Team as needed. The purpose of this Technical Advisor group is to 1) provide additional technical depth to the Core Team, and 2) provide an independent review of various recommendations when needed.

In order to develop informed monitoring and adaptive management recommendations, the Core Team will be convened periodically (frequency TBD) to review pertinent data and analysis. If the Core Team needs additional input or assistance in resolving a disagreement regarding data analysis, or an adaptive management recommendation, they would call on the Technical Advisors for input based on interpreted and analyzed information they would provide to the Technical Advisors.

Based on monitoring data collected from Braided Reach 1, Phase 1 projects, the Core Team has three potential decision pathways:

1. They can determine the project is meeting objectives according to the success indicators. In this case, monitoring practices would be evaluated and the team would determine whether to continue with the same monitoring schedule or to perhaps reduce, eliminate or vary appropriate metrics.
2. They can conclude objectives are not yet being met, but a trend toward meeting objectives is apparent. Under these circumstances, the Core Team must determine if the rate of progress is appropriate given project timelines, whether to continue with the monitoring schedule as described above, or implement a design change to address the rate of progress.
3. They can determine the project objectives are unlikely to be met. This third conclusion requires the team to evaluate potential causes for why the objectives are not being met. This may be due to a) metrics do not capture the appropriate information and thus do not reflect changes in limiting factors, b) restoration treatments are ineffective or c) objectives are not appropriate for the project area.

If the Core Team decision falls under category 2 or 3 above, that recommendation would be forwarded to the Tribe's design team to incorporate the new management approach and/or a design change into the planning and implementation process (the specific approach and response will also depend on what stage of implementation the project is in). The Technical Advisors would be called on for input if significant changes are warranted or if there are questions, irresolvable differences, or other confounding factors associated with developing a specific recommendation. In some cases, significant changes to designs or management may require re-initiation of dialog with the Peer Reviewer Advisory Team and/or Kootenai River Habitat Restoration Project Policy Team before moving to development of revised designs. Once the revised design is finalized and implemented, monitoring data from the new or modified project would provide new information to support further decisions.

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Appendix A. Monitoring Methods

Floodplain and Channel Morphology Surveys

Metrics evaluated: *Area and stability of depositional surfaces; Side channel flow capacity; Hydraulic complexity (side channel geometry); Hydrologic connectivity; Pool spacing; Pool/ Riffle habitat length Cover type distribution*

Surveys of floodplain and channel bed morphology provide topographic data that can be used to measure the response of restoration treatments on mainstem and side channel geometry, including flow capacity, hydrologic connectivity, pool and riffle depth channel dimensions, bank erosion and the area and stability of depositional surfaces.

Floodplain and channel morphology will be assessed using one or more of the following methods, as dictated by site conditions:

- Field surveys
- Multi-beam bathymetric data collection
- LiDAR data collection

Data Collection Methods

In areas where ground surveying is feasible, representative channel cross-sections will be surveyed using standard methods (Harrelson et al. 1994). Cross-sections will span the active bankfull channel, adjacent floodplain, and low terrace features; and will intersect pool, riffle, run, and glide features where they are present (Bisson et al. 1982). Cross section elevations will be collected at defined intervals or topographic breaks using a survey-grade GPS and laser level. Cross-section locations will be established in the as-built survey.

Multi-beam bathymetric data will be collected to support surveys of the channel bed in areas where cross section monitoring is not feasible. Multi-beam bathymetric data is collected using an active remote sensor (multi-beam echo sounder) on the water surface that emits acoustic beams toward the channel bed. The sensor measures the return interval between emission and reflectance from the channel bed, and calculates bed elevation data based on the angle of the signal and the timing of the signal return interval (Barton et al. 2010). These data will be used to create a spatial representation of channel bed elevations (and, in some cases, substrate composition) using terrain modeling tools within a Geographic Information System (GIS).

Another method to measure topography in areas not covered by water is the collection of Light Detection and Ranging (LiDAR) data. LiDAR data is collected by directing a laser pulse from an aircraft-borne sensor toward a land surface, and measuring the time that elapses between emission and the return signal (NOAA 2008). Raw LiDAR data consists of a series of points that represent the location and elevation of all return signals measured by the sensor. Post-processing of this raw data results in a spatial data layer that displays ground elevation information at a high vertical and horizontal accuracy.

These field-based and remotely-sensed topographic data collection methods result in a high-resolution representation of floodplain and channel surfaces.

Data Analysis

Cross section data will be used to evaluate channel geometry and hydrologic connectivity metrics. Raw cross-section data will be entered into Rivermorph (RIVERMorph LLC. 2005) and plotted in station/elevation format in the cross-section module. Surveyed cross-section points and identifying features such as channel bottom, edge of water, bankfull indicators, top of bank, floodplains and terraces are selected and downloaded to the cross-section module. The cross-section module is used to generate channel metrics used for basic hydraulic calculations. Metrics generated in this module will be summarized and used to obtain a range of values for riffle, pool, run and glide features at the reach scale.

Longitudinal profiles will be used to evaluate pool spacing, pool-riffle habitat length, and hydrologic connectivity metrics. Longitudinal profiles will be established in each surveyed reach and include the entire reach. Due to the size and depth of the Kootenai River mainstem, long profile analyses will be based on remotely sensed bathymetric data (as described above). The profiles will include consistent measurement of left and right channel bankfull indicators, channel thalweg, low terraces, and water surface elevations at select locations along the profile.

Raw longitudinal profile (LP) data will be entered into Rivermorph and plotted in station/elevation format in the LP module. Data types such as channel thalweg, water surface and bankfull points are automatically selected, and any additional data points such as right or left bank, terrace features or other survey data, are selected manually.

In order to further assess floodplain hydrologic connectivity, water surface profiles (one data type collected as part of longitudinal profiles) will be surveyed at discharges corresponding to ecologically significant flows (16,000 to 24,000 cfs) and compared with elevations of constructed floodplain surfaces. GIS and CAD tools will be used to process survey data and develop maps displaying the relationship between constructed floodplain elevations and selected ecologically significant flows for comparison with indicators.

Data collected from field surveys of channel and floodplain surfaces will be used to evaluate the area and stability of depositional surfaces and support the remotely-sensed data collected for metrics such as hydrologic connectivity (described above). Spatial elevation data collected during field surveys will be entered into a GIS, where observations of deposition, vegetation recruitment, and hydrologic indicators can be evaluated alongside other spatial data such as stage flow model outputs and aerial photos.

Bank Erosion Monitoring

Metrics evaluated: *Bank erosion rates*

The bank erosion monitoring described here is performed in order to evaluate bank erodibility potential. This data will be used during restoration planning and adaptive management of project areas in order to identify areas where high potential for erosion may negatively impact the restoration effort. Other monitoring methods, such as *Floodplain and Morphology Surveys*, *Floodplain Vegetation Cover Monitoring*, and *Structure Monitoring* will evaluate quantifiable changes in bank geometries.

Prediction of stream bank erosion rates and sediment loading will be made using the Bank Assessment for Non-point Source Consequences of Sediment (BANCS) method (Rosgen, 2006). The method utilizes two bank erodibility estimation tools including the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS). The application involves evaluating bank characteristics and flow distribution along the river reach and mapping various risk ratings commensurate with bank and channel changes. A numerical reach score is then developed to rank streambank erosion potential on a scale ranging from very low to extreme.

Bank pins are smooth steel rods, four feet long, which are driven horizontally and flush to the bank surface at various positions in the streambank. The mount of exposed pin upon resurvey following runoff evens is measured as the amount of lateral erosion at the site (Rosgen 2006).

The BEHI procedure integrates multiple bank integrity parameters which have a direct impact on streambank stability, including the following.

- Ratio of streambank height to bankfull stage
- Ratio of riparian vegetation rooting depth to streambank height
- Degree of rooting density
- Composition of streambank materials
- Streambank angle
- Bank material stratigraphy
- Bank surface protection afforded by woody debris and vegetation

The BEHI index incorporates these seven variables into a numerical reach score that is used to rank streambank erosion potential on a scale ranging from very low to extreme. BEHI sites will be established during the as-built survey.

Procedures for processing bank erosion data are outlined in *Watershed Assessment of River Stability and Sediment Supply* pages 6-13 (Rosgen 2006).

Floodplain and Channel Substrate Monitoring

Metrics evaluated: *Floodplain substrate; Channel particle size distribution*

Channel materials will be sampled to characterize bed material characteristics as well as to complement hydraulic and sediment transport evaluations. Several sampling methods will be employed to meet these requirements.

In areas where direct substrate sampling is feasible (low flow areas such as side channels), the Wolman method (Wolman 1954) will be used to characterize the particle size distribution of channel materials. The material sampling locations will be replicated for each survey and will be established in the as-built survey. The intermediate axis of each particle will be measured (Wolman 1954; Bunte and Abt 2001). Samples from habitat units will be recorded separately and reported individually and as a composite.

In areas where direct substrate sampling is not a viable monitoring method, underwater videography will be used in order to characterize substrate materials and dimensions. Underwater videography is performed by capturing video footage of the channel bed with an underwater camera outfitted with a reference laser. The laser emits two beams at a set distance apart which are then used as a size reference to determine the dimensions of substrate materials captured during underwater filming (Barton et al. 2010). Substrate materials will be identified through expert interpretation of the underwater video footage.

Floodplain sediments will be monitored using volumetric bar samples or other similar methods appropriate for the scale of the mainstem Kootenai River. Volumetric bar samples will be sieved using standard sieves and a scale (Rosgen 2006). Sieves are stacked according to sieve opening size with coarser sieves on top and the finest sieve on the bottom. The stacked sieves are placed on a drain bucket. Sediment samples are placed in the top sieve and the sieve column is agitated while water was poured over the sieve column. Sand particles that pass through all of the sieves are retained in the drain bucket. Once the samples are completely sieved, each sieve is weighed. The weight of the sieve and the sample collected in that sieve is recorded. The weight of the sieve is deducted from the sieve and sample weight to calculate the weight of the sample retained. Once the weight for each sieved sample is completed, a total weight is calculated for all samples. A relative weight for each size class is derived by comparing the individual sieve results to the overall total weight of the sample.

Channel substrate data including pebble counts and bar samples will be entered into Rivermorph, processed and reported. Unlike long profile and cross section data, no analytical tools are applied to refine the substrate data.

Structure Monitoring

Metrics evaluated: *Structural integrity and observed function; LWD count*

The purpose of structure monitoring is to evaluate constructed bank restoration structures (vegetated soil lifts, wrapped coir logs) and constructed wood features (large woody debris structures, lower bank treatments). Bank restoration structures will be monitored to assess the structural integrity of the feature and to ensure that structures are maintaining appropriate bank morphology as specified in the restoration design. Constructed wood features will be monitored to assess structural integrity, scour pool formation, and recruitment of natural woody debris.

Bioengineering structures will be monitored using visual observation.

For constructed bank restoration structures, any structural deformities should be recorded and photographed in order to evaluate structure success indicators and inform future maintenance needs. Structural deformities to be recorded as part of monitoring include:

- Loss of structural components
- Rips and/or tears in structure fabric
- Slumping of structure face
- Loss of structure toe material

For constructed wood structures, observations will include:

- Loss of structural components
- Recruitment of natural woody debris
- Appropriate effect on channel morphology (creation of scour pools, etc.)

Cover Type Mapping

Metrics evaluated: *Cover type distribution*

Cover type mapping is performed in order to evaluate the distribution of cover types within the project area. Cover type distribution is evaluated using a combination of field surveys and computerized mapping within a GIS.

Floodplain cover types are modified from Hauer and others (2002). These are landscape scale cover types that represent a functioning floodplain when distributed proportionately (Table B-1). Floodplain cover types will be observed using a combination of aerial photograph interpretation, evaluation of channel cross section elevation data and interpretation of percent cover vegetation data collected in monitoring plots established along floodplain-wide transects. These data will be used to delineate floodplain cover types within the project area. Once floodplain cover type data are evaluated, the proportional abundance of established and developing cover types will be compared with desired cover type distributions.

Ecological types are plant communities described in Hansen and others (1995). Within this system, Community Types represent ecological types dependent upon, or created by, disturbance—for example, floods. Habitat types represent mature (later succession) plant communities that reflect a site's potential given soils, hydrology, climate and landform. Ecological type classification will be used to evaluate site progress at the plant community scale. Ecological cover types will be recorded using a combination of aerial photograph interpretation and on-the-ground data collection. Standardized forms will be developed that will aim to record data within planting polygons to determine what type of ecological type is developing. This information will be used to detect trends toward development of Floodplain Cover Types as described in Appendix B.

Cover type mapping is performed by recording the specific locations, or approximate extents of vegetation communities, depositional features, anthropogenic features, or water features using field maps and a GPS. Data collected during field observation should include:

- Recording of boundaries between vegetation communities or other cover types
- Spatial data collection of features that may be obscured in available aerial photography
- Detailed notes on the geomorphic, hydrologic, or vegetative characteristics of mapped areas

Information collected during field observations is used in conjunction with aerial photography interpretation to create comprehensive cover type maps using a GIS. Mapping within a GIS is accomplished through a combination of techniques:

- Digitization of cover type boundaries using aerial photography cues (including the spectral response of features in the near-infrared band)
- The use of pattern recognition programs to identify areas that have similar spectral or morphological characteristics
- Modification of existing cover type maps based on field observations that indicate changes in cover type boundaries or conversion between cover classes.

Survival Monitoring

Metrics evaluated: *Containerized plant survival; Transplant survival*

The purpose of survival monitoring is to assess the survival of containerized woody shrubs, and transplanted shrubs installed as part of floodplain revegetation. Floodplain revegetation seeks to establish native woody cover on restored floodplain surfaces as a means of providing bank stability, natural woody debris recruitment sources, and native cover type distribution throughout the project area.

Survival monitoring is performed by establishing assessment plots on a variety of restored floodplain surfaces. Plot dimensions are variable and defined by the shape and distribution of planting areas. The corners of each plot are permanently monumented and recorded using a GPS for future relocation. Photographs should be taken from each plot corner, and recorded by plot ID and photo azimuth.

Within each survival assessment plot, each installed containerized plant or transplanted shrub is recorded by species and survival status (alive or dead). The total number of surviving plants is then divided by the total number of installed plants to determine the survival rate within the plot. Survival data is summarized by plot location and species in order to assess revegetation indicators, and to inform maintenance and adaptive management needs.

Floodplain Vegetation Cover Monitoring

Metrics evaluated: *Woody shrub canopy cover; Streambank canopy cover; Woody seedling recruitment*

Floodplain vegetation cover monitoring assesses canopy cover, species composition, and natural recruitment of woody shrub species within defined plots or along bioengineering structures. Species composition and natural recruitment data are used to evaluate the progression of restoration cover types toward the desired condition, and to inform potential maintenance such as weed management. Canopy cover data is used to assess progress toward woody species canopy cover, and overhanging streambank canopy cover indicators.

Floodplain vegetation cover monitoring is performed by establishing assessment plots on a variety of restored floodplain surfaces. Plot dimensions are variable and defined by the sampling design (to be determined). The corners of each plot are permanently monumented and recorded using a GPS for future relocation. Photographs should be taken from each plot corner, and recorded by plot ID and photo azimuth.

Within each cover plot, all herbaceous and woody species are recorded by species name and percent cover. Within a subset of plots, woody seedling density is recorded to evaluate natural recruitment of willows and cottonwoods. Percent cover for herbaceous species will be based on visual estimation and assigned a cover code based on USDA Forest Service Northern Region ECODATA (1989) class codes (Table A-1).

Cover percent for woody species will be assessed using two methods, corresponding to two restoration treatment types where woody shrubs are installed:

In **floodplain planting areas**, woody canopy cover is assessed using a grid (dimensions TBD depending on shape and distribution of planting areas). Along each transect line within the grid, the presence or absence of woody vegetation is recorded at specified intervals. The total number of points where woody plants are intercepted is divided by the total number of possible points in the grid in order to calculate a canopy cover percentage for each plot.

Canopy cover is also assessed along **bioengineering structures**, where live willow cuttings have been installed. Canopy cover is measured by taking densitometer readings along the face of the structure at specified distance intervals. Average canopy cover for each structure can then be calculated by summing the densitometer readings for each interval and dividing by the total number of readings taken along the structure.

Table A-2. USDA Forest Service Northern Region ECODATA cover class codes.

Code	Percent Cover	Midpoint
T	<1%	0.5%
P	1-5%	3%
1	5-15%	10%
2	15-25%	20%
3	25-35%	30%
4	35-45%	40%
5	45-50%	50%
6	55-65%	60%
7	65-75%	70%
8	75-85%	80%
9	85-95%	90%
F	95-100%	97.5%

Browse Evaluation

Metrics evaluated: *Woody vegetation browse*

Browse evaluation monitors the impact of forage by livestock or wildlife on revegetation treatments within a defined project area. Observations of browse extent and locations are used to inform browse exclosure maintenance requirements and adaptive management of restored floodplain areas.

The level of browse on woody vegetation will be evaluated by recording the level of browse on each plant monitored within plant survival monitoring plots. Browse level will be recorded using a numeric code according to the following criteria:

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

Noxious Weed Mapping

Metrics evaluated: *Weed cover and distribution*

Noxious weed mapping is performed on a project scale in order to identify the locations, extents, and density of weed infestations. Noxious weed cover negatively impacts floodplain revegetation efforts by limiting the cover of desirable native herbaceous and woody shrub species.

Noxious weeds are documented by species, area of infestation, and relative density throughout the project area. The location of noxious weed infestations should be recorded using a GPS device as follows:

- For small infestations (< 0.5 acres), a single GPS point should be recorded. Species and density information for the infestation should be recorded in conjunction with the point data.
- For larger infestations (> 0.5 acres), a polygon feature should be recorded that encompasses the entire extent of the infestation. Species and density information for the infestation should be recorded in conjunction with the point data. For areas where GPS data collection is not feasible , the infestation extents can be delineated on field maps and then later be digitized in GIS.
- For linear infestations (along streambanks or reclaimed access routes), a line feature should be recorded. Species and density information for the infestation should be recorded in conjunction with the line data.

Following field data collection, weed mapping data should be incorporated into a GIS, where spatial information can be used to generate map displays of the locations, extents, and relative densities of all infestations in the project area. This information can then be used to inform maintenance activities such as herbicide application, mowing, and hand-pulling. Noxious weed species identified during data collection will be based on the Idaho State Department of Agriculture's (ISDA) Noxious Weeds Program.
(http://www.idahoag.us/Categories/PlantsInsects/NoxiousWeeds/indexnoxweedmain.php)

Disturbance Observation Monitoring

Metrics evaluated: *Livestock use; Miscellaneous site disturbance*

Disturbance of project restoration areas can take many forms, including livestock use, off-road vehicle travel, recreational use, or vandalism of project treatments. Visual observation and photo documentation of disturbance effects are important monitoring activities that can inform project maintenance needs, and adaptive management requirements.

Disturbance monitoring can be performed as part of other monitoring activities, or during routine site visits. Disturbance monitoring does not require the establishment of plots or transects, and instead relies on visual observations, detailed notes, and photo documentation of disturbance effects throughout the project area. The locations and extents of observed disturbance effects should be thoroughly documented for maintenance needs, and, if necessary, the locations should be recorded using a GPS. Disturbance effects include, but are not limited to:

- Evidence of livestock or wild animal occupation (tracks, waste, browse)
- Evidence of unauthorized vehicle use (tire tracks, ruts)
- Evidence of unauthorized recreational use (fire pits, campsite materials, litter)
- Destruction of treatment elements (holes in fencing, uprooted or damaged shrubs)

Photo Monitoring

Metrics evaluated: *N/A*

The purpose of photo monitoring is to visually document project response to restoration treatments. Photo monitoring supports other monitoring methods, and is a repeatable visual documentation of site response to restoration treatments on a project-wide scale.

Most field-based monitoring methods discussed in this appendix incorporate photo documentation as part of the prescribed data collection. In general, photos should be taken to document the extents of performed monitoring plots or transects, and to record evidence of any maintenance needs or site disturbance. In all instances, detailed notes regarding the location of the photo, information conveyed, and photo azimuth should be recorded.

Greenline photo monitoring is performed as a distinct monitoring action. The purpose of greenline photo monitoring is to capture the entire project area through a set of repeatable panoramic photos. These photos are repeated over time (as prescribed in the monitoring timeline) in order to capture project-scale response to restoration treatments.

Greenline photo monitoring is performed by identifying, in the field, a series of locations that capture the entire project area. At each greenline photo point, a set of photos should be taken that capture the entire range of visible treatments (Figure A-1), and the azimuth and camera height should be recorded for each photo. Each photo point should be monumented and recorded with a GPS.

Subsequent monitoring of the greenline should be performed on an annual basis by locating each established photo point and replicating the camera height, azimuth and field of view.

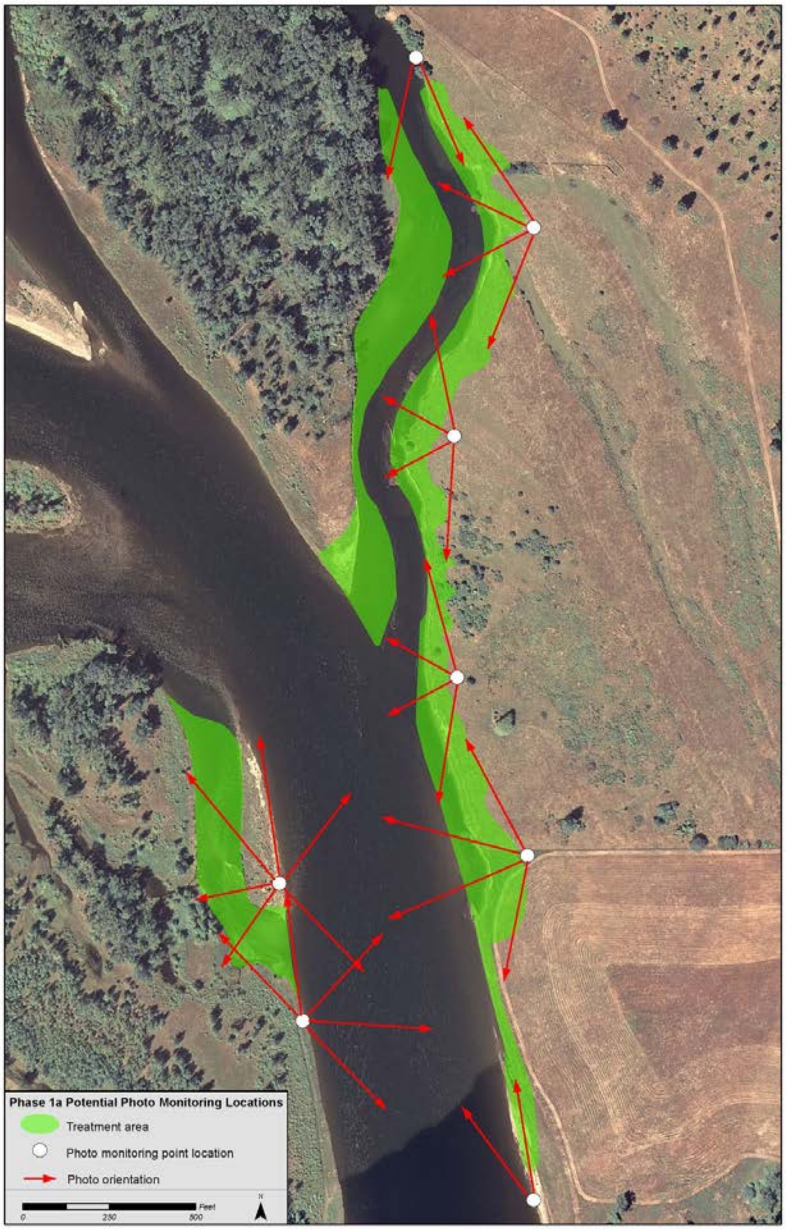

Figure A-1. An example of potential greenline photo monitoring points for the Phase 1a project area.

Appendix B. Cover Type Descriptions

Desired vegetation communities were identified by consolidating plant communities mapped by Egger (2007) into broader plant community groups (Restoration Cover Types) that are more meaningful in the context of restoration design. Selected Restoration Cover Types are similar to those used for other restoration projects (State of Montana 2008), and are based on cover classes identified by Hauer and others (2002). These Restoration Cover Types are described below.

Within the Phase 1 project area, most of the Restoration Cover Types shown in Table B-1 will be present. Most of the areas targeted for revegetation will be depositional features located below the ordinary high water mark (OHWM), and other revegetation areas will be along river or side channel banks immediately adjacent to the river and transitioning to uplands. Restoration Cover Types included as part of Phase 1 are described below.

The exposed depositional (EXD) restoration cover type will be a non-vegetated cover type composed of sand, gravel and cobble that is either currently present, or will be placed during project construction. These surfaces will be inundated during significant portions of the growing season, and geomorphic disturbance will be very high. While some annual vegetation (including cottonwood and willow seedlings) may become established during a single growing season, most of these areas will be scoured annually and will not support development of perennial plants. Some areas within the exposed depositional cover type will shift to colonizing depositional over time as floodplain surfaces develop and become complex and rough enough to support perennial vegetation.

The colonizing depositional (CD) restoration cover type will occur on surfaces composed of sand, gravel and cobble where the elevation is such that the surface is exposed during significant portions of the growing season, and suitable protected areas are present to prevent annual scouring of vegetation. Some of these areas will develop over time to the cottonwood shrub restoration cover type, while other areas may convert back to the exposed depositional cover type. Vegetation on the colonizing depositional cover type will consist of young (one to five year age class) cottonwood and willow species, in addition to other forbs and grasses. This restoration cover type will develop from natural recruitment of cottonwoods, willows and other shrubs, and surfaces will be constructed with sufficient large wood to provide protected areas that will support development of perennial vegetation.

The cottonwood shrub (CS) restoration cover type will occur on more stable depositional surfaces (medium geomorphic disturbance) that are separated from the active channel by the colonizing depositional restoration cover type. This cover type has five to ten year old cottonwoods, willows and other shrubs, in addition to an herbaceous understory that may include grasses, forbs or wetland herbaceous species such as sedges or bulrushes. Vegetation on these surfaces is large and dense enough to trap significant amounts of finer sediment to support floodplain building processes. As part of Phase 1a restoration, some surfaces will be planted with containerized nursery stock. Plant species used in these areas are described below.

The riparian shrub (RS) restoration cover type will be located on constructed and re-graded banks associated with Upper Bank Restoration Treatments (Appendix A and Section 4). Soils will consist of gravel, sand and finer textured materials and will be stabilized using fabric, wood, seed and soil amendments such as compost. Plant species used in these areas are described below.

The bankfull cottonwood forest (CF) restoration cover type will occur on floodplain surfaces that are inundated annually or up to a ten year return interval on average. These surfaces are stable enough to support development of mature cottonwood stands. These areas will trap sediment and include some soil development. Understory vegetation will be diverse and may include herbaceous wetland vegetation, riparian shrubs or conifer seedlings.

The low terrace cottonwood forest (CF) restoration cover type will occur on floodplain surfaces that are inundated between a 10 year and 25 year return interval on average. These surfaces will include many upland plant species in the understory, and will be stable enough to support development of mature cottonwood stands. These areas will have well-developed floodplain soils that derive from a combination of sediment accumulation and organic debris accumulation over time. Trees and shrubs will represent older age classes, and some succession toward conifer-dominated riparian forests may be occurring.

The mixed conifer forest (MCF) restoration cover type will be located in upland areas adjacent to the floodplain. In many cases, these areas will be former floodplain areas that were formerly connected to the river prior to dam-controlled flows. Overstory species will include mature cottonwoods, aspen, ponderosa pine, and other conifers. Understory species will vary depending on elevation relative to groundwater, and may include grass, forbs, shrubs and seedlings of more shade-tolerant conifer species such as western redcedar.

The emergent wetland (EM) restoration cover type will be located in floodplain depressions where deeper, anaerobic soil has developed over time. These areas will be inundated frequently, but hydraulic shear will be low, allowing the deeper, fine-textured soils to develop. These areas will be located in off-channel floodplain zones and along side channels. Plant species will include bulrush, sedges, rushes, wetland grasses and other herbaceous species. Emergent wetland may develop in the side channel within the Phase 1a project area as part of the floodplain building process.

Table B-1. Desired proportions of cover types over time.

Restoration Floodplain Cover Types	Geomorphic Feature	Percent of Total Cover at 0 to 15 years (base flow)	Percent of Total Cover 15 + years (base flow)
Exposed Depositional (Non-vegetated)	Bankfull Channel	5 to 15	5 to 10
Colonizing Depositional (Vegetated)	Bankfull Channel	10 to 25	5 to 15
Cottonwood Shrub	Bankfull Channel; Active Floodplain	10 to 25	15 to 30
Riparian Shrub	Bankfull Channel; Active Floodplain	25 to 40	25 to 40
Bankfull Cottonwood Forest	Bankfull Channel; Active Floodplain	15 to 25	20 to 30
Low Terrace Cottonwood Forest	Low Terrace	5 to 15	5 to 15
Mixed Conifer Forest	Floodplain Terrace	0 to 10	0 to 10
Emergent Wetland	Bankfull Channel; Active Floodplain	5 to 10	5 to 10