Kootenai River Habitat Restoration Project Master Plan

Chapter 3 – Restoration Strategies, Treatments and Habitat Actions

Kootenai Tribe of Idaho

July 2009

Chapter 3: Table of Contents

3 Restoration Strategies, Treatments and Habitat Actions.....3-1
3.1 Chapter Overview 3-1
3.2 Summary of Restoration Strategies and Treatments.....3-3
3.3 Restoration Strategies and Treatments by Reach 3-9
3.3.1 Project-Wide Strategy and Treatments..... 3-10
3.3.2 Braided Reaches Strategy, Treatments and Habitat Action 3-15
3.3.3 Straight Reach Strategy, Treatments and Habitat Action 3-26
3.3.4 Meander Reaches Strategy, Treatments and Habitat Action 3-35
3.4 Summary 3-52

Chapter 3: Figures

Figure 3-1. Relationship of Chapter 3 to Master Plan components in chapters 1, 2 and 4.....3-2

Chapter 3: Tables

Table 3-1. Summary of limiting factors, restoration strategy components and restoration treatments for the Kootenai River Habitat Restoration Project. 3-5
Table 3-2. Summary of potential habitat actions and restoration treatments by reach. 3-9
Table 3-3. Ability of treatments to address limiting factors in the Braided Reaches. 3-25
Table 3-4. Ability of treatments to address limiting factors in the Straight Reach. 3-33
Table 3-5. Ability of treatments to address limiting factors in the Meander Reaches. 3-48

3 Restoration Strategies, Treatments and Habitat Actions

This chapter describes conceptual restoration treatments that address the limiting factors described in Chapter 2. As described previously, limiting factors provide the causative theme that link project goals, restoration strategies, and measurable objectives to create a framework for designing restoration projects in an adaptive management context. This chapter describes a toolbox of potential restoration treatments that when combined in different configurations can be used to overcome limiting factors, resulting in a restored ecosystem that provides suitable habitat for native plants, animals and fish and helps to sustain the local culture and economy.

3.1 Chapter Overview

This section is intended to orient the reader to the terminology used in this Master Plan. Figure 3.1 on the following page provides a visual summary of how these terms are reflected in Master Plan chapters 1, 2, 3 and 4, and is intended to help the reader understand the relationships among restoration strategies, restoration treatments, habitat actions, and implementation scenarios and how these in turn relate to goals, objectives and limiting factors.

The following terminology is used throughout this document to organize components of the Master Plan conceptual framework that links limiting factors (problems) to restoration treatments (solutions):

- ***Limiting Factors –*** Limiting factors are physical, biological, and ecological conditions within the project reaches that: 1) limit the ability of the ecosystem to sustain diverse native plant and animal populations, and to accommodate natural disturbances; 2) limit habitat that supports all life stages of endangered Kootenai sturgeon and other focal species; and 3) limit the ability of the ecosystem to sustain the local culture and economy. Limiting factors can be addressed by active restoration or changes in management.
- ***Constraints –*** Constraints are features like roads, bridges and other infrastructure that for a variety of reasons cannot be changed by management or active restoration, but must be considered during the design process. Constraints also include aspects of dam operations and land management practices have impacts on the habitat, but cannot be addressed within the context of proposed project restoration actions.
- ***Restoration Strategy –*** Restoration strategies are the broad approaches to habitat restoration that will be used in each project reach. Each restoration strategy is described in terms of how the river channel, banks and floodplain would need to be modified in a reach to overcome limiting factors given specific conditions and constraints that are present.

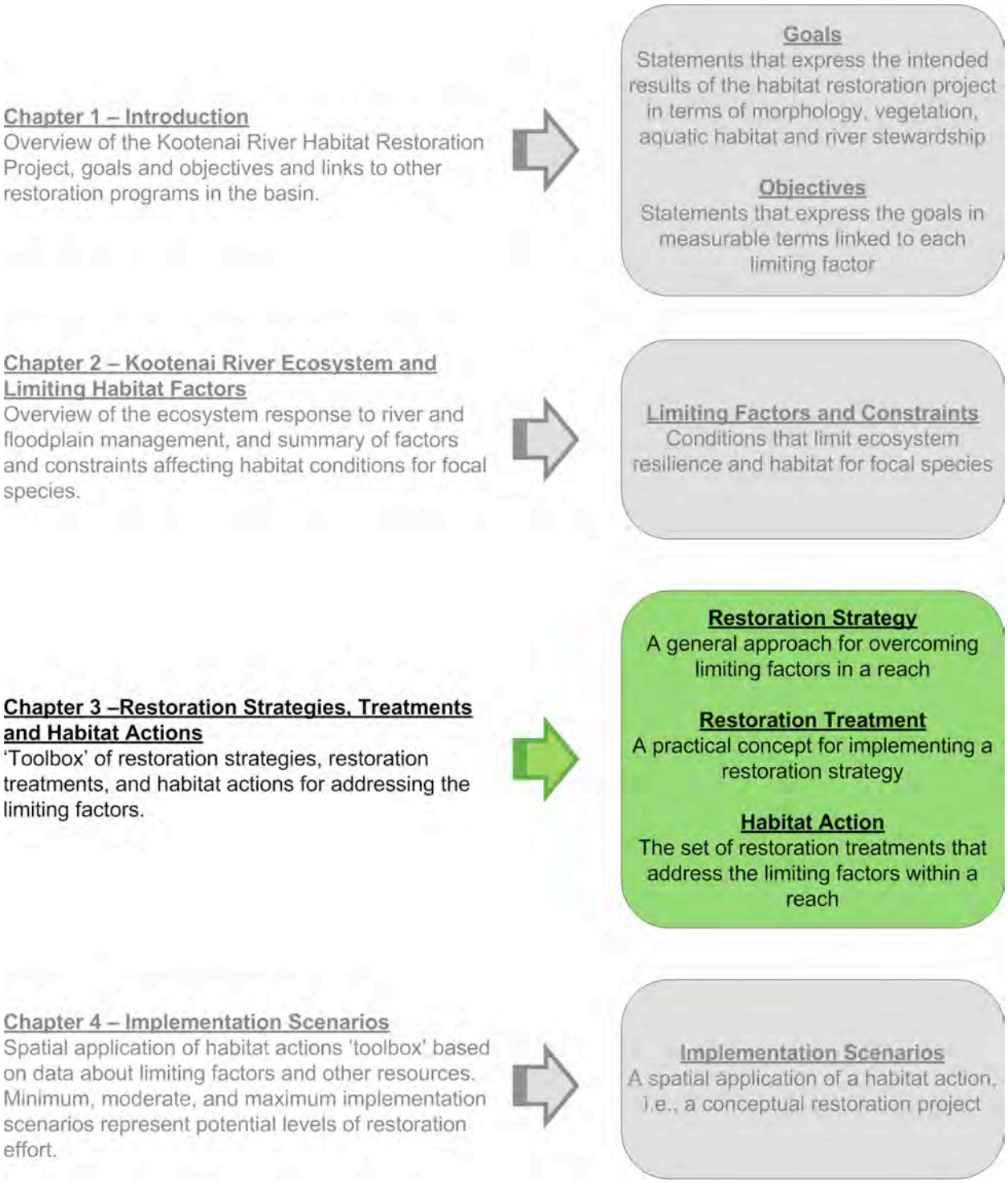


Figure 3-1. Relationship of Chapter 3 to Master Plan components in chapters 1, 2 and 4.

- ***Restoration Treatment –*** Restoration treatments are actionable concepts that support a restoration strategy. Restoration treatments were selected based on analysis of limiting factors in the Kootenai subbasin (described in Chapter 2) and knowledge gained from efforts in other river systems where these types of restoration treatments have been successfully used to address similar habitat limiting factors.
- ***Habitat Action –*** A habitat action is the combined set of restoration treatments that address the limiting factors within a reach.
- ***Implementation Scenario –*** An implementation scenario is a spatial application of a habitat action based on criteria (described in Chapter 4) to determine a level of restoration effort. An implementation scenario is a quantifiable habitat action that can be used to estimate implementation costs at a conceptual level.

3.2 Summary of Restoration Strategies and Treatments

Restoration strategies are the broad approaches that will be used in each reach to overcome limiting factors identified in Chapter 2. Restoration treatments are actionable concepts for implementing a restoration strategy.

The restoration treatments described in this chapter were selected based on analysis of limiting factors in the Kootenai subbasin, while also taking into account the constraints (limiting factors and constraints are described in Chapter 2); knowledge gained from project contractors with experience implementing treatments in other river and floodplain habitat restoration projects; reviews of available literature, publications, and studies of the project area; input and professional opinion provided by an interdisciplinary group of technical experts, regional fish biologists and co-managers; and the following supplemental information, which is included in the Master Plan appendices:

1. Hydraulic modeling of a range of pre- and post-dam discharge conditions (Appendix A);
2. Analysis of sediment-transport characteristics using measured bedload and suspended sediment data (Appendix B);
3. Evaluation of existing vegetation conditions using field data (Appendix C);
4. Review of biological information pertaining to recruitment failure hypotheses for Kootenai sturgeon and life stage history and behavior for other focal species (Appendix D); and
5. Investigation of the morphological departure between existing and historical river conditions (Appendix E).

Limiting factors, and potential restoration treatments designed to address those limiting factors, were initially collaboratively identified at a Kootenai River Habitat Restoration Project Design Team meeting early in the project planning process.[1] At this meeting an extensive list of

[1] As describe in Chapter 1, the Kootenai River Habitat Restoration Project Design Team (Design Team) was established by the Kootenai Tribe to support this project. Participants included KTOI staff, federal and state agency staff representing a range of disciplines, regional co-managers, and consultants. The Design Team's role was to provide technical input and information, assist in technical reviews, and to provide a sounding board to the Tribe and their river

potential restoration treatments was identified and discussed to ensure that no potential treatments were prematurely excluded from the conceptual design framework. Participants at this meeting represented a range of disciplines and technical expertise (e.g., river restoration designers, hydrologists, geomorphologist, fish biologists, natural resource managers, engineers, environmental compliance specialists, etc.) This preliminary list of restoration treatments was then refined by the Kootenai Tribe's river design contractors in order to eliminate duplicative treatments, refine the conceptual detail associated with each treatment, and ensure that all of the restoration treatments presented in this Master Plan were able to address one or more of the limiting factors.

This Master Plan is intended to provide a conceptual framework to support design and implementation of the Kootenai River Habitat Restoration Project. Additional data collection, monitoring and analysis, and other inputs will be used to refine and validate the restoration treatments during the preliminary and final design phases and continuing through the implementation process.

Table 3-1 illustrates the link between the restoration treatments described in this chapter and the limiting factors described in Chapter 2. In Table 3-2 (next page) restoration treatments are arranged by reach in order to form habitat actions that address the reach-specific limiting factors.

---

design contractors. Design Team participants include: the Kootenai Tribe; the Tribe's contractors (including the river design contractors, project managers, researchers); and representatives from USFWS, USACE, USGS, BPA, IDFG, MFWP, and BC MoE.

Table 3-1. Summary of limiting factors, restoration strategy components and restoration treatments for the Kootenai River Habitat Restoration Project.

Limiting Factors	Restoration Strategy Components	Restoration Treatments
Morphological limiting factors		
River and floodplain response to altered flow regime and altered hydraulics	Establish channel dimensions that are sustainable given the morphological setting and governing flow and sediment regimes	▪ Excavate or dredge the river to modify the channel geometry ▪ Install bank structures ▪ Install instream structures
River and floodplain response to altered sediment supply and sediment-transport conditions	Gradually reduce sediment supply and transport competence in a downstream direction in order to promote deposition of sediment on the floodplain in the Braided reaches and reduce deposition of sediment on the channel bed in downstream reaches	▪ Excavate or dredge the river to modify the channel geometry ▪ Construct floodplain surfaces ▪ Install bank structures ▪ Excavate floodplain adjacent to the river ▪ Manage the backwater from Kootenay Lake
Loss of floodplain connection	Establish channel and floodplain connection at mean annual peak flow where feasible given constraints from river and floodplain management	▪ Excavate or dredge the river to modify the channel geometry ▪ Excavate floodplain adjacent to the river
Bank erosion and reduced boundary roughness	Establish bank vegetation Increase channel roughness	▪ Revegetate the floodplain ▪ Revegetate the riparian corridor and establish a riparian buffer ▪ Install bank structures
Riparian vegetation limiting factors		
Lack of surfaces that support riparian recruitment	Increase floodplain areas with suitable substrate and elevation relative to the water table in order to support riparian vegetation recruitment and establishment	▪ Construct floodplain surfaces ▪ Construct or enhance wetlands ▪ Construct or enhance secondary channels ▪ Excavate floodplain adjacent to the river
Lack of outer bank vegetation	Establish bank vegetation	▪ Revegetate the riparian corridor and establish a riparian buffer ▪ Install bank structures ▪ Revegetate the floodplain
Frequent scour/deposition of floodplain surfaces	Increase stability/longevity of floodplain surfaces	▪ Construct or enhance wetlands ▪ Revegetate the floodplain ▪ Install bank structures
Altered hydroperiod	Increase floodplain areas with appropriate elevation ranges relative to the water table to support native tree and shrub species	▪ Construct or enhance wetlands ▪ Construct or enhance secondary channels ▪ Construct or enhance wetlands adjacent to the river ▪ Construct or enhance wetlands behind the levees and connect to the river ▪ Construct or enhance secondary channels adjacent to the river

Table 3-1. Summary of limiting factors, restoration strategy components and restoration treatments for the Kootenai River Habitat Restoration Project.

Limiting Factors	Restoration Strategy Components	Restoration Treatments
		▪ Construct or enhance secondary channels behind the levees and connect to the river
Invasive weeds	Reduce weed cover so weeds do not limit recruitment and establishment of native plant species	▪ Construct or enhance wetlands ▪ Revegetate the floodplain ▪ Revegetate the riparian corridor and establish a riparian buffer ▪ Revegetate the floodplain adjacent to the river ▪ Manage land use practices
Lack of native plants and seed sources	Establish nodes of diverse, native vegetation within the Straight Reach and Meander Reaches	▪ Revegetate the riparian corridor and establish a riparian buffer ▪ Construct or enhance wetlands adjacent to the river ▪ Construct or enhance wetlands behind the levees and connect to the river ▪ Revegetate the floodplain adjacent to the river
Lack of nutrient sources for primary productivity and limited carbon storage (reduced primary productivity)	Increase amount and diversity of native vegetation and wetlands within the Meander Reaches	▪ Construct or enhance wetlands ▪ Revegetate the floodplain ▪ Construct or enhance wetlands adjacent to the river ▪ Construct or enhance wetlands behind the levees and connect to the river ▪ Revegetate the floodplain adjacent to the river
Aquatic habitat limiting factors		
Insufficient depth for Kootenai sturgeon migration preference	Provide depth conditions for normal Kootenai sturgeon migration and spawning behavior in sturgeon migration reaches	▪ Excavate or dredge the river to modify the channel geometry
Insufficient velocity for Kootenai sturgeon spawning preference	Provide velocity conditions for Kootenai sturgeon spawning and embryo/free-embryo incubation and rearing in sturgeon spawning reaches	▪ Excavate or dredge the river to modify the channel geometry ▪ Install instream structures
Lack of coarse substrate for Kootenai sturgeon egg attachment	Provide substrate conditions for Kootenai sturgeon embryo/free-embryo incubation and rearing in sturgeon spawning reaches	▪ Excavate or dredge the river to modify the channel geometry ▪ Install instream structures
Lack of cover for juvenile fish	Increase instream and bank cover by constructing instream structures and establishing bank vegetation	▪ Construct or enhance secondary channels ▪ Install bank structures ▪ Revegetate the riparian corridor and establish a riparian buffer ▪ Install instream structures ▪ Revegetate the floodplain adjacent to the river
Lack of pool-riffle complexity	Increase hydraulic habitat complexity by establishing ratios of pool and riffle habitat that are appropriate for the morphological setting	▪ Excavate or dredge the river to modify the channel geometry ▪ Install instream structures

Table 3-1. Summary of limiting factors, restoration strategy components and restoration treatments for the Kootenai River Habitat Restoration Project.

Limiting Factors	Restoration Strategy Components	Restoration Treatments
Simplified foodweb from lack of nutrients	Increase nutrient availability	▪ Construct or enhance wetlands ▪ Revegetate the floodplain ▪ Construct or enhance wetlands adjacent to the river ▪ Construct or enhance wetlands behind the levees and connect to the river
Insufficient pool frequency	Establish pool frequency that is appropriate for the morphological setting	▪ Excavate or dredge the river to modify the channel geometry ▪ Install instream structures
Lack of fish passage into tributaries	Establish fish passage at known barriers on tributaries within the project area	▪ Tributary restoration
Lack of off-channel habitat for rearing	Increase availability of off-channel habitat for native aquatic species	▪ Construct or enhance secondary channels adjacent to the river ▪ Construct or enhance secondary channels behind the levees and connect to the river ▪ Tributary restoration
Altered water quality	Identify and reduce point source pollutant inputs into Kootenai River and tributaries	▪ Revegetate the riparian corridor and establish a riparian buffer ▪ Construct or enhance wetlands adjacent to the river ▪ Construct or enhance wetlands behind the levees and connect to the river ▪ Revegetate the floodplain adjacent to the river
Constraints on restoration due to river and floodplain management		
Dam controlled flow regime	Develop habitat actions that are compatible with modified regimes and work with Libby Dam managers so operations support habitat restoration efforts	▪ Manage the discharge from Libby Dam
Dam controlled sediment regime	Develop habitat actions that are compatible with modified regimes and work with Libby Dam managers so operations support habitat restoration efforts	▪ Manage the discharge from Libby Dam
Dam controlled thermal regime	Develop habitat actions that are compatible with modified regimes and work with Libby Dam managers so operations support habitat restoration efforts	▪ Manage the discharge from Libby Dam
Dam controlled nutrient regime	Develop habitat actions that are compatible with modified regimes and work with Libby Dam managers so operations support habitat	▪ Manage the discharge from Libby Dam

Table 3-1. Summary of limiting factors, restoration strategy components and restoration treatments for the Kootenai River Habitat Restoration Project.

Limiting Factors	Restoration Strategy Components	Restoration Treatments
	restoration efforts	
Floodplain land use	Coordinate with landowners and grazing lessees to explore development of grazing management plans that allow floodplain vegetation to develop	▪ Develop land use practices that support habitat restoration
Bank armoring	Coordinate with appropriate parties to maintain, modify or remove bank armoring to support channel, riparian and floodplain ecological processes according to specific habitat actions	▪ Mitigate for impacts from or to infrastructure
Levees and diking districts	Coordinate with diking districts and other effected parties to maintain and/or modify levees to support channel, riparian and floodplain ecological processes according to specific habitat actions	▪ Mitigate for impacts from or to infrastructure
Transportation corridors	Develop habitat actions that are compatible with existing infrastructure; and work with owners to mitigate for potential impacts to infrastructure from project actions	▪ Mitigate for impacts from or to infrastructure
Floodplain draining/pumping	Work with diking districts, NRCS, SCD, and landowners as appropriate to Identify areas where floodplain draining and pumping can be modified to restore floodplain hydrology	▪ Mitigate for impacts from or to infrastructure
Backwater influence from Kootenay Lake	Reduce the negative effects of the backwater influence in the Braided Reaches	▪ Manage the backwater from Kootenay Lake
Urban development adjacent to river	Design habitat actions that do not place urban infrastructure at risk, and create riparian buffers to separate Bonners Ferry from the river where possible by working with the City of Bonners Ferry and landowners	▪ Mitigate for impacts from or to infrastructure ▪ Revegetate the riparian corridor and establish a riparian buffer

3.3 Restoration Strategies and Treatments by Reach

This section describes restoration strategies for each project reach, and how proposed restoration treatments for each reach combine to address the limiting factors and form a habitat action. Table 3-2 provides the list of restoration treatments that together form the habitat action for each reach. Each restoration treatment description includes example photos and figures to show the treatment in the context of river and stream restoration projects. For each treatment, the following summary information is provided: 1) description; 2) limiting factors addressed; 3) applicable river reaches; 4) anticipated benefits; 5) potential drawbacks; and 6) role of the treatment in the context of a habitat action. At the end of each project reach description, a table is included that uses small, medium and large dots to illustrate to what degree each restoration treatment might overcome each limiting factor (a larger dot indicates the treatment is estimated to be more likely to address a limiting factor).

Within this section, management-related restoration treatments that apply to the entire project area are discussed first because those treatments are integrated into the habitat action for each reach. After project-wide restoration treatments are described, specific restoration treatments are described for the Braided Reaches, Straight Reach and Meander Reaches.

Table 3-2. Summary of potential habitat actions and restoration treatments by reach.

Habitat Action	Treatment Name	Treatment Identifier
Stewardship Actions that Apply to All Reaches	Manage the discharge from Libby Dam	KR-A
	Manage the backwater from Kootenay Lake	KR-B
	Manage land use practices	KR-C
	Mitigate for impacts from or to infrastructure	KR-D
	No action	KR-E
Braided Reaches Habitat Action	Excavate or dredge the river to modify channel geometry	BR-A
	Construct floodplain surfaces	BR-B
	Construct and/or enhance wetlands	BR-C
	Construct and/or enhance secondary channels	BR-D
	Revegetate the floodplain	BR-E
	Install bank structures (bank stabilization, bioengineering)	BR-F
	Install instream structures (habitat, river training, grade control)	BR-G
Straight Reach Habitat Action	Excavate or dredge the river to modify the channel geometry	SR-A
	Revegetate the riparian corridor and establish a riparian buffer	SR-B
	Install bank structures (bank stabilization, bioengineering)	SR-C
	Install instream structures (habitat, river training, grade control)	SR-D
Meander Reaches Habitat Action	Excavate or dredge the river to modify the channel geometry	MR-A
	Excavate floodplain adjacent to the river	MR-B
	Construct or enhance wetlands adjacent to the river	MR-C
	Construct or enhance wetlands behind the levees and connect to the river	MR-D
	Construct or enhance secondary channels adjacent to the river	MR-E
	Construct or enhance side channels behind the levees and connect to the river	MR-F
	Revegetate the floodplain adjacent to the river	MR-G
	Install bank structures (bank stabilization, bioengineering)	MR-H
	Install instream structures (habitat, river training, grade control)	MR-I
	Tributary restoration	MR-J

3.3.1 Project-Wide Strategy and Treatments

The following treatments address project area constraints imposed by river and floodplain management. The strategy for implementing these treatments is to promote stewardship by working with private citizens, river resource managers and infrastructure owners to develop practices that support the objectives of the Kootenai River Habitat Restoration Project. The following treatments have been identified as project-wide treatments to address the river and floodplain management constraints.

KR-A. Manage the discharge from Libby Dam

Treatment Description

This treatment involves working with the managers of Libby Dam to ensure that flow management programs support the habitat actions identified in this Master Plan. Efforts to restore more normative flow conditions are underway related to the Libby Dam BiOp (USFWS 2006).

Libby Dam impounds the Kootenai River and has affected the timing, duration and magnitude of channel forming flows.

Limiting Factors Addressed

- Management factors: Dam controlled regimes

Applicable Reaches

- All reaches

Anticipated Benefits

- Increased flows for Kootenai sturgeon migration and spawning including increased depth and velocity
- Improved thermal regime

Potential Drawbacks

- Difficulty of balancing multiple demands for Libby Dam water uses
- Increased flood risk from higher flows
- May not be compatible with land use practices
- Manipulation of flow patterns has implications to habitat project design flow criteria
- Response of disturbed river system to potentially damaging higher flows

Role of Treatment in a Habitat Action

Due to the disturbed nature of the river in the project area, this restoration treatment will likely not fully meet project objectives without simultaneous implementation of other restoration treatments, addressing existing land use practices, and other limiting factors that cannot be addressed through a flow-only alternative, such as nutrient production, improved channel and floodplain interaction and revegetation.

KR-B. Manage the backwater from Kootenay Lake

Treatment Description

This restoration treatment involves reducing the negative impacts of the Kootenay Lake backwater by working with Kootenay Lake managers to lower Kootenay Lake levels on the rising limb of the spring freshet during the initial pulse of bedload movement. A lower lake level could produce subtle increases in velocity and shear stress that would improve sediment-transport characteristics in the Braided and Straight Reaches given the current, dam-controlled flow regime.

Altered flow combined with the backwater effects from Kootenay Lake have resulted in channel aggradation in Braided Reach 2.

Limiting Factors Addressed

- Morphological factors: altered sediment-transport

Applicable Reaches

- All reaches

Anticipated Benefits

- Increased channel velocity
- Reduced in-channel sediment deposition in the Braided Reaches
- Reduced lateral migration in the Braided Reaches
- Reduced bank erosion

Fine sand deposition on coarse mid-channel bars in Braided Reach 2 upstream of Bonners Ferry.

Potential Drawbacks

- Difficulty of balancing multiple demands for Kootenay Lake water uses, including unknown impacts on fish resources in Kootenay Lake
- International coordination
- Potential for increased flow to exacerbate bank erosion

Role of Treatment in a Habitat Action

Managing the Kootenay Lake backwater does not address many of the project area limiting factors and does not address conditions within the whole project area. As a stand-alone restoration treatment, this will have a higher risk because it is sensitive to annual flow conditions and may not be possible to achieve every year.

KR-C. Manage land use practices

Treatment Description

This treatment involves coordination with landowners, agencies and appropriate parties to maintain, modify or encourage practices that support channel, riparian and floodplain ecological processes according to specific habitat actions. Examples of this treatment would include public outreach programs and development of community land use management programs that balance agricultural practices and protection of river resources.

Removal and cutting of large trees along the Kootenai River for levee management.

Limiting Factors Addressed

- Management factors: floodplain land use (i.e., tilling, grading, draining, pumping), bank armoring, and levees and diking districts
- Riparian vegetation factors: invasive weeds, and lack of outer bank vegetation
- Aquatic habitat factors: water quality

Tilling and agricultural practices adjacent to the Kootenai River have replaced historical riparian vegetation.

Applicable Reaches

- All reaches

Anticipated Benefits

- Improved riparian and floodplain processes
- Improved water quality
- Increased availability of off-channel habitat

Potential Drawbacks

- May not be compatible with present land use practices

Role of Treatment in a Habitat Action

This treatment will primarily address land use practices associated with off-channel areas and along streambanks. The treatment encourages development of appropriate off-channel habitat conditions that increase ecosystem productivity through collaborative shifts in land use. Due to the disturbed nature of the river in the project area, this restoration treatment will likely not fully meet project goals and objectives without simultaneous implementation of other restoration treatments.

KR-D. Mitigate for impacts from or to infrastructure

Treatment Description

This restoration treatment involves using a variety of techniques to mitigate potential conflicts between infrastructure and implementation of the potential habitat actions. Elements of this treatment include establishing riparian buffers and installing alternative bank protection measures that encourage riparian and floodplain ecological processes according to specific habitat actions. Any such measures would happen through a collaborative process that includes those entities responsible for infrastructure integrity. Conversely, mitigation measures such as bank armoring or infrastructure relocation may be required to protect infrastructure from habitat actions.

The USGS gaging station no. 12309500 upstream of Bonners Ferry. Restoration design will ensure proposed restoration treatments mitigate potential impacts to existing infrastructure.

Limiting Factors Addressed

- Management factors: bank armoring, levees and diking districts, and transportation corridors (i.e., railroads, bridges, urban development)
- Aquatic habitat factors: lack of fish passage into tributaries

The Union Pacific Railroad Bridge downstream of Bonners Ferry in the Straight Reach.

Applicable Reaches

- All reaches

Anticipated Benefits

- Improved channel, riparian and floodplain processes
- Improved water quality
- Increased structure protection

Potential Drawbacks

- Infrastructure mitigation may impede implementation of certain habitat actions

Role of Treatment in a Habitat Action

These treatments can be implemented as "stand alone" techniques and in combination with other restoration techniques including channel and floodplain restoration, installation of bank, channel and habitat structures, and revegetation.

KR-E. No action

Treatment Description

No action may be an appropriate treatment for segments of the project area that presently exhibit high quality habitat for Kootenai sturgeon and other focal species. In other areas, due to land ownership, infrastructure limitations or other factors, no action may be the appropriate treatment because other restoration treatments are not feasible.

Portions of the Kootenai River upstream of Braided Reach2 are stable, structurally confined stream types. Pending further research and monitoring, implementation of a no action alternative may be appropriate for portions of this reach.

Limiting Factors Addressed

- None

Applicable Reaches

- All reaches in areas with current high quality habitat

Anticipated Benefits

- No additional disturbance or risk created by a restoration treatment

Potential Drawbacks

- No change to limiting factors for morphology, riparian vegetation, and aquatic habitat

Role of Treatment in a Habitat Action

No action in one portion of the river will require coordination with other restoration treatments implemented in other reaches to improve aquatic habitat conditions in the project area.

3.3.2 Braided Reaches Strategy, Treatments and Habitat Action

As described in Chapter 2, portions of the Braided Reaches do not exhibit, nor trend toward a channel form that would occur naturally within the existing morphological setting. Until a dynamic equilibrium is established, the Braided Reaches will display instability as the river attempts to adjust its location, gradient and flow capacity to the altered hydraulics.

With a large portion of the subbasin sediment supply captured by Libby Dam, the dynamic behavior of the river today is attributed to the supply of sediment delivered from bank erosion within the project area and lack of availability of sediment storage areas due to a loss of floodplain connection. As a result, sediment delivered from the subbasin and recruited via bank erosion is stored temporarily within the active channel in Kootenai sturgeon spawning reaches rather than on the floodplain.

The existing wide and shallow channel geometry results in low velocities and shallow depths, which have been identified as limiting factors for some life stages of project focal species including Kootenai sturgeon. Unstable and shifting depositional surfaces, particularly in Braided Reach 2, limit the ability of riparian vegetation to become established. In addition, the Kootenay Lake backwater exacerbates conditions in Braided Reach 2 by causing seasonal fluctuations in water-surface elevation, energy gradient and sediment-transport capacity. While floodplain vegetation is abundant in portions of Braided Reaches, some areas lack stable surfaces that can sustain riparian plant community development processes, and other areas have been cleared of vegetation for agricultural purposes.

To address these conditions, the restoration strategy in the Braided Reaches focuses on establishing channel dimensions that are sustainable given the morphological setting, governing flow and sediment regimes, gradually reducing sediment supply and transport competence in a downstream direction, promoting deposition of sediment on the floodplain, constructing side channels that will provide access to floodplain surfaces and convey portions of high flows, constructing a new floodplain that is connected to the channel during average annual peak flows, and revegetating the floodplain in a way that results in a complex, multi-structured native plant community with a mosaic of age classes and hydrologic regimes.

Because natural processes that would form instream habitat for focal species are not currently functioning in the Braided Reaches, the restoration strategy also includes instream and bank structures that would function as habitat for aquatic species in the short-term. Over the long-term, as riparian and wetland plant communities develop on the floodplain and along stream banks, natural processes would result in large and coarse wood being recruited into the stream channel, providing ingredients for future aquatic habitat like woody debris jams, buried logs and the pools that would result from this addition of complex hydraulic components in comparable unaltered rivers.

Based on this strategy, the following restoration treatments would be implemented in the Braided Reaches.

BR-A. Excavate or dredge the river to modify the channel geometry

Treatment Description

This treatment includes establishing sustainable channel dimensions given the morphological setting and governing flow and sediment regimes. A reconstructed channel will gradually reduce sediment supply and transport competence in a downstream direction, promoting deposition of fine sediment on the floodplain rather than in the channel. In addition, a reconstructed channel includes construction of habitat features such as pools and riffles that will provide a range of aquatic habitat conditions. Heavy equipment will be used to excavate, dredge and re-grade the channel into a new configuration.

Limiting Factors Addressed

- Morphological factors: altered hydraulics and altered sediment-transport
- Aquatic habitat factors: insufficient depth for Kootenai sturgeon, insufficient velocity for Kootenai sturgeon, lack of pool-riffle complexity, and insufficient pool frequency

Excavator with muck bucket modifying channel geometry for an abandoned oxbow reactivation.

Anticipated Benefits

- Channel dimensions are sustainable for given flow and sediment inputs
- Reduced downstream sediment supply
- Increased depth for Kootenai sturgeon
- Increased velocity for Kootenai sturgeon
- Improved hydraulic complexity
- Increased pool frequency

River excavation utilizing a barge mounted excavator with muck bucket is used to restore pool morphology.

Potential Drawbacks

- Disturbance
- May take more than one year to implement within a reach

Role of Treatment in a Habitat Action

Modifying the channel geometry in the Braided Reaches will diversify and enhance aquatic habitat conditions and improve hydraulic and sediment-transport functions. For this treatment to be successful, it will need to be implemented in conjunction with other treatments that improve its sustainability and address the other limiting factors present in the Braided Reaches. Because equipment is not able to establish a channel configuration in the same manner as a natural fluvial system, the raw, post-construction condition of the river following this treatment will not be sustainable without temporary measures that provide interim protection of constructed features. For example, the river banks will need to be treated with structures to maintain a level of bank protection that allows vegetation communities to grow and provide longer term bank protection and stability typical of a natural river system. Similarly, modifying the channel geometry supports the sustainability of other treatments such as revegetation by establishing floodplain hydrology that establishes an appropriate hydroperiod for riparian vegetation recruitment and maturation and persistence.

BR-B. Construct floodplain surfaces

Treatment Description

This restoration treatment includes reestablishing floodplain surfaces, hydrologically connected to the main channel, to store sediment and facilitate riparian plant establishment in the Braided Reaches. Using heavy equipment, portions of the currently over-widened channel will be filled with soil excavated from channel reconstruction (Treatment BR-A) to create floodplain surfaces with hydrologic connection that supports riparian vegetation. Floodplain surfaces created at the appropriate elevations relative to the channel promote the establishment of riparian vegetation and create topographic features that increase floodplain roughness, allowing for scour and deposition across the floodplain. A floodplain at the proper elevation maintains channel dimensions by allowing frequent access by overbank flows, thereby relieving shear stress in the channel.

An example of a constructed floodplain surface with added microtopography and coarse woody debris.

Temporary measures such as braced retaining walls are used to backfill over-widened channel areas and construct vegetated floodplain surfaces.

Limiting Factors Addressed

- Morphological factors: altered sediment-transport and hydraulic characteristics
- Riparian vegetation factors: lack of surfaces that support riparian recruitment and altered hydroperiod

Anticipated Benefits

- Improved deposition of fine sediments on the floodplain
- Improved riparian vegetation recruitment
- Improved hydroperiod

Potential Drawbacks

- Length of time to implement

Role of Treatment in a Habitat Action

Construction of floodplain surfaces will contribute to overall restoration within the Braided Reaches by creating topographically diverse surfaces adjacent to the river that can be accessed by average peak flows. For this treatment to be successful, it will need to be implemented in conjunction with channel dredging and excavation so the floodplain has the correct elevation to allow annual flooding and sediment storage, and other valuable floodplain habitat structure and function. In addition, river banks will need to be protected to limit floodplain erosion from channel migration or avulsion. Similarly, floodplain revegetation will increase roughness, adding a sediment filtering function that will promote long-term sediment storage as part of natural floodplain building processes.

BR-C. Construct or enhance wetlands

Treatment Description

This restoration treatment includes creating or enhancing wetland features connected to the main channel, such as those that historically existed along the Kootenai River. Wetland construction involves restoring or creating wetland hydrology and hydrophytic vegetation. Constructed wetlands filter and store sediment; supply nutrients; provide habitat for invertebrates, amphibians, juvenile fish species, and birds; and support the food web. Wetland treatments may include:

- Planting wetland vegetation
- Weed management
- Installing large wood for habitat

Reestablishing channel-floodplain connectivity facilitates the recovery of drained emergent and shallow water wetlands.

Limiting Factors Addressed

- Riparian vegetation factors: lack of surfaces that support riparian vegetation, frequent scour/deposition of floodplain surfaces, altered hydroperiod, and invasive weeds
- Aquatic habitat factors: simplified food web from lack of nutrients

A mosaic of floodplain wetlands increases the functions and values of the river system by creating areas that support waterfowl habitat, off-channel rearing, and sediment filtration.

Anticipated Benefits

- Sediment storage and reduced sediment supply to downstream reaches
- Improved riparian and floodplain vegetation
- Improved off-channel habitat for fish rearing

Potential Drawbacks

- Land uses may need to be modified to accommodate wetland development and enhancement

Role of Treatment in a Habitat Action

Constructed wetlands will contribute to overall restoration and biological productivity within the Braided Reaches by filtering and storing sediments, supplying nutrients, and creating aquatic, riparian and terrestrial habitats. This restoration treatment will have greater success when combined with other treatments that address floodplain connection and protect constructed wetlands from disturbance caused by impaired channel processes such as bank erosion.

BR-D. Construct or enhance secondary channels adjacent to the river

Treatment Description

This restoration treatment includes constructing secondary channels that will offer off-channel aquatic habitat for juvenile fish, and route water and sediment from the main channel to floodplain storage areas. Secondary channel features will have the following general characteristics: upstream and downstream connection to the main channel, low gradients, and varied dimensions in support of hydraulic diversity. Elements of this restoration treatment include:

- Side channel construction
- Revegetation of floodplain areas along secondary channels
- Bioengineering to establish woody vegetation along secondary channel banks
- Woody debris placement for cover, sediment trapping, and habitat diversity

Secondary channels distribute floodwater across the channel migration zone, recharging the water table and providing adequate soil moisture for riparian plants.

Secondary channels provide valuable off-channel habitat for fish wildlife and help dissipate river energy during extreme flood events.

Limiting Factors Addressed

- Riparian vegetation factors: altered hydroperiod
- Aquatic habitat factors: lack of cover for juvenile fish

Anticipated Benefits

- Improved off-channel habitat complexity
- Reduced sediment supply to the Kootenai River
- Improved floodplain connectivity

Potential Drawbacks

- Diminished stream flow in main channel
- Potential for capturing too much flow from main channel and causing major shift in channel alignment.

Role of Treatment in a Habitat Action

Construction of secondary channels will facilitate routing water and sediment to floodplain storage areas and provide off-channel refuge for juvenile fish and other aquatic biota. Secondary channels will also serve as 'relief valves' for excess flow from the main channel during flood events. The success of secondary channel construction or enhancement actions would be improved by the addition of large wood habitat features, revegetation of floodplains and riparian areas, and other treatments that would protect secondary channels from disturbance.

BR-E. Revegetate the floodplain

Treatment Description

This restoration treatment includes a variety of activities to create conditions for newly constructed floodplain surfaces to support a diverse mosaic of plant communities in the Braided Reaches. A structurally diverse vegetated floodplain provides many functions that will address limiting factors including sediment filtration, velocity reduction during overbank flows, streambank stabilization, organic matter inputs to the stream and floodplain, complex surfaces that promote native plant species diversity and therefore limit opportunities for weed invasion, and a native plant community that can provide seed sources to sustain plant community succession. Activities applicable to revegetating the floodplain include:

- Containerized planting, mature shrub salvage and transplant, dormant plant material installation
- Removal or management of invasive weed species
- Placement of woody debris and construction of microtopography
- Substrate variation and soil amendments
- Seeding

Constructing microtopographic depressions (i.e., swales) and placing coarse woody material creates sheltered areas and encourages natural plant establishment on floodplain surfaces.

Example floodplain revegetation technique incorporating solarization mats to discourage competition between plants and non-native grasses. Protectors are used to discourage browsing by animals.

Limiting Factors Addressed

- Morphological factors: reduced channel boundary roughness and bank erosion rates
- Riparian vegetation factors: addresses all factors
- Aquatic habitat factors: simplified food web from lack of nutrients; lack of cover for juvenile fish

Anticipated Benefits

- Reduced sediment supply to downstream reaches
- Restoration of natural floodplain processes
- Improved riparian and floodplain vegetation, and primary and secondary biological production

Potential Drawbacks

- Long time frame for plant communities to establish to maximize floodplain function
- Many activities require long-term routine maintenance such as watering

Excavating floodplain swales and transplanting mature shrubs and sod mats can improve riparian and floodplain functions.

Role of Treatment in a Habitat Action

Floodplain revegetation will contribute to overall restoration within the Braided Reaches by creating relatively stable surfaces adjacent to the river that can be accessed by average peak flows. Vegetation will increase roughness, adding a sediment filtering function that will promote long-term sediment storage as part of natural floodplain building processes. For this treatment to be successful, it will need to be implemented in conjunction with channel dredging and excavation so the

adjacent channel has the correct elevation and dimensions to allow annual flooding and sediment storage. In addition, stream banks across from the floodplain will need to be treated to limit recruitment of excess sediment from bank erosion, and so the channel can maintain its dimensions (which is critical to maintain a connected floodplain). Initially, instream habitat will be constructed using imported wood and substrate, but over the long-term, revegetating the floodplain will result in available large wood that can be naturally recruited into the stream and will support instream habitat.

BR-F. Install bank structures

Treatment Description

Installation of bank structures addresses bank erosion and reduced channel boundary roughness by creating conditions that will support establishment of bank vegetation. In addition, bank structures can offer benefits to aquatic habitat such as bank cover and channel margin complexity. A wide range of structure options are available under this restoration treatment including:

- Bioengineering for revegetation
- Large woody debris placement for aquatic habitat and pool formation
- Sod and wood toe structures

Bioengineering structures create suitable conditions for native vegetation to become established along the streambank. Deep-rooted native vegetation will stabilize streambanks and create roughness along the channel margins. Stable, vegetated banks coupled with reduced velocity resulting from the roughness will lessen bank erosion. Large woody debris structures create instream habitat and maintain channel dimensions by dissipating flow energy away from the banks and sustaining pool habitat. Sod and wood toe structures create interim protection for newly constructed channels while woody bank vegetation becomes established over the long-term.

Limiting Factors Addressed

- Morphological factors: altered sediment-transport, reduced channel boundary roughness, and bank erosion rates
- Riparian vegetation factors: lack of outer bank vegetation and frequent scour/deposition of floodplain surfaces
- Aquatic habitat factors: lack of cover for juvenile fish

Anticipated Benefits

- Reduced bank erosion and downstream sediment supply
- Improved channel margin complexity

Potential Drawbacks

- Bank structures may limit erosion (and therefore sediment deposition) in the short term, but over the long term, this will result in banks that are vegetated but still able to migrate at natural rates given the geomorphic setting.

Role of Treatment in a Habitat Action

Bank structures will contribute to the overall restoration within the Braided Reaches by creating near-bank aquatic habitat and protecting surfaces adjacent to the river so that riparian vegetation can become established. Vegetated banks will reduce bank erosion, add boundary roughness and reduce the supply of sediment to the river. Vegetation will increase roughness, adding a sediment filtering function that will promote long-term sediment storage as part of natural floodplain building processes. This treatment may be implemented in conjunction with other treatments, such as excavating and dredging the channel, to reduce stress on banks.

Example river bank structures incorporating large wood, bioengineering, and vegetation (Year 1 following installation with other treatments including channel excavation).

Streambank construction technique used to buffer the stream from an eroding terrace. Large woody debris complexes, sod mats, and whole shrub transplants were utilized (Year 3 following installation).

BR-G. Install instream structures

Treatment Description

Installation of instream structures addresses aquatic habitat deficiencies by introducing coarse substrate for spawning substrate and maintaining instream habitat elements such as pools and riffles. A wide range of instream structure options are included under this treatment:

- Alluvium placement for spawning substrate, roughness and hydraulic complexity
- Boulder placement for cover, complexity and grade control (to maintain floodplain connection)
- Flow redirection for hydraulic complexity, bank protection, and existing substrate scour

Constructed riffle used for grade control and energy dissipation.

Instream structures create habitat such as pools and patches of coarse substrate, increase channel complexity, and direct channel velocity.

Floodplain bar used to narrow the existing channel and provide connected off-channel habitat.

Limiting Factors Addressed

- Morphological factors: altered hydraulics and bank erosion
- Aquatic habitat factors: lack of cover for juvenile fish, lack of pool-riffle complexity, and insufficient pool frequency

Anticipated Benefits

- Reduced bank erosion and sediment supply
- Increased instream complexity
- Increased pool frequency
- Increased coarse substrate composition

Single log vane used to re-direct flow, provide temporary bank stability and facilitate growth of mature riparian plants.

Potential Drawbacks

- Construction access to the river (physical obstructions and private land ownership)
- Disturbance

Role of Treatment in Habitat Action

Instream structures will contribute to the overall restoration within the Braided Reaches by enhancing aquatic habitat and protecting surfaces adjacent to the river so that riparian vegetation can become established. For this treatment to be successful, it will need to be implemented in conjunction with other treatments that improve its sustainability and address the other limiting factors present in the Braided Reaches. Performance of instream structures can be enhanced when the treatment is paired with other treatments, such as modifying channel geometry, because of increased control of adjacent site conditions provided by the other treatments.

The restoration treatment descriptions provided in this section present the treatment details in a manner that illustrates why habitat actions comprised of combinations of treatments are more likely to address the limiting factors than stand-alone treatments.

Table 3-3 presents the Braided Reaches habitat actions in a matrix of limiting factors and restoration treatments to summarize how various habitat actions address the reach-specific limiting factors. Restoration treatments were rated as having either high, moderate, low or no ability to address the limiting factors (represented respectively by large, medium, small and no dots). The habitat action (HA) rating for each limiting factor is the highest rating of any restoration treatment relative to that limiting factor. For example, if one or more treatments are estimated to have a high ability to address a limiting factor, the habitat action receives a high rating for that limiting factor. ***Thus, the following matrix is intended to illustrate how restoration treatments within a reach combine as a habitat action to address most or all limiting factors.*** Conversely, the matrices also illustrate that a single restoration treatment would not address every limiting factor within a reach; therefore, it is necessary to use multiple restoration treatments in a reach.

The following general guidelines, in addition to professional judgment, were used to establish the ratings represented by dot sizes and presented in Tables 3-3 through 3-6.

High rating – the treatment *directly* addresses the limiting factor by employing a physical modification *and* by managing a process that affects the limiting factor. A treatment given a high rating is likely to address the limiting factor in a sustainable manner in the shortest period of time.

Moderate rating – the treatment *directly* addresses the limiting factor by managing a process. A treatment given a moderate rating *may* address the factor in a sustainable or intermittent manner, but it may take a longer period of time to address the factor due to its reliance on environmental variables.

Low rating – the treatment *indirectly* addresses the limiting factor by influencing a related process that is not the primary cause of the limiting factor. A treatment given a low rating will not address the limiting factor, however, it may reduce the severity of the limiting factor.

No rating – the treatment does not address the limiting factor.

Treatment key for Table 3-3	
BR-A	Excavate or dredge the river to modify channel geometry
BR-B	Construct floodplain surfaces
BR-C	Construct and/or enhance wetlands
BR-D	Construct and/or enhance secondary channels
BR-E	Revegetate floodplain
BR-F	Install bank structures
BR-G	Install instream structures
KR-A	Manage discharge from Libby Dam
KR-B	Manage backwater from Kootenay Lake
KR-C	Manage land use practices
KR-D	Mitigate for impacts from or to infrastructure

Table 3-3. Ability of treatments to address limiting factors in the Braided Reaches.

	BR-A	BR-B	BR-C	BR-D	BR-E	BR-F	BR-G	KR-A	KR-B	KR-C	KR-D	HA Rating
Limiting factors for morphology												
Altered hydraulics	●	•	•	•	•	•	•	●	•			●
Altered sediment-transport	●	●	•	•	•	●	•	•	●			●
Reduced channel boundary roughness	•				●	●	•			•		●
Bank erosion	•	•			●	●	•		•	•		●
Limiting factors for riparian vegetation												
Lack of surfaces that support riparian recruitment	•	●	●	●	•	•						●
Lack of outer bank vegetation					●	●				•		●
Frequent scour/deposition of floodplain surfaces	•	•	●	•	●	●			•			●
Altered hydroperiod		•	●	●				•	•			●
Invasive weeds		•	●	•	●	•				●		●
Limiting factors for aquatic habitat												
Insufficient depth for Kootenai sturgeon migration preference	●						•	•	•			●
Insufficient velocity for Kootenai sturgeon spawning preference	●						•	•				●
Lack of cover for juvenile fish			•	●	•	●	●					●
Lack of pool-riffle complexity	●					•	●					●
Simplified food web from lack of nutrients		•	●	•	●	•				•		●

Table 3-3. Ability of treatments to address limiting factors in the Braided Reaches.

	BR-A	BR-B	BR-C	BR-D	BR-E	BR-F	BR-G	KR-A	KR-B	KR-C	KR-D	HA Rating
Insufficient pool frequency	●					•	●					●
Constraints from river and floodplain management												
Dam controlled flow regime								●				●
Dam controlled sediment regime												
Dam controlled thermal regime								•				•
Floodplain land use										●		●
Kootenay Lake backwater									●			●
Bank armoring										●	●	●
Levees and diking districts										●	●	●
Transportation corridors											•	•

• Low potential to address limiting factors.

● Moderate potential to address limiting factors.

● High potential to address limiting factors.

Blank – No potential to address limiting factors.

3.3.3 Straight Reach Strategy, Treatments and Habitat Action

The Straight Reach is approximately one mile long and flows through the urbanized center of Bonners Ferry. Aquatic and riparian habitat conditions are severely degraded in this reach due to bank armoring and vegetation removal.

The Straight Reach is subject to constraints from infrastructure including a high percentage of riprap banks, two bridges at its upper end and levees along its entire length. These levees, combined with naturally occurring confined morphology, result in no floodplain being present in this reach and therefore no areas are available where sediment can deposit or plants can grow. As such, the Straight Reach is effective at routing sediment from the Braided Reaches into the downstream Meander Reaches.

Dominant bed substrate transitions from gravel to sand in the lower half of the reach due to seasonal fluctuations in the Kootenay Lake backwater, which influences the energy gradient through the reach. Riparian vegetation is present along banks, but is mostly growing in narrow bands on levees, so a riparian buffer that could provide habitat or water quality protection is lacking in this reach.

The restoration strategy in the Straight Reach is focused on improving aquatic habitat by increasing cover, pool habitat and hydraulic complexity, and establishing a riparian buffer along the channel margins. This strategy would be accomplished by installing instream structures and allowing the river to 'do the work'. To accomplish this, instream structures would project into the channel to re-direct and concentrate flows into a narrower channel that exhibits improved hydraulic complexity. Areas behind the structures would remain open water, but flow velocities would be relatively slower, allowing sediment to accumulate and eventually form a small, inset floodplain. Where possible, the riparian area width would be increased by planting woody vegetation. The Straight Reach and Braided Reaches strategies are linked, so they would need to be implemented together to most effectively address habitat limiting factors.

Based on this strategy, the following restoration treatments would be implemented in the Straight Reach.

SR-A. Excavate or dredge the river to modify the channel geometry

Treatment Description

This restoration treatment includes establishing sustainable channel dimensions given the morphological setting and governing flow and sediment regimes. A reconstructed channel will gradually reduce sediment supply and transport competence in a downstream direction, promoting deposition of fine sediment on the floodplain rather than in the channel. In addition, a reconstructed channel will include construction of habitat features such as pools and riffles that would provide a range of aquatic habitat conditions. Heavy equipment will be used to excavate, dredge and re-grade the channel into a new configuration.

Limiting Factors Addressed

- Morphological factors: altered hydraulics and altered sediment-transport
- Aquatic habitat factors: insufficient depth for Kootenai sturgeon, insufficient velocity for Kootenai sturgeon, lack of pool-riffle complexity, and insufficient pool frequency

Excavator with muck bucket modifying channel geometry for an abandoned oxbow reactivation.

Anticipated Benefits

- Channel dimensions are sustainable for given flow and sediment inputs
- Reduced downstream sediment supply
- Increased depth for Kootenai sturgeon
- Increased velocity for Kootenai sturgeon
- Improved hydraulic complexity
- Increased pool frequency

River excavation utilizing a barge mounted excavator with muck bucket is used to restore pool morphology.

Potential Drawbacks

- Disturbance
- Potential conflict with infrastructure
- Length of time to implement

Role of Treatment in a Habitat Action

Modifying the channel geometry in the Straight Reach will diversify and enhance aquatic habitat conditions and improve hydraulic and sediment-transport functions. For this treatment to be successful, it will need to be implemented in conjunction with other treatments that improve its sustainability and address the other limiting factors present in this reach. Because equipment is not able to establish a channel configuration in the same manner as a natural fluvial system, the raw, post-construction condition of the river following this treatment will not be sustainable without temporary measures that provide interim protection of constructed features. For example, the river banks will need to be treated with structures to maintain a level of bank protection that allows vegetation communities to grow and provide longer term bank protection typical of a natural river system. Similarly, modifying the channel geometry supports the sustainability of other treatments such as revegetation by establishing floodplain hydrology that establishes an appropriate hydroperiod for riparian vegetation recruitment and maturation.

SR-B. Revegetate the riparian corridor and establish a riparian buffer

Treatment Description

This restoration treatment involves revegetating the riparian corridor to reestablish native riparian trees and shrubs. Riparian corridors bracket the river, providing large wood, sediment, and nutrients to the river as well as storing river-derived materials. Possible treatments to revegetate riparian corridors include:

- Streambank, floodplain and terrace vegetation planting
- Removal or management of invasive weed species

A well vegetated channel migration zone provides a variety of ecological benefits to the river system.

Limiting Factors Addressed

- Morphological factors: reduced channel boundary roughness
- Riparian vegetation factors: lack of outer bank vegetation, frequent scour/deposition of floodplain surfaces, invasive weeds, and lack of native seed sources
- Aquatic habitat factors: altered water quality

Mature vegetation moderates bank erosion and promotes complex habitat through channel scour and floodplain deposition.

Anticipated Benefits

- Enhanced channel margin complexity
- Reduced sediment supply to downstream reaches
- Reduced bank erosion
- Runoff filtration at the urban interface

Potential Drawbacks

- Length of time and effort to establish native plants in an urban environment
- Establishing plants greater than 4 inch diameter on levees conflicts with USACE management practices
- Potential conflict with infrastructure

Role of Treatment in a Habitat Action

This restoration treatment may be implemented as a stand-alone action, but will be enhanced by addressing the factors that limit vegetation establishment, including regulated flows, backwater, and levees.

SR-C. Install bank structures

Treatment Description

Installation of bank structures addresses bank erosion and reduced channel boundary roughness by creating conditions that will support establishment of bank vegetation. In addition, bank structures can offer benefits to aquatic habitat such as bank cover and channel margin complexity. A wide range of structure options are available under this restoration treatment including:

- Bioengineering for revegetation
- Large woody debris placement for aquatic habitat and pool formation
- Sod and wood toe structures

Bioengineering structures create suitable conditions for native vegetation to become established along the streambank. Deep rooted native vegetation will stabilize streambanks and create roughness along the channel margins. Stable, vegetated banks coupled with reduced velocity resulting from the roughness will lessen bank erosion. Large woody debris structures create instream habitat and maintain channel dimensions by dissipating flow energy away from the banks and sustaining pool habitat. Sod and wood toe structures create interim protection for newly constructed channels while woody bank vegetation becomes established over the long-term.

Example river bank structures incorporating large wood, bioengineering, and vegetation (Year 1 following installation with other treatments including channel excavation).

Limiting Factors Addressed

- Morphological factors: altered sediment-transport, reduced channel boundary roughness, and bank erosion rates
- Riparian vegetation factors: lack of outer bank vegetation and frequent scour/deposition of floodplain surfaces
- Aquatic habitat factors: lack of cover for juvenile fish

Streambank construction technique used to buffer the stream from an eroding terrace. Large woody debris complexes, sod mats, and whole shrub transplants were utilized (Year 3 following installation).

Anticipated Benefits

- Reduced bank erosion and downstream sediment supply
- Improved channel margin habitat and hydraulic complexity

Potential Drawbacks

- Bank structures may limit erosion (and therefore sediment deposition) in the short term, but over the long term, this will result in banks that are vegetated but still able to migrate at natural rates given the geomorphic setting.
- Potential conflict with infrastructure

Role of Treatment in a Habitat Action

Bank structures will contribute to the overall restoration within the Straight Reach by creating near-bank aquatic habitat and protecting surfaces adjacent to the river so that riparian vegetation can become established. Vegetated banks will reduce bank erosion, add boundary roughness and reduce the supply of sediment to the river. Vegetation will increase roughness, adding a sediment filtering function that will promote long-term sediment storage as part of natural floodplain building processes.

This treatment will need to be implemented in conjunction with other treatments, such as revegetation, that improve its sustainability and address the other limiting factors present in the Straight Reach. Similarly, performance of bank structures can be enhanced when the treatment is paired with other treatments, such as modifying channel geometry, because of increased control of adjacent site conditions provided by the other treatments.

SR-D. Install instream structures

Treatment Description

Installation of instream structures addresses aquatic habitat deficiencies by introducing coarse substrate for spawning substrate and maintaining instream habitat elements such as pools and riffles. A wide range of instream structure options will be deployed under this treatment including:

- Alluvium placement for spawning substrate, roughness and hydraulic complexity
- Boulder placement for cover, complexity and grade control (floodplain connection)
- Flow redirection for hydraulic complexity, bank protection, and existing substrate scour

Boulder structure used for grade control and energy dissipation.

Instream structures create habitat such as pools and patches of coarse substrate; increase channel complexity; and direct channel velocity.

Floodplain bar used to narrow the existing channel and provide connected backwater habitat.

Limiting Factors Addressed

- Morphological factors: altered hydraulics and bank erosion
- Aquatic habitat factors: lack of cover for juvenile fish, lack of pool-riffle complexity, insufficient pool frequency, insufficient velocity for Kootenai sturgeon spawning, and lack of coarse substrate for Kootenai sturgeon egg attachment

Anticipated Benefits

- Reduced bank erosion and sediment supply
- Increased instream complexity
- Increased pool frequency
- Increased coarse substrate composition

Rock vane used to re-direct flow, provide temporary bank stability and facilitate growth of mature riparian plants.

Potential Drawbacks

- Construction access to the river (physical obstructions and private land ownership)
- Disturbance
- Potential conflict with infrastructure

Role of Treatment in Habitat Action

Instream structures will contribute to the overall restoration within the Straight Reach by enhancing aquatic habitat and protecting surfaces adjacent to the river so that riparian vegetation can become established. Because of the confined morphology and armored banks within the Straight Reach, installation of structures and allowing the river to 'do the work' is a viable treatment to improve instream hydraulic habitat conditions without using equipment to modify the channel geometry. For this treatment to be successful, it will need to be implemented in conjunction with other treatments that address the other limiting factors present in the Straight Reach, such as establishment of a riparian buffer.

Table 3-4 presents the Straight Reach habitat actions in a matrix of limiting factors and restoration treatments in order to summarize the ability of the habitat action to address the reach-specific limiting factors.

Refer to the discussion preceding Table 3-3 in Section 3.3.2 for additional information about the guidelines used to develop the table.

Treatment key for Table 3-4	
SR-A	Excavate or dredge the river to modify the channel geometry
SR-B	Revegetate the riparian corridor and establish a riparian buffer
SR-C	Install bank structures
SR-D	Install instream structures
KR-A	Manage discharge from Libby Dam
KR-B	Manage backwater from Kootenay Lake
KR-C	Manage land use practices
KR-D	Mitigate for impacts from or to infrastructure

Table 3-4. Ability of treatments to address limiting factors in the Straight Reach.

	SR-A	SR-B	SR-C	SR-D	KR-A	KR-B	KR-C	KR-D	HA Rating
Limiting factors for morphology									
Altered hydraulics	●	•	•	●	●	•			●
Altered sediment-transport	●	●	●	●	• ●	•			●
Reduced channel boundary roughness	•	●	●	●			•		●
Limiting factors for riparian vegetation									
Lack of surfaces that support riparian recruitment	•	●	•						●
Lack of outer bank vegetation		●	●				•		●
Frequent scour/deposition of floodplain surfaces	●	●	●			●			●
Altered hydroperiod					●	●			●
Invasive weeds		●	•				●		●
Lack of native seed sources		●	•						●
Lack of nutrient sources for primary productivity		●	•						●

Table 3-4. Ability of treatments to address limiting factors in the Straight Reach.

	SR-A	SR-B	SR-C	SR-D	KR-A	KR-B	KR-C	KR-D	HA Rating
Limiting factors for aquatic habitat									
Insufficient depth for Kootenai sturgeon migration preference	●			•	•	•			●
Insufficient velocity for Kootenai sturgeon spawning preference	●			•	•				●
Lack of coarse substrate for Kootenai sturgeon egg attachment	●				•				●
Lack of cover for juvenile fish		●	●	●					●
Lack of pool-riffle complexity	●		•	●					●
Insufficient pool frequency	●		•	●					●
Altered water quality		●	•				●	•	●
Constraints from river and floodplain management									
Dam controlled flow regime					●				●
Dam controlled sediment regime									
Dam controlled thermal regime					•				•
Kootenay Lake backwater						●			●
Floodplain land use							●		●
Bank armoring							●	●	●
Levees and diking districts							●	●	●
Transportation corridors								•	•

• Low potential to address limiting factors. ● Moderate potential to address limiting factors. ● High potential to address limiting factors. ***Blank*** – No potential to address limiting factors.

3.3.4 Meander Reaches Strategy, Treatments and Habitat Action

The historically dynamic Meander Reaches have been altered by a wide range of river and floodplain management activities. The 55,000-acre historical floodplain in the project area is entirely disconnected from river due to levees and decreased mean annual peak flows, which result in water-surface elevations that are nearly 10 feet lower than historical levels. Fine sediment that historically deposited on the floodplain is now deposited on the channel bed in the Meander Reaches, thus potentially reducing Kootenai sturgeon spawning (embryo incubation) success (Anders et al. 2002). Much of the historical riparian floodplain vegetation and wetlands have been converted to agricultural land, and lands are dewatered to facilitate agricultural practices. The consequences of these alterations on the ecosystem are significant, with the decline of Kootenai sturgeon being one indicator of an ecosystem in decline. Similarly, the loss of floodplain connection, reduced availability of nutrients, lack of diverse habitat and altered sediment and flow regimes place stress on food web dynamics and function and dependent species.

In the Meander Reaches, the restoration strategy focuses on improving interaction between the river and floodplain. Due to the large percentage of private land ownership on the floodplain, site specific rather than reach-scale opportunities (such as in the Braided and Straight Reaches) to improve aquatic habitat are included as part of the restoration strategy. However, this will be further evaluated during later design phases. Meander Reach restoration strategies focus on areas inside the levees adjacent to the river and areas outside the levees that are known to be much lower in elevation and closer to the range of post-levee and post-dam river stage elevations.

The Meander Reaches strategy includes placement of instream and bank structures to improve habitat conditions and reduce bank erosion. Known Kootenai sturgeon spawning areas are located near Shorty's Island in Meander Reach 1, so these are areas where suitable spawning substrate could be placed. Outer meander bends could be supplemented with woody debris structures to create hiding cover for some aquatic focal species. Additional woody debris could be placed near tributary mouths to improve instream habitat at these confluences.

Adjacent to the channel, some areas have been identified where levees are located a distance from the river; floodplain surfaces could be excavated in these areas without compromising flood control infrastructure. These areas would be lowered to an elevation corresponding to the average peak flow river stage to create connected areas of restored floodplain.

Other leveed areas along the river have sparse or no bank vegetation and/or unstable banks. In these areas, banks would be stabilized using a combination of natural materials like trees and river alluvium combined with planted vegetation.

Outside of the levees, in the largely agricultural floodplain, the land elevation is relatively low; in places, the floodplain is several feet below the peak flow river stage. Because of these lower elevations, it is not feasible to remove or significantly modify existing levees without compromising overall flood control infrastructure. Working closely with landowners and diking districts however, there may be opportunities to restore wetlands and riparian plant communities in some of these low floodplain areas. Associated with riparian and wetland restoration, some of these areas could be connected to the river as a way to create off-channel habitat that would support some life stages of aquatic focal species.

Also in the floodplain, several tributaries are present that include fish passage barriers, which would be removed as part of the Meander Reaches restoration strategy. In addition to removing fish passage barriers, there are opportunities to restore aquatic and riparian habitat along tributary streams. Restoring tributaries would support various life stages of some aquatic focal species discussed in Chapter 2.

To support this strategy, the following restoration treatments would be implemented in the Meander Reaches.

MR-A. Excavate or dredge the river to modify the channel geometry

Treatment Description

This restoration treatment involves establishing sustainable channel dimensions given the morphological setting and governing flow and sediment regimes. To accomplish this in the Meander Reaches, channel reconstruction will address the loss of floodplain connection by lowering the adjacent floodplain and/or raising the channel bed. A reconstructed channel will gradually reduce sediment supply and transport competence in a downstream direction, promoting deposition of fine sediment on the floodplain rather than in the channel. In addition, a reconstructed channel will be narrower and include construction of habitat features such as pools and riffles that will provide a range of aquatic habitat conditions and localized increases in velocity and turbulence. Heavy equipment will be used to excavate, dredge and re-grade the channel into a new configuration.

Limiting Factors Addressed

- Morphological factors: altered hydraulics, altered sediment-transport, and loss of floodplain connection.
- Aquatic habitat factors: insufficient velocity for Kootenai sturgeon.

Excavator with muck bucket modifying channel geometry for an abandoned oxbow reactivation.

Anticipated Benefits

- Channel dimensions are sustainable for given flow and sediment inputs
- Improved channel and floodplain interaction
- Reduced instream deposition
- Increased velocity for Kootenai sturgeon

Potential Drawbacks

- Disturbance
- Feasibility of balancing earthwork cut and fill
- Increased flood risk
- Feasibility of construction dewatering
- Length of time to implement
- Land ownership

River excavation utilizing a barge mounted excavator with muck bucket is used to restore pool morphology.

Role of Treatment in a Habitat Action

Modifying the channel geometry in the Meander Reaches will address floodplain connection and improve hydraulic and sediment-transport functions. However, there are significant feasibility issues associated with this treatment including flood risk, construction feasibility, length of time to implement and consequences of instream disturbance. If construction is determined to be feasible during later design phases, the treatment will need to be implemented in conjunction with other treatments that improve its sustainability and address the other limiting factors present in the Meander Reaches. Because equipment is not able to establish a channel configuration in the same manner as a natural fluvial system, the raw, post-construction condition of the river following this treatment will not be sustainable without temporary measures that provide interim protection of constructed features. For example, the river banks would need to be treated with structures to maintain a level of bank protection that allows vegetation communities to grow and provide longer term bank protection typical of a natural river system. Similarly, modifying the channel geometry supports the sustainability of other treatments such as revegetation by establishing floodplain hydrology that results in an appropriate hydroperiod for riparian vegetation recruitment and maturation.

MR-B. Excavate floodplain adjacent to the Kootenai River

Treatment Description

This restoration treatment includes excavating floodplain areas adjacent to the main channel at select locations. These areas will be excavated to an elevation that will allow floodplain connection with the channel under the altered hydrologic regime. The amount of sediment available for bank erosion will be reduced and excavated areas will become suitable locations to establish vegetation along the river banks. This restoration treatment will occur where constructed levees are not located directly along the main channel and there is sufficient room to excavate new floodplain surfaces without disturbing the flood protection levee system. Elements of this restoration treatment include:

- Floodplain excavation and grading

Levees constrict the channel and eliminate channel-floodplain interaction, leading to simplified riparian communities.

Removing levees and constructing floodplain surfaces adjacent to the channel can reestablish natural floodplain processes, when combined with other restoration treatments including bank structures and floodplain revegetation.

Limiting Factors Addressed

- Morphological factors: altered sediment-transport and loss of channel and floodplain connection
- Riparian vegetation factors: lack of surfaces that support riparian recruitment and altered hydroperiod

Anticipated Benefits

- Reduced sediment supply from bank erosion
- Improved channel and floodplain interaction
- Improved access to off-channel habitats on the floodplain
- Improved hydroperiod

Potential Drawbacks

- Disturbance
- Land ownership
- Disposal location needed for excavated soils

Role of Treatment in a Habitat Action

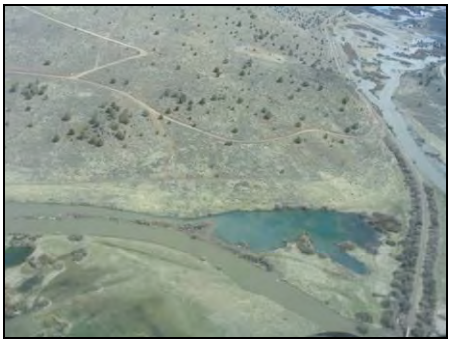
Floodplain excavation will contribute to overall restoration within the Meander Reaches by creating topographically diverse surfaces adjacent to the river that can be accessed by average peak flows, supporting riparian vegetation and facilitating the exchange of floodplain nutrients between the river and floodplain. In order for this treatment to be effective it must be implemented in conjunction with floodplain revegetation and bank protection structures. Floodplain excavation will promote vegetation establishment by providing microsites where seed and plant propagules can be deposited and protected during floodplain scour events. Vegetation will increase roughness, adding a sediment filtering function that will promote long-term sediment storage as part of natural floodplain building processes.

MR-C. Construct or enhance wetlands adjacent to the river

Treatment Description

This restoration treatment includes developing off-channel wetlands in select locations within the Meander Reaches. Off-channel wetlands differ from other wetland treatments in that they are connected to the main channel, and are essentially backwater habitats. Off-channel wetlands filter sediment; supply nutrients; provide habitat for invertebrates, amphibians, juvenile fish species, and birds; support the food web; and promote the establishment of a diverse mosaic of plant communities within the near channel environment. Off-channel wetlands consist of varied hydrologic zones that are directly influenced by the river stage. Elements of this restoration treatment include:

- Construction of wetland features adjacent to the river channel
- Enhancement of existing and constructed wetland features through construction of diverse microtopography, placement of large wood to form wetland habitat niches/microtopography and planting a variety of herbaceous and woody plants



An example connected backwater wetland provides off-channel refugia for juvenile fish and contributes nutrients to the main river. Backwater wetlands also improve water quality by filtering and encouraging deposition of fine sediments.

Example of constructed and disconnected off channel shallow water and emergent wetland.

Limiting Factors Addressed

- Riparian vegetation factors: lack of surfaces that support riparian recruitment, frequent scour/deposition of floodplain surfaces, altered hydroperiod, lack of native seed sources, lack of nutrient sources for primary productivity, and altered carbon balance
- Aquatic habitat factors: lack of cover for juvenile fish, lack of off-channel rearing, simplified food web from lack of nutrients, and altered water quality

Anticipated Benefits

- Increased sediment storage and reduced sediment supply to downstream reaches
- Improved riparian and floodplain vegetation
- Improved floodplain connectivity
- Increased nutrient production

Potential Drawbacks

- Treatments may conflict with existing land uses
- Backwater fluctuations affect hydroperiod

Role of Treatment in a Habitat Action

Construction of off-channel wetlands will contribute to overall restoration within the Meander Reaches by trapping sediment, producing nutrients, creating habitat, and supporting the food web. In order for this treatment to be effective it must be implemented in conjunction with other treatments such as excavation of floodplain surfaces adjacent to the river and construction of secondary channels, which will facilitate connection between the water in the river and the wetlands.

MR-D. Construct or enhance wetlands behind the levees and connect to the river

Treatment Description

This restoration treatment includes developing off-channel wetlands behind levees in the Meander Reaches. Off-channel wetlands will be connected to the Kootenai River via tributaries or secondary channels. These off-channel wetlands will consist of large areas of open water but retain a primary thalweg to maintain connectivity from upstream to downstream systems. Elements of this restoration treatment include:

- Off-channel wetland feature construction
- Enhancement of existing and constructed off-channel wetlands features through construction of diverse microtopography, placement of large wood to form off-channel habitat niches/microtopography and planting a variety of herbaceous and woody plants

An example levee system and off-channel wetland (background) in the Klamath National Wildlife Refuge. This treatment can be employed in the Meander Reach.

Off-channel wetlands route and filter floodwater while providing habitat for fish and wildlife.

Limiting Factors Addressed

- Riparian vegetation factors: altered hydroperiod, lack of native seed sources, lack of nutrient sources for primary productivity, and altered carbon balance
- Aquatic habitat factors: lack of cover for juvenile fish, lack of off-channel rearing, simplified food web from lack of nutrients, and altered water quality

Anticipated Benefits

- Sediment storage and reduced sediment supply to downstream reaches
- Improved riparian vegetation
- Increased nutrient production

Potential Drawbacks

- Treatments may conflict with existing land uses

Role of Treatment in a Habitat Action

Construction of off-channel wetlands will contribute to overall restoration within the Meander Reaches by trapping sediment, producing nutrients, creating habitat, and supporting the food web. In order for this treatment to be effective it must be implemented in conjunction with other treatments such as construction of secondary channels, which will facilitate connection between the water in the river and the wetlands.

MR-E. Construct or enhance secondary channels adjacent to the river

Treatment Description

This restoration treatment includes constructing secondary channels that will provide off-channel aquatic habitat for juvenile fish, and route water and sediment from the main channel to floodplain storage areas. Secondary channel features will have the following general characteristics: upstream and downstream connection to the main channel, low gradients, and varied dimensions in support of hydraulic diversity.

Secondary channels distribute floodwater across the channel migration zone, recharging the water table and providing adequate soil moisture for riparian plants.

Elements of this restoration treatment include:

- Side channel construction
- Revegetation of floodplain areas along secondary channels
- Bioengineering to establish woody vegetation along secondary channel banks
- Woody debris placement for cover, sediment trapping, and habitat diversity

Secondary channels provide valuable off-channel habitat for fish wildlife and help dissipate river energy during extreme flood events.

Limiting Factors Addressed

- Riparian vegetation factors: altered hydroperiod
- Aquatic habitat factors: lack of cover for juvenile fish, lack of off-channel rearing, and simplified food web from lack of nutrients

Anticipated Benefits

- Improved off-channel habitat complexity
- Delivery of sediment to floodplain storage areas
- Improved floodplain connectivity
- Delivery of floodplain nutrients to the river.

Potential Drawbacks

- Diminished streamflow in main channel
- Potential for capturing too much flow from main channel and causing major shift in channel alignment
- Backwater fluctuations affect hydroperiod

Role of Treatment in a Habitat Action

Construction of secondary channels will facilitate routing water and sediment to floodplain storage areas, deliver nutrients from the floodplain to the channel, and provide off-channel refuge and rearing for juvenile fish. Secondary channels will also serve as 'relief valves' for excess flow from the main channel during flood events, thus increasing flow capacity and reducing flood risk. The success of secondary channel construction or enhancement actions will be improved by the addition of large wood habitat features, revegetation of floodplains and riparian areas, and other treatments that will protect secondary channels from disturbance.

MR-F. Construct or enhance secondary channels behind the levees and connect to river

Treatment Description

This restoration treatment includes constructing secondary channels that will provide off-channel aquatic habitat for juvenile fish, and route water and sediment from the main channel to floodplain storage areas. Secondary channel features will have the following general characteristics: controlled upstream and/or downstream connection to the main channel, low gradients, and varied dimensions in support of hydraulic diversity. Elements of this restoration treatment include:

- Side channel construction
- Revegetation of floodplain areas along secondary channels
- Bioengineering to establish woody vegetation along secondary channel banks
- Woody debris placement for cover, sediment trapping, and habitat diversity

Secondary channels can be incorporated in the floodplain design to connect off-channel wetlands in the Meander Reach to the main river.

Secondary channels would be constructed with a low width-to-depth ratio to maintain depth and provide suitable habitat for fish.

Limiting Factors Addressed

- Riparian vegetation factors: lack of surfaces that support riparian recruitment and altered hydroperiod
- Aquatic habitat factors: lack of cover for juvenile fish, lack of off-channel rearing and simplified food web from lack of nutrients.

Anticipated Benefits

- Delivery of sediment to floodplain storage areas
- Improved off-channel habitat complexity
- Improved access to habitat for juvenile fish
- Delivery of floodplain nutrients to the river

Potential Drawbacks

- Diminished streamflow in main river
- Flooding risks would need to be considered and potentially isolated

Role of Treatment in a Habitat Action

Construction of secondary channels will facilitate routing water and sediment through levees to floodplain storage areas, deliver nutrients from the floodplain to the channel, and provide off-channel refuge and rearing for juvenile fish. Secondary channels will also serve as 'relief valves' for excess flow from the main channel during flood events, thus increasing flow capacity and reducing flood risk. The success of secondary channel construction or enhancement actions will be improved by the addition of large wood habitat features, revegetation of floodplains and riparian areas, and other treatments that will protect secondary channels from disturbance.

MR-G. Revegetate the floodplain

Treatment Description

This restoration treatment includes a variety of activities to create conditions that will support a diverse mosaic of plant communities on both existing and constructed floodplain surfaces. A structurally diverse vegetated floodplain provides many functions that will address limiting factors including sediment filtration, velocity reduction during overbank flows, streambank stabilization, organic matter inputs to the stream and floodplain, complex surfaces that promote native plant species diversity and therefore limit opportunities for weed invasion, and a native plant community that can provide seed sources to sustain plant community succession. Activities applicable to revegetating the floodplain include:

- Containerized planting, mature shrub salvage and transplant, dormant plant material installation
- Removal or management of invasive weed species
- Site preparation to suppress agricultural grasses and forbs
- Placement of woody debris and construction of microtopography
- Substrate variation and soil amendments
- Seeding

Constructing microtopographic depressions (i.e., swales) and placing coarse woody material creates sheltered areas and encourages natural plant establishment on floodplain surfaces.

Example floodplain revegetation technique incorporating solarization mats to discourage competition between plants and non-native grasses. Protectors are used to discourage browsing by animals.

Excavating floodplain swales and transplanting mature shrubs and sod mats can improve riparian and floodplain functions.

Limiting Factors Addressed

- Morphological factors: reduced channel boundary roughness and bank erosion rates
- Riparian vegetation factors: addresses all factors
- Aquatic habitat factors: simplified food web from lack of nutrients

Anticipated Benefits

- Reduced sediment supply to downstream reaches
- Restoration of natural floodplain processes
- Improved riparian and floodplain vegetation

Potential Drawbacks

- Long time frame for plant communities to establish to maximize floodplain function
- Many activities require long-term routine maintenance such as watering

Role of Treatment in a Habitat Action

Floodplain revegetation will contribute to overall restoration within the Meander Reaches by creating relatively stable surfaces adjacent to the river that can be accessed by average peak flows. Vegetation will increase roughness, adding a sediment filtering function that will promote long-term sediment storage as part of natural floodplain building processes. For this treatment to be successful, it will need

to be implemented in conjunction with channel dredging and excavation so the adjacent channel has the correct elevation and dimensions to allow annual flooding and balanced sediment-transport. In addition, stream banks across from the floodplain will need to be stabilized to limit recruitment of excess sediment from bank erosion, and so the channel can maintain its dimensions (which is critical to maintain a connected floodplain). Initially, instream habitat will be constructed using imported wood and substrate, but over the long-term, revegetating the floodplain will result in available large wood that can be naturally recruited into the stream and will support instream habitat.

MR-H. Install bank structures

Treatment Description

Installation of bank structures addresses bank erosion and reduced channel boundary roughness by creating conditions that will support establishment of bank vegetation. In addition, bank structures can offer benefits to aquatic habitat such as bank cover and channel margin complexity. A wide range of structure options are available under this restoration treatment including:

- Bioengineering for revegetation
- Large woody debris placement for aquatic habitat and pool formation
- Sod and wood toe structures

Example river bank structures incorporating large wood, bioengineering, and vegetation (Year 1 following installation with other treatments including channel excavation).

Bioengineering structures create suitable conditions for native vegetation to become established along the streambank. Deep-rooted native vegetation will stabilize streambanks and create roughness along the channel margins. Stable, vegetated banks coupled with reduced velocity resulting from the roughness will lessen bank erosion. Large woody debris structures create instream habitat and maintain channel dimensions by dissipating flow energy away from the banks and sustaining pool habitat. Sod and wood toe structures create interim protection for newly constructed channels while woody bank vegetation becomes established over the long-term.

Streambank construction technique used to buffer the stream from an eroding terrace. Large woody debris complexes, sod mats, and whole shrub transplants were utilized (Year 3 following installation).

Limiting Factors Addressed

- Morphological factors: altered sediment-transport, reduced channel boundary roughness, bank erosion rates
- Riparian vegetation factors: lack of outer bank vegetation and frequent scour/deposition of floodplain surfaces
- Aquatic habitat factors: lack of cover for juvenile fish

Anticipated Benefits

- Reduced bank erosion and downstream sediment supply
- Improved channel margin complexity

Potential Drawbacks

- Bank structures may limit erosion (and therefore sediment deposition) in the short term, but over the long term, this will result in banks that are vegetated but still able to migrate at natural rates given the geomorphic setting.

Role of Treatment in a Habitat Action

Bank structures will contribute to the overall restoration within the Meaner Reaches by creating near-bank aquatic habitat and protecting surfaces adjacent to the river so that riparian vegetation can become established. Vegetated banks will reduce bank erosion, add boundary roughness and reduce the supply of sediment to the river. Vegetation will increase roughness, adding a sediment filtering function that will promote long-term sediment storage as part of natural floodplain building processes. This treatment will need to be implemented in conjunction with other treatments, such as revegetation, that improve its sustainability and address the other limiting factors present in the Meander Reaches.

MR-I. Install instream structures

Treatment Description

Installation of instream structures addresses aquatic habitat deficiencies by introducing coarse substrate for spawning substrate and maintaining instream habitat elements such as pools and riffles. A wide range of instream structure options will be deployed under this treatment including:

- Alluvium placement for spawning substrate, roughness and hydraulic complexity
- Flow redirection for hydraulic complexity, bank protection, and existing substrate scour

Instream structures create habitat such as pools and patches of coarse substrate, increase channel complexity, and direct channel velocity.

Constructed riffle used for grade control and energy dissipation.

Floodplain bar used to narrow the existing channel and provide connected off-channel habitat.

Single log vane used to re-direct flow, provide temporary bank stability and facilitate growth of mature riparian plants.

Limiting Factors Addressed

- Morphological factors: altered hydraulics and bank erosion
- Aquatic habitat factors: lack of cover for juvenile fish, insufficient velocity for Kootenai sturgeon spawning, and lack of coarse substrate for Kootenai sturgeon egg attachment

Anticipated Benefits

- Reduced bank erosion and sediment supply
- Increased instream complexity
- Increased coarse substrate composition

Potential Drawbacks

- Construction access to the river (physical obstructions and private land ownership)
- Disturbance

Role of Treatment in Habitat Action

Instream structures will contribute to the overall restoration within the Meander Reaches by enhancing aquatic habitat and protecting soil surfaces adjacent to the river so that riparian vegetation can become established. For this treatment to be successful, it will need to be implemented in conjunction with other treatments that improve its sustainability and address the other limiting factors present in the Meander Reaches.

MR-J. Tributary restoration

Treatment Description

This restoration treatment includes a broad range of techniques that will be applied to improve habitat in tributary streams and remove barriers that prevent migration into tributary habitat. Elements of this restoration treatment may include:

- Tributary channel and floodplain grading to improve channel geometry and hydraulics
- Instream and bank structures
- Floodplain revegetation
- Fish passage barrier removal

IDFG and Partridge (1983) have identified numerous fish passage barriers on tributaries to the Kootenai River in the Meander Reach. Perched and undersized culverts pose barriers to upstream fish passage.

Limiting Factors Addressed

- Aquatic habitat factors: lack of fish passage into tributaries, simplified food web from lack of nutrients, and lack of off-channel cover and habitat for rearing

Anticipated Benefits

- Improved habitat conditions for native fish species
- Improved fish passage into tributaries
- Improved access to tributary spawning and rearing habitats
- Enhanced in-channel complexity
- Improved delivery of nutrients from tributaries
- Reduced fine sediment delivery from impaired tributaries

An example stream simulation culvert incorporating a natural streambed and large roughness elements to improve fish passage conditions.

Potential Drawbacks

- Proposed treatments may not be compatible with existing land uses

Role of Treatment in a Habitat Action

Because many of the focal species are migratory fish, their habitat is not only limited to the Kootenai River, but also includes tributaries that flow into the project area. Elimination of fish passage barriers expands the habitat available to focal species including younger life stages that need off-channel habitat. This treatment could be implemented as a stand-alone treatment; however, it does not address directly conditions within the mainstem Kootenai River.

Table 3-5 presents the Meander Reaches habitat actions in a matrix of limiting factors and restoration treatments in order to summarize the ability of the habitat action to address the reach-specific limiting factors. Refer to the discussion preceding Table 3-3 in Section 3.3.2 for additional information about the guidelines used to develop the table.

Treatment key for Table 3-5	
MR-A	Excavate or dredge the river to modify the channel geometry
MR-B	Excavate floodplain adjacent to the river
MR-C	Construct or enhance wetlands adjacent to the river
MR-D	Construct or enhance wetlands behind the levees and connect to the river
MR-E	Construct or enhance secondary channels adjacent to the river
MR-F	Construct or enhance side channels behind the levees and connect to the river
MR-G	Revegetate the floodplain adjacent to the river
MR-H	Install bank structures
MR-I	Install instream structures
MR-J	Tributary restoration
KR-A	Manage discharge from Libby Dam
KR-B	Manage backwater from Kootenay Lake
KR-C	Manage land use practices
KR-D	Mitigate for impacts from or to infrastructure

Table 3-5. Ability of treatments to address limiting factors in the Meander Reaches.

	MR-A	MR-B	MR-C	MR-D	MR-E	MR-F	MR-G	MR-H	MR-I	MR-J	KR-A	KR-B	KR-C	KR-D	HA Rating
Limiting factors for morphology															
Altered hydraulics	●	•	•		•	•	•	•	•		●	•			●
Altered sediment-transport	●	●	•	•	•	•	•	•	•		•	●			●
Loss of channel and floodplain connection	●	●	•	•	•	•									●
Reduced channel boundary roughness	•						•	●	•				•		●

Table 3-5. Ability of treatments to address limiting factors in the Meander Reaches.

	MR-A	MR-B	MR-C	MR-D	MR-E	MR-F	MR-G	MR-H	MR-I	MR-J	KR-A	KR-B	KR-C	KR-D	HA Rating
Bank erosion	•	•					●	●				●	•		●
Limiting factors for riparian vegetation															
Lack of surfaces that support riparian recruitment	•	●	●	●				●							●
Lack of outer bank vegetation							●	●					•		●
Frequent scour/deposition of floodplain surfaces	•	●	●	●			•	●				●			●
Altered hydroperiod		●	●	●	●	●	●				●	●			●
Invasive weeds		•	●	●	•	•	●						●		●
Lack of native seed sources			●	●			●			●					●
Lack of nutrient sources for primary productivity		●	●	●			●			●					●
Altered carbon balance		•	●	●			●			●					●
Limiting factors for aquatic habitat															
Insufficient velocity for Kootenai sturgeon spawning preference	●						•		●		●	●			●

Table 3-5. Ability of treatments to address limiting factors in the Meander Reaches.

	MR-A	MR-B	MR-C	MR-D	MR-E	MR-F	MR-G	MR-H	MR-I	MR-J	KR-A	KR-B	KR-C	KR-D	HA Rating
Lack of coarse substrate for Kootenai sturgeon egg attachment							●	•	●	•	•				●
Lack of cover for juvenile fish			•	•	●	●	●	●	●	●					⬤
Simplified food web from lack of nutrients		•	●	●	●	●	●			●			•		⬤
Lack of fish passage into tributaries										●	•	•	●	●	⬤
Lack of off-channel habitat for rearing			●	●	●	●				●					⬤
Altered water quality		●	●	●			●						●	•	⬤
Constraints from river and floodplain management															
Dam controlled flow regime											●				●
Dam controlled sediment regime															
Dam controlled thermal regime											•				•
Floodplain land use													●		●

Table 3-5. Ability of treatments to address limiting factors in the Meander Reaches.

	MR-A	MR-B	MR-C	MR-D	MR-E	MR-F	MR-G	MR-H	MR-I	MR-J	KR-A	KR-B	KR-C	KR-D	HA Rating
Bank armoring													●	●	●
Levees and diking districts													●	●	●
Transportation corridors														•	•

• Low potential to address limiting factors.

● Moderate potential to address limiting factors.

● High potential to address limiting factors.

Blank – No potential to address limiting factors.

3.4 Summary

In summary, the habitat actions shown in this chapter represent a toolbox of restoration treatments for each reach. These combinations of treatments were chosen because they are likely to overcome most, or all, limiting factors within a reach. The following chapter illustrates how the toolbox of restoration techniques described in this chapter could be applied at a spatial scale to specific areas within the Kootenai River Habitat Restoration Project using information about where limiting factors are most problematic and other information about which areas are most suitable for restoration.