Kootenai River Habitat Restoration Project Master Plan

A Conceptual Feasibility Analysis and Design Framework
Developed by the Kootenai Tribe of Idaho – July 2009

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Executive Summary

Kootenai Tribe elders pass down the history of the beginning of time, which tells that the Kootenai people were created by Quilxka Nupika, the supreme being, and placed on earth to keep the Creator-Spirit's Covenant – to guard and keep the land forever. The Kootenais have never lost sight of their original purpose as guardians of the land.

Today, the Kootenai Tribe of Idaho seeks to fulfill this purpose by developing and implementing innovative, scientific approaches to guardianship of the land that consider the whole ecosystem at the watershed/subbasin scale, are socially and economically responsible, are supported by the local community and other partners within the watershed, and that incorporate adaptive management principles.

Towards this end, the Tribe has developed this Kootenai River Habitat Restoration Project Master Plan (Master Plan), which presents a framework for an ecosystem-based river habitat restoration project to be implemented in the Idaho portion of the Kootenai River subbasin. This Master Plan is the first planning phase of a multi-phase project. The Master Plan sets the stage for the Tribe and their partners to identify, rank in order of priority, design, and implement meaningful habitat restoration actions. The purpose of the Kootenai River Habitat Restoration Project described in this Master Plan is to:

- Restore and enhance Kootenai River habitat by addressing ecological limiting factors and constraints related to river morphology, riparian vegetation, aquatic habitat and river management. The desired result is a more resilient ecosystem, capable of sustaining diverse native plant and animal populations, and tolerant of natural disturbances and altered regimes.
- Restore and maintain Kootenai River habitat conditions that support all life stages (i.e., migration, occupancy, spawning, incubation, recruitment and early rearing) of endangered Kootenai River white sturgeon (*Acipenser transmontanus)* and other aquatic focal species; and
- Restore the Kootenai River landscape in a way that sustains Tribal and local culture and economy and contributes to the health of the Kootenai subbasin as both an ecological and socio-economic region.

During this initial Master Planning phase, the Kootenai Tribe's design team collected and analyzed large amounts of existing and new information and data in order to understand: historical and existing conditions in the Kootenai subbasin; specific physical and biological characteristics in each of the river reaches in the project area; and limiting factors related to habitat for focal aquatic species and other species within the project area. Based on this understanding, the Tribe's design team developed restoration strategies and habitat restoration treatments that could be used to address those limiting factors in each project reach. These restoration treatments were combined to form habitat actions that address all limiting factors within a reach, and then applied spatially as implementation scenarios to provide examples of potential minimum, moderate, and maximum restoration levels of effort. These implementation scenarios were also used as a basis to develop conceptual cost estimates. This initial Master Plan development phase also resulted in development of a conceptual adaptive management and

monitoring program, identification of anticipated environmental compliance and consultation requirements, a funding analysis, and identification of specific actions to be accomplished in subsequent project phases.

During later phases of this project, Kootenai Tribe and their design team will collect additional data to support designs, select and prioritize specific restoration actions for preliminary design, prepare preliminary designs of those selected actions, complete required environmental compliance and consultation, prepare final designs, and implement habitat restoration in a logical sequence. Ongoing stakeholder outreach and coordination will be significant components of all phases of the project.

The Kootenai Tribe developed this Master Plan with funding from the Bonneville Power Administration provided through the Northwest Power and Conservation Council's Columbia Basin Fish and Wildlife Program (Project 200200200).

Project Context

During the last century, the Kootenai subbasin was modified by agriculture, logging, mining, flood control, the Kootenai River was impounded by Libby Dam (Koocanusa Reservoir) upstream and Corra Linn Dam (Kootenay Lake) downstream. Conversion of more than 50,000 acres of floodplain to agricultural fields has resulted in loss of riparian and wetland plant and animal species, and related functions that normally support a healthy ecosystem.

Constructed levees were built on top of natural sand levees for flood control, limiting the hydrologic connection between the Kootenai River and its floodplain. Construction of Libby Dam began in 1966; the dam was completed in 1972 and became fully operational in 1974. Operations of Libby Dam effectively reducing annual peak flows by half, disrupting the hydrograph which historically had a single spring freshet that provided energy to help drive many ecosystem processes. Collectively, these modifications resulted in unnatural flow fluctuations in the Kootenai River and largely eliminated connection with the river's floodplain.

Although levee construction and the regulation of the natural flood regime through operations of Libby Dam benefited agriculture and played an important role in flood control, these activities also severely limited the capacity of the ecosystem to provide suitable habitat to support the complete life cycles of many species. This altered ecosystem reduced the Kootenai Tribe's access to traditional resources that the Tribe had historically relied on for long-term subsistence and cultural uses. Today, this modified ecosystem is no longer able to support the biological complexity it sustained historically.

Following construction of the levees and completion of Libby Dam, native fish stocks such as Kootenai River white sturgeon, burbot (*Lota lota*), kokanee (*Oncorhynchus nerka*), redband trout (*Oncorhynchus mykiss garideini*), westslope cutthroat trout (*O. clarki lewisii*) and bull trout (*Salvelinus confluentus*) as well as local wildlife populations began to decline. Restoration of these native fish stocks and local wildlife is the primary impetus for the Kootenai River Habitat Restoration Project.

The status of the Endangered Species Act (ESA) listed Kootenai sturgeon population imposes a particularly urgent timeline for implementation of the habitat restoration actions described in this Master Plan. The next 5 to 20 years are critical to the recovery of the Kootenai Sturgeon population. There may still be an adequate number of reproductive white sturgeon in the

Kootenai River population to take advantage of suitable spawning and rearing conditions if appropriate habitat is quickly identified and restored. However, without timely action, the wild population will continue to decline and mature fish will find it increasingly difficult to find mates. At some point, the few remaining fish will no longer be adequate to affect recovery and critical components of the native diversity will be lost. Without intervention, functional extinction will occur well before the last wild fish dies. Currently, the Kootenai Tribe's Tribal Sturgeon Hatchery is preventing extinction of Kootenai sturgeon while measures are taken to implement the habitat restoration actions described in this Master Plan.

Reintroduction of native burbot to the lower Kootenai River (i.e., rebuilding the population using genetically and behaviorally similar stock from within the Kootenai River) is also a matter of high priority for the Kootenai Tribe. Kootenai River burbot are functionally extinct, a status that occurs when populations are so small they are unable to recover on their own.

Because of the unique circumstances related to Kootenai sturgeon and native burbot, the Tribe is also submitting a separate Master Plan to the Northwest Power and Conservation Council for the *Kootenai River Native Fish Conservation and Aquaculture Programs* that will help to ensure survival of Kootenai sturgeon and support reintroduction of burbot while the habitat restoration actions described in this Master Plan are further refined, prioritized and implemented.[1]

Project Location

The Kootenai River Habitat Restoration Project will be implemented in the Idaho portion of the Kootenai subbasin. The project area consists of a 55-mile reach of the Kootenai River that extends from the confluence of the Moyie and Kootenai rivers, downstream to the international border.

For the purposes of this Master Plan, the project area is divided into three major river reaches based on their unique geomorphic properties: the Braided Reaches, Straight Reach and Meander Reaches. The Braided and Meander reaches are each further delineated into two sub-reaches. Each of the project reaches are described below in reference to river miles (RM). These river miles represent defined locations along the river that were identified at a point in time. These RM locations have remained fixed while the river itself has moved; therefore, actual lengths of reaches are usually slightly different than the calculated difference between two river mile designations. Figure 1 shows the project area in the context of the Kootenai subbasin.

Braided Reach 1 extends nearly 4 river miles (RM 160.9 to RM 156.2) from the Moyie River confluence downstream to the upstream extent of the backwater influence from Kootenay Lake. Braided Reach 2 extends approximately 2.2 river miles (RM 156.2 to RM 152.7) from the upstream extent of the backwater, downstream to the U.S. Highway 95 Bridge. The Kootenai River from Libby Dam to near the confluence of the Moyie River is characterized by a steeper gradient and confined channel morphology. The Kootenai River downstream from the Moyie River confluence enters a wider valley with a decreasing gradient. Multi-channel, meandering, riffle-

[1] The Kootenai River Native Fish Conservation Aquaculture Programs Master Plan proposes critically needed renovations and expansions of the Tribal Sturgeon Hatchery, construction of a new artificial production facility for Kootenai sturgeon and burbot at the confluence of the Moyie and Kootenai rivers, and use of remote streamside incubation and early rearing facilities to imprint Kootenai sturgeon on waters from locations upstream of the current Tribal Sturgeon Hatchery.

pool characteristics predominate through the Braided Reaches. Gravel and cobble are dominant channel substrates in both Braided Reach 1 and 2.

The Straight Reach extends 1.1 river miles (RM 152.7 to RM 151.7) from the U.S. Highway 95 Bridge, downstream to Ambush Rock. This reach is characterized by a narrowed river corridor that is locked in place by flood protection measures designed to protect the town of Bonners Ferry, which occupies both banks through much of the reach. The U.S. Highway 95 bridge and train trestle are also confining features in the reach. Historically, the reach was naturally constrained by lateral hillslopes and bedrock. Channel substrate transitions from gravels to sand through the reach.

The combined Meander Reaches extend from the downstream end of Ambush Rock to Kootenay Lake. Meander Reach 1 begins at Ambush Rock and extends 9.7 river miles (RM 151.7 to RM 141.8) downstream to slightly below Shorty's Island. Meander Reach 2 spans 35.5 miles (RM 141.8 to RM 105.9) from the end of Meander Reach 1 to the international border. The Meander Reaches are situated in a low gradient lacustrine valley and channel substrates are dominated by sand and clay. Prior to levee construction, the Meander Reaches were free to migrate within portions of the historic floodplain.

The U.S. Fish and Wildlife Service designated Kootenai River white sturgeon critical habitat is included in the project area and spans 18.3 river miles from upstream of Bonners Ferry (RM 159.7) to downstream to below Shorty's Island (RM 141.4) (USFWS 2008). The critical habitat reach spans a portion of the Braided Reaches, the entirety of the Straight Reach, and the upstream portion of the Meander Reaches. Critical habitat includes the reach of the river where Kootenai sturgeon are known to spawn (Bonners Ferry downstream to Shorty's Island), as well as portions of the river where habitat conditions are believed to be conducive to successful egg adherence and embryo survival (Bonners Ferry to RM 159.7) but where spawning does not currently appear to be occurring.

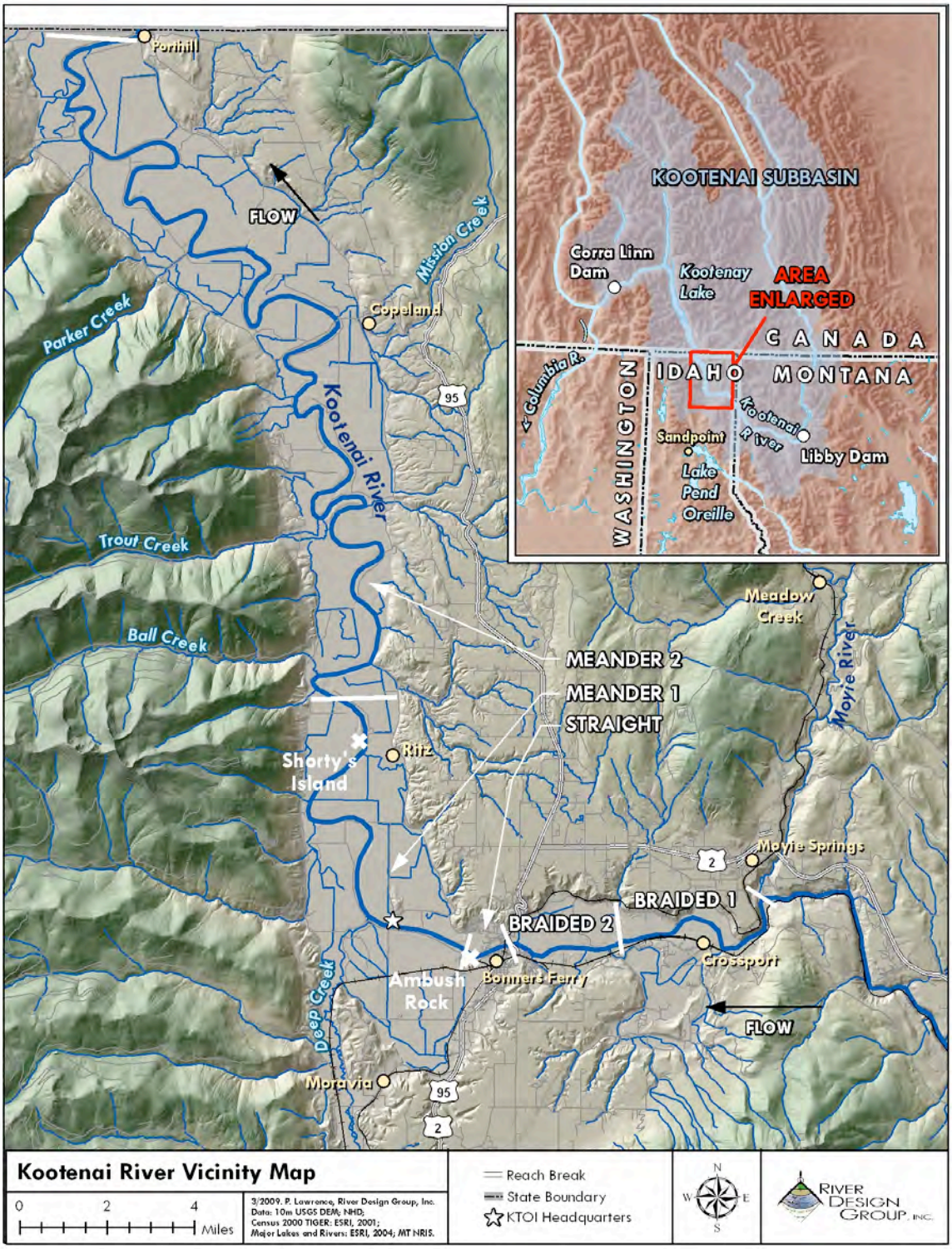

Figure 1. Project location within the Kootenai subbasin.

Project Vision, Goals and Relationship to Limiting Factors

The Kootenai Tribe envisions the Kootenai River and its floodplain as a healthy ecosystem with clean, connected terrestrial and aquatic habitats, which fully support traditional Tribal uses and other important societal uses.

In developing and implementing approaches to Kootenai River habitat restoration the Tribe will continue to emphasize a collaborative approach that takes into consideration the needs and values of the region. The Kootenai Tribe believes that cooperation among all groups with a stake in the region is the only way to ensure the sound and prosperous future of the Kootenai subbasin.

The Kootenai River Habitat Restoration Project has four goals, which address morphology, riparian vegetation, aquatic habitat, and river stewardship. Each of these four goals represents a logical grouping of the limiting factors and constraints the ecosystem restoration project is designed to address. The project's goals are:

- **Morphology**. Restore physical habitat by reducing the negative effects to river and floodplain ecological processes caused by river response to the altered landscape.
- **Riparian vegetation**. Restore native vegetation by establishing stream bank and floodplain conditions that sustain plant community development processes.
- **Aquatic habitat**. Restore aquatic habitat conditions that support all life stages of native fish and promote sustainable populations
- **River stewardship**. Create opportunities for river and floodplain stewardship in the community.

In the context of this Master Plan, limiting factors are defined as physical, biological, and ecological conditions within the project area that: 1) limit the ability of the ecosystem to sustain diverse native plant and animal populations, and to accommodate natural disturbances; 2) limit the quality or availability of 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 tribal culture, subsistence needs, and the economy. Limiting factors can be addressed by active restoration or changes in management. In contrast, constraints are components like roads, bridges and other infrastructure that cannot be changed by management or active restoration, but must be considered during the design process.

Table 1 presents a summary of the habitat limiting factors and river and floodplain stewardship constraints identified in the project area. These limiting factors are generally interrelated and cumulative in their effects.

Table 1. Limiting factors related to morphology, riparian vegetation, aquatic habitat, and constraints related to river and floodplain stewardship in the project area.			
Morphology limiting factors	**Riparian vegetation limiting factors**	**Aquatic habitat limiting factors**	**Constraints related to river and floodplain stewardship**
Factors that have altered natural and historical morphological processes:	Factors that have altered the native riparian vegetation community:	Factors that have altered the aquatic habitat conditions:	Several aspects of the ecosystem have been affected by river and floodplain management:
▪ River response to altered hydraulics ▪ River response to altered sediment transport ▪ Loss of channel and floodplain connection ▪ Reduced channel boundary roughness (smooth banks lacking vegetation or woody debris) ▪ Bank erosion	▪ Lack of surfaces that support riparian vegetation recruitment ▪ Lack of outer bank vegetation ▪ Frequent scour and deposition of floodplain surfaces ▪ Altered hydroperiod (the length of time during the growing season when water is available in the rooting zone) ▪ Invasive plant species ▪ Lack of native plant diversity and seed sources ▪ Lack of nutrient sources for primary productivity ▪ Altered carbon balance (due to depletion of wetland systems)	▪ Insufficient depth for Kootenai sturgeon migration ▪ Insufficient velocity for successful Kootenai sturgeon spawning ▪ Lack of coarse substrate for egg attachment ▪ Lack of cover for juvenile fish ▪ Lack of pool-riffle complexity ▪ Simplified food web from lack of nutrients ▪ Insufficient pool frequency ▪ Lack of fish passage into tributaries ▪ Lack of off-channel habitat for rearing Altered water quality	▪ Dam controlled flow regime ▪ Dam controlled sediment regime ▪ Dam controlled thermal regime ▪ Dam controlled nutrient regime ▪ Bank armoring ▪ Levees and diking districts ▪ Transportation corridors ▪ Floodplain land use

Restoration Strategies, Treatments and Implementation Scenarios

The following terminology is used to organize components of the Master Plan framework that link limiting factors (problems) to restoration treatments (solutions):

- **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.
- **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 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 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.

This Master Plan includes a toolbox of restoration strategies, restoration treatments and examples of potential implementation scenarios. In the Master Plan, both reach-specific and project-wide restoration strategies and treatments are identified. Reach-specific strategies present ways to modify the river channel, river banks and floodplain to overcome limiting factors throughout the project area and within each reach. Project -wide strategies are related to potentially manipulating timing of Libby Dam release flows and Kootenay Lake-controlled water levels to improve velocity and depth components of habitat, although these strategies may also have some effect on sediment transport. Other project-wide restoration strategies include working with landowners to adjust land management so it is compatible with restoration goals, and working with infrastructure owners to mitigate effects of infrastructure and limit restoration project impacts on infrastructure.

Restoration Treatments

The following discussion provides an overview of restoration strategies for the Braided Reaches, Straight Reach and Meander Reaches.

Braided Reaches Restoration Strategy

Due to altered flow and sediment regimes, portions of the Braided Reaches do not exhibit, nor trend toward a channel form that would occur naturally within the existing morphological setting. Until this is corrected, the Braided Reaches will attempt to adjust their location, gradient and flow capacity to match the altered hydraulics. A large portion of the subbasin sediment supply is being captured by Libby Dam, while a significant portion of the sediment supply below Libby Dam comes from bank erosion within the project area. Since the channel does not access its floodplain as it did during the pre-dam era, a greater proportion of the sediment load is stored temporarily within the active channel in Kootenai sturgeon spawning reaches rather than on the floodplain, causing the channel to remain wide and shallow and burying historical spawning beds. This results in lower velocities and shallower depths, which have been identified as limiting factors for some life stages of aquatic focal species including Kootenai sturgeon. Also, because surfaces where sediment is being deposited are scoured frequently, it is difficult for 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 the 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.

In order to address these conditions, the restoration strategy in the Braided Reaches focuses on establishing channel dimensions that are sustainable given the morphological setting and governing flow and sediment regimes, gradually reducing sediment supply and transport

competence in a downstream direction, promoting deposition of sediment on the floodplain, 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.

Straight Reach Restoration Strategy

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 the Straight Reach due to bank armoring and vegetation removal. The 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 entrenched 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 these would allow the river to form pools and move sediment to channel margins, forming a narrow floodplain. 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.

Meander Reaches Restoration Strategy

The Meander Reaches have been altered by a wide range of river and floodplain management activities. The 55,000-acre historical floodplain 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. 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 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. Specific opportunities for restoration in the Meander Reach 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 eroding 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. Working closely with landowners and diking districts, 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.

Restoration Treatments

Table 2 provides a summary of specific restoration treatments that together form a habitat action for each reach. Restoration treatments are proposed to achieve restoration strategies and address limiting factors and constraints for the entire project area and within each reach. The Master Plan includes a description for each restoration treatment that explains how each treatment would address limiting factors, anticipated benefits, potential drawbacks, and the degree to which each restoration treatment might overcome each limiting factor.

Table 2. Summary of potential habitat actions and restoration treatments by reach.	
Habitat Action	**Treatment Name**
Stewardship Actions that Apply to All Reaches	▪ Manage the discharge from Libby Dam ▪ Manage the backwater from Kootenay Lake ▪ Manage land use practices ▪ Mitigate for impacts from or to infrastructure ▪ No action
Braided Reaches Habitat Action	▪ Excavate or dredge the river to modify channel geometry ▪ Construct floodplain surfaces ▪ Construct and/or enhance wetlands ▪ Construct and/or enhance secondary channels ▪ Revegetate the floodplain ▪ Install bank structures (bank protection, bioengineering) ▪ Install instream structures (habitat, river training, grade control)
Straight Reach Habitat Action	▪ Excavate or dredge the river to modify the channel geometry ▪ Revegetate the riparian corridor and establish a riparian buffer ▪ Install bank structures (bank protection, bioengineering) ▪ Install instream structures (habitat, river training, grade control)
Meander Reaches Habitat Action	▪ Excavate or dredge the river to modify the channel geometry ▪ Excavate floodplain adjacent to the river ▪ 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 ▪ Construct or enhance side channels behind the levees and connect to the river ▪ Revegetate the floodplain adjacent to the river ▪ Install bank structures (bank protection, bioengineering) ▪ Install instream structures (habitat, river training, grade control) ▪ Tributary restoration

Implementation Scenarios

The habitat actions shown in Table 2 above represent a toolbox of restoration treatments for each reach. These combinations of treatments were chosen because they are likely to overcome most or all of the limiting factors within a reach. In order to better illustrate where, and to what extent, restoration treatments might be applied within each reach, and in order to develop conceptual cost estimates, the Kootenai Tribe developed implementation scenarios, which are examples of how habitat actions could be applied spatially. Implementation scenarios do not represent specific recommended sets of restoration treatments; rather, they are ways to illustrate low, medium and high levels of effort that can then be translated into estimated costs to help with program planning. In addition, implementation scenarios show examples of different ways that restoration treatments could be combined to overcome key limiting factors where benefits to habitat increase as the level of restoration effort increases.

Because the Kootenai River Habitat Restoration Project covers such a large area and is designed to address such a complex combination of interrelated limiting factors, it will likely take a number of years to complete the work. This will likely result in various restoration phases being implemented in different reaches at different times. Funding availability, environmental compliance, and permitting schedules will also influence implementation sequencing. Later design phases will consider sequencing in greater detail with the recognition that the Kootenai

River Habitat Restoration Project is a single endeavor with component parts that are all inter-linked and inter-dependent.

The implementation scenarios presented in the Master Plan represent potential approaches to implementation and a way to understand the impacts of scale to both cost and project effectiveness; however, the actual restoration treatments, scale of implementation, and details about prioritization and sequencing of implementation will be determined in subsequent phases of this project. It is important to remember that the minimum, moderate and maximum implementation scenarios presented in the Master Plan are illustrative examples only.

Adaptive Management and Monitoring

In order to continually evaluate whether the Kootenai River Habitat Restoration Project is accomplishing the project purpose, goals and objectives described in the Master Plan, an adaptive management and monitoring program will be implemented to support the restoration project. The purpose of the Kootenai River Habitat Restoration Project Adaptive Management and Monitoring Plan is to provide a framework to:

- Evaluate the effectiveness of the implemented habitat actions in terms of achieving the project goals;
- Identify project maintenance needs;
- Identify any potential unforeseen negative impacts on infrastructure;
- Support decisions to modify restoration treatments; and
- Refine or modify restoration treatments that might be implemented in later phases of the project.

The Adaptive Management and Monitoring program provides a mechanism to make the design process adaptable and accountable, and to determine whether habitat restoration goals are being achieved. Goals are described in terms of limiting factors related to morphology, riparian vegetation and aquatic habitat (and constraints related to river stewardship) that must be overcome to restore habitat; restoration strategies are identified to overcome limiting factors, and objectives are quantifiable ways to determine whether limiting factors are being addressed by treatments. In this document, some objectives include placeholders for thresholds that will be developed during the next phase of the design process and used to determine whether success criteria are being met.

Once preliminary designs are completed for a project reach, success criteria will be developed based on either quantitative or qualitative criteria developed as part of the design. Success criteria provide a way to explicitly state the expected outcomes of restoration treatments within both short-term and long-term time frames. The associated monitoring program must include ways to measure these criteria in a manner that is quantifiable, repeatable and accurate. To accomplish this, metrics will be selected for each success criteria. Monitoring metrics are ways of measuring criteria; for example, size class distribution is a metric for sediment transport and feet per year is a metric for lateral bank erosion.

Three types of monitoring are necessary to establish the integrated monitoring program. These include baseline, implementation, and effectiveness monitoring.

- ***Baseline monitoring*** documents the pre-restoration condition.
- ***Implementation monitoring*** (also called as-built monitoring) documents the restoration project as completed.
- ***Effectiveness monitoring*** addresses whether project objectives are being met, determines maintenance needs, and provides inputs into decision pathways.

To support the Adaptive Management and Monitoring Program, the Kootenai Tribe will convene an interdisciplinary adaptive management and monitoring team that will include representatives from key management agencies (co-managers), a range of necessary disciplines (e.g., fish and plant biologists, hydrologists, etc.) and other experts in the field of restoration. This team will critically review monitoring data and other project-related information (in the office and in the field) so team members can interpret monitoring results in the context of developing ecosystem functions and processes. Through this framework, it will be possible to determine whether the implemented restoration treatments are meeting project objectives based on success criteria, which corrective measures may be necessary, whether maintenance is necessary, and whether monitoring methods and/or success criteria should be modified.

In addition to data collected specifically to support the Kootenai River Habitat Restoration Project, other data focused on biological populations are currently being collected to support related programs. The Kootenai River Habitat Restoration Project Adaptive Management and Monitoring Program will include data from other programs as part of evaluating the effects of the habitat restoration project. Data will be stored and managed in a centrally accessible database that will be designed to support adaptive management.

Environmental Compliance and Consultation

Various federal, state, and local environmental laws and administrative requirements will apply to the Kootenai River Habitat Restoration Project. The Master Plan provides an overview of anticipated environmental compliance and consultation requirements related to subsequent phases of the project. Applicable laws and environmental requirements include: NEPA, Clean Water Act, Idaho water quality requirements, local floodplain permits, other permits related to air quality and land use, Endangered Species Act, National Historic Preservation Act, and Federal Farmland Protection Policy Act. Comprehensive permit requirements, schedule, and associated costs will be developed and refined in the preliminary and final design phases.

Estimated Costs

To develop conceptual cost estimates, the Kootenai Tribe contracted with a large construction firm with extensive experience planning, estimating, and building projects of similar scope and scale. Cost estimates were developed for estimated construction and construction related costs, for the minimum, moderate and maximum implementation scenarios for each of the project reaches. The conceptual costs for the minimum, moderate and maximum implementation scenarios for each project reach were then translated into unit costs (e.g., feet, acres, units) in order to provide a flexible way to look at potential project costs by reach, scenario and treatment that is consistent with the conceptual framework presented in this Master Plan. Cost

estimates were based on the following categories: planning and coordination, data collection, preliminary and final design; construction; as-built documentation and establishment of monitoring baselines; post-construction effectiveness monitoring; biological monitoring; post-construction maintenance; permitting and environmental compliance; and management of land use practices.

As noted previously, the Kootenai River Habitat Restoration Project will likely be implemented over a number of construction seasons. Sequencing will be extremely important in managing costs. As designs and implementation strategies and planning are refined during preliminary and final design phases, it will be possible to determine which approach is likely be most cost efficient in accomplishing the varying scopes of work.

Next Steps

This Master Plan provides a framework for planning, design and implementation of the Kootenai River Habitat Restoration Project; it represents the first planning phase of this project. Critical next steps will include:

- **Interim Planning** – This phase will included targeted data collection and analysis necessary to address uncertainty, better understand risks associated with specific actions, and necessary to further refine specific design elements; prioritization and selection of the specific restoration treatments and implementation scenarios that will move forward to the preliminary and final design phases; and other necessary planning and coordination activities.
- **Preliminary Design Phase** – The preliminary design phase will include continued evaluation of project feasibility, through a series of documents that address data gaps, summarize data collection and analysis efforts, and identify specific reaches and floodplain areas where restoration work will occur. Environmental compliance activities will also be initiated, and in some cases completed in the preliminary design phase.
- **Final Design Phase** – The final design phase will include development of a series of specific documents and design drawings that describe the design elements for each of the project components and/or the river reaches and floodplain areas based on the project sequencing plan. Environmental compliance activities will be completed in the final design phase.
- **Implementation Phase** – During the implementation phase, the restoration project will be constructed, monitored and maintained according to the project sequencing schedule.

It is possible that various habitat restoration components of the Kootenai River Habitat Restoration Project will be proceeding through the preliminary and final design phases and implementation phase at different points in time. For example, there may be a phase 1 round of projects, followed by a phase 2 and phase 3 round of projects – all of which will be developed and adaptively managed within the framework of the Kootenai River Habitat Restoration Project.

The Kootenai River Habitat Restoration Project is a large and complex project. Successful design and implementation will require the ongoing cooperation and collaboration of a broad community of individuals and entities. The Tribe places a great deal of importance in ongoing

stakeholder outreach and coordination, and these will be significant components of all phases of the project.

This habitat restoration project will also complement and enhance the benefits derived from other related habitat and aquaculture projects that are being, and have been, implemented by the Tribe and others (e.g., Kootenai River Native Fish and Conservation Aquaculture Program, nutrient restoration, Libby Dam Operational Loss Assessment, wildlife mitigation, Kootenai River Valley Wetlands and Riparian Conservation Strategy, tributary restoration efforts, etc.)

The Kootenai Tribe looks forward to working with the regional co-managers, agency, and community partners to implement this important project.

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v. Glossary

Abiotic – The nonliving or physical aspects of an ecosystem.

Accretion – A natural process of gradual sediment accumulation on channel features, especially channel bed and banks or bottomland surfaces including the floodplain and low-lying terraces, through the deposition of fine fluvial sediment.

Active restoration – The direct structural modifications to the river, its floodplain or infrastructures (i.e., channel realignment, levee removal, instream habitat structures, or revegetation) to reestablish the natural process, vegetation, and habitat of an ecosystem.

Adaptive management – A management approach that allows for new information gained through monitoring to be integrated into the restoration planning process to support changes in implementation.

Aggradation – A geologic process where sediment deposition results in the progressive buildup or rise in elevation of the channel bed and floodplain.

Alluvial fan – A triangular or fan-shaped deposit of alluvium that forms when a stream transitions from a steep to a flatter gradient resulting in a loss of velocity and deposition of sediments.

Alluvium – Sediments, such as sand, silt, clay, gravel, or rock that are deposited by running water.

Anadromous -- Fish that spend portions of their life cycle in both fresh and salt water, leaving salt water to spawn in fresh water.

Anthropogenic – The influence of human beings on natural objects.

Aquaculture -- The farming or cultivation of aquatic organisms, including fish, mollusks or aquatic plants, that involves some form of intervention in the rearing process, such as stocking, feeding, protection from predators, or fertilizing of water.

Aquatic – Relating to living, being or growing in water.

Augmentation flows – The increase in duration, frequency, or intensity of the flow of water released from a dam for the purpose of supporting downstream aquatic resources.

Avulsion – The shift in a channel's location where a portion of channel is abandoned as a new portion of channel forms through adjacent terrain.

Backwater effect – The rise in surface water elevation upstream of a dam or other natural or artificial flow obstruction.

Bank armoring – Structural treatments designed to stabilize channel banks.

Bankfull – The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels.

Bars (Alluvial) – Sediment accumulations along waterways deposited by moving water. Examples include: 1) point bars — bars that are formed on the inside of a meander channel, 2)

side bars — bars that are formed along the edges of relatively straight sections of a river, 3) mid-channel bars — these are found within the channel and generally become more noticeable during low flow periods, and 4) delta bars — formed immediately downstream of the confluences of a tributary and the main river.

Base flow – The portion of the stream discharge or flow that is not attributable to direct runoff from precipitation or melting snow; it is usually sustained by ground-water discharge.

Bed armoring – Structural treatments designed to stabilize channel bed elevations.

Bedform – The topography of the channel bed resulting from the interaction of stream flow patterns and bed sediments.

Bedload – Sand, silt, gravel and rock, mainly not in suspension, carried by a stream along its bed.

Belt width – A measure of the lateral extents of a channel pattern expressed as the average width occupied by a meandering channel within a floodplain.

Bioaccumulation – general term for the accumulation, through respiration, food intake, skin contact or other means, of substances, such as organic chemicals in an organism or part of an organism resulting in higher concentration of the substance in the organism than in the organism's surrounding environment.

Bioengineering – The use of live plant materials, as a stand-alone treatment or in conjunction with conventional engineering techniques, to provide erosion control, slope and stream bank stabilization, landscape restoration, and wildlife habitat.

Biomes – A terrestrial region inhabited by well-defined types of life, especially vegetation, that generally cannot live outside that specific region. Examples include types of deserts such as 'high' or 'low' desert; grasslands such as prairies or coastal dunes; or forests such as temperate or rain forests.

Biomonitoring – The study of biological organisms and their responses to assess the ecological condition of the environment.

Biota – All living organisms, including plants and animals, of a region, as in a stream or other body of water.

Biotic – Related to living organisms.

Boundary conditions – The mathematical expression of a state of the physical system that constrains the equations of the mathematical model.

Channel bars – In-channel sediment of relatively coarse bed material, typically coarse sand through cobbles in size, that is generally deposited during the recession of a high flow and is mostly exposed during periods of low flow; (see also **Bars**).

Channel bed armor layer – The coarse surface layer of bed particles that is coarser than the particles supplied as bedload.

Channel unit or channel habitat unit – Relatively homogeneous areas of a channel that differ in depth, velocity, and substrate characteristics from adjoining areas, creating different habitat types in a stream channel.

Competence – The ability of a current of water to transport specified particle sizes of sediment (see also **Sediment competency**).

Cover type – An aggregation of plant communities, grouped and named by the species with the greatest canopy coverage in the overstory or upper layer.

Critical habitat – USFWS designation of specific geographic areas, whether occupied by a listed species or not, that are essential for its conservation and that have been formally designated by rule published in the Federal Register.

Cross-section (channel) – Measurements taken through a stream at right angles to the main (average) direction of flow.

D50 (and others: D16, D50, D84 and D100) – The particle size for which 50 percent of the mass sampled is less than the particle size.

Deciduous – Plants that shed or lose leaves annually.

Degradation – Geomorphology context: The lowering of a bottomland surface through the process of erosion; conceptually it is the opposite of the vertical component of aggradation and is most frequently applied to sediment removed from a channel bed or other low-lying parts of a stream channel. It is also referred to as downcutting.

Ecological context – The incremental and progressive impairment of an ecosystem caused by stress events or disturbances that occur with such frequency that recovery is not possible.

Demersal eggs – Eggs that are deposited or sink to the bottom of the channel.

Deposition – The settlement or accumulation of material out of the water column and onto the stream bank or bed that occurs when the energy of flowing water is unable to support the load of suspended sediment.

Depositional bar – Bed sediment, generally sand and gravel, that is deposited as part of the normal process of fluvial sorting of sediment.

Drafting period – The time period when water stored in a reservoir is released. Reservoir drafting is typically undertaken to increase reservoir capacity prior to spring runoff, to increase downstream flows for recreation, or augment downstream river flows for fisheries requirements.

Ecology – The study of interactions between living organisms and between organisms and their environment.

Ecological processes – The dynamic attributes of ecosystems, including interactions among organisms and interactions between organisms and their environment (see also **Process**).

Ecological restoration – The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed.

Ecosystem – The complex of living organisms and the abiotic environment with which they interact at a specified location.

Entrenchment – The relationship of the river to its valley and landform features defined as the vertical containment of a river and the degree to which it is incised in the valley floor.

Ephemeral – Anything that is short-lived, lasting for short period of time or transitory.

Ephemeral flow -- Stream flows in channels that are short-lived or transitory and occur from precipitation, snow melt, or short-term water releases.

Extinction -- The death of the last surviving individual of a species, group, or gene either globally or locally.

Fauna – All of the animal life of any particular region or time.

Fine sediment – Some mixture of silt, sand, and fine gravel that is sorted from coarser fractions during certain phases of sediment transport that tend to have high transport velocities and can be flushed rapidly from streams.

Forb – A flowering herbaceous plant that is not grass or grass-like.

Flora – All plant life occurring in an area or time period, especially the naturally occurring or indigenous plant life.

Flow area – A channel's cross-sectional area required for conveying flow.

Flow ramping – An increase in river discharge typically related to upstream reservoir drafting.

Flow regime – The pattern of stream flow with respect to velocity, depth, and specific energy as well as time of year and average values over time (yearly or seasonally).

Fluvial – From the Latin word, fluvius, for river, refers to or pertains to streams; included are stream processes (fluvial processes), fluvial landforms, such as fluvial islands and bars, and biota living in and near stream channels; common usage is often extended by geomorphologists to include hydrologic processes on hillslopes.

Focal species – Species that serve an umbrella function in terms of encompassing habitats needed for many other species, play a key role in maintaining community structure or processes, are sensitive to changes likely to occur in the area, or otherwise serve as an indicator of ecological sustainability.

Freshet – Minor flooding or overflowing of a stream caused by heavy rains or snowmelt.

Functional extinction – A condition where a population is no longer viable because there are no individuals able to reproduce, or the small population of breeding individuals will not be able to sustain itself due to inbreeding depression and genetic drift, which leads to a loss of fitness.

Gas supersaturation – The overabundance of dissolved gases in water which may be harmful or fatal to fish and other aquatic and marine organisms.

Genetic conservation – The application of genetic studies to preserve species.

Genetic introgression – The movement of a gene from one species into the gene pool of another by backcrossing an interspecific hybrid with one of its parents.

Geomorphology – The study of landforms including investigations into the processes that cause and alter the landforms.

Geomorphic processes – The primary mechanisms for forming the drainage patterns, channel, floodplain, terraces, and other watershed and stream corridor features such as erosion, sediment transport or sediment deposition.

Glacio-lacustrine valley type – Valleys formed by glacially-derived sediments that deposited into lakes.

Glide – A shallow stream reach with a maximum depth that is 5% or less of the average width and without surface turbulence. The glide habitat unit typically succeeds a pool and precedes a riffle habitat unit.

Gill net – A flat fishnet suspended vertically in the water to entangle fish by their gills.

Goal – A desirable and ideal condition.

Grade control – Structures installed to maintain a desired streambed elevation.

Gradient – The elevation change per unit of horizontal distance; also referred to as slope. As applied to stream channels, is the rate of elevation change between two specified sites of horizontal distance measured along the thalweg of the channel; it is generally expressed as a non-dimensional number (m m-1).

Growing season – The frost-free portion of the year.

Habitat actions – A set of restoration treatments that addresses the limiting factors within a specified area.

Habitat fragmentation – The transformation of a continuous habitat into habitat patches that vary in size and configuration. Fragmentation can be natural or anthropocentric.

Habitat Types – The land area that supports, or has the potential of supporting, the same primary climax vegetation.

Herbaceous – Plants that do not have wood and above ground parts generally do not persist outside of the growing season.

Hydraulics – The analysis of bulk flow patterns of water surface shape, velocity, shear stress, and discharge through a stream reach.

Hydraulic capacity – A measure of the volume and flow of water within a watercourse.

Hydraulic complexity – The diverse motion and action of water, or the confluence of multiple flow paths.

Hydraulic radius – A ratio of the wetted cross-sectional area to the wetted perimeter of a stream or closed conduit.

Hydric soil – A soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

Hydroecology – The examination of the effect of physical, chemical and biological factors on the structure and function of aquatic communities.

Hydrograph – A graph of water discharge or depth against time which can refer to the pattern of streamflow which occurs over a season or year. The section of the hydrograph where the

flow is increasing is called the rising limb and the section where the hydrograph is decreasing is the falling limb.

Hydroperiod – The duration that a soil or substrate is inundated or saturated over the course of a year.

Hydrophytic vegetation – A plant that is adapted to growing in water or a substrate that is at least periodically saturated and deficient in oxygen during the growing season.

Interpolate – To estimate or calculate a value or values between two or more existing data points.

Introduced species – A species that was intentionally or accidently brought into an area outside of its native geographical range (see also **Non-native species**).

Invasive species – An introduced species that spreads rapidly or becomes a nuisance causing harm to native species.

Lacustrine - Relating to lakes or standing bodies of water.

Large woody debris – Logs, stumps, or root wads occurring or placed in the stream channel, its banks, or the floodplain.

Lateral migration – The movement of a channel across its floodplain by the process of bank erosion. The outside banks of meanders move laterally across the valley floor and down the valley. New floodplain is built at the inside of the meanders.

Lentic – Refers to or relates to still or sluggish water such as lakes, ponds, and swamps; lentic species are organisms that live in still or sluggish water.

Longitudinal profile – A depiction of the gradient of a stream along its length typically illustrating changes in landform, water surface, and channel bed elevations with changes in channel habitat units.

Lotic – Refers to or relates to moving water, especially streamflow; lotic species are organisms that live in moving water.

Macroinvertebrate – An organism that is large (macro) enough to be seen with the naked eye and lacks a backbone (invertebrate).

Macrophyte – An aquatic plant that grows in or near water and is emergent, submergent, or floating.

Mean annual peak flow – The arithmetic mean of peak flows for a given year (see also **Peak flow**).

Meander scrolls – Evidence of historical meander patterns in the form of lines visible on the inside of meander bends (particularly on aerial photographs) which resemble a spiral or convoluted form in ornamental design. These lines are concentric and regular forms in high sinuosity channels and are largely absent in poorly developed braided channels.

Mesic – Ecosystems or habitats characterized by intermediate moisture conditions, i.e., neither wet nor dry.

Microtopography – Topographic variability on a small scale, such as surface depressions.

Migration (channel) – The movement of a river channel across its floodplain.

Mitigation – An approach or strategy used by government agencies to require that unavoidable environmental damage be compensated by ecological restoration or another activity (e.g., rehabilitation, reclamation, enhancement).

Morphology – Pertaining to rivers: physical attributes of a water body and the methods for measuring those attributes.

Native species - Species that are normally found as part of a particular ecosystem; a species that was present in a defined area prior to European settlement.

Non-native species – A species that was intentionally or accidently brought into an area outside of its native geographical range (see also **Introduced species**).

Noxious weed – A legal designation applied at a national, state, or local level to plant species that are injurious or problematic to humans, crops, or livestock. The designation generally requires that the plant species be controlled.

Objective – A specific, short-term, and direct result that is desired from project work and will contribute eventually to the achievement of project goals.

Outer bank – The outside streambank on a stream meander or bend in the river pattern.

Outwash – Soil particles or sediment that move over an upland surface with overland flow to a surface depression such as a rill or gully where they are re-deposited on areas of lesser slope. More commonly, outwash is used as a geomorphic term referring to rock debris that is removed from a glacier by meltwater and is re-deposited in the stream channel as glaciofluvial sediment.

Overstocking – An accumulation of units that is denser than the average condition.

Palustrine – A wetland system defined by Cowardin et al. (1979) with fresh water and dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens.

Passive restoration – A strategy that relies on the river and its associated ecological processes to re-establish desired function after stopping activities that caused degradation or prevent recovery.

Peak flow (peak runoff) – The maximum instantaneous discharge, or flow, of a given hydrograph.

Perennial – Occurring for or lasting for several years. Perennial streams flow continuously during both wet and dry times.

Periphyton – Microflora, such as algae or cyanobacteria, growing on the channel bottom, or on other submerged substrates, including higher plants.

Phytoplankton – Tiny, photosynthetic organisms living in water that are a major part of the aquatic food web.

Point source discharge – Water or other fluid, that may be a pollutant, emitted from a specific, discernable location.

Planform – The shape of a stream or an object as viewed from above.

Plane-bed – Channel units including glide, riffle, and rapid morphologies that lack discrete bars, a condition that is associated with low width to depth ratios and large values of relative roughness.

Pole – A tree with an average diameter at breast height between 4 and 10 inches (i.e., pole cottonwood).

Pool – A region of deeper, slower-moving water with fine bed materials.

Pool tailout – The downstream extent of a pool or glide habitat unit and the transition to a riffle habitat unit.

Primary productivity – The amount of biomass produced through photosynthesis per unit area and time by plants, the primary producers.

Process – The dynamic aspect of an ecosystem or landscape, sometimes considered synonymous with *function,* including interactions such as transpiration, competition, parasitism, animal-mediated pollination and seed dispersal, mycorrhizal relationships, and other symbiotic relationships (see also **Ecological processes**).

Recharge – An area through which water is added to an aquifer.

Recruitment – The number of fish from a year class reaching a certain age. For example, all fish reaching their second year would be age 2 recruits.

Recruitment failure – Failure of fish from one year class reaching an older year class. For example, the failure of larval fish maturing to juvenile fish.

Redd – Depression, usually a pit or a trough in the stream gravel, dug in preparation for, or during, spawning. Eggs are laid, fertilized, covered with gravel and hidden in the redd where they are oxygenated by the current.

Regulated river – Regulated river systems are flow-controlled by dams or other flow-altering infrastructure.

Restored ecosystem -- An area containing sufficient biotic (living organisms) and abiotic (non-living factors) resources to continue its development without further assistance; that will sustain itself structurally and functionally, demonstrate resilience to normal ranges of disturbance and interact with contiguous ecosystems in terms of biotic and abiotic flows and cultural interactions.

Revetment – Materials (such as rock, riprap, or matting) or a structure placed to restrain underlying material from being transported away.

Riffle – A short, relatively shallow and coarse-bedded length over which the stream flows at ordinarily higher velocity and greater turbulence than it does through upstream and downstream pooled reaches where cross-sectional areas of the channel are greater, bed material is smaller, and velocities and turbulence are less.

Riparian – Biotic communities on the shores of streams and lakes.

Riparian buffer – Vegetated corridor next to a stream or river that functions to protect water quality, and provide wildlife and aquatic habitat. Usually refers to woody vegetation.

Riparian corridor – A strip of land of variable width along a river that is influenced by the river processes and associated flood events.

River channel morphology – The field of science dealing with changes of river planform.

Riverine system – A wetland system generally described as habitats contained within a channel.

River training structures – Engineering river-works built in order to direct the flow, or to lead it into a prescribed channel, or to increase the water depth for navigation and other uses.

Roughness – An object or structure that obstructs streamflow in a channel and influences hydraulics and the pattern of bed load transport and deposition in a stream reach.

Run – A channel unit defined by swiftly flowing water, little to moderate surface agitation, waves, or turbulence, no major flow obstructions, approximately uniform flow, substrates of variable particle size, and water surface slope steeper than the overall stream gradient.

Scour – The movement of bed materials during a flood.

Secondary productivity – The rate of biomass production by heterotrophs (animals, microorganisms), which feed on plant products or other heterotrophs.

Sediment competency (sediment transport capacity) – The maximum sediment quantity per unit time which can be transported by a specified flow in a channel (see also **Competency**).

Sediment loading – The delivery of sediment to a stream section from upstream sources, lateral streambank sources, or from the channel bed.

Self-sustaining natural production – A population's ability to regenerate without outside input or influence.

Shear stress – The portion of stress acting tangentially as a tearing action (as opposed to that portion that acts as a normal stress) to a plane or surface; thus, a sediment particle on a channel bed is affected by the shear stress created by water moving on the bed.

Spawning – Fish reproduction process characterized by females and males depositing eggs and sperm into the water simultaneously or in succession to fertilize the eggs.

Succession (vegetation succession) – The sequence of stages that occur in species composition and in species abundance, community structure, and the complexity of interspecific interactions as an ecosystem develops or recovers from disturbance.

Taxa – (taxon, plural taxa, noun) A taxonomic unit such as a population or a group of populations that are usually inferred to be phylogenetically related and have characters in common which differentiate the unit from other such units.

Terraced/alluvial valley type – A valley that is most readily identified by the presence of multiple river terraces positioned laterally along broad valleys with gentle, down-valley elevation relief. Alluvial terraces and floodplains are the predominant depositional landforms which produce a high sediment supply.

Terrestrial – Relating to living, being or growing on land.

Thalweg – The path of a stream that follows the deepest part of the channel (Armantrout 1998).

Thermal regimes – The thermal distribution and heat flows in water, air, or ground.

Trophic – Relating to the food web and the relationships between the feeding habits of organisms in the food web.

Upland – Any area that is not a wetland because the associated hydrologic regime is not sufficiently wet to support the development of vegetation, soils, and/or hydrologic characteristics associated with wetlands. In floodplains, these areas are more appropriately termed non-wetlands or riparian.

Water year – The 12-month period from October through September, designated by the calendar year in which it ends and which includes 9 of the 12 months.

Wetland – A general wetland definition (USFWS definition) and a regulatory definition (Clean Water Act) are included below.

USFWS definition: Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and and is saturated with water or covered by shallow water at some time during the growing season each year.

Clean Water Act definition: A subset of "Waters of the United States" (33 CFR 328.3) and those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevelance of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (40 CFR 230.3).

Wetland creation – The conversion of a persistent non-wetland area into a wetland through some human activity.

Wetland enhancement – The increase in one or more values of all or a portion of an existing wetland by human activities.

Width to depth ratio – A measure of channel shape and stream type classification, calculated by dividing the channel width by its mean depth. The width to depth ratio describes the distribution of available energy within a channel, and the ability of various discharges occurring within the channel to move sediment.

Wild population – A population of organisms that has maintained natural reproduction with little or no supplementation from human activities (e.g., fish hatchery production).

Xeric – Refers to an environment (habitat) that is characterized by deficient moisture.

vi. Abbreviations and Acronyms

ADCP	Acoustic Doppler Current Profiling
BANCS	Bank Assessment for Non-point source Consequences of Sediment
BCMoE	British Columbia Ministry of Environment
BEHI	Bank Erosion Hazard Index
BiOP	Biological Opinion (part of ESA)
BPA	Bonneville Power Administration
CFS	Cubic Feet per Second
EA	Environmental Assessment (part of NEPA)
ESA	Endangered Species Act
FC	Flood Control
IAA	Inverted Annual Hydrograph Analysis
IDFG	Idaho Department of Fish and Game
IKERT	International Kootenai/y Ecosystem Restoration Team
ISAB	Independent Scientific Advisory Board
ISRP	Independent Scientific Review Panel
KRWS	Kootenai River White Sturgeon
KTOI	Kootenai Tribe of Idaho
KVRI	Kootenai Valley Resource Initiative
MD-SWMS	USGS Multidimensional Surface-Water Modeling System
MEP	Modified Einstein Procedure
MFWP	Montana Fish Wildlife & Parks
NBP	Near-Bank Stress ratings
NEPA	National Environmental Policy Act
NPCC	Northwest Power and Conservation Council
NWI	National Wetland Inventory
SARA	Species at Risk Act (Canada)
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VARQ	Variable Discharge flood control plan

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1 Introduction

This document is the Kootenai Tribe of Idaho's (Kootenai Tribe) Master Plan for the Kootenai River Habitat Restoration Project. This Master Plan was developed by the Kootenai Tribe with funding from the Bonneville Power Administration (BPA) provided through the Northwest Power and Conservation Council's (NPCC) Columbia Basin Fish and Wildlife Program (project # 200200200).

This Master Plan presents a conceptual feasibility analysis and design framework for the Kootenai River Habitat Restoration Project. The Tribe is proposing to implement this ecosystem-based river habitat restoration project in the Idaho portion of the Kootenai River subbasin (Kootenai subbasin).

Chapter 1 provides an introduction to the Kootenai River Habitat Restoration Project and this Master Plan. This chapter describes the purpose of the project and why the project is needed; presents project history and context; and describes the relationship of this project to other fish and wildlife projects in the Kootenai subbasin. This chapter also includes a description of the Tribe's approach to ecosystem restoration, specific project goals and objectives, a description of the project area, and an overview of the Master Plan organization and content.

1.1 Overview

Section 1.1 describes the overarching purpose of the Kootenai River Habitat Restoration Project and the need for the project.

1.1.1 Purpose of the Kootenai River Habitat Restoration Project

The purpose of the Kootenai River Habitat Restoration Project is to:

- Restore and enhance Kootenai River habitat by addressing ecological limiting factors and constraints related to river morphology, riparian vegetation, aquatic habitat and river stewardship. The desired result is a more resilient ecosystem, capable of sustaining diverse native plant and animal populations, and tolerant of natural disturbances.
- Restore and maintain Kootenai River habitat conditions that support all life stages of (i.e., migration, occupancy, spawning, incubation, recruitment and early rearing) endangered Kootenai River white sturgeon (*Acipenser transmontanus*) and other aquatic focal species; and
- Restore the Kootenai River landscape in a way that sustains Tribal and local culture and economy and contributes to the health of the Kootenai subbasin as both an ecological and socio-economic region.

1.1.2 Need for the Kootenai River Habitat Restoration Project

During the last century, the Kootenai subbasin was modified by agriculture, logging, mining, flood control and impoundment in the forms of Libby Dam (Koocanusa Reservoir) upstream and

Corra Linn Dam (Kootenay Lake) downstream. Conversion of more than 50,000 acres of floodplain to agricultural fields has resulted in loss of riparian and wetland plant and animal species, and related functions that normally support a healthy ecosystem. Constructed levees were built on top of natural sand levees for flood control, limiting the hydrologic connection between the Kootenai River and its floodplain.

Libby Dam became operational in 1972 effectively reducing annual peak flows by half disrupting the hydrograph, which had a single spring freshet that provided energy to drive ecosystem processes. These modifications resulted in unnatural flow fluctuations in, the Kootenai River and its floodplain, which no longer provide suitable habitat to support the complete life cycles of some aquatic species, and the ecosystem can no longer support many aspects of the traditional life styles it sustained historically.

Although major habitat alterations such as levee construction and the regulation of the natural flood regime by Libby Dam benefited agriculture, they also reduced the Kootenai Tribe's access to traditional resources previously relied upon for long-term subsistence and cultural uses. Following levee construction and flood regulation by Libby Dam, native fish stocks such as Kootenai River white sturgeon, burbot (*Lota lota*), kokanee (*Oncorhynchus nerka*), redband trout (*Oncorhynchus mykiss garideini*), westslope cutthroat trout (*O. clarki lewisii*) and bull trout (*Salvelinus confluentus*) as well as local wildlife populations began to decline.

1.1.2.1 Kootenai River White Sturgeon

The Kootenai sturgeon is a naturally landlocked, locally adapted population that has been isolated since the last glacial age approximately 10,000 years ago. The Kootenai sturgeon have profound cultural significance to the Kootenai Tribe.

Recognizing the need for immediate protection of Kootenai sturgeon, in 1989 the Kootenai Tribe initiated a conservation aquaculture program as a stopgap measure designed to ensure an adequate demographic and genetic basis for a healthy future Kootenai sturgeon population. The Tribe's conservation aquaculture program currently provides the only significant source of recruitment in the Kootenai River. It is likely that the next Kootenai sturgeon generation will be produced primarily, or entirely, by the conservation aquaculture program while necessary habitat improvement measures are being finalized and implemented.

The Kootenai sturgeon was listed as endangered under the Endangered Species Act (ESA) in 1994. The population has been in decline for at least 50 years and is estimated to consist of between 500 and 1,000 wild adults. There has been no significant recruitment of young sturgeon observed since the early 1970s and consistent annual recruitment has not been seen since the 1950s. The remaining wild population of large old fish is declining by about 9% per year. Put another way, as fish die naturally and are not replaced, every eight years 50% of the population disappears. At this rate, there will be no wild population by about 2030 to 2040, and functional extinction could occur long before that time. Importantly, Kootenai sturgeon numbers have already reached critically low levels where genetic and demographic risks are acute, only their long life span (estimated at 80+ years) has forestalled extinction of this population to this point. The Kootenai Tribe's Tribal Sturgeon Hatchery plays a critical role in preventing extinction of Kootenai sturgeon while measures are taken to implement the habitat restoration actions described in this Master Plan.

The U.S. Fish and Wildlife Service (USFWS) Kootenai River White Sturgeon Recovery Team was convened in 1994 and completed the Recovery Plan for the Kootenai River Population of White Sturgeon in 1999 (USFWS 1999). The recovery plan outlined a four part strategy for recovery including measures to restore natural recruitment, use of conservation aquaculture to prevent extinction, monitoring of survival and recovery, and updates to the recovery plan criteria and objectives as new information becomes available.

Table 1-1 provides a summary of critical benchmarks related to Kootenai sturgeon recovery efforts.

Table 1-1. Summary of critical benchmarks related to Kootenai River white sturgeon recovery efforts.

Date	Benchmarks
1980	▪ Population problems first reported for Kootenai sturgeon (Andrusak 1980)
1983	▪ Recruitment failure reported in Idaho portion of Kootenai River (Partridge 1983) ▪ Estimated adult population size of 8,000-9,000 fish
1984	▪ Idaho sturgeon fishery closed to harvest; catch and release fishery remained open
1987	▪ Comprehensive NPCC Fish and Wildlife Program recommends Kootenai sturgeon measures
1988	▪ Kootenai Tribe Fisheries Department is established
1988	▪ Kootenai Tribe initiates Kootenai sturgeon studies and program planning
1990	▪ First Kootenai sturgeon is spawned in makeshift river-bank hatchery and eggs are flown to College of Southern Idaho to incubate and hatch
1991	▪ Construction of Kootenai Tribe experimental sturgeon hatchery completed ▪ First successful production of progeny from wild Kootenai River broodstock ▪ Recovery of first wild sturgeon eggs
1992	▪ First release of hatchery-produced fish into the Kootenai River
1993	▪ Breeding plan developed for Kootenai River white sturgeon (Kincaid 1993)
1994	▪ Kootenai River white sturgeon listed as federally endangered under ESA ▪ Hatchery production stopped while under federal review ▪ Catch and release sturgeon angling prohibited in the Kootenai River in ID and B.C. ▪ Population abundance estimated at 1,694 fish ▪ USFWS Kootenai River White Sturgeon Recovery Team formed
1995	▪ Hatchery program reinitiated following ESA listing
1996	▪ Draft Sturgeon Recovery Plan mandates use of Kootenai Tribal Sturgeon Hatchery (USFWS 1996) ▪ Adult population abundance estimated at 1,700 fish
1997	▪ 1997 year class lost due to hatchery equipment failure and inadequacy of initial low cost experimental facility design
1998	▪ Funding request approved by NPPC and BPA to bring the hatchery facility and equipment up to standard
1999	▪ Sturgeon Recovery Plan completed and signed by USFWS Regional Director (USFWS 1999; Duke et al. 1999); hatchery upgrades completed ▪ KTOI provides funding and direction for B.C. Kootenay Hatchery program to be developed as failsafe and additional rearing site ▪ Sturgeon tiered flows begin

Table 1-1. Summary of critical benchmarks related to Kootenai River white sturgeon recovery efforts.	
Date	Benchmarks
2000	▪ Large-scale annual releases of sturgeon begin ▪ Data collection and river modeling for habitat restoration project begins ▪ Kootenai Hatchery Genetic Management Plan completed ▪ Initial genetic analyses (mtDNA) of wild and broodstock groups completed
2002	▪ Adult population abundance estimated at 620 fish
2003	▪ Mark-recapture studies reveal high wild survival rates of hatchery fish ▪ VARQ flood control adopted by USACE
2004	▪ Updated demographic study puts extinction without intervention on the calendar (Paragamian et al. 2005) ▪ Program goals revised to maximize broodstock numbers and releases from dwindling wild population (KTOI 2004) ▪ Initial microsatellite genetic analysis completed (> 94% of wild alleles represented by broodstock to date; Rodzen et al. 2004) ▪ Comprehensive Adaptive Conservation Aquaculture Plan completed by Kootenai Tribe and subcontractors ▪ Kootenai Tribal Sturgeon Hatchery program incorporated into Kootenai Subbasin Plan.
2005	▪ Adult population abundance estimated at approximately 500 fish
2006	▪ Release size (age) increases after monitoring identified poor survival of earlier life stages ▪ Kootenai Tribe Project Proposal for Kootenai River Habitat Restoration Project, Restore Natural Recruitment, Kootenai River White Sturgeon, submitted to Northwest Power and Planning Council (NPCC) and Bonneville Power Administration (BPA) in January ▪ Biological Opinion regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon and Bull Trout released by the USFWS in February (clarified in 2008)
2007	▪ Stocking goals are best met with larger fish (age 1+) at release to provide favorable survival rates ▪ Experiments are implemented with fertilized egg and larval fish releases in high-quality habitat upstream from existing spawning sites
2008	▪ Planning begins for new Twin River Hatchery at the confluence of the Moyie and Kootenai Rivers that will provide additional production capacity for sturgeon and burbot help address critical uncertainty regarding imprinting; as well as upgrades and expansion of the existing Tribal Sturgeon Hatchery
2009	▪ Kootenai River Habitat Restoration Master Plan completed ▪ Kootenai River Native Fish Conservation Aquaculture Programs Master Plan completed

Although the purpose of this project is to restore habitat in the Kootenai River ecosystem, the status of the endangered Kootenai sturgeon population imposes an urgent timeline. The next 5 to 20 years are critical to the recovery of this population. There may still be an adequate number of reproductive white sturgeon in the Kootenai River population to take advantage of suitable spawning and rearing conditions if appropriate habitat is quickly identified and restored. However, if timely action is not taken, the wild population will continue to decline and mature fish will find it increasingly difficult to find mates. At some point, the few remaining fish will no longer be adequate to affect recovery and critical components of the native diversity will be lost. Without intervention, functional extinction will occur well before the last wild fish dies.

1.1.3 Project location

The Kootenai River Habitat Restoration Project will be implemented in the Idaho portion of the Kootenai subbasin. The project area consists of a 55-mile reach of the Kootenai River that

extends from the confluence of the Moyie and Kootenai rivers, downstream to the international border.

For the purposes of this Master Plan, the project area is divided into three major river reaches based on their unique geomorphic properties: the Braided Reaches, Straight Reach and Meander Reaches. The Braided and Meander reaches are each further delineated into two sub-reaches. Reaches are described below in reference to river miles (RM). The river miles presented below represent defined locations along the river that were identified at a point in time. Because the river has shifted over time, actual lengths of reaches are usually slightly different than the calculated difference between two river mile designations (for example, the Straight Reach is 1.1 miles long if measured along the thalweg, but it extends from RM 152.7 to 151.7).

Figure 1.1 shows the project area in the context of the Kootenai subbasin.

Braided Reaches 1 and 2

Braided Reach 1 extends nearly 4 river miles (RM 160.9 to RM 156.2 from the Moyie River confluence downstream to the upstream extent of the backwater influence from Kootenay Lake. Braided Reach 2 extends approximately 2.2 river miles (RM 156.2 to RM 152.7) from the upstream extent of the backwater, downstream to the U.S. Highway 95 Bridge.

Straight Reach

The Straight Reach extends 1.1 river miles (RM 152.7 to RM 151.7) from the U.S. Highway 95 Bridge downstream to Ambush Rock.

Meander Reaches

The combined Meander Reaches extend from the downstream end of Ambush Rock to Kootenay Lake. Meander Reach 1 begins at Ambush Rock and extends 9.7 river miles (RM 151.7 to RM 141.8) downstream to slightly below Shorty's Island. Meander Reach 2 spans 35.5 miles (RM 141.8 to RM 105.9) from the end of Meander Reach 1 to the international border.

The federally designated Kootenai River white sturgeon critical habitat is included in the project area and spans 18.3 river miles from upstream of Bonners Ferry (RM 159.7) to downstream to below Shorty's Island (RM 141.4) (USFWS 2008). The critical habitat reach spans a portion of the Braided Reaches, the entirety of the Straight Reach, and the upstream portion of the Meander Reaches.

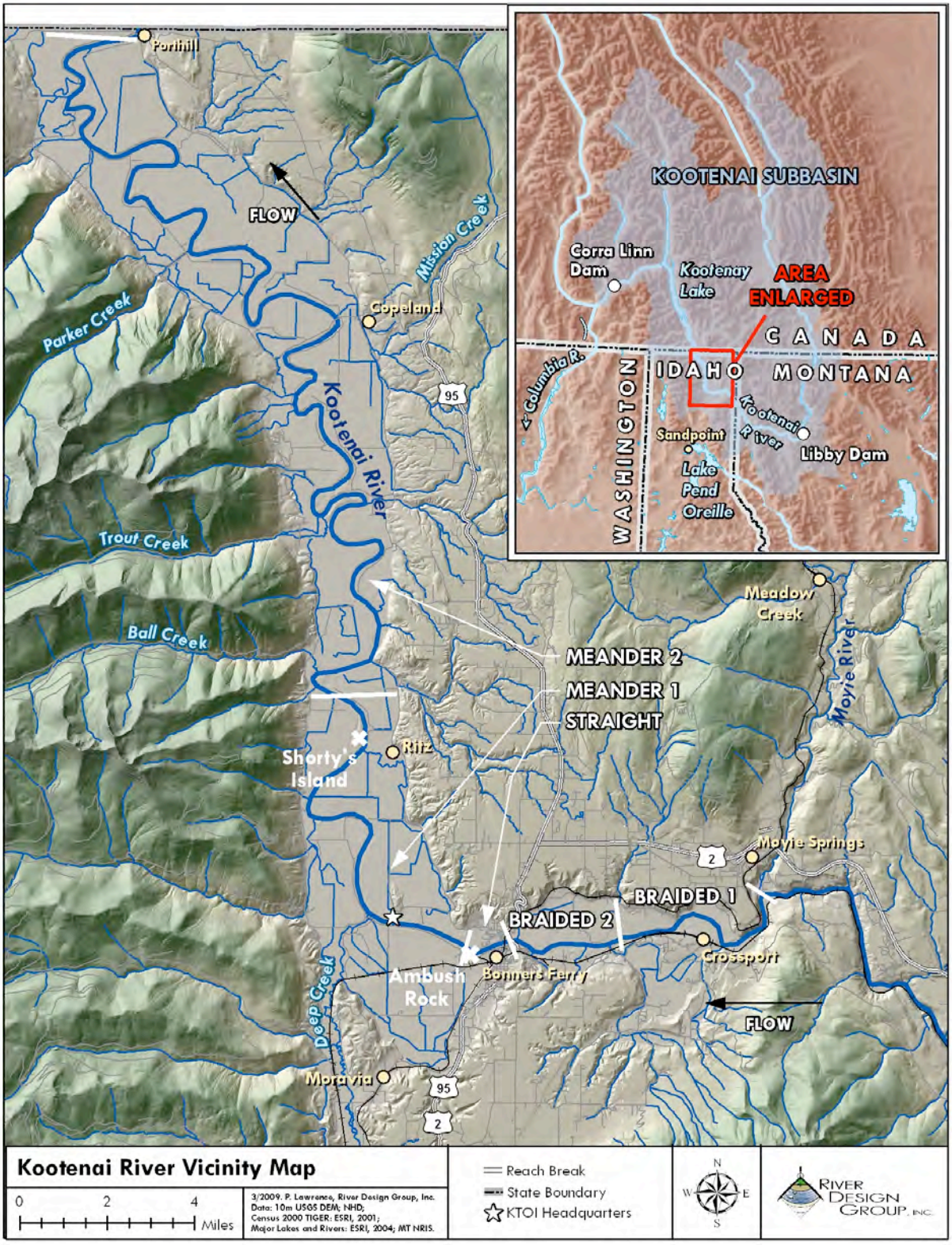

Figure 1-1. Project location within Kootenai Subbasin.

1.1.4 Relationship to Other Projects in the Kootenai Subbasin

Because there are many interrelated factors that may be contributing to greater or lesser extents to the Kootenai sturgeon population's decline, and because of the urgent need for action, the Kootenai Tribe in coordination with multiple agency partners has embraced an ecosystem-based adaptive management approach to restoration actions in the Kootenai subbasin. This ecosystem-based approach is also critical to restoring and maintaining all life stages of other aquatic focal species.

In 2004, the Kootenai Tribe participated in a multi-agency adaptive management workshop to develop a long-term adaptive management framework for the Kootenai subbasin. The resulting 20-year adaptive management framework is a work in progress that includes aquatic, riparian, terrestrial and avian components and has helped to guide implementation of coordinated ecosystem restoration projects in the Kootenai subbasin.

A summary of other Kootenai subbasin projects and activities that complement the Kootenai River Habitat Restoration Project described in this Master Plan is provided below. In addition, Table 1-2 shows the relationship of individual projects to the ecosystem component they address, target benefits, amount of time before benefits are realized, potential negative effects, and monitoring requirements. Table 1-1, also provides additional context for the Kootenai Tribe's aquaculture program's critical role the recovery of Kootenai sturgeon.

Native Fish Restoration and Conservation Aquaculture Program

Beginning in 1989 as a small experimental white sturgeon hatchery, this program has evolved to include many aspects of native fish restoration and aquaculture for native white sturgeon, burbot, and kokanee. The release of young Kootenai sturgeon juveniles from the Kootenai Tribal Sturgeon Hatchery has helped to prevent extinction of this important species while habitat restoration activities presented in this Master Plan are planned, evaluated and implemented. The Kootenai Tribe is currently submitting a proposal through the NPCC's Three-Step Review Process to fund critically needed improvements to the Tribal Sturgeon Hatchery at Bonners Ferry, and to construct a new facility at Twin River on Tribally owned lands to support expanded production objectives to allow Kootenai sturgeon to imprint on waters further upstream. The new Twin Rivers hatchery facility will also allow the Tribe to implement a Kootenai River native burbot conservation aquaculture program.

Kootenai River Ecosystem Improvement Project

This project, which was initiated in 1994, involves a comprehensive biomonitoring program designed to document baseline ecological conditions in the Kootenai River. The project includes monitoring of water quality, algal, invertebrate, and fish community conditions. Also, under this project large-scale nutrient restoration experiments are being conducted in the South Arm of Kootenay Lake, and in the Kootenai River, beginning in 2004 and 2005 respectively.

Libby Dam Operational Loss Assessment Project

The Tribe's ancestral lands and the fish and wildlife resources the Tribe relied upon for subsistence are in areas downstream from Libby Dam. The purpose of this project is to quantify and mitigate the ecological losses due to the operation of Libby Dam in such a way that the methodologies and assessment framework are transferable to other areas in the Columbia Basin.

Wildlife Mitigation Project

Through implementation, this project protects, enhances, and mitigates wetland and riparian wildlife habitats as part of ongoing mitigation for construction impacts associated with the Albeni Falls hydroelectric project within the Kootenai Tribe's ancestral lands.

Kootenai River Valley Wetlands and Riparian Conservation Strategy

This strategy contains information about local issues and concerns, wetland/riparian areas, educational opportunities, and provides approaches to coordinate and link together conservation programs, community needs, and economic, social, and natural resources interests. These elements function together to ensure a comprehensive approach that emphasizes community involvement.

Reconnect Kootenai River with the Historical Floodplain

This project involves investigating the feasibility of actions to reconnect the Kootenai River with its historical floodplain based on ecosystem restoration principles. Investigations have specifically targeted the restoration of selected tributaries to their original channel.

Tributary Restoration

The Tribe is applying a model watershed approach to habitat restoration of selected tributaries to the Kootenai River tributaries that includes community driven initiatives, scientific assessment and restoration techniques to reestablish native riparian vegetation, aquatic insects, and native trout and kokanee salmon habitats and populations.

Table 1-2 Relationship among projects funded by BPA in the Kootenai subbasin and the ecosystem adaptive management program component they address.

BPA Project #	**199404900 198806500**	**199404900 199500400 198806400**	**198806400 198806500**	**200200200 198806500 198806400**	**198806500 199500400 200715200**	**200200800 200201100**
Ecosystem Component:	**Kootenai River nutrient restoration**	**Transboundary nutrient restoration, kokanee introductions, tributary restoration and enhancement**	**White sturgeon and burbot conservation aquaculture**	**Habitat modification to improve sturgeon spawning and recruitment**	**Ecosystem restoration flows - winter low, naturalized spring runoff peaking, summer stable or gradually declining summer flows**	**Flood plain reconnection and Operational Loss Assessments**
Target Benefit	Aquatic, riparian communities, increased growth, survival, and biological. condition	Kokanee, burbot, sturgeon, trout; Aquatic, riparian communities	Addresses stock limitation, genetic conservation, demographic safety net	Increase survival of eggs, larvae. Increase in habitat complexity and resiliency	Sturgeon and burbot recruitment, salmonid recruitment, cottonwood recruitment, natural floodplain processes	Lentic, lotic, riparian and terrestrial communities, all trophic levels
Potential Negative Effects	Stimulation of non-target species.	Stimulation of non-target species.	Overstocking could limit wild production, however no natural recruitement has been observed for decades	Possible unintended hydraulic consequences	Seepage at higher flows, cooler water temperatures inhibit sturgeon spawning, reduced productivity in reservoir (not refilled)	Possible unintended hydrologic consequences
Required Time to See Effect	Periphyton -weeks Inverts-months, Fish = 2-3 yrs,	Kokanee, 1-3 years	Variable depending on life stage and objective	In-season detection of larvae, 2+ yrs to fully recruit to gill nets; 30+ years for population effect for sturgeon	In-season detection of larvae, 2+ yrs to fully recruit to gill nets, 30+years for population effect for sturgeon	Lower trophic levels-responses within summer season, higher trophic level responses across years
Monitoring Requirements	All taxa responses in Kootenay Lake and lower Kootenai River	All taxa responses in tributaries and Kootenay Lake Stream and riparian habitat health and condition estimators and metrics	Survival, growth and biological condition	Recruitment magnitude and frequency. Evaluation of ecological and physical parameters in newly created habitat	Recruitment magnitude and frequency. Ecological condition and biological productivity of post-treatment communities and functions	Nutrient availability and habitat heterogeneity contributions. Ecological condition and biological productivity of post-treatment communities and functions

1.2 Project Background and History

Section 1.2 summarizes project background and history relative to BPA project number 200200200, under which this Master Plan is being funded and developed.

1.2.1 Data Collection and Analysis Prior to Project start

Many individuals and agencies have played a critical role in collecting and analyzing data necessary to understanding the Kootenai River ecosystem. Following is a summary of data collection and analysis that contributed significantly to this project and other projects in the Kootenai subbasin:

- During 1997, the U.S. Geological Survey (USGS) began studying the hydraulic and sediment characteristics of Kootenai sturgeon spawning habitat near Bonners Ferry. An acoustic Doppler current profiling survey was completed during 1997 to characterize the spatial distribution of stream velocities upstream, within, and downstream from the white sturgeon spawning habitat. Results were published in Lipscomb et al. (1997).
- During 1998, USGS and Idaho Department of Fish and Game (IDFG) personnel conducted a seismic-subbottom-profiling reconnaissance of Kootenai River substrate and sediments in the white sturgeon spawning area to define and characterize the lithology of shallow streambed sediments in habitat areas important to sturgeon spawning (Barton 1998).
- During 2000,USGS collected 35 3.5-meter long vibracores and collected seismic subbottom profiles in the USFWS-defined white sturgeon critical habitat reach of the Kootenai River.
- During 2001, USGS analyzed changes in the channel substrate, suspended sediment-transport, and channel geometry in the white sturgeon spawning habitat near Bonners Ferry.

1.2.2 Project Implementation from 2002 Through 2005

The Kootenai Tribe submitted a proposal in 2001 to the NPCC, and received funding from BPA to implement a project entitled, Assess Surface-Water Flow And Feasibility of Enhancing White Sturgeon Spawning Substrate Habitat, in Kootenai River (project # 200200200). The Tribe sponsored the project, which was developed by the USGS and other entities as a collaborative interagency effort. From 2002 through 2006 USGS continued as lead investigator on behalf of the Tribe and accomplished the following:

- During 2002, the USGS began to construct a suite of hydraulic and sediment-transport models including: 1) a 1-dimensional hydraulic model of the 105-kilometer reach of the Kootenai River in Idaho, 2) a 1-dimensional sediment-transport model encompassing a 24-kilometer reach of the Kootenai River including the 18-kilometer Critical Habitat reach downstream of Bonners Ferry, and 3) a 10-kilometer multi-dimensional flow model encompassing the dominant spawning locations within the Critical Habitat reach. Data collection in support of model construction and validation included: 1) detailed mapping of channel geometry suitable for both 1-dimensional and multi-dimensional models, 2) detailed velocity profiles of 17 cross-sections within the 10-kilometer multi-dimensional

modeling reach, 3) suspended-sediment samples to support development of suspended-sediment rating curves, and 4) select cross-sectional and longitudinal profiles over a range of flows to determine changes in cross-section geometry and dune geometry respectively. One abstract involving project work was published during 2002.

- During 2003, the USGS continued to develop, calibrate and validate the hydraulic models and collected additional channel geometry data in support of model refinement. Stage and velocity were monitored at the Tribal Hatchery gaging site. A report characterizing channel substrate and changes in suspended sediment-transport and channel geometry within the white sturgeon spawning reach in the Kootenai River following the closure of Libby Dam was published during 2003 (http://id.water.usgs.gov/public/reports.html).
- During 2004, the 10-kilometer multi-dimensional hydraulic model calibration and validation was completed and a preliminary analysis of spatial correlations between model-simulated velocity and depth and field collected spawned egg locations was completed. USGS prepared a report on the surveyed cross-sections of the Kootenai River between Libby Dam, Montana, and Kootenay Lake, British Columbia (Barton et al. 2003; http://id.water.usgs.gov/public/reports.html). Two additional abstracts involving this work were published during 2004.
- During 2005, the USGS completed the 105-kilometer 1-dimensional hydraulic model of Kootenai River in Idaho, the 24-kilometer 1-dimensional sediment-transport model, and the 18-kilometer multi-dimensional hydraulic model of the Critical Habitat reach. During this period the extended multi-dimensional model was completed (Barton et al. 2005). As well as providing the spatial distribution of velocity, depth and sediment mobility over a range of flows, the multi-dimensional hydraulic model has been used to gain insight into the hydraulic cues the white sturgeon use to spawn (McDonald et al. 2005). These three hydraulic and sediment-transport models for the Kootenai River are found at: http://id.water.usgs.gov/public/reports.html.

The extensive data collection, analysis and modeling work completed by the USGS on behalf of the Kootenai Tribe laid the groundwork for the transition of the Tribe's project #200200200 to the current habitat restoration focus reflected in this Master Plan. These foundational data collection and analysis activities were critical to the development of this Master Plan, as were contributions of many collaborating agency, private sector, and academic scientists and researchers.

1.2.3 Master Plan Development

In 2005, the Kootenai Tribe submitted a proposal to the NPCC titled, *Restore Natural Recruitment, Kootenai River White Sturgeon* (a continuation of project #200200200). In late 2006, the Tribe received approval and initiated formal project planning to develop this Master Plan. At that time, the Tribe changed the title of the project to the *Kootenai River Habitat Restoration Project* to more accurately reflect this project's ecosystem-based approach.

From 2007 through early 2009 the Kootenai Tribe, in coordination with their consultants, identified and collected additional specific data necessary to develop and confirm the conceptual feasibility of various restoration treatments and designs, conducted additional analysis and modeling associated with conceptual design and feasibility assessments (see appendices A, B, C, and E), and developed the content of the Master Plan.

To facilitate communication, coordination, policy guidance, and technical integration among disciplines, agencies and stakeholders the Tribe established advisory and technical committees early in the project planning stages. These included the following:

- Project management – includes contractors to the Tribe; responsible for project oversight and coordination, procurement and contracting assistance, and project management.
- Design team – includes contractors to the Tribe; responsible for developing the conceptual restoration framework presented in this Master Plan.
- Kootenai Habitat Policy Team – includes appointed policy level representatives from the Kootenai Tribe, Confederated Salish and Kootenai Tribes, federal agencies, British Columbia, and the states of Idaho and Montana; they provide ongoing policy guidance, coordination and help resolve critical issues as they arise.
- Interdisciplinary technical advisory group – participation varied based on need for input or coordination on specific topics. Included participation of various project contractors, and technical representatives from BPA, USACE, USFWS, USGS, IDFG, Montana Fish Wildlife & Parks (MFWP), and British Columbia (B.C.) Ministry of Environment (BCMoE). Their role was to provide technical input and review, assist in development of potential habitat treatments, evaluative tools, and review drafts of the Master Plan.
- Internal "peer" reviewers – includes individuals representing a range of technical disciplines and organizational affiliations. They were invited to participate in technical reviews of two draft versions of the Master Plan.

In late 2008, the Tribe distributed a partially completed draft of the Master Plan for an internal technical "peer," co-manager and agency review. Based on input gathered from this review, the Tribe and their consultants substantially reorganized and revised the Master Plan.

A second revised draft document was distributed for another internal technical review round in May of 2009. The response to the second draft was very positive with most reviewers acknowledging improved document organization, improved clarity of project purpose and improved goals and objectives. In addition to noting the document strengths, several reviewers identified improvements that could still be made to the Master Plan. Many of these suggestions were incorporated into this document; however, others are best deferred to the next phases of the project.

1.2.3.1 Purpose of the Master Plan

This Master Plan provides a conceptual feasibility analysis and design framework for the proposed Kootenai River Habitat Restoration Project. It is intended to:

1. Communicate the project purpose, goals and objectives to a broad range of audiences including Tribal members, state and federal agencies, local governments and communities, non-governmental organizations, local businesses and industry, local landowners, interested stakeholders and members of the public;
2. Identify limiting habitat factors, describe restoration strategies, and identify a toolbox of restoration treatments that will address limiting factors; and
3. Identify how decisions will be made about where restoration projects should be implemented within the project area, how much restoration might cost, how decisions

will be made with respect to project sequencing, and how monitoring information will be used to support the decision-making process and determine treatment effectiveness.

The main focus of this Master Plan is to provide a framework for identifying, refining and implementing restoration actions in a collaborative manner that takes into account related restoration programs and includes a mechanism for incorporating new information into the decision-making process (i.e., adaptive management—see Chapter 6). This Master Plan also identifies specific data gaps that need to be addressed in order to further ascertain feasibility and refine the design of habitat actions (Chapter 9).

Chapter 9 describes planned next steps after completion of the Master Plan including additional targeted data collection, and preliminary and final design activities.

1.3 Project Vision, Goals and Objectives

Section 1.3 describes the Kootenai Tribe's vision, ecosystem restoration philosophy, and project goals and objectives.

1.3.1 Vision

Kootenai Tribe elders pass down the history of the beginning of time, which tells that the Kootenai people were created by Quilxka Nupika, the supreme being, and placed on earth to keep the Creator-Spirit's Covenant – to guard and keep the land forever. The Kootenais have never lost sight of their original purpose as guardians of the land.

The Kootenai Tribe envisions the Kootenai River and its floodplain as a healthy ecosystem with clean, connected terrestrial and aquatic habitats, which fully support traditional Tribal uses and other important societal uses. The Tribe recognizes that protection of the environment, including recovery of Kootenai River white sturgeon needs to occur within the context of a sustainable local community and economy. Towards this end the Kootenai Tribe is committed to developing innovative and collaborative approaches to shared guardianship of the land.

In developing and implementing approaches to Kootenai River habitat restoration and related programs aimed at Kootenai sturgeon recovery, the Tribe will continue to emphasize a collaborative approach that takes into consideration the needs and values of our region. The Kootenai Tribe believes that cooperation among all groups with a stake in the region is the only way to ensure the sound and prosperous future of the Kootenai subbasin.

Because the entire ecosystem has been altered for decades, much has been lost. However, the Tribe looks to the future with the hope that native fish and wildlife may once again inhabit the Kootenai drainage in abundance. Much of this hope rides on the rapidly advancing field of ecological restoration and the Tribe recognizes there are a variety of schools of thought among restoration practitioners and researchers. The following section describes the Tribe's philosophy of ecosystem restoration.

1.3.2 Ecosystem Restoration Philosophy

Ecological restoration can be defined as the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER 2004). The Society for Ecological Restoration (2004) defines a restored ecosystem as one containing sufficient biotic (living) and

abiotic (non-living) resources to continue its development without further assistance and that will sustain itself structurally and functionally, demonstrate resilience to normal ranges of disturbance and interact with contiguous ecosystems in terms of biotic and abiotic flows and cultural interactions. This Master Plan is based on a restoration approach that emphasizes a holistic, multidisciplinary approach to evaluating and restoring ecosystem function and structure. The concepts of ecosystem function and structure are closely intertwined and both include abiotic and biotic elements and processes.

This philosophy emphasizes the need for improving or re-establishing both the structural components and the functions of the river ecosystem to restore the conditions necessary to create and maintain habitat benefiting a range of species in dynamic environments. Species are often the most noticeable symptom of ecosystem decline, but the holistic ecosystem approach to restoration focuses on system-wide stressors and interactions that are responsible for those declines. Within this Master Plan, we refer to these system-wide stressors as limiting factors. By identifying combinations of restoration strategies to address multiple limiting factors, we incorporate the idea that an ecosystem is made up of a diverse set of interacting components such that no single restoration action will restore the ecosystem.

This philosophy is consistent with the NPCC's Fish and Wildlife Program's Habitat Strategies, one of which states, 'Restore Ecosystems, Not Just Single Species'. This strategy recognizes that increasing the abundance of single populations may not, by itself, result in long-term recovery and that restoration efforts must focus on restoring habitats and developing ecosystem conditions and functions that will allow for expanding and maintaining diversity within and among species. Taking this approach to restoration will help sustain a system of robust populations in the face of environmental variation (NPCC 2009).

A central premise of an ecosystem-based approach to restoration is that restoration should create conditions that will sustain natural processes and prevent the system's further degradation while simultaneously conserving its native plants and animals. Given that ecosystems are in constant flux and that there is no single correct condition, this philosophy accepts the possibility of a number of responses, trajectories or end points for restoration actions. However, in a restored system, this flux would happen within the bounds of a most probable state (Leopold 2004). This concept, based on observations of unimpeded ecosystem processes, suggests that riverine systems achieve a relatively stable form over time based on a balanced distribution of energy throughout the system. Within the most probable state, constant change would be the norm, driven by natural ecosystem processes such as flows and other stochastic events.

Thus, restoration planning at the ecosystem scale requires integrating a "toolbox" of restoration strategies and techniques within an adaptive framework that allow strategies to shift according to ecosystem response. The techniques and strategies included in this plan include both active and passive approaches to allow natural river processes to create the biotic and abiotic components of habitat. Active techniques involve direct structural modifications to the river, its floodplain or infrastructures (i.e. channel realignment, levee removal, instream habitat structures). Passive techniques rely on the river to do the work (flow augmentation, changes in land use) (Stanford et al. 1996). This type of integrated approach is necessary in altered ecosystems where allowing natural processes alone to create habitat or other desired functions may not be feasible given limiting factors, social and economic factors or necessary timeframes for recovery. For example, when changes in the ecosystem have altered hydrologic inputs and sediment loads it may not be reasonable to expect pre-disturbance channel dimensions and

habitat to be created and maintained by current processes. This approach also recognizes that a failure to account for human interactions within restored systems is both unrealistic and undesirable for their long-term sustainability.

This approach integrates a range of disciplines and schools of thought regarding river restoration, including ecosystem theory applied to restoration (Frissell et al. 1993; Stanford 1996 and Kondolf et al. 2006) and reference or analog approaches through evaluations of historical conditions including use of reference sites and applied models describing geomorphology—flow—sediment-transport relationships (SER 2005; Rosgen 1996). The Tribe does not subscribe solely to any one of these approaches, but recognizes that each has value and that they collectively form a conceptual toolbox that makes it possible to contemplate ecosystem restoration at the scale of the Kootenai River Habitat Restoration Project.

Consistent with this ecosystem restoration philosophy, as noted earlier in this chapter, the purpose of the Kootenai River Habitat Restoration Project is to:

- Restore and enhance Kootenai River habitat by addressing ecological limiting factors and constraints related to river morphology, riparian vegetation, aquatic habitat and river stewardship. The desired result is a more resilient ecosystem, capable of sustaining diverse native plant and animal populations, and tolerant of natural disturbances.
- Restore and maintain Kootenai River habitat conditions that support all life stages (i.e., migration, occupancy, spawning, incubation, recruitment and early rearing) of endangered Kootenai River white sturgeon and other aquatic focal species; and
- Restore the Kootenai River landscape in a way that sustains Tribal and local culture and economy and contributes to the health of the Kootenai subbasin as both an ecological and socio-economic region.

1.3.3 Project Goals and Objectives

The goals for the Kootenai River Habitat Restoration Project address:

- **Morphology.** Restore physical habitat by reducing the negative effects to river and floodplain ecological processes caused by river response to the altered landscape.
- **Riparian vegetation.** Restore native vegetation by establishing stream bank and floodplain conditions that sustain plant community development processes.
- **Aquatic habitat.** Restore aquatic habitat conditions that support all life stages of native fish and promote sustainable populations.
- **River stewardship.** Create opportunities for river and floodplain stewardship in the community.

These goals support several stated objectives in the Kootenai Subbasin Plan that relate to habitat (KTOI and MFWP 2005). Within the Kootenai Subbasin Plan, objectives were organized according to habitat types (mainstem, tributaries, and reservoir), focal species (bull trout, sturgeon, burbot, kokanee, redband and westslope cutthroat trout), and biomes (regulated mainstem, wetland, riparian, grassland/shrub, xeric forest, and mesic forest). For each of these components, several objectives were identified and numbered, for example, Objective M1 is Mainstem Objective 1. Table 1-3 identifies Kootenai Subbasin Plan objectives related to habitat that would be addressed by each project goal. Kootenai Subbasin Plan objectives are repeated verbatim from that document.

Table 1-3. Kootenai Subbasin Plan objectives that support Habitat Restoration Project goals.	
Project Goal	**Supporting Subbasin Plan Habitat Objective** [1]
1. Morphology. Restore physical habitat by reducing the negative effects to river and floodplain ecological processes caused by river response to the altered landscape.	**M6 (Mainstem Kootenai River).** Improve channel stability to a level equivalent to the QHA-generated, channel stability habitat restoration scores of reference streams, assuming that such levels will support sustainable population levels of focal species that function naturally and may be capable of supporting appropriate forms of human use.
2. Riparian Vegetation. Restore native vegetation by establishing stream bank and floodplain conditions that sustain plant community development processes.	**T2 (Tributary).** Restore riparian habitats to levels equivalent to the QHA-generated riparian condition habitat restoration scores of reference streams.
	RP1 (Riparian). Restore riparian vegetation communities on 10% of the riparian acres in those subunits for which the Floodplain Vegetation Index/Vegetation Distribution Intensity Index in the TBA spreadsheet tool is < a value of 8, consistent with current or future management and mitigation plans.
	RP4. Restore riparian vegetation communities on 10% of the riparian acres in those subunits for which the Floodplain Vegetation Index/Vegetation Distribution Intensity Index in the TBA spreadsheet tool is > a value of 8, consistent with current or future management and mitigation plans.
	Most Grassland/shrub, Xeric Forest and Mesic Forest Objectives in the Subbasin Plan also support this goal.
3. Aquatic Habitat. Restore aquatic habitat conditions that support all life stages of native fish, and promote sustainable populations.	**M2.** Improve riparian function and complexity of mainstem riparian habitat to levels that support or contribute to sustainable population levels of focal species that function naturally and may be capable of supporting appropriate forms of human use.
	M5. Improve habitat diversity to levels equivalent to the QHA-generated habitat diversity habitat restoration scores, and habitat diversity conditions based on ecological primary literature and possible references rivers.
	T1 (Tributary). Protect and maintain prime, functioning tributary habitat (identified as Class 1 in QHA analysis)
	T6a. Protect habitat diversity in Class 1 streams and reaches. **T6b.** Improve habitat diversity to a level equivalent to the QHA-generated habitat diversity scores of reference streams.
	T7b. Determine opportunities for altered hydro operations to remove delta blockages from tributary streams.
	T8. Restore and provide passage to migratory fish by removing potential man-caused barriers, i.e. impassable culverts, hydraulic headcuts, water diversion blockages, landslides, and impassable deltas.
	WST1 (White Sturgeon), BT5 (Bull Trout), and KOK1 (Kokanee). Restore primary, secondary, and tertiary productivity rates and nutrient values downstream from Libby Dam to pre-dam condition (equal to those of inflows into Koocanusa Reservoir, corrected for downstream lateral input).
	KOK1 (Kokanee). Restore primary, secondary, and tertiary productivity rates and values downstream from Libby Dam to pre-dam condition (equal to those of inflows into Koocanusa Reservoir).
4. River Stewardship. Create opportunities for river and floodplain stewardship in the community.	**RP3.** Secure management rights and implement management agreements to conserve, maintain and restore 10% in those subunits for which the Floodplain Vegetation Index in the TBA spreadsheet tool is > a value of 7, consistent with current or future management and mitigation plans.
	RP5. Monitor and treat an average of 10% of acres in those subunits for which the Exotic Vegetation Index in the TBA spreadsheet tool is > a value of 6, consistent with current and future management and mitigation plans.
	Most Grassland/shrub, Xeric Forest and Mesic Forest Objectives support this goal.

[1] Although not specifically identified in this table, it is anticipated that project goals will also help address most Subbasin Plan Biological Objectives for focal species.

Each of the four goals described above (morphology, riparian vegetation, aquatic habitat and river stewardship) represents a logical grouping of the limiting factors identified as part of this Master Plan development process (Tables 1-4 through 1-7). Broad actions aimed at addressing each limiting factor are referred to as strategies, and for each strategy, one or more objectives have been identified as a way to state, in a quantifiable manner, expected outcomes of restoration actions.

These limiting factors are repeated throughout the Master Plan, recurring as a common theme that: 1) explains what problems the habitat project is intended to solve (this Chapter); 2) provides a way to organize the discussion of historical and existing conditions and how each limiting factor was identified (Chapter 2); 3) explains why specific habitat actions were selected in each Reach within the Project Area (Chapter 3); 4) supports criteria used to develop Implementation Scenarios; and 5) provides a way to organize the monitoring and adaptive management program associated with the Habitat Restoration Project (Chapter 5). Figure 1-2 illustrates the relationship among goals, limiting factors, strategies, objectives and other terms used throughout the Master Plan.

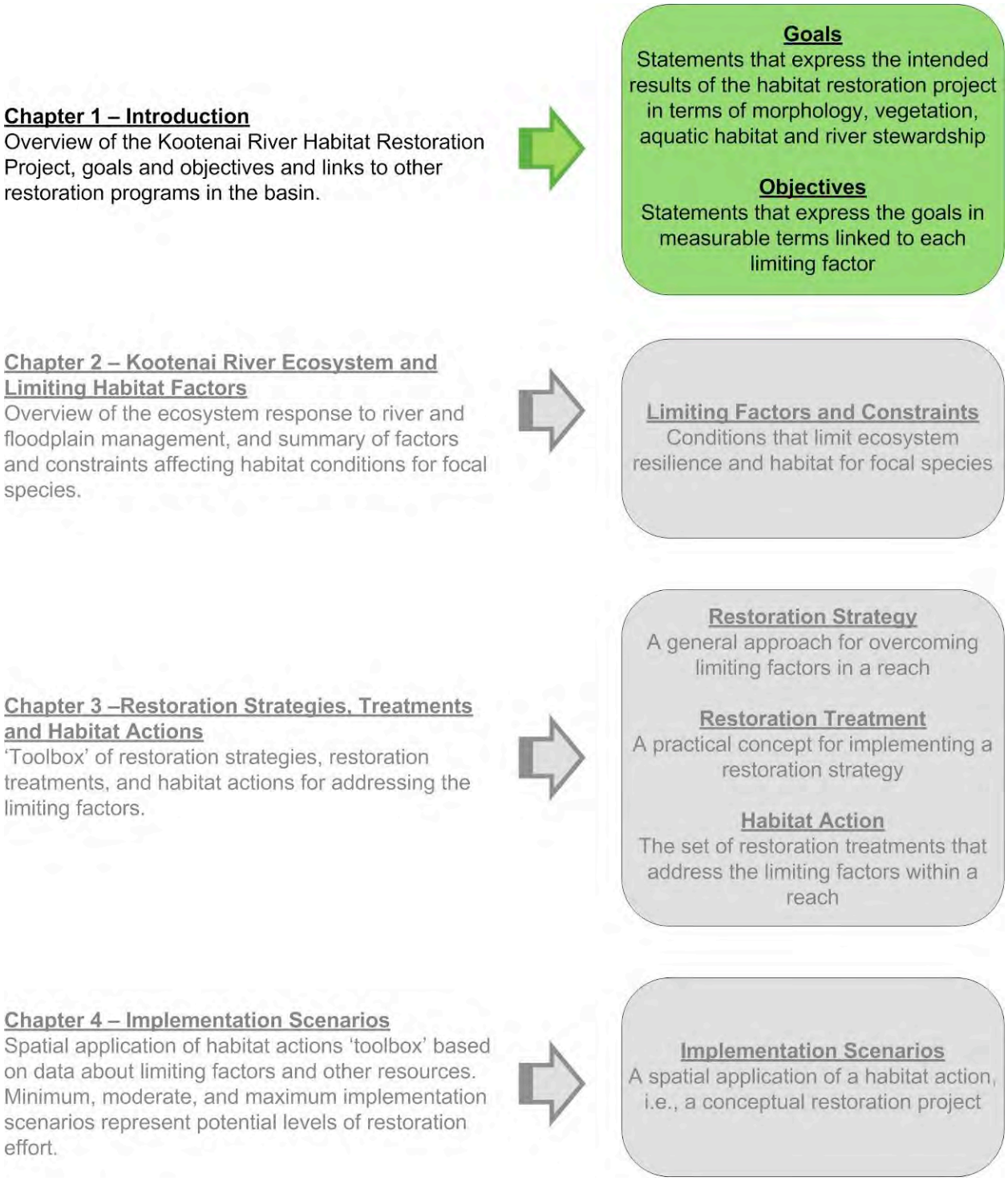

Figure 1-2. Relationship among Master Plan components.

In Tables 1-4, 1-5, 1-6 and 1-7, limiting factors are grouped according the project goals stated above (morphology, riparian vegetation, aquatic habitat and river stewardship). The quantifiable objectives provided for each of these limiting factors are intended to serve as an example of how

progress toward achieving restoration strategies will be measured. These objectives are based on past restoration projects that have addressed goals similar to the Kootenai Rive Habitat Restoration Project goals. Final objectives will be determined during the design phase, and objectives may be modified over time as effectiveness monitoring data is evaluated according to the adaptive management process described in Chapter 5. Because some objectives cannot be fully quantified until the design phase, an "x" is used as a placeholder until appropriate numbers can be developed for these objectives. In addition to additional data collection and analysis associated with design, some objectives will need to be made more specific through a collaborative process that involves stakeholders.

Goal 1. Morphology

The morphological goal addresses the need to restore physical habitat that forms the foundation for biological habitat including riparian vegetation and the aquatic ecosystem. Components of physical habitat include the flow regime, sediment-transport, river channel morphology and related processes, and floodplain formation processes. Restoration strategies include both management actions and active restoration actions. Objectives are stated in terms of measurable aspects of each physical habitat component.

Table 1-4. Limiting factors, strategies and habitat restoration project objectives related to goal 1 morphology.

Limiting Factors	Strategies	Quantifiable Objectives
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	• Construct a meandering gravel-bed channel with side channels in the Braided Reaches • Construct a confined gravel-bed channel in the Straight Reach • Excavate floodplain adjacent to the channel in the Meander Reaches
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 and reduce deposition of sediment on the channel bed in downstream reaches	• Provide floodplain surfaces in the Braided and Straight Reaches that will store X tons of sediment over X years • Provide river and floodplain sediment-transport conditions in the Braided and Straight Reaches that deposit X tons of sediment on the floodplains and less than X tons of sediment in the channel annually
Loss of floodplain connection	Establish channel and floodplain connection at mean annual peak flow where feasible given constraints from river and floodplain management	• In the Braided and Straight Reaches, create x acres of new floodplain surfaces at elevations that correspond to river stage at 30,000 cfs • In the Meander Reaches, connect x acres of floodplain surfaces at elevations that correspond to river stage at 30,000 cfs
Accelerated bank erosion and reduced boundary roughness	Establish bank vegetation Increase channel roughness	• Within identified bank treatment areas, lateral bank migration is 0 ft per year for first five years while vegetation is becoming established • Within identified bank treatment areas, less than 10% of bank length moves laterally more than 5 ft between years 5 and 10 • Within identified bank treatment areas, less than 30% of bank length moves laterally more than 10 ft between years 10 and 20

Goal 2. Riparian vegetation

The riparian vegetation goal addresses the need to restore riparian vegetation that provides floodplain habitat, important components of aquatic habitat such as overhanging bank cover and large woody debris within the river and floodplain, and food web support among other important functions. Riparian vegetation includes cottonwood and conifer forests, shrub complexes and other wetland and upland habitats. Restoration strategies include management actions such as weed control and development of riparian buffers, in addition to active restoration actions such as bioengineering, direct planting and construction of microtopography features. Objectives are stated in terms of measurable aspects of the riparian and floodplain ecosystems that are expected to exhibit variable responses to specific restoration actions.

Table 1-5. Limiting factors, strategies and habitat restoration project objectives related to goal 2, riparian vegetation.

Limiting Factors	Strategies	Quantifiable Objectives
Lack of surfaces that support riparian recruitment	Increase floodplain areas with suitable substrate and elevation relative to the water table that can support riparian vegetation recruitment and establishment	• In Braided Reach 1, create x acres of new floodplain surfaces • In Meander Reach 1, x acres of floodplain is (surface) connected to the river at 30,000 cfs, including x acres with sand/gravel/cobble substrate • In Meander Reach 1, x acres of floodplain has hydrology in the rooting zone sufficient to support hydrophytic vegetation
Lack of outer bank vegetation	Establish bank vegetation	• Within identified bank treatment areas, x live willow and shrub stems per square foot on bank face by year 3 • Within identified bank treatment areas, 80% canopy cover of native shrubs by year 5
Frequent scour/deposition of floodplain surfaces	Increase stability/longevity of floodplain surfaces	• Maximum x% change in footprint of point bars per year over three years (allows some movement, but not complete annual redistribution of point bars)
Altered hydroperiod	Increase floodplain areas with appropriate elevation ranges relative to the water table to support native tree and shrub species	• Link this objective to a design table that represents proportional abundance of elevation patches per unit area
Invasive weeds	Reduce weed cover so weeds do not limit recruitment and establishment of native plant species	• Weed canopy cover is less than 10% by year five within active restoration areas
Lack of native seed sources	Establish nodes of diverse, native vegetation within the Straight Reach and Meander Reaches	• Link this objective to design plant palletes that include a list of species by layer and target density/canopy cover over short, medium and long-term timeframes
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	• Targets would be established for each project design

Goal 3. Aquatic habitat

The aquatic habitat goal addresses the need to restore the aquatic ecosystem that provides habitat for native fish and other aquatic organisms. Aquatic habitat includes physical components such as depth, velocity, substrate, cover, pools and water quality; it also includes ecological components such as the food web, nutrient cycling, and factors that influence interactions among species assemblages. Restoration strategies include management actions related to flow and temperature regulation, in addition to active restoration actions such as constructing specific habitat features and providing fish passage between the river and tributaries. Objectives are stated in terms of measurable aquatic habitat components that are expected to exhibit variable responses to specific restoration actions.

Table 1-6. Limiting factors, strategies and habitat restoration project objectives related to goal 3, aquatic habitat.

Limiting Factors	Strategies	Quantifiable Objectives
Insufficient depth for Kootenai sturgeon migration preference	Provide depth conditions for normal Kootenai sturgeon migration and spawning behavior in Kootenai sturgeon migration reaches	• Provide intermittent depths of 16.5 to 23 ft or greater in 60% of the area of rocky substrate from RM 152 to RM 157 during peak augmentation flows[1]
Insufficient velocity for Kootenai sturgeon spawning preference	Provide velocity conditions for Kootenai sturgeon spawning and embryo/free-embryo incubation and rearing in Kootenai sturgeon spawning reaches	• Provide velocities of 3.3 ft/s and greater in approximately 60% of the area of rocky substrate from RM 152 to RM 157 during post-peak augmentation flows while avoiding harmful fluctuations during critical life stages[1]
Lack of coarse substrate for Kootenai sturgeon egg attachment	Provide substrate conditions for Kootenai sturgeon embryo/free-embryo incubation and rearing in Kootenai sturgeon spawning reaches by placing substrate or create hydraulic or sediment conditions to expose existing coarse substrate	• Create or expose coarse substrate (X mm) in approximately X miles of the Meander Reaches at the locations of known spawning behavior, generally corresponding with pool tailout locations in Meander Reach 1
Lack of cover for juvenile fish	Increase in-stream and bank cover by constructing in-stream structures and establishing bank vegetation	• Create dense vegetation bank cover for approximately X% of the Braided Reaches, X% of the Straight Reach and X% of the Meander Reaches
Lack of pool-riffle complexity	Increase hydraulic habitat complexity by establishing ratios of pool and riffle habitat that are appropriate for the morphological setting	• Establish X% pool/glide habitat and X% riffle/run habitat in all reaches
Simplified food web from lack of nutrients	Increase nutrient availability	• Reference nutrient addition program and reference other goals/objectives aimed at increasing ecosystem productivity
Insufficient pool frequency	Establish pool frequency that is appropriate for the morphological setting	• Establish pool frequency of one pool per unit length corresponding to 5 to 7 bankfull widths
Lack of fish passage into tributaries	Establish fish passage at known barriers on tributaries within the project area	• Remove fish passage barriers on tributaries
Lack of off-channel habitat for rearing	Increase availability of off-channel habitat for native aquatic species	• Create x acres of off-channel habitat that is connected to the mainstem at x cfs. This could be linked to a design table that specifies how habitat should be distributed in terms of wetland systems/classes

Table 1-6. Limiting factors, strategies and habitat restoration project objectives related to goal 3, aquatic habitat.		
Limiting Factors	**Strategies**	**Quantifiable Objectives**
Altered water quality	Identify and reduce point source pollutant inputs into Kootenai River and tributaries	• Identify specific opportunities to reduce pollutant inputs

[1] Objectives follow criteria in the Biological Opinion (BiOp) for Kootenai River White Sturgeon. The clarified 2008 BiOp replaced the intermittent depths of 16.5 to 23 feet with minimum depths of 23 feet.

Goal 4. River stewardship

The river stewardship goal addresses the need to work directly with community members and stakeholders within the project area. River stewardship includes modifying agricultural practices near streams to protect streambanks and water quality, managing flows and water levels to support ecological processes, limiting risks to infrastructure from restoration actions, and coordinating with landowners and other stakeholders to identify appropriate locations for restoration projects. Restoration strategies include management actions related to flow and land use, in addition to coordinating restoration in such a way that it is compatible with the local economy, community and culture. Objectives are stated in broad terms and focus on making sure the community and stakeholders are involved with all components of the restoration project that might affect them.

Table 1-7. Limiting factors, strategies and habitat restoration project objectives related to project goal 4, river stewardship.		
Limiting Factors	**Strategies**	**Quantifiable Objectives**
Dam controlled flow regime	Develop habitat actions that are compatible with modified flows and work with Libby Dam managers so operations support habitat restoration efforts	▪ Verify that coordination is happening based on outreach as described in Chapter 9
Dam controlled sediment regime	Develop habitat actions that are compatible with modified sediment regime and work with Libby Dam managers so operations support habitat restoration efforts	▪ Verify that coordination is happening based on outreach as described in Chapter 9
Dam controlled thermal regime	Work with Libby Dam managers to manage temperatures in a way that supports habitat needs	▪ Verify that coordination is happening based on outreach as described in Chapter 9 and verify that BiOp conditions are being met
Dam controlled nutrient regime	Coordinate with nutrient addition project	▪ Verify that coordination is happening based on outreach as described in Chapter 9
Floodplain land use	Coordinate with landowners and grazing lessees to explore development of grazing management plans that allow floodplain vegetation to develop	▪ Verify that coordination is happening based on outreach as described in Chapter 9
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	▪ Verify that coordination is happening based on outreach as described in Chapter 9
Levees and diking districts	Coordinate with diking districts and other affected parties to maintain, modify or remove levees to support channel, riparian and floodplain ecological processes according to	▪ Verify that coordination is happening based on outreach as described in Chapter 9

Table 1-7. Limiting factors, strategies and habitat restoration project objectives related to project goal 4, river stewardship.		
Limiting Factors	**Strategies**	**Quantifiable Objectives**
	specific habitat actions	
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	▪ Verify that coordination is happening based on outreach as described in Chapter 9
Floodplain draining/pumping	Assist diking districts, NRCS, SCD, and landowners as appropriate to identify areas where floodplain draining and pumping can be modified to restore floodplain hydrology	▪ Verify that coordination is happening based on outreach as described in Chapter 9
Floodplain tilling/grading	Work with NRSC, SCD, and landowners as appropriate to identify areas where microtopography and roughness can be restored to floodplain surfaces	▪ Verify that coordination is happening based on outreach as described in Chapter 9
Backwater influence from Kootenay Lake	Work with B.C. and other entities to explore and identify potential modifications to Kootenay Lake level management and design habitat actions that would compliment those modifications	▪ Reduce the backwater influence on X miles of river by lowering backwater elevations by X feet during flows greater than X cfs
Urban development adjacent to river	Design habitat actions that do not place urban infrastructure at risk and create riparian buffers to separate city from river where possible by working with City of Bonners Ferry and landowners	▪ Establish riparian buffers for X feet of river frontage based on results of coordinating with landowners

1.4 Master Plan Organization and Content

This section summarizes the organization and content of the remaining chapters and appendices of the Kootenai River Habitat Restoration Master Plan.

Chapter 2 provides an overview of the historical and existing conditions in the Kootenai subbasin, river and floodplain stewardship implications for the river corridor, the characteristics of the river reaches in the project area, and the factors that limit habitat for focal aquatic species and other species within the project area. This chapter presents background information on the historical condition of the Kootenai River and subbasin and explains how human activities have affected the ecosystem.

Chapter 3 describes restoration strategies and treatments that will be used to address limiting factors identified in Chapter 2. Restoration treatments are presented by project reach, and all treatments for a given reach are combined to form a habitat action. Habitat actions represent the restoration toolbox for a particular reach.

Chapter 4 describes how data on limiting factors and other resources within a reach are applied spatially to identify 1) specific locations where habitat is unsuitable and needs to be restored and 2) areas having the greatest potential for restoration success. The result is a set of criteria for each reach that are used to define minimum, moderate and maximum levels of restoration effort (implementation scenarios). These criteria are applied to each reach to estimate quantities of each restoration treatment for each implementation scenario, and this information is used as a basis for estimating costs in Chapter 7.

Chapter 5 describes the Adaptive Management and Monitoring program for the Kootenai River Habitat Restoration Project. The Adaptive Management and Monitoring program is a long-term decision-making framework that provides a formal way to incorporate effectiveness monitoring data related to specific restoration treatments, monitoring information from other related programs, and other new information that may become available. This chapter describes the monitoring and decision-making components that will be used to support Adaptive Management, and describes links to other restoration and monitoring programs.

Chapter 6 provides an overview of anticipated environmental compliance and consultation requirements related to subsequent phases of the Kootenai River Habitat Restoration Project. In this chapter the applicability to this project of each law, regulation, ordinance, or guideline, is defined.

Chapter 7 presents estimated costs associated with the Kootenai River Habitat Restoration Project conceptual framework presented in this Master Plan. This chapter includes an overview of the Kootenai Tribe's approach to developing cost estimates for this Master Plan, discussion of the cost categories used, identification of assumptions associated with each category and examples of costs by category, discussion of additional cost considerations, and estimated costs and cost considerations for implementation scenarios.

Chapter 8 provides a funding analysis and discusses development of a funding strategy for implementation of the Kootenai River Habitat Ecosystem Restoration Project.

Chapter 9 provides an overview of the planned next steps for the Kootenai River Habitat Restoration Project. This chapter presents a summary of the general tasks scheduled for the upcoming phases of this project including interim planning actions, environmental compliance, work associated with the preliminary and final design phases, funding, and project implementation.

This Master Plan also includes six appendices: Appendix A: Hydrology and Hydraulics Summary, Appendix B: Sediment-transport Analyses, Appendix C: Vegetation Analysis, Appendix D: Prioritized Fish and Physical Habitat Factors, Appendix E: Supplemental Geomorphic Data and Analyses, and Appendix F: Cost Analysis.

Appendix A contains a summary of the hydraulic analyses completed for the Master Plan. This appendix includes a summary of historical hydraulic departure by reach. This appendix also contains a brief discussion of data used, methods, analytical procedures, assumptions and limitations of the analyses.

Appendix B consists of sediment-transport data including: a sampling summary, suspended sediment summary, bedload sediment summary, bed material sediment summary, and a provisional sediment-transport analysis. This appendix also contains a brief discussion of data used, methods, analytical procedures, assumptions and limitations of the analyses.

Appendix C consists of the vegetation assessment and supporting information. This appendix provides supporting information related to plant community distribution and ecological processes driving plant community succession and composition for Kootenai River habitat restoration reaches. This appendix describes the results of field assessments and observations made for areas within the Meander Reach and Braided Reach. The purpose of this appendix is to provide supporting information related to further describe limiting factors associated with

developing riparian and floodplain revegetation restoration strategies related to various habitat actions.

Appendix D provides a summary of prioritized fish and physical habitat factors for each of the six focal species.

Appendix E provides a summary of geomorphic data that was used to support development of morphological limiting factors.

Appendix F provides a detailed breakdown of estimated costs in support the cost estimates presented in Chapter 7.

In addition to the information presented in the Master Plan and associated appendices a variety of key support documents used in the development of this Master Plan are available for download on the Kootenai Tribe's website at: http://www.kootenai.org/fish_resources.html.

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2 Kootenai Subbasin Ecosystem and Limiting Habitat Factors

Chapter 2 provides an overview of the Kootenai subbasin, river and floodplain stewardship implications for the river corridor, the characteristics of the river reaches in the project area, and the factors that limit habitat for focal aquatic species and other species within the project area. This chapter presents background information on the historical condition of the Kootenai River and subbasin and explains how human activities have affected the ecosystem. Chapter 2 builds on the project goals and objectives presented in Chapter 1, and provides the basis for developing the restoration strategies, treatments and habitat actions described in Chapter 3. The toolbox of restoration strategies, treatments and habitat actions is applied spatially to reaches within the project area in Chapter 4, resulting in implementation scenarios used to define a potential range of restoration levels of effort. The relationship among these chapters, and related terminology, is illustrated in Figure 2-1 on the following page.

In the context of this Master Plan, limiting factors are defined as physical, biological, and ecological conditions within the project area that: 1) limit the ability of the ecosystem to sustain diverse native plant and animal populations, and to accommodate natural disturbances; 2) limit the quality or availability of 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 tribal culture, subsistence needs, and the economy. Limiting factors can be addressed by active restoration or changes in management. In contrast, constraints are components like roads, bridges and other infrastructure that cannot be changed by management or active restoration, but must be considered during the design process.

The Kootenai sturgeon is one of six focal species that are discussed in this chapter. The Kootenai sturgeon is given more attention throughout the document due to their federally endangered species status. The species is also considered an indicator species for ecosystem health, and the decline of the species suggests that ecosystem components are degraded, limiting, or missing. Although emphasis in this chapter is often placed on rehabilitating the Kootenai sturgeon population, the Kootenai River Habitat Restoration Project is directed towards restoring the broad range of habitats within the project area.

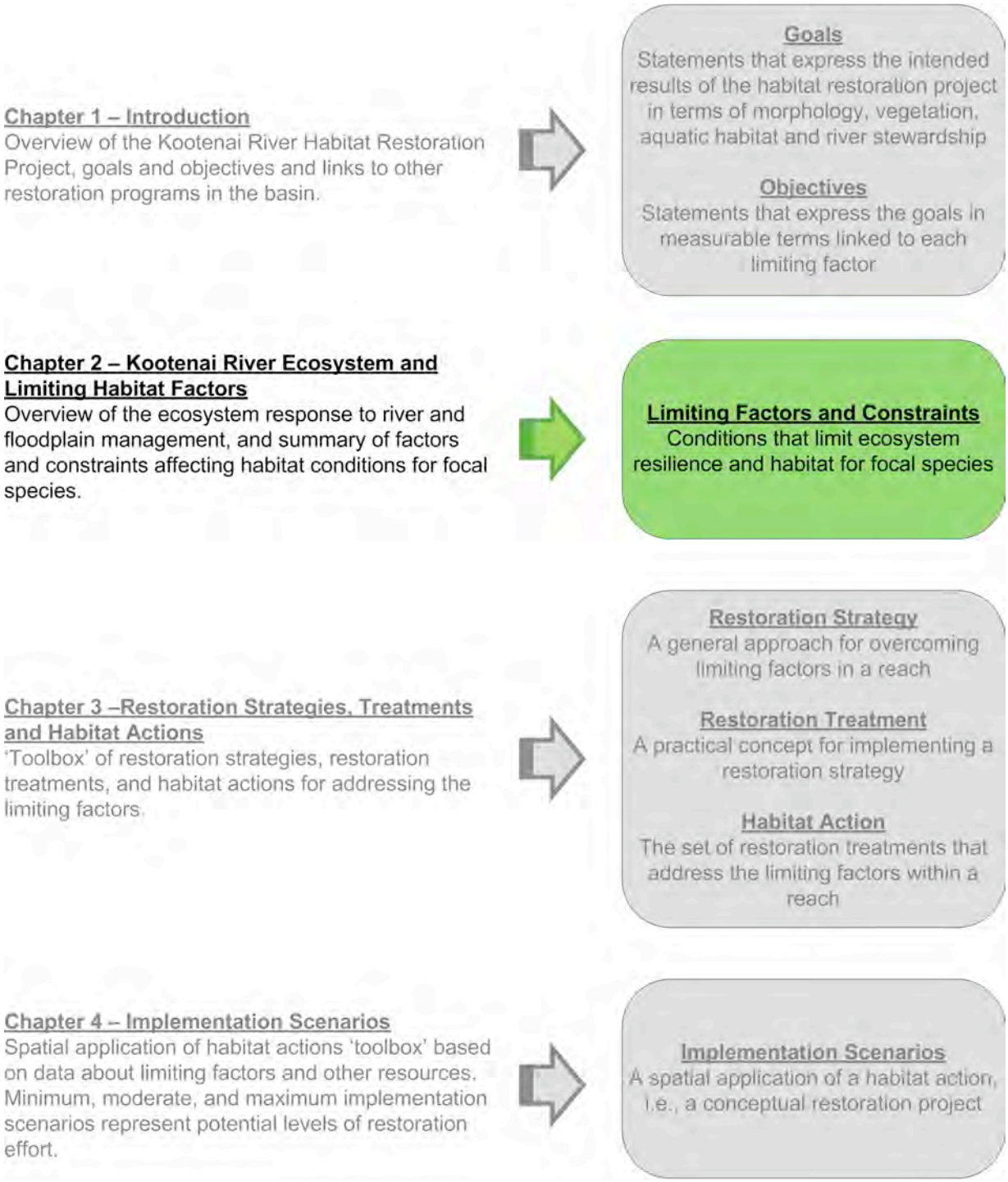


Figure 2-1. Relationship of Chapter 2 to other chapters in this Master Plan and related terminology.

While there is a great deal of literature supporting identification of limiting factors for many of the focal species (Fausch 1989; MBTSG 1996; Anders et al. 2002; Paragamian et al. 2002), a number of the limiting factors (particularly those related to Kootenai sturgeon) are derived from ongoing research and evolving recruitment failure hypotheses (Anders 1991; Duke et al. 1999; USFWS 1999; Anders et al. 2002; Anders 2004; Coutant 2004; Paragamian et al. 2005). The list of limiting factors identified in this Master Plan is therefore based on the best available information found in published papers, the gray literature, recent data collection, analysis completed as part of the Master Plan effort, and expert opinion provided by the Tribal staff, project design team members, co-managers, technical experts from partners agencies, and internal peer reviewers.

The four general categories used to organize the limiting factors in this Master Plan include:

- **River and floodplain management constraints** – features like roads, bridges and other infrastructure that cannot be changed by management or active restoration, but must be considered during the design process. River management has also resulted in changes to the rate and timing of flow and changes to temperature regimes. Although there is some flexibility in river management to address flow and temperature there are also significant constraints.
- **Morphological limiting factors** – physical conditions that are on a trajectory away from normative habitat conditions or exhibit departure from historical conditions. Although returning the physical environment to the conditions of pre-European settlement is not feasible, addressing the morphological limiting factors is aimed at restoring a trend towards more normative morphological conditions.
- **Riparian vegetation limiting factors** – processes or conditions that prohibit establishment of native plant communities. Riparian vegetation limiting factors are directly influenced by morphological limiting factors.
- **Aquatic habitat limiting factors** – missing components of the ecosystem that support habitat requirements for all life stages of the focal aquatic species. Aquatic habitat limiting factors are directly influenced by morphological limiting factors and riparian vegetation limiting factors.

2.1 Summary of Limiting Factors in the Project Area

Limiting factors in the project area are summarized in the following paragraphs and described in greater detail later in this chapter. Reach-specific limiting factors are summarized in Chapter 3.

2.1.1 Constraints from River and Floodplain Management

River and floodplain management has affected many aspects of the Kootenai subbasin ecosystem. River and floodplain management actions are recognized as elements within the river system that are of critical importance to our society, but pose constraints to ecosystem restoration. Constraints from river and floodplain management identified in this chapter include:

- **Dam controlled flow regime** – Flow regulation at Libby Dam is considered to be one of the major reasons for the continued decline of Kootenai sturgeon, burbot, and other focal species' populations. Regulated spring peak flows are less than half the pre-Libby

Dam (pre-dam) peak flows, while winter flows have increased by 300% relative to the pre-dam period (USFWS 1999). High spring flows similar to pre-dam conditions, which are thought to be necessary for successful Kootenai sturgeon reproduction, have rarely occurred during the May-July spawning season since the closure of Libby Dam in 1972. In addition, historically (i.e., pre-dam) higher flushing flows kept pockets of spawning substrate clean and exposed. The high winter flows necessary for reservoir drawdown also negatively impact burbot spawning migrations. The dam controlled flow regime and its departure from the pre-dam flow regime are described in more detail in Section 2.3.

- **Dam controlled sediment regime** – Flow regulation at Libby Dam has altered the sediment regime in the Kootenai River by trapping bedload and suspended load from the upper Kootenai subbasin and reducing the sediment transport capacity of the river. Pre-dam, these materials provided a greater sediment supply to the Kootenai River in the area addressed by this project. The dam controlled sediment regime and its departure from the pre-dam sediment regime are described in more detail in Section 2.3.
- **Dam controlled thermal regime** – Flow regulation at Libby Dam has led to typically warmer water temperatures in the winter and cooler water temperatures in the summer. Changes in the thermal regime have affected the focal species by influencing seasonal behavior patterns, most notably spawning cues for Kootenai sturgeon and burbot. The dam controlled thermal regime and its departure from the pre-dam thermal regime are described in more detail in Section 2.3.
- **Dam controlled nutrient regime** – Nutrients delivered from the upper Kootenai subbasin are sequestered in Lake Koocanusa. "Clean" water downstream from Libby Dam has resulted in reduced primary productivity with corresponding ecosystem effects including depressed fish populations (P. Anders, personal communication, 2008). Kokanee populations inhabiting Kootenay Lake dwindled following closure of Libby Dam and cessation of phosphorus mining in the subbasin. Nutrient augmentation programs directed towards rehabilitating nutrient levels in the Kootenai River and Kootenay Lake have resulted in measured biological responses (Andrusak 2003; Holderman et al. 2009a, 2009b). Effects of the dam controlled nutrient regime are described in more detail in Section 2.6.
- **Bank armoring** – Bank armoring can affect the assemblage of riparian vegetation, reduce channel and floodplain complexity, and decrease sediment delivery to the river. Armoring may impact vegetation recruitment, debris delivery to the river corridor, and diminish aquatic habitat complexity.
- **Levees and diking districts** – Levees simplify the floodplain by restricting flood flows to the main channel. Similarly, confinement of floodwater to the channel reduces the overall productivity of the river-floodplain system as the shallow water habitats that are created on the floodplain during high flows are excluded by the levee network. Therefore, levees have reduced backwater and off-channel habitats that historically provided diverse microhabitats, food sources, and resting areas for fish in the Kootenai subbasin. Locations of levees and diking districts are identified in Figure 2-4 in Section 2.3.
- **Transportation corridors** – Highway and railroad transportation corridors parallel the Kootenai River in portions of the project area. U.S. Highway 95 and the Union Pacific

railroad cross the river at Bonners Ferry. The Burlington Northern Santa Fe railroad parallels portions of the project area and has cut off portions of the floodplain. Transportation corridors and infrastructure are discussed in Section 2.3.

- **Floodplain land use** – Land use practices such as grazing, agriculture, tilling, groundwater pumping and vegetation clearing have altered the character of the floodplain and distribution of sediment, nutrients, and debris to the Kootenai River. Other resource management practices such as forestry and mining have altered the landscape. Development, removal of riparian buffers and installation of bank armoring have affected the assemblage of riparian bank vegetation, reduced channel and floodplain complexity, and altered sediment delivery to the river.
- **Backwater influence from Kootenay Lake** – Fluctuations in Kootenay Lake levels affect water surface elevations upstream past Bonners Ferry. Kootenai River habitat is affected by the dynamic conditions caused by the large fluctuations in water surface elevation between baseflow and mean annual peak flow. How these dynamic conditions interact with other factors to affect morphology, riparian vegetation and aquatic habitat is described throughout this Chapter. Kootenay Lake levels are controlled by both natural conditions and managed operations. The primary constraint posed by the Kootenay Lake backwater is the limited ability to manage the lake level for habitat benefits without negatively affecting other operational needs.

2.1.2 Limiting Factors for Morphology

Morphological limiting factors are derived from the effects of river and floodplain management in the Kootenai subbasin. Factors that have altered natural and historical morphological processes in the project area include:

- **River Response to altered hydraulics** – Departure from historical conditions has changed the hydraulics that influence existing channel behavior. Mean annual peak values for channel depth, velocity and shear stress are lower due to lower mean annual peak flows. The Kootenai River's response to altered hydraulics varies by reach due to differences in morphology, but in general, the response has caused negative impacts to aquatic habitat, ecological processes and KRWS behavior. Altered hydraulics are described in more detail in Section 2.4.1 and Appendix A.
- **River Response to altered sediment-transport** – Sediment transport in the project area is affected by a reduction in sediment supply from the watershed due to sediment trapping at Libby Dam and changes in sediment transport competence and capacity due to altered hydraulics. The effects of altered sediment tranport have implications for aquatic habitat including: 1) reduced supply of suitable spawning substrate delivered to the project area, and 2) increased embeddedness of coarse substrate with sand and finer sediment. Not only does altered sediment transport affect aquatic habitat, but it also affects channel morphology and vegetation processes. The Kootenai River's response to altered sediment transport is described in more detail in Section 2.4.2 and Appendix B.
- **Loss of channel and floodplain connection** – Floodplain conditions are characterized by floodplain surfaces that are too high and are no longer accessed due to reduced mean annual peak flows and levee construction. Implications of loss of floodplain connectivity

are described in more detail with respect to riparian vegetation and aquatic habitat limiting factors in Sections 2.5 and 2.6, respectively.

- **Reduced channel boundary roughness and bank erosion** – Bank erosion and sediment loading have always played a role in the morphology of the Kootenai River. However, bank erosion rates are affected by river and floodplain management, the lack of bank vegetation, and the river's response to altered hydraulics and sediment transport. Preliminary comparisons using measured bank erosion data indicate that bank erosion accounts for approximately 15 to 30% of the measured bed material supply within the project area. Bank erosion and associated rates of channel migration, if accelerated, could cause excessive disturbance and have negative effects on aquatic habitat and ecological processes. Moreover, bank erosion and land loss is a costly problem that affects river stewardship as well as river and floodplain management. Bank erosion is discussed in more detail in Section 2.4.4 and Appendix E.

2.1.3 Limiting Factors for Riparian Vegetation

Factors that have altered the native riparian vegetation community in the project area are listed in the following bullets. Additional detail is presented in Section 2.5.

- **Lack of surfaces that support riparian vegetation recruitment** – Because fewer depositional surfaces are formed due to the altered hydrograph, altered sediment-transport regime and loss of floodplain channel connection, recruitment of riparian vegetation such as cottonwoods (*Populus* species) and willows (*Salix* species) has decreased.
- **Lack of outer bank vegetation** – Lack of vegetation on outer banks is due to floodplain modifications, streambank armoring and levees, vegetation clearing, and hydraulic processes such as bank erosion. Vegetation on outer banks contributes to bank stability, cover for aquatic species, and support of the food web; it also provides seed sources that support establishment of new plant communities.
- **Frequent scour and deposition of floodplain surfaces** – In upstream portions of the project area, deposited floodplain surfaces are scoured and re-deposited too quickly for plant communities to become established. In downstream portions of the project area, backwater effects from Lake Kootenay, combined with flows that are confined to the main channel, contribute to unstable depositional surfaces within the levee system.
- **Altered hydroperiod** (the length of time during the growing season when water is available in the rooting zone) – Changes to the hydrologic conditions in the Kootenai River as a result of dam operations have interrupted patterns of vegetation succession by impacting riverine and floodplain processes that maintain riparian plant communities, including sediment deposition and scour, seed dispersal, hydrograph recession, floodplain water storage, and the exchange of nutrients and organic matter between the river and floodplain. Altered hydroperiod is probably one of the most significant factors driving the reduced extents of riparian and wetland plant communities. Figure 2-11 shows the pre- and post-dam stage and discharge relationships.
- **Invasive plant species** – Non-native, invasive plant species have displaced native riparian vegetation resulting in less streambank cover, reduced streambank and floodplain

stability and loss of primary and secondary productivity. Some non-native, invasive vegetation out-competes native vegetation, homogenizing plant community structure and reducing species diversity, habitat complexity and ecosystem function.

- **Lack of native plant diversity and seed sources** – Agricultural and infrastructure development in portions of the floodplain (primarily in the Straight Reach and Meander Reaches) have removed native vegetation and reduced the availability of native seed sources for establishing and maintaining riparian vegetation communities.
- **Lack of nutrient sources for primary productivity** – Operation of Libby Dam and lack of vegetation in the project area have combined to reduce nutrient inputs to the river, or primary production from riparian vegetation.
- **Altered carbon balance** – In the Kootenai subbasin, extensive wetland acreage has been converted to cropland and pastureland. The depletion of wetland systems has likely contributed to decreased carbon availability, likely reducing the biological energy available to drive ecosystem processes and support the food web.

2.1.4 Limiting Factors for Aquatic Habitat

Factors that have altered the aquatic habitat conditions in the project area are listed in the following paragraphs. Specific factors that impact Kootenai sturgeon and other focal fish species are presented. Additional detail is presented in Section 2.6.

- **Insufficient depth for Kootenai sturgeon migration** – Higher width-to-depth ratios, shallower water depths due to lower peak flows and instream sediment deposition may affect Kootenai sturgeon during their upstream spawning migration.
- **Insufficient velocity for Kootenai sturgeon spawning sturgeon spawning, incubation, and early life stages** – Reduced velocities due to lower peak flows and higher width-to-depth ratios may affect Kootenai sturgeon spawning, incubation, and early life survival.
- **Lack of coarse substrate for egg attachment** – Deposition of finer sediments over coarse substrate on the streambed has created conditions that are not ideal for Kootenai sturgeon demersal egg attachment, embryo development, or free-swimming embryo survival.
- **Lack of cover for juvenile fish** – Changes in the riparian community, loss of bank vegetation cover, floodplain habitat simplification, reduction of interstitial cobble spaces on the streambed, and decreased large and small wood and associated habitat structure in the system have reduced refuge areas for juvenile fish and aquatic periphyton and invertebrates assemblages.
- **Lack of pool-riffle complexity** – Increased silt loading has filled in deep pools in the river, resulting in a more homogenous channel bed profile. This habitat simplification impacts fish and other aquatic organisms. Deep pools provide holding habitat for adult fish during winter and when migrating upstream to spawn as well as refuge areas for juvenile fish.
- **Simplified food web from lack of nutrients** – Changes in the nutrient flux as a result of nutrient sequestration in Lake Koocanusa, decreased floodplain connectivity in the

project area, and changes in the riparian vegetation community have led to decreased primary and secondary productivity.

- **Insufficient pool frequency** – Decreased frequency of pools in the Kootenai River system reduces available habitat for focal fish species. Bull trout, redband trout, Kootenai sturgeon, and other focal fish species require complex habitats with deep pools.
- **Lack of fish passage into tributaries** – Tributaries serve as important spawning and rearing habitat for many of the focal fish species, especially native trout and kokanee salmon. Altered sediment-transport and deposition patterns have caused aggradation of sediments in the deltas of many tributaries to the Kootenai River upstream of the project area. As a result, many of these deltas have become barriers to fish passage, especially at low flows. Other tributaries are blocked by natural falls and human-caused fish passage barriers such as road crossings, respectively.
- **Lack of off-channel habitat for rearing, primary, and secondary production and species diversity** – Decreased floodplain-channel connectivity has resulted in fewer off-channel habitats in the system. Off-channel habitats provide important rearing areas for juvenile fish, and for critical supporting primary and secondary biological production, including species richness and biodiversity.
- **Altered water quality** – Nutrient fluxes in the Kootenai River have changed over time with changes in land uses, closure of fertilizer production facilities and mines, and Libby Dam operation. Altered water quality affects primary and secondary productivity, and may decrease food availability for fish. Other water quality concerns include legacy heavy metals stored in the river bed sediment and point and non-point source pollutants discharged from agricultural fields and the urban corridor of Bonners Ferry and other municipalities in the Kootenai subbasin.

2.2 Kootenai Subbasin and Project Area Overview

From its headwaters in the Canadian Rockies, the Kootenai River flows over 400 miles traversing the international border separating the United States and Canada before joining the Columbia River at Castlegar in southeastern British Columbia. Draining portions of British Columbia, Montana, and Idaho, the geomorphic character of the river is shaped by glacially-influenced landscapes. In addition to political boundaries, the river system drains a diverse subbasin characterized by varied geology, climatic regimes, vegetation, and land uses. The following sections provide an overview of the Kootenai subbasin.

2.2.1 Location

The Kootenai subbasin overlays parts of southeastern British Columbia, northern Idaho, and northwestern Montana, covering a 16,180 square mile area. Nearly two-thirds of the Kootenai River's 485-mile-long channel and almost 70% of the Kootenai subbasin is located within British Columbia. The Montana portion of the Kootenai subbasin makes up about 23% of the total subbasin, while the Idaho portion is only about 6.5% (Knudson 1994). The primary focus of the Kootenai River Habitat Restoration Project is on the portion of the subbasin that lies within the

State of Idaho. Figure 2-2 on the following page shows the location of the Kootenai subbasin and the reaches comprising the project area.

2.2.2 Climate

The climate in the Kootenai subbasin is affected by both maritime and continental weather patterns. Maritime influences moderate the harsher continental climate. Winters are neither as wet nor as warm as Pacific coastal areas, but generally are not as cold and dry as areas to the east. Weather patterns are complex, with local variations stemming from differences in elevation. The average annual air temperature at Bonners Ferry is 46.9°F (9.8°C), reaching or exceeding 90°F (32.2°C) on half the days in July and August, and averaging 22°F (-5.6°C) in January. Mean annual precipitation in the Idaho portion of the subbasin is 30 inches, approximately 70% to 80% of which falls as snow between November and March.

2.2.3 Geology, Soils and Land Types

The Kootenai subbasin lies within ranges of the Rocky Mountains, trending north to northwest, that are separated by long straight valleys. These valleys tend to be relatively broad and flat. Quartzite-based and granitic rocks underlie the subbasin. Soils derived from quartzite deposits are significantly more stable and resilient on hill slopes and in stream channels than the coarse weathered granitic sands. Bedrock in the subbasin is typically covered with glacial till. The till derived from quartzite rocks is medium-textured with a moderate amount of rock fragments. That derived from granite is usually sandier and varies more in its rock-fragment content. The top portion of the glacial till is loose and permeable, while the lower part can be dense and impermeable. The dense layer can restrict water movement and root penetration. Deposits of outwash and alluvium transported by streams are found in valley bottoms. A layer of volcanic ash that is 0.5 to 1.5 feet thick covers most of the glacial material. The ash usually has a silt-loam texture with little gravel, cobble, or rock fragments. It normally has a high infiltration rate, high permeability, and a high water- and nutrient-holding capacity. Ash, however, is easily compacted and displaced by heavy equipment.

Upstream reaches of the Kootenai River in British Columbia flow through the Purcell Range, the southern Rocky Mountain Trench, and the southern Rocky Mountains. The Purcell Trench, which the Kootenai River enters at Bonners Ferry, is perhaps the most prominent structural feature of the lower part of the subbasin. Lying between the Selkirk and Purcell mountains, it is a glacially-enlarged, asymmetric, fault-bounded valley.

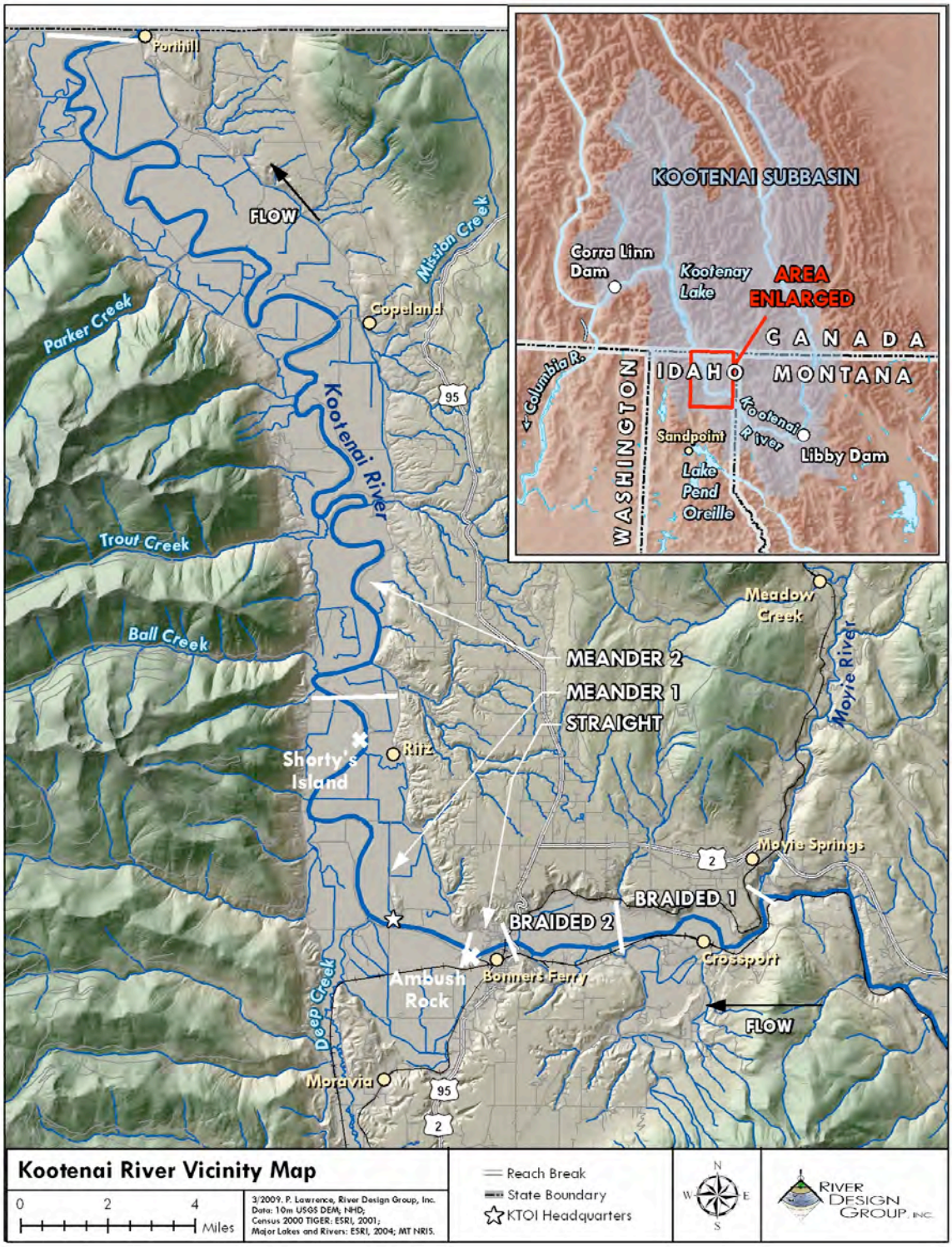


Figure 2-2. The Kootenai subbasin and location of the proposed Kootenai River Habitat Restoration Project.

The Purcell Trench is the glacially scoured basin that contains Kootenay Lake. The bottom of the trench, the lower slopes of the valley and alluvial terraces are covered with deposits of glacial

debris and older sediments. Other major structural features created by faults in this part of the subbasin include the Moyie River corridor and the valley between the Purcell and Cabinet mountains (Daley et al. 1981). Bonnington Falls marks the geologic structural outlet of Kootenay Lake. The falls, although presently inundated, historically formed a fish passage barrier that has isolated Kootenai sturgeon since at least the last ice age.

2.2.4 Geomorphology

The historical geomorphology of the Kootenai River was shaped by the region's geology and glaciation during the late Pleistocene and early Holocene. Repeated ice dam formation and destruction at the outlet of glacial Kootenay Lake influenced the Kootenai subbasin. The last ice dam failure approximately 10,000 years ago drained Kootenay Lake to near its current elevation. Fine sand and silts deposited during lacustrine periods, filled the bottom of the Purcell Trench, a north-trending glacially modified valley running from Coeur d'Alene, Idaho into Canada (Doughty and Price 2000). The deposited fines shaped the valley bottom forming the contemporary floodplains and terraces observed today. Additional discussion regarding geomorphology is provided in Section 2.4.3 and Appendix E.

Prior to Euro-American settlement in the Kootenai subbasin, the river interacted with the adjacent floodplain on an annual basis. The dynamic floodplain characterized by diverse riparian communities, side channels and ponds, and tributary streams exchanged materials with the river. Sediment, nutrients, large wood and debris mobilized by the river would have deposited on the adjacent floodplain. Similarly, these materials would have also have been reclaimed by the river during annual high water. Relict floodplain features mapped by the General Land Office (GLO) suggest the Kootenai River actively migrated within its floodplain, leaving channel scrolls that evolved into floodplain ponds, oxbows and other wetland habitats over time.

2.2.5 Habitat and Biota

The pre-European Kootenai River corridor was characterized by the primary river channel, connected backwater habitats, floodplain channels that were activated during flood runoff, and tributary streams that meandered across the floodplain to join the Kootenai River. Richards (1997) highlighted the historical floodplain conditions between Bonners Ferry and Kootenay Lake.

> The Kootenai River, like other river-floodplain ecosystems, was historically characterized by seasonal floods that promoted the exchange of nutrients and organisms among a mosaic of habitats, and thus enhanced biological productivity (Junk et al. 1989, Bayley 1995, Sparks 1995). Prior to the construction of Libby Dam, the Kootenai River was characterized by a four to six kilometer wide floodplain [the active river corridor is now generally limited to the primary channel] in the furthest downstream 128 km of the river [extending from downstream from Bonners Ferry to Kootenay Lake-approximately the Meander Reach]. Diking of this stretch of river, from the 1920s to the 1950s, eliminated approximately 50,000 acres of natural floodplain in Idaho alone. Estimated floodplain loss in British Columbia may be equal or greater.

Despite the diverse floodplain corridor, the Kootenai River historically supported a fish community with a relatively low species diversity (Table 2-1) compared to other drainages in the Columbia Basin. The low number of fish species inhabiting the Kootenai River is related to the isolation by Bonnington Falls. The multiple runs of anadromous salmon, steelhead, and lamprey that were historically common in other tributaries to the Columbia River did not develop post-glacially in the Kootenai River due to these barrier falls. Several of the land-locked species in the Kootenai River have anadromous life form counterparts (e.g., white sturgeon and kokanee) that inhabit water bodies connected to the ocean.

Table 2-1. Fish species in the Kootenai subbasin.

Native Species		**Introduced Species**	
Common Name	***Genus species***	***Common Name***	***Genus species***
Westslope cutthroat trout	*Oncorhynchus clarki lewisi*	Rainbow trout	*Oncorhynchus mykiss*
Redband trout	*Oncorhynchus mykiss subspecies*	Brown trout	*Salmo trutta*
Bull trout	*Salvelinus confluentus*	Brook trout	*Salvelinus fontinalis*
Kokanee salmon	*Oncorhynchus nerka*	Bluegill	*Lepomis macrochirus*
Mountain whitefish	*Prosopium williamsoni*	Pumpkinseed	*Lepomis gibbosus*
Burbot	*Lota lota*	Smallmouth bass	*Micropterus dolomieu*
White sturgeon	*Acipenser transmontanus*	Largemouth bass	*Micropterus salmonides*
Redside shiner	*Richardsonius balteatus*	Northern pike	*Esox lucius*
Peamouth chub	*Mylocheilus caurinus*	Yellow perch	*Perca flavescens*
Northern pikeminnow	*Ptychocheilus oregonensis*	Black bullhead	*Amerius melas*
Largescale sucker	*Catostomus macrocheilus*		
Longnose sucker	*Catostomus catostomus*		
Torrent sculpin	*Cottus rhotheus*		
Slimy sculpin	*Cottus cognatus*		
Longnose dace	*Rhinichthys cataractae*		

2.2.6 Focal Species

Six native Kootenai River fish species identified as focal species in the Kootenai Subbasin Plan (KTOI and MFWP 2004) were also used as indicators to evaluate potential habitat restoration actions presented in this Master Plan. These species include: Kootenai River white sturgeon, burbot, bull trout, westslope cutthroat trout, redband trout, and kokanee.

These species were chosen as focal species in the *Kootenai Subbasin Plan* because:

1. They are designated as a Federal endangered or threatened species or have been otherwise designated a priority species for conservation actions; and/or
2. They play an important ecological role in the Kootenai subbasin (for example as a functional specialist or as a critical functional link species); and/or
3. They possess economic or cultural significance to the people of the Kootenai subbasin.

The following estimates of current abundance of various species as a percent of their historical population level, is presented in the Kootenai Subbasin Plan (MFWP and KTOI 2004):

- Bull trout — 60% of historical levels
- Westslope cutthroat trout — 20% of historical levels
- Redband trout — 10% of historical levels
- Kokanee — 40-50% of historical levels
- White sturgeon and burbot — 0-10% of historical levels

Section 2.6.1 provides additional summary information on historical and current populations, habitat requirements, and limiting factors affecting the focal species populations. Additional information is provided below for the Kootenai sturgeon since it is listed as endangered under the Endangered Species Act (ESA) by the U.S. Fish and Wildlife Service (USFWS), and as an endangered species under the Canadian Species at Risk Act (SARA), and is thus an essential area of concern in the design and implementation of the Kootenai River Habitat Restoration Project.

2.2.7 Riparian and Wetland Communities

Historical riparian and wetland communities within the lower Kootenai subbasin have been documented in several reports (Jamieson and Braatne 2001; KTOI and MFWP 2004; Egger et al. 2007). The following section summarizes historical conditions of riparian and wetland communities in the portion of the Kootenai subbasin addressed by this project, as presented in the above referenced reports.

During pre-European settlement times, riparian and wetland plant communities in the lower Kootenai subbasin were more widespread and diverse than they are now. The intact and functioning ecosystem processes of the pre-European settlement Kootenai subbasin would have supported the following functions:

- Provided the array of habitats and ecological niches needed to support the various life stages of the native flora and fauna;
- Provided exchange of sediment, nutrients, large wood and debris between the river and floodplain environment to support overall system productivity;
- Provided above and below ground, transport of dissolved particulate materials and nutrients by river flow;
- Provided an interconnected corridor linked not only along the river, but also to associated tributary streams and adjacent uplands;
- Provided water quality benefits through streambank stabilization, sediment filtering, and dissipating stream energy to allow sediment deposition and streambank building; and
- Provided groundwater and aquifer recharge through floodwater retention.

Historically, the hydroecology of the Kootenai subbasin was predictable. It was characterized by a large, sustained, snow-melt driven runoff period in late spring, followed by a gradual recession in early autumn, and low winter flows (Burke 2006). The complex and expansive riparian and

wetland habitats of the lower subbasin were created and maintained by these hydrologic cycles. The frequent flood-pulse disturbances would have changed the floodplain landscape frequently and supported associated riparian and wetland plant communities. Channel movement combined with flooding would have driven vegetation successional processes by creating opportunities for early pioneering species like cottonwood and willow to establish. This dynamic, intact floodplain would have been characterized by: diverse riparian communities, side channels and ponds, and tributary streams that exchanged materials with the river on an annual basis. According to Jamieson and Braatne (2001), the lower Kootenai subbasin probably supported one of the largest and richest riparian forest and wetland complexes in the Pacific Northwest. Historically, the lower Kootenai River was thought to have included approximately 70,000 acres of contiguous floodplain and related riparian and wetland ecosystems (Jamieson and Braatne 2001). Of these 70,000 floodplain acres, approximately 22,000 acres were estimated to be wetlands (USEPA 2004).

Within the terraced/alluvial and glacio-lacustrine valley types, riparian and floodplain communities would have been extensive, spreading throughout the valley floor and forming in response to channel migration patterns and sediment deposition. The surface hydrology connection between the Kootenai River and its floodplain would have created and maintained side channels and off-channel wetlands, resulting in diverse habitats representing multiple age classes. In inter-gorge and other structurally-controlled reaches, these interactions would have been reduced, resulting in narrow strips of riparian communities and minimal wetland development.

Within the glacio-lacustrine valley type, natural sand levees would have driven plant community distribution. Exactly how plant communities were distributed in this valley type is not clear and much of the existing literature does not address this directly. To fill this data gap, the Kootenai Tribe is developing a model of historical vegetation and potential natural vegetation in the floodplain (Egger et al. 2007; Benjankar 2009). It seems logical, however, that the plant communities immediately adjacent to the river may have been dominated by grasses or upland shrubs rather than cottonwoods due to the high elevation of sand levees relative to the river. Given this topography, cottonwood communities would have occurred in narrow bands within the natural levees, but also would have been located further away from the channel in areas subject to scour and deposition, possibly where high flows occasionally breached natural levees. This process has not been documented in the literature, however, and other factors may have influenced plant community distribution in the glacio-lacustrine valley type. Figure 2-3 shows the low floodplain elevations relative to the river stage at average peak flows in the main channel. River stages used for comparison in Figure 2-3 are based on the U.S. Geological Survey (USGS) HEC-RAS Model (Berenbrock 2005) using a discharge of 30 kcfs and a downstream boundary condition at Porthill, Idaho of water-surface elevation 1,754 ft (mean Kootenay Lake backwater elevation at mean annual peak flow); floodplain elevations are based on LiDAR data. These data show that the lowest areas of the floodplain are located some distance from the main channel.

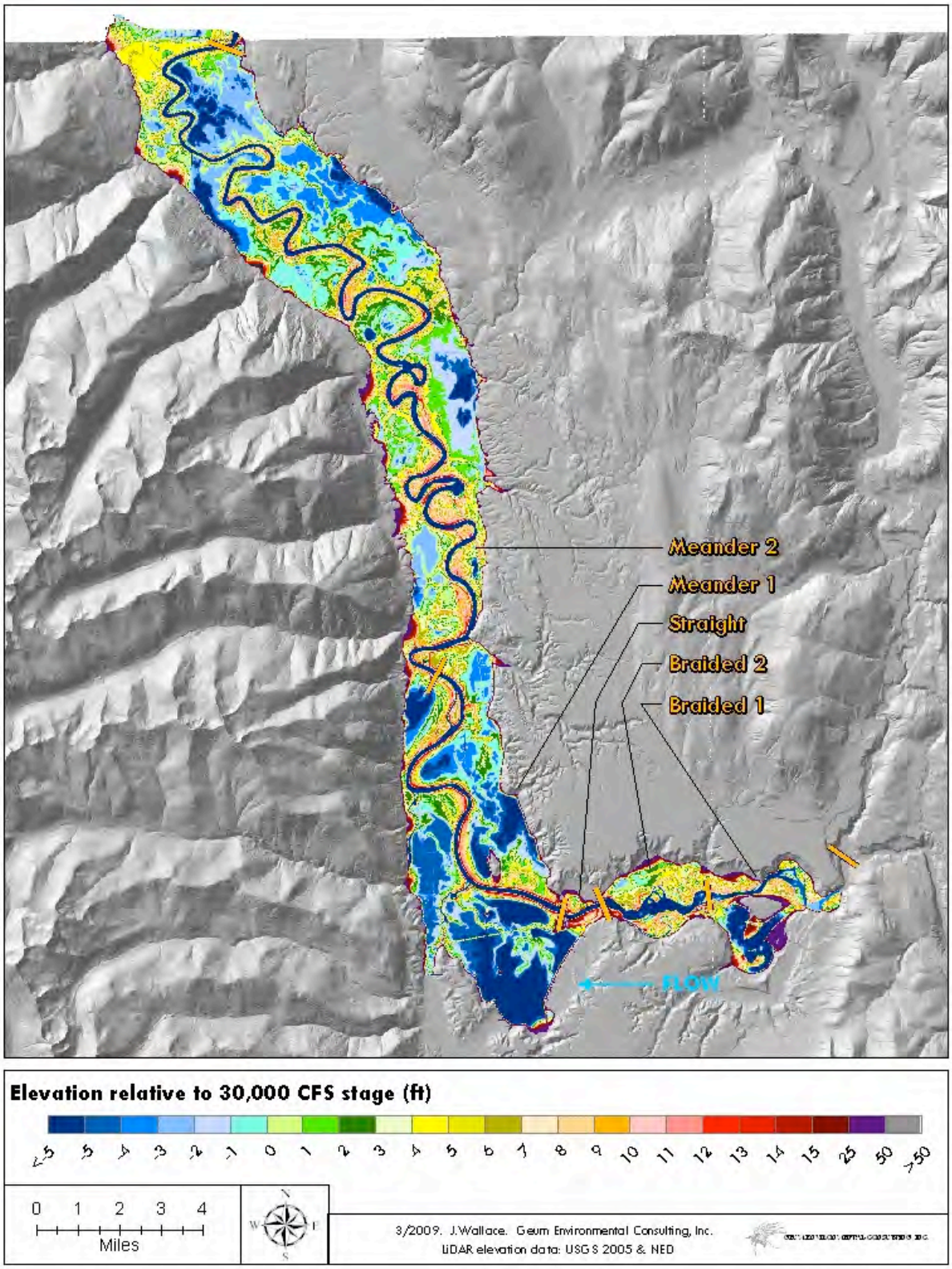


Figure 2-3. Kootenai River project area floodplain elevations relative to the 30 kcfs water-surface.

2.2.8 Delineation of Kootenai River Reaches within the Project Area

The 55-mile Kootenai River project area covered by this Master Plan extends from the Moyie River confluence with the Kootenai River, downstream to the international border. For the purposes of this Master Plan, the project area was delineated into three major reaches (Braided, Straight and Meander) based on geomorphic properties and then the Braided and Meander reaches were further delineated into two sub-reaches (Figure 2-2). The project reaches identified in the Master Plan are similar, although not entirely identical, to delineations identified during previous work on the Kootenai River (Paragamian et al. 2001; Burke 2006; USFWS 2008).

The river miles in the following reach descriptions represent defined locations along the river that were identified at a point in time. Because the river has shifted over time, actual lengths of reaches are usually slightly different than the calculated difference between two river mile designations (for example, the Straight Reach is 1.1 miles long if measured along the thalweg, but it extends from RM 152.7 to 151.7). This section also includes a description of adjacent river reaches, which although not directly addressed through the restoration treatments and actions identified in this Master Plan, are discussed in some of the analysis in this chapter.

Braided Reaches

Braided Reach 1 extends nearly 4 river miles (RM 160.9 to RM 156.2) from the Moyie River confluence downstream to the upstream extent of the backwater influence from Kootenay Lake. Braided Reach 2 extends approximately 2.2 river miles (RM 156.2 to RM 152.7) from the upstream extent of the backwater downstream to the U.S. Highway 95 bridge. The Kootenai River from Libby Dam to near the confluence of the Moyie River is characterized by a steeper gradient and confined channel morphology. The Kootenai River downstream from the Moyie River confluence enters a wider valley with a decreasing gradient. Multi-channel, meandering, riffle-pool characteristics predominate through the Braided Reaches. Gravel and cobble are dominant channel substrates found in the Braided Reaches.

Straight Reach

The Straight Reach extends 1.1 river miles (RM 152.7 to RM 156.2) from the U.S. Highway 95 bridge, downstream to Ambush Rock. This reach is marked by a narrowed river corridor with a confined floodplain that is laterally constrained by flood protection measures and floodplain development in the town of Bonners Ferry. The U.S. Highway 95 bridge and train trestle are also confining features in the reach. Historically, the reach was laterally constrained by hillslopes and bedrock. Channel substrate transitions from gravels to sand through the reach.

Meander Reaches

The combined Meander Reaches extend from the downstream end of Ambush Rock to Kootenay Lake. Meander Reach 1 begins at Ambush Rock and extends 9.7 river miles (RM 151.7 to RM 141.8) downstream to slightly below Shorty's Island. Meander Reach 2 spans 35.5 miles (RM 141.8 to RM 105.9) from the end of Meander Reach 1 to the international border. The Meander Reaches are situated in a low gradient lacustrine valley and channel substrates are dominated by sand and clay. Prior to levee construction, the Meander Reaches were laterally active.

The USFWS designated Kootenai River white sturgeon critical habitat is included in the Master Plan project area and spans 18.3 river miles (USFWS 2008) from upstream of Bonners Ferry (RM 159.7) downstream to below Shorty's Island (RM 141.4). The critical habitat reach spans a portion

of the Braided Reaches, the entirety of the Straight Reach, and the upstream portion of the Meander Reaches. Critical habitat includes the reach of the river where Kootenai sturgeon are known to spawn (Bonners Ferry downstream to Shorty's Island), as well as portions of the river where habitat conditions are believed to be conducive to successful egg adherence and embryo survival (Bonners Ferry to RM 159.7) but where spawning does not currently appear to be occurring.

Adjacent Reaches

The area upstream of the Braided Reaches is referred to as the Canyon Reach (RM 171.9 to RM 160.4). The Canyon Reach is characterized by confined morphology, cobble substrate and pool riffle bedforms. The Kootenai Tribe and their partners decided to exclude the Canyon from this Master Plan since habitat conditions in this reach are generally reported to be good, Kootenai sturgeon Critical Habitat is not included in this reach and because the reach is located in Canada.

The area downstream of Meander Reach 2 to Kootenay Lake is referred to as Meander Reach 3 (RM 105.6 to RM 76.8). Meander Reach 3 is similar in character to the other Meander Reaches and it includes the Kootenay Lake delta.

2.2.9 Summary

The historical Kootenai subbasin was characterized by a dynamic river-floodplain system that supported fish species exhibiting complex life histories. The spring freshet inundated off-channel habitats and exchanged organic material and sediment between the river and floodplain. Delivery and sequestration of nutrients, sediment and wood created a mosaic of diverse habitats. Riparian forests and extensive wetlands occupied the broad, low gradient Kootenai River floodplain. Sediment deposits formed natural levees paralleling both tributary streams and the Kootenai River, creating topographic high points that sustained upland vegetation species.

2.3 River and Floodplain Management in the Kootenai Subbasin

Management of the Kootenai River and its floodplain has resulted in several constraints that limit the restoration potential for the river corridor. As stated in Chapter 1, the purpose of this project is to develop habitat restoration strategies that are compatible with existing land uses and river and floodplain management priorities in the project area. However, to develop logical habitat restoration strategies, restoration treatments, and habitat actions that address limiting factors, it is necessary to understand the impacts that have resulted from land use and river management over time.

Dam operations in Montana and British Columbia, as well as historical and contemporary forestry and industrial land uses, agricultural, and residential and municipal development have affected the subbasin overall as well as river corridor conditions. The following paragraphs summarize constraints related to river, floodplain, and adjacent land use management.

Euro-American settlement of the Kootenai subbasin in the vicinity of present day Bonners Ferry, Idaho began in the mid-1800s. Early settlers farmed and ranched on the productive floodplain.

As the local population grew and the railroad brought access to distant markets, logging and mining became important forms of commerce. Primary land uses since the mid-1800s have included forestry, coal and hard rock mining, smelting, agriculture, hydroelectric dam operation, and city and residential development. Prior to regulation, frequent floods (i.e., nearly annual) inundated the floodplain, necessitating flood protection measures to ensure stable farming conditions and to enable development of Bonners Ferry. While Libby Dam was developed as part of a system-wide network of flood control dams to protect inhabitants of southern Washington and northern Oregon from Columbia River flooding, the towns of Libby and Troy, Montana, and Bonners Ferry, Idaho also benefited from these flood control measures. The following sections summarize historical and contemporary land uses in the Kootenai subbasin.

2.3.1 Forestry Practices

Forestry is the dominant industry in the Kootenai subbasin. The following excerpt from the Kootenai Subbasin Plan (KTOI and MFWP 2004) summarizes forestry practices in the subbasin.

> The forest products industry remains the most dominant employment and most extensive development activity in the subbasin. Roughly 90% of the drainage is forested. Logging and associated road building has occurred in nearly all of the lower elevation valleys and on many higher elevation ridges. Roadless areas larger than 5,000 acres are uncommon. Nine roadless areas totaling 139,600 acres exist in the Idaho portion of the subbasin (IPNF 1991). In the Montana portion, nine roadless areas totaling 241,500 acres are present, including approximately 60,000 acres of upper Libby and Lake Creeks within the Cabinet Mountains Wilderness Area (USDA 1987). The largest contiguous block of land without logging roads in the British Columbia portion of the Kootenay Basin is the 390,000-acre Kootenay/Mt. Assiniboine National and Provincial Parks (Rocchini 1981). Approximately 150,000 acres of the headwaters of the St. Mary River and Findlay Creek northwest of Cranbrook/Kimberley are within the Purcell Wilderness Conservancy. The total surface area of undeveloped areas amounts to about 10% of the Kootenai subbasin above Kootenay Lake.

2.3.2 Mining Practices

Hard rock mining has also influenced the Kootenai subbasin. Large-scale mining in both Canada and the United States degraded water quality and habitat in the Kootenai River and its tributaries. Industrial mining in the subbasin included Cominco Ltd.'s Sullivan Mine, one of the world's largest lead and zinc mining facilities that operated in Kimberley, British Columbia from 1917 to 2001. Wastewater from the mine was discharged into tributaries of the St. Mary River, a tributary to the Kootenai River. By 1979, wastewater treatment facilities, which removed heavy metals from the effluent before it entered the waterways, were completed at the mine (Knudson 1994).

Other industrial mining operations included the Cominco Fertilizers Ltd. plant also located in Kimberly, British Columbia. The following from Richards (1997) describes inputs and impacts of the fertilizer plant on the Kootenai River.

> The Cominco plant expanded from a lead smelter to the production of fertilizer in 1953 (Partridge 1983), and began discharging wastes into the St. Mary River, a tributary of the Kootenai River. Fertilizer production was doubled in 1962 and increased again in 1965. Water pollution control at the plant was improved in 1969, but it was not operating optimally until 1975 (Daley et al. 1981). Waste discharges from this plant increased phosphorus load throughout the Kootenai system, resulting in a four-fold increase from 1951 to the 1960s (Northcote 1973). By 1965, new production created more waste than the plant's disposal facilities could properly dispose of, and high levels of zinc, fluoride, ammonia, and phosphate combined to create toxic conditions for aquatic organisms in the St. Mary River. In 1968, a waste system was installed at the plant, which reduced the levels of toxic compounds being discharged into the Kootenai River (Partridge 1983). Fertilizer productions decreased in the 1970s and 1980s until the plant closed in 1987 (Knudson 1994).

The W.R. Grace Company's vermiculite mine northeast of Libby, Montana, discharged wastewater and vermiculite to Rainy Creek, a tributary to the Kootenai River downstream from Libby Dam. Rainy Creek was designated a federal Superfund site that necessitated an environmental clean up. A copper and silver mine near Troy, Montana, also discharged contaminated runoff to surface waters joining the Kootenai River. Each of these mining operations has affected Kootenai River tributaries due to discharge of mine waste.

The Kootenai Subbasin Plan (KTOI and MFWP 2004) also highlighted coal mining as a prominent mining activity in the subbasin, particularly along the Elk and St. Mary rivers. Large-scale, open-pit coal mining began in the Elk River watershed in the early 1970s.

Crestbrook Forest Industries continues to operate a paper pulp mill in Skookumchuck, British Columbia. Since 1968, Crestbrook Forest Industries' pulp mill in Skookumchuck has been the largest point source discharge directly into the Kootenai River. During the 1970s angler use of the river below Skookumchuck decreased due to the adverse effects caused by the mill (discoloration of the river, toxicity, and fish tainting problems). The following excerpt from Richards (1997) provides an overview of the Crestbrook Forest Industries' pulp mill clean up efforts.

> Attempts to reduce pollution at the mill began in 1981 when Crestbrook began disposing of its effluent during low flow periods. In 1992, a major upgrading of the mill began in order to reduce polluted effluent discharging into the river (Knudson 1994).

2.3.3 Agriculture

Agriculture is the dominant land use on the Kootenai floodplain from Bonners Ferry to Kootenay Lake. Flood control projects on the Kootenai River dating to the late 1800s were necessary to facilitate floodplain farming. Oats, wheat and barley production account for 62% of the agricultural output in the Bonners Ferry/Creston area, with livestock production accounting for 20% (KTOI and MFWP 2004). Other important cash crops include hops, a crop sensitive to soil moisture. Hay and grass seed production and livestock grazing are the most common agricultural activities in the rest of the subbasin (KTOI and MFWP 2004).

Richards (1997) provided an historical perspective on agricultural floodplain development in the vicinity of Bonners Ferry.

> Movement of the Kootenai River and tributary streams in the valley and springtime flooding formed numerous marshes and sloughs which, along with fertile soils, provided a variety of fisheries habitats (Partridge 1983). Early attempts at diking the river began in 1892 with a desire to reclaim this land for agricultural purposes, although there was little success until the 1920s (Northcote 1973). In order to prevent flooding, drainage districts were formed in the 1920s. This in turn channelized the natural meandering tributary streams into straight ditches between the mountains and the (Kootenai) river. By 1935, over 90% of the valley bottom in Idaho was in drainage districts (Partridge 1983). Topographic map comparison shows that an estimated 5,512 acres of wetland area was lost between 1928 and 1965.

Agriculture has been a critical element in the development of the Bonners Ferry area and the northern Idaho Panhandle. To build a diverse multi-crop agricultural industry, the native floodplain system of the Kootenai River was modified to support the farming-based economy. While essential to the prosperity of the region, agriculture has affected the Kootenai River. Historical plant communities were displaced as the swampy lowlands were filled with the rich soils plowed from the floodplain. Tributaries and flood channels were straightened to speed the drainage of water from newly cleared land. With the improving agricultural conditions, changes in the native plant communities, wildlife and fisheries, and water quality signified the transition from historical conditions to a growing agricultural industry.

Reclamation projects were funded through both government bonds and private backing. Based on review of historical news articles, the reclamation projects appeared to have benefited large agricultural interests on the Kootenai River floodplain from Bonners Ferry to the Canadian border.

The U.S. Bureau of Reclamation wrote in 1948, in a comprehensive report on the development of water resources in the Columbia River Basin (USACE 1948):

> Dikes have been constructed by private interests to protect some of the 50,000 acres of bottom land along the Kootenai between Bonners Ferry, Idaho, and the Canadian border. These dikes do not provide complete flood protection. Some of the lands are within the influence of backwater produced by artificial regulation and storage in Kootenai Lake by Canadian Interests.

Early news articles did not detail the origin of the materials that were used to build the dike network, however, Tolman (1923) related that floodplain soils were the likely material for building dikes. Draglines such as one purchased by Klockmann in 1919 would have been capable of excavating fill material from both the floodplain and the river channel. Burke et al. (2006) included channel dredging between 1900 and 1940 as one of the disruptive management activities implemented during land reclamation. Dredging has also been identified as one of the causative agents for streambank instability and channel longitudinal profile discontinuities in the Kootenai River (Wildland Hydrology 2008).

2.3.4 Development

Changes in the river corridor have enabled residential and agriculture development of the historical floodplain. In addition to the operation of Libby and Cora Linn dams for flood control, floodplain alterations including ditches and dikes, pumping stations, drainage channel networks, railroad and road embankments, and the Creston Valley Wildlife Management Area (Matt Neufeld, BC MoE, personal communication, 2008) have nearly eliminated river flooding between Bonners Ferry and Kootenay Lake. High runoff years may exact some agricultural losses due to high ground water and tributary flooding created by backwatering of tributary streams by the Kootenai River, however, relative to the historical conditions, flooding is an infrequent occurrence in the river corridor. Figure 2-4 displays the majority of known infrastructure in the project area.

Floodplain dikes and drainage ditch networks date to the late 1800s downstream from Bonners Ferry. Early efforts were limited by technology, personnel, and funding. However, organized agricultural interests formed drainage districts by the early 1920s. Districts acquired federal funding to initiate networks of dikes, replacing the berms erected in the late 19th century. During this period, floodplains were ditched and tiled to lower the water table and allow agricultural interests to farm the land earlier in the year than previously possible. The installation of pump stations also permitted lowering the water table to allow earlier planting. These activities in addition to land clearing and leveling, tributary stream straightening, and the draining of floodplain lakes and ponds, allowed farmers to expand the growing season and plant a wider variety of crops.

In addition to agriculture development, municipalities in the Kootenai subbasin also influence river function and ecology. The following excerpt from Richards (1997) highlights treated wastewater discharge to the Kootenai River.

> Major municipalities in the Kootenai River Basin served by secondary waste treatment facilities include: Cranbrook, Kimberly, Fernie, Creston, Sparwood, and Elkford, British Columbia; Libby, Montana; Bonners Ferry, Idaho; and Troy and Eureka, Montana (Knudson 1994; Woods and Falter 1982; Bonde and Bush 1975). The rest of the populations in the basin use septic tanks or smaller community systems. All municipalities in the drainage basin discharge effluent directly into the Kootenai River, or into the water table by subsurface seepage, therefore degrading water quality. In 1976, Cranbrook ceased sewage discharge by employing a spray irrigation system. Water quality effects downstream from Libby, Bonners Ferry, and Troy are not as great as the effects from cities on smaller-scale tributaries, due to the high volume of water, therefore greater dilution of the Kootenai River. All industrial and municipal operations in the Kootenai River Basin have an effect on the water quality of the Kootenai River. In turn, the degradation of water quality in the river affects the entire aquatic ecosystem.

Transportation Corridors

U.S. Highway 95 crosses the Kootenai River at Bonners Ferry near the upstream end of the Straight Reach. Built in 1983, the U.S. Highway 95 bridge has seven piers located in the active channel and an additional two piers and two abutments located in the floodplain. The spacing between piers is 155 feet. Riprap bank protection currently extends upstream and downstream on both banks adjacent to the bridge.

The Union Pacific and Burlington Northern Santa Fe (BNSF) Railroads parallel the Kootenai River along the northern and southern edges of the Braided Reaches, respectively. At several locations along the southern edge, the BNSF railroad embankment interacts with the active channel and isolates floodplain area, leaving portions of the historical floodplain disconnected from the river. The Union Pacific crosses the Kootenai River at Bonners Ferry near the upstream end of the Straight Reach, about 500 feet downstream from the U.S. Highway 95 bridge.

Because of the confined morphology of the Straight Reach, the bridges do not have a significant effect on river morphology; however, the riprap banks limit establishment of a riparian buffer and development of bank cover for aquatic habitat. The piers and abutments pose constraints to habitat restoration in the vicinity of the bridge by potentially limiting implementation of restoration treatments that could alter river hydraulics and potentially jeopardize bridge stability.

Water Intakes, Diversions and Points of Discharge

Several water intakes, points of diversion and points of discharge are located in the Kootenai River project area. Most of these facilities are privately managed and are associated with agricultural operations. Although the following paragraphs focus on the Bonners Ferry facilities and the Kootenai Tribal Sturgeon Hatchery, the discussion applies to all facilities, private and public, whose operations depend on water from the Kootenai River. In general, water intakes, diversions and points of discharge will not constrain habitat restoration, but instead will add additional considerations to the design process in order to protect the facilities. Design considerations will be discussed with the owners of the facilities before initiating the next phase of the design process.

Bonners Ferry maintains a water supply intake on the southern edge of the river near the downstream end of the Braided Reach. Additionally, the town maintains a sewage treatment plant discharge on the northern edge of the river near the downstream end of the Straight Reach. Riprap bank revetment protects both locations. The intake and discharge are two examples of stream-side developments along the urbanized segment of the river that limit establishment of a riparian buffer and development of bank cover for aquatic habitat through the Bonners Ferry portion of the project area. Design considerations related to the intake include evaluating the effects of restoration treatments on water quality, the facility's ability to intake water at the present location, and bank stability at the intake. The sewage treatment plant discharge will require similar design considerations.

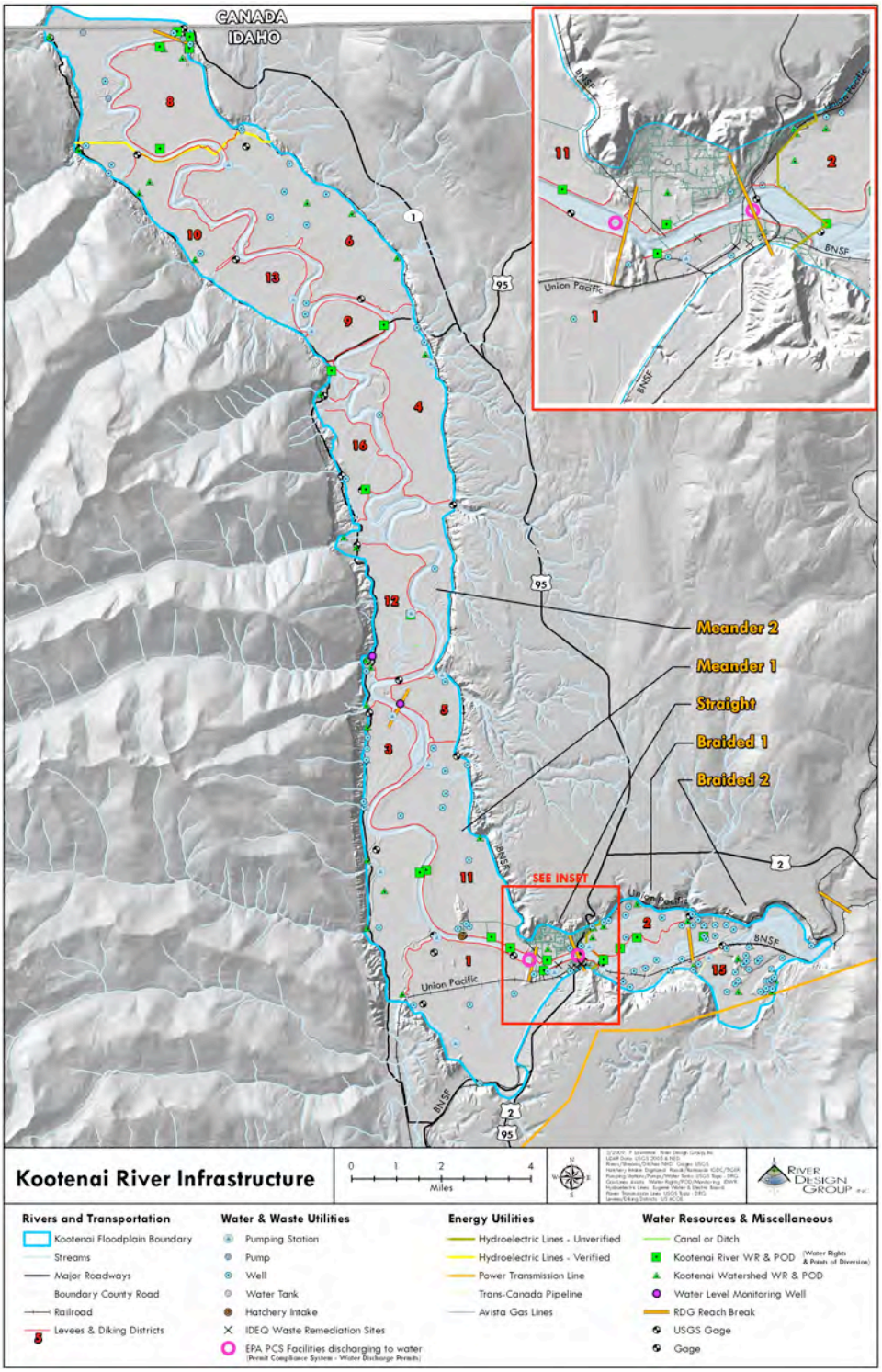


Figure 2-4. Infrastructure in the Kootenai River project area.

The Kootenai Tribe currently operates a water intake for the Kootenai Tribal Sturgeon Hatchery near the upstream end of the Meander Reach. The surface water intake is operated for most of the year except when high turbidity events and temperatures degrade water quality. Similar to

the Bonners Ferry municipal water facilities, the hatchery intake poses a constraint to habitat restoration by potentially limiting implementation of restoration treatments that could adversely affect water quality, influence the ability to intake water at the present location, or jeopardize bank stability at the intake. Space limitations and the absence of a high quality groundwater source have prevented the expansion of the Kootenai Tribal Sturgeon Hatchery at Bonners Ferry (KTOI 2008, draft Aquaculture Master Plan). The Tribe is currently proposing construction of a new Tribal hatchery facility (through the NPCC three-step planning process) near the Moyie River confluence with the Kootenai River. This new hatchery would provide expanded rearing capacity for Kootenai sturgeon and space for the Tribe's proposed burbot conservation aquaculture program. River water from both the Kootenai River and the Moyie River, in addition to groundwater, will be used for the proposed facility. Sturgeon will be reared on the surface water supply that has been filtered and disinfected to control pathogens in order to imprint them on waters closer to existing suitable habitat upstream from the current Tribal Sturgeon Hatchery (KTOI 2008).

Utilities

Avista Corporation maintains a network of power transmission and natural gas lines within Bonners Ferry. A cable-suspended gas line crosses the Kootenai River near the downstream end of the Straight Reach. An overhead power transmission line crosses the Kootenai River near the downstream end of the Braided Reaches. Neither crossing appears to pose a significant constraint to habitat restoration efforts.

River Gages

The USGS operates two river gages in the project area, one at the upstream end of the Meander Reaches, and another near the border at Porthill, Idaho. In addition, several other, smaller gages are maintained throughout the project area to support ongoing river studies. Similar to other instream constraints, the USGS gages pose a constraint to habitat restoration by potentially limiting implementation of restoration treatments that could adversely affect operation of the gages. Modification of the river in the vicinity of the river gages could require recalibration of the gages to the altered river conditions and result in temporary losses of gage operation. Nonetheless, it is feasible to mitigate for impacts to USGS gages in the design process, and efforts will be coordinated with USGS.

Levees and Diking Districts

Levees and dikes, combined with other aspects of river and floodplain stewardship (particularly flow management), have resulted in loss of connection between the river and floodplain within the project area. In addition, levees and dikes function to confine high water within a narrow band near the river channel, artificially causing vegetation to be submerged at times during the growing season. Certain aspects of habitat restoration may require working near levees, and levee management in the project area is complicated for several reasons. Responsibility for dike maintenance was transferred to landowners within diking districts years ago, leaving maintenance to each individual. Some diking districts have followed U.S. Army Corps of Engineers (USACE) suggested maintenance standards, while others have not. These standards include removal of woody vegetation, so any restoration actions that include revegetation on levees will need to be coordinated with landowners and the USACE. Although the levees and dikes pose some constraints on habitat restoration, they also function to control floods and support agriculture and other land uses in the historical floodplain. Therefore, restoration

designs that may affect levees and dikes will be developed through a collaborative process that includes landowners and other entities that have a stake in how levees and dikes are maintained.

2.3.5 Dam Operations

The 55-mile Kootenai River Master Plan project area is unique in that both the hydraulic and sediment regimes are significantly influenced by the operation of multiple dams, including Libby Dam, Corra Linn Dam, and Duncan Dam, which controls the Duncan River inflow to Kootenay Lake. Figure 2-5 includes dam and river gage locations.

Since the completion of Libby Dam in 1972 (which became fully operational in 1974), notable changes to the primary hydraulic and sediment regimes have been observed, including: a shift in the annual hydrograph to an "inverted" regime characterized by a 50% reduction in spring peak flows, a 300% increase in winter flows, a dampening of natural flood pulses, and trapping of the sediment contribution from nearly half (8,985 square miles) of the 19,300 square mile Kootenai subbasin (Tetra Tech 2004).

Figure 2-6 presents the mean daily discharge recorded at the USGS Porthill, Idaho stream gage. The USFWS has issued three opinions on Libby Dam (1995, 2000, and 2006). Discharge for the pre-dam and post-dam periods is presented in Figure 2-6; post-dam discharge is split into the period prior to the first opinion was issued in 1995 and after the 1995 opinion. In 2006, the USFWS issued the Biological Opinion regarding the effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout and Critical Habitat (Libby Dam BiOp), which was further clarified in 2008.

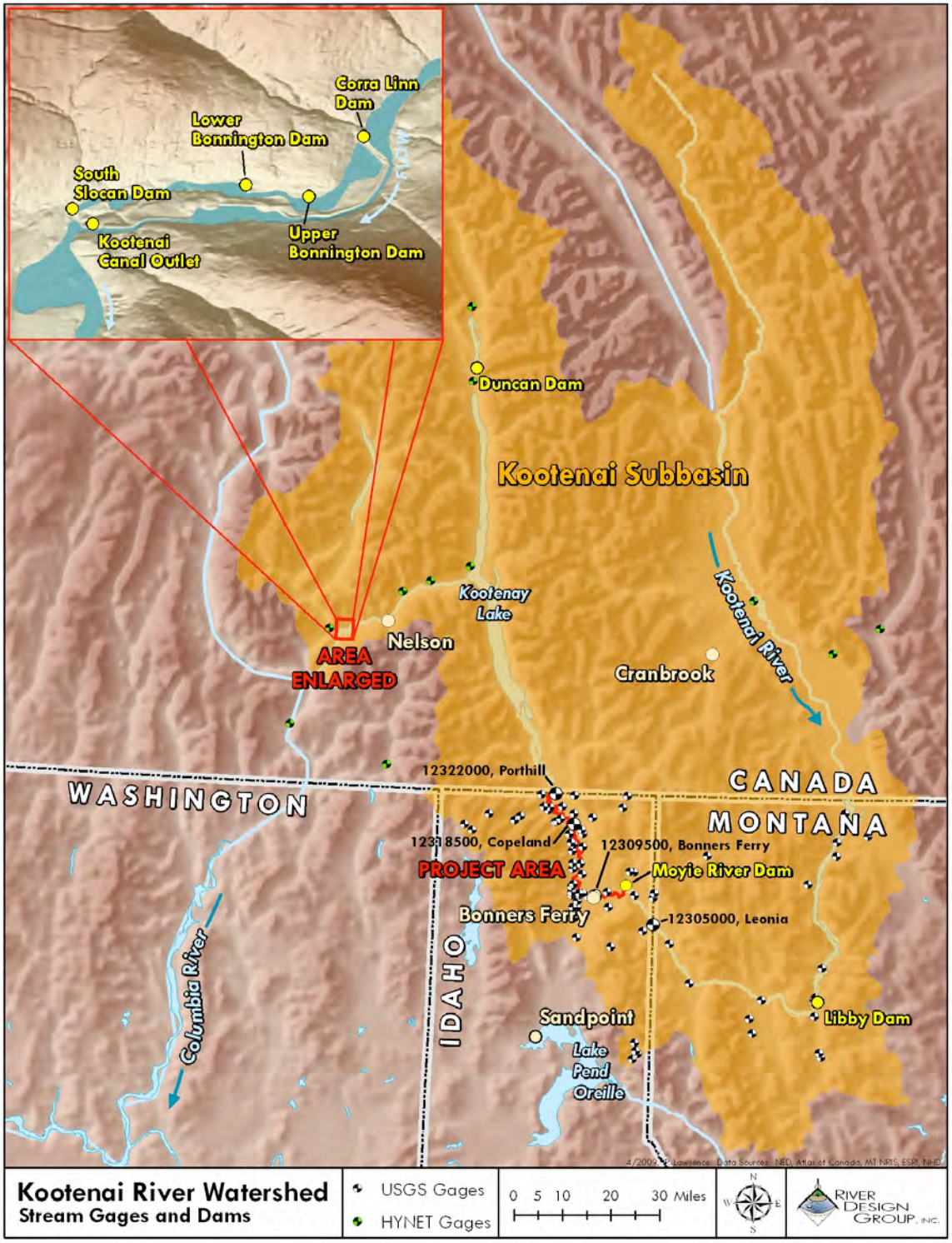


Figure 2-5. Dam and stream gage locations in the project area. USGS gages that are referred to in the Master Plan are highlighted

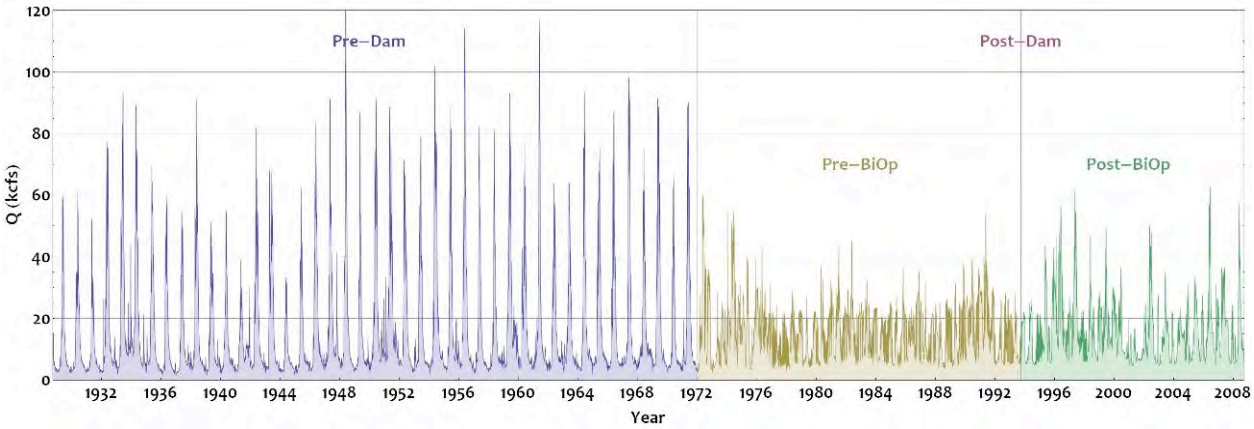


Figure 2-6. The historical mean daily discharge of the Kootenai River measured at Porthill, Idaho (USGS Sta # 12322000). The post-BiOp period includes three opinions from USFWS: 1995, 2000 and 2006. The 2006 Libby Dam BiOp was clarified in 2008.

Historically, the minimum water-surface elevation of Kootenay Lake was naturally controlled by the Grohman Narrows, a bedrock sill in the west arm of Kootenay Lake upstream of the Corra Linn Dam. This combined with the extremely flat valley slopes of the Purcell Trench historically created a backwater effect that extended upstream of Bonners Ferry, Idaho. Following excavation of the Grohman Narrows in 1939 to reduce hydraulic losses in the forebay of Corra Linn Dam, the dam was operated such that the mean maximum elevations of Kootenay Lake were lowered approximately 6 feet from historical levels, which helped in reducing the upstream backwater effects during peak events. Conversely, beginning in the fall through the spring peak (October through May), Kootenay Lake regulation has increased the median lake levels by approximately three feet (Figure 2-7).

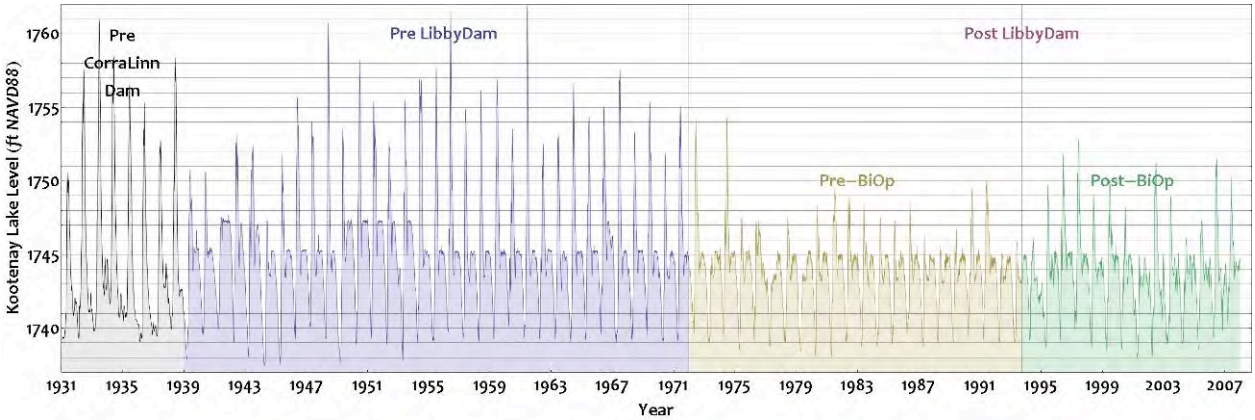


Figure 2-7. Historical water-surface elevations for Kootenay Lake at Queens Bay, British Columbia.

Despite their distance from the project area, the combined effect of Libby and Corra Linn dams resulted in a departure of the primary hydraulic and sediment boundary conditions of the Kootenai River from pre-dam conditions. This departure from pre-dam consitions has subsequently affected the geomorphic response and ecological function of the Kootenai River between the two dams, with the most notable departure in the area subjected to the backwater influence (Tetra Tech 2004; Burke 2006). In general, the upstream transition between the

backwater and free-flowing water within the project area varies as a function of both Libby Dam discharge and Kootenay Lake level. The location of the backwater transition point changes within and between years with changing boundary conditions (i.e., upstream discharge and downstream lake level), and in the post-dam era has generally migrated over a distance of about 6 river miles (Figure 2-8). At the downstream end, this transition point is typically limited to RM 152 near the downstream end of the Straight Reach. Downstream from this location, the river is influenced by the Kootenay Lake backwater year-round. At the upstream end, the location of the transition point varies through the Straight and Braided reaches, and generally does not extend higher than RM 158 midway through Braided Reach 1.

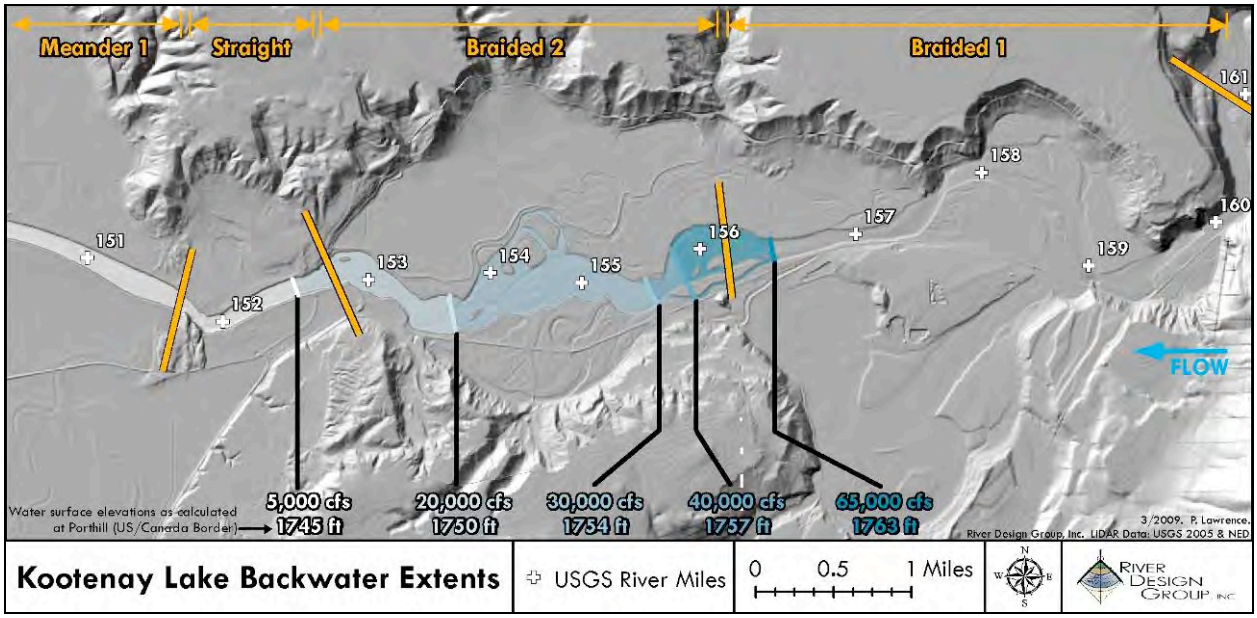


Figure 2-8. Backwater extents on the Kootenai River in the Bonners Ferry area based on hydraulic modeling results and varied boundary conditions (discharge and Kootenay Lake elevation which is represented in the figure by water-surface elevations measured at the Porthill gage). Datum is NAVD88.

The thermal regime of the Kootenai River has also been affected by Libby Dam operations. A selective withdrawal system was implemented in 1977 to better control the temperature of water released from Libby Dam. In the post-dam era, Libby Dam operations have generally increased median Kootenai River temperatures by more than 5°F (2.8°C) during the winter months, increased by about 2°F (1°C) on the rising limb of the spring freshet, and reduced the summer median temperatures by about 2°F (1°C) until the fall. Figure 2-9 compares water temperatures before and after Libby Dam became operational based on Days of the Water Year (DWY) summarizes DWY relative to calendar months.[1]

[1] The Libby Dam selective withdrawal system became operational in 1977; however, implementation of selective withdrawal management actions to specifically benefit sturgeon has only occurred in recent years. Figure 2-8 above simply compares water temperatures before and after Libby Dam became operational.

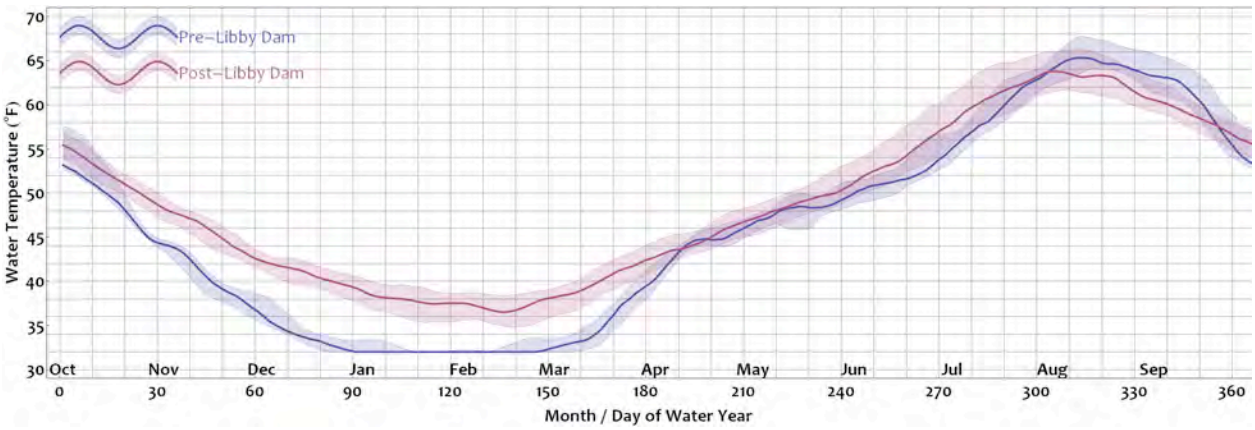


Figure 2-9. Pre and post dam water temperatures for the Kootenai River at Porthill (USGS Sta # 12322000).

Table 2-2. Relationship between calendar year and water year.

Month	DWY Range	Month	DWY Range
January	93 – 123	July	274 – 304
February	124 – 151	August	305 – 335
March	151 – 182	September	336 – 365
April	183 – 212	October	1 – 31
May	213 – 243	November	32 – 61
June	244 – 273	December	62 – 92

2.3.6 Operational Constraints

Both Libby and Duncan dams are operated in concert with other Columbia River Dams under the final objective of not exceeding the Initial Controlled Flow (ICF) downstream at the City of Dalles, Oregon, the site of the Dalles Dam. Corra Linn operations are influenced by system flood control operations but the dam does not provide system flood control (E. Lewis, USACE, personal communication, 2009). Operation of Libby and Corra Linn dams are influenced by a number of competing objectives with additional transnational constraints posed by the Boundary Water Treaty of 1909, the International Joint Commission (IJC) 1938 Order on Kootenay Lake, and the Columbia River Treaty (CRT) of 1961 (the CRT re-evaluation period begins in 2014 with the potential for re-negotiation or termination of the treaty by 2024). The CRT affects Libby and Duncan dams, but not Corra Linn Dam.

Historically, the primary objective of the Canadian dams (aside from Corra Linn Dam) was system flood control as well as power generation and supplemental water storage for downstream power generating dams in the West Kootenay region. Corra Linn Dam flood control operations focus on minimizing flood impacts on Kootenay Lake. To date, the maximum operating water-surface elevations on Kootenay Lake has been controlled by the IJC Order for Storage based on gage measurements at Queens Bay, British Columbia. The following excerpt summarizes the seasonal operation of Corra Linn Dam (K. Ketchum, BC Hydro, personal communication, 2009).

> The water discharge out of Kootenay Lake is equal to the sum of discharges at the Corra Linn and Kootenay Canal projects. FortisBC owns, maintains, and operates the Corra Linn project and holds the IJC Order for Kootenay Lake. BC Hydro owns,

maintains, operates, and dispatches the Kootenay Canal project. Under the terms of the Canal Plant Agreement, BC Hydro normally directs the discharges for Corra Linn; however, FortisBC retains the right to override BC Hydro's directions for various reasons, including meeting the IJC Order.

The Kootenay Lake IJC Order states that the Corra Linn project must be operated, to the extent possible, to keep the Kootenay Lake level at or below specified lake elevations. This IJC Order curve has variable (inflow dependent) maximum lake levels during the spring freshet and fixed maximum lake levels at other times (Table 2-3 on following page).

Normally, the lake is drafted down into the range 1738 ft to 1739 ft in late March and early April, just prior to the spring freshet. In March-April, under some low inflow conditions, it may be possible to draft the lake below 1738 ft (Figure 2-10). However, there are potential stakeholder impacts, including those related to ferry operations on the lake, at lake levels near and below 1738 ft. These impacts are considered when planning the operation of Kootenay Lake.

Typically, in order to improve flood control for Kootenay Lake stakeholders (i.e., to reduce maximum lake levels later in the year), the lake discharge is maximized (restricted only by the hydraulic control at Grohman Narrows) from late March or April until:

1) The lake level has peaked and receded to below 1749.5 ft, or,
2) BC Hydro and FortisBC agree that the lake level is expected to remain below 1749.5 ft.

BC Hydro and FortisBC consider the 1749.5 ft level the "onset of flood damage concern". Current practice is to pass maximum discharge from Kootenay Lake to avoid exceeding this level or to minimize the time above this level. After the threat of flood damage abates, discharges from Kootenay Lake are reduced. Both FortisBC and BC Hydro are careful to ensure that the lake level remains below the IJC curve, which falls during the receding limb of the freshet until the level at Nelson reaches 1743.32 ft.

If Grohman Narrows were excavated further, then there would be additional operating flexibility to draft Kootenay Lake prior to the freshet, including the option to draft below 1738 ft (subject to stakeholder issues) and/or to discharge more during the ascending limb of the hydrograph. This would reduce the likelihood of the lake level exceeding 1749.5 ft (or any other specified flood level). In addition, such excavation would allow lake discharges to be reduced earlier in the freshet, since the risk of exceeding 1749.5 ft would be reduced.

Table 2-3. The IJC Order rule curve for managing the Kootenay Lake level.			
Start Date	**End Date**	**DWY Range**	**Lake Elevation at Queens Bay**
September	January 7	336 to 123	Fall Refill Period Maximum Elevation of 1745.32 ft
January 7	February 1	93 to 124	Drafting Period Straight-line rule from 1745.32 ft to 1744.0 ft
February 1	March 1	124 to 152	Drafting Period Straight-line rule from 1744.00 ft to 1742.4 ft
March 1	April 1	152 to ~183	Drafting Period Straight-line rule from 1742.4 ft to 1739.32 ft
April 1	Declaration of the Start of Spring Freshet	~183 to ~218	Spring Refill Period Endeavor to maintain elevation at or below 1739.32 ft
During Spring Freshet		~165 to ~218	Variable Depending on Inflows
Post-Freshet	September 1	~218 to 336	Post Peak Period Elevation gradually declines to at or below 1743.32 ft at Nelson.
** Water-surface elevations referenced to NAVD 1988 vertical datum.*			

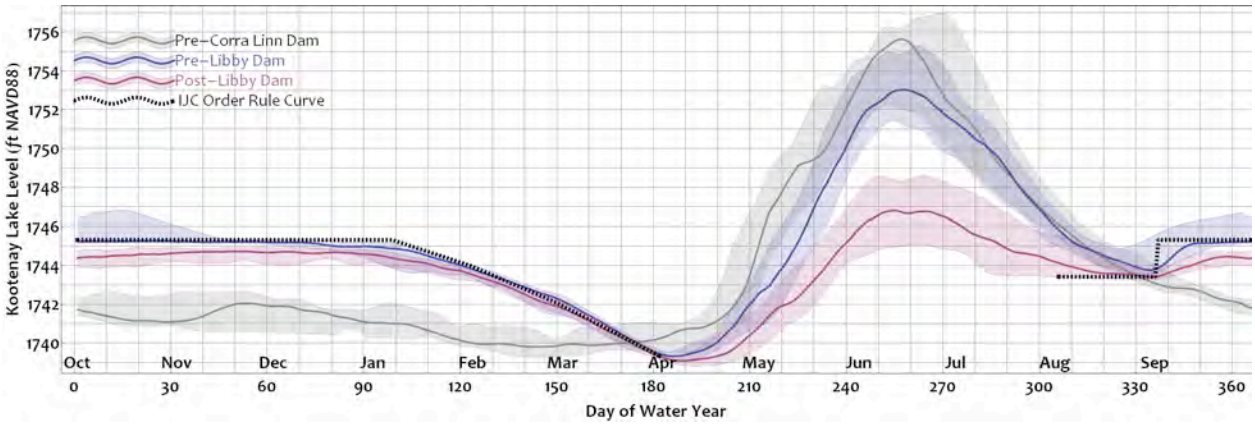


Figure 2-10. Operational regime comparison for Kootenay Lake at Queens Bay, British Columbia (08NH064).

In 2003, the USACE began to implement a variable flow flood control strategy (VarQ) in order to improve the multipurpose operation of Libby Dam while not reducing flood protection in the downstream Kootenai subbasin as outlined in Table 2-4 below. A variable end-of-December draft strategy began in 2005.

Table 2-4. Libby Dam Annual Operational Modes.			
Month	**DWY**	**Operational Period**	**Operational Constraints**
October	1	Fall Operations	▪ Operation governed by power (not flood control)
November	32		
December	62	Drafting Period under VarQ Flood Control	▪ Begin variable December draft based on water supply forecasts (WSP) ▪ Continue drafting until spring refill which typically begins in April ▪ Begin spring refill period 10 days before unregulated flow is expected to exceed the initial controlled flow (ICF) at the Dalles
January	93		
February	124		
March	152		
April	183		
May	213	Refill Period under VarQ Flood Control Additional biological requirements.	▪ Commencement of the spring rise/freshet ▪ Sturgeon pulse flow (May-June) ▪ Refill Period; variable outflow in accordance with VarQ procedures ▪ Final refill period typically by July ▪ Draft to 2439 ft by end of summer in most years for salmon flow augmentation
June	244		
July	274		
August	305	Biological	▪ Bull trout flows
September	336	Return to Fall Operations	▪ Return to power governed operations

In 2008, the USFWS issued a clarification of the 2006 Libby Dam BiOp Reasonable and Prudent Alternatives (RPAs) as listed in Table 2-5 on the following page.[2]

The Libby Dam BiOp seeks to address habitat attributes associated with Kootenai sturgeon and bull trout recovery that have been negatively impacted by operation of Libby Dam. Towards this end, the Libby Dam BiOp identifies a number of specific measures and objectives to address each identified habitat attribute.

In the context of this Master Plan, this information has been considered in relationship to the overarching goals and objectives of the Kootenai River Habitat Restoration Project, which seeks to address a broad range of interrelated limiting factors, in order to recovery naturally self-sustaining populations of Kootenai sturgeon and other native aquatic focal species. As previously noted, the Kootenai River Habitat Restoration Project is intended to address a broad range of interrelated limiting factors through implementation of an ecosystem-based restoration project.

[2] The Libby Dam BiOp, is located online at http://www.fws.gov/easternwashington/documents/Final%20Libby%20Dam%20BiOp%202-18-06lr3.pdf. At the time this document was being finalized the 2008 clarification of the 2006 Libby Dam BiOp was not available online.

Table 2-5. Libby Dam BiOp RPA for Critical Habitat Reach (RM 141.4 to RM 159.7).		
Attribute	**Measure**	**Objective**
Timing of Augmentation Flows	▪ May into July (triggered by sturgeon spawning condition), in all years except for Tier 1.[3]	▪ Provide conditions for normal sturgeon migration and spawning behavior. ▪ Between May 15 and Sept 30, minimum bull trout discharge is 6kcfs.
Duration of Peak Augmentation Flows for Adult Migration and Spawning	▪ Maximize peak augmentation flows with available water for as many days as possible, up to 14 days during the peak of the spawning period with pulses1, in all years except for Tier 1	▪ Through in-season management, provide peak augmentation flows that lead to a biological benefit for sturgeon to maximize migration and spawning behavior via a normalized hydrograph.
Duration of Post-Peak Augmentation Flows for Incubation and Rearing	▪ Maximize post-peak augmentation flows with available water for as many days as possible, up to 21 days, in all years except for Tier 1.	▪ Through in-season management, provide post-peak augmentation flows that lead to a biological benefit for sturgeon to maximize embryo/free-embryo incubation and rearing via descending limb of a normalized hydrograph.
Minimum Flow Velocity	▪ 3.3 ft/s and greater in approximately 60% of the area of rocky substrate in the area of RM 152 to RM 157 during post-peak augmentation flows.	▪ Provide conditions for spawning and embryo/free-embryo incubation and rearing.
Temperature Fluctuation	▪ Optimize temperature releases at Libby Dam to maintain 50° F with no more than a 3.6° F drop.	▪ Provide conditions for normal migration and spawning behavior via a normalized thermograph.
Depth at Spawning Sites	▪ Intermittent depths of 23 ft or greater in 60% of the area of rocky substrate from RM 152 to RM 157 during peak augmentation flows.	▪ Provide conditions for normal migration and spawning behavior.
Substrate Extent/Spawning Structures	▪ Approximately 5 miles of continuous rocky substrate; create conditions/features that improve the likelihood of recruitment success.	▪ Provide habitat for embryo/free-embryo incubation and rearing.
Minimum Frequency of Occurrence	▪ To facilitate meeting the attributes via: powerhouse plus up to 10 kcfs flow test: a flow test will occur 2010 through 2012 (or until the Kootenai River Habitat Restoration Project is implemented) if the Service determines in 2008 and 2009 that the success criteria described in Action 1.3(b) have not been met. ▪ Habitat improvement projects and other options: through adaptive management, as noted in RPA Components 2 and 5.	

2.4 Morphological Limiting Factors

Human activities have changed the channel morphology and channel-floodplain connectivity along the lower Kootenai River since the early 1900s. The most serious impacts resulted from

[3] Per the 2006 Libby Dam BiOp, the sturgeon pulse volume is determined from a tiered flow structure based upon the USFWS May Final Water Supply Forecast for the period of April-August.

water impoundment and diversion, river diking, stream channel straightening, wetland draining, urban and residential development, land clearing for agriculture, and road development. This degradation impaired key geomorphic processes, altering hydraulic conditions, sediment filtering, channel plan form and profile, streambank stability, water storage, aquifer recharge, dissipation of stream energy, and fish and wildlife habitat.

Within the lower Kootenai subbasin, the specific anthropogenic activities that have had the most direct effects on channel morphology include:

- River diking, flood control and channelization;
- Dam construction and operation;
- Water diversion for irrigation;
- Land clearing for agriculture;
- Suburban and urban development; and
- Road building and other transportation corridors.

The primary effects of these activities on channel morphology include the following:

- Altered hydraulics resulting in reduced velocity, depth and shear stress in the project area;
- Altered sediment-transport resulting in reduced supply of coarse bedload from the watershed, reduced sediment transport competence (particle mobility for given size class), reduced sediment transport capacity (volume of sediment moved), and increased embeddedness of coarse substrate;
- Altered channel plan form, profile and dimension including over-sized channel cross-sections, higher width to depth ratios, loss of floodplain connection and decreased lateral channel migration zone; and
- Bank erosion resulting in sediment loading and channel migration.

The above effects have led to the following primary factors limiting restoration of channel morphology in the Kootenai subbasin:

- River and floodplain response to altered flow regime and altered hydraulics;
- River and floodplain response to altered sediment supply and sediment sediment-transport;
- Loss of channel and floodplain connection; and
- Bank erosion and reduced channel boundary roughness.

These effects and factors are described in greater detail in the following sections.

2.4.1 Altered Hydraulics

The long-term effects of both upstream and downstream regulation of the governing hydrologic boundary conditions (i.e., Libby Dam discharge and Kootenay Lake stage) have resulted in a departure from the historical hydraulic conditions and geomorphic response under which the

Kootenai River developed. Within the project area, the geomorphic response corresponding to water and sediment conveyance is generally controlled by the available energy, which is consumed as water and sediment are routed downstream.

The morphology within the project area reflects a state of dynamic equilibrium between any remaining energy and the erodible materials in the channel boundary. The magnitude of the potential energy available for water conveyance and sediment-transport is characterized by the reach energy grade slope, which is generally a function of valley slope, discharge, and local flow resistance created by sediment, vegetation, or other obstructions to flow. The Kootenay Lake backwater also dampens stream energy. The departure of hydraulic response to changes in energy grade can be further evaluated by considering select hydraulic parameters such as shear stress, which represents the force per unit area of the river bed available to entrain and transport sediment.

Additionally, water velocity may also be evaluated to determine hydraulic conditions as hydraulics are correlated with geomorphic processes and ecological function. For the analysis of the Kootenai River conducted as part of this Master Plan, select hydraulic parameters were synthesized for the dominant historical hydrologic regime periods (e.g., pre-dam, pre-BiOp, and post-BiOp) using existing conditions geometry (the rationale for, and limitations of, this exercise are described in Appendix A). Comparing hydraulic conditions for these hydrologic regime periods allowed an approximate comparison of the magnitude and variability of hydraulic departure.

Figure 2-11 illustrates the seasonal departure in upstream and downstream boundary conditions affecting the project area annually for a multi-year hydrologic regime. The seasonal degree of variability around the median is shown as the shaded inner quartile range of the 25th and 75th percentiles.

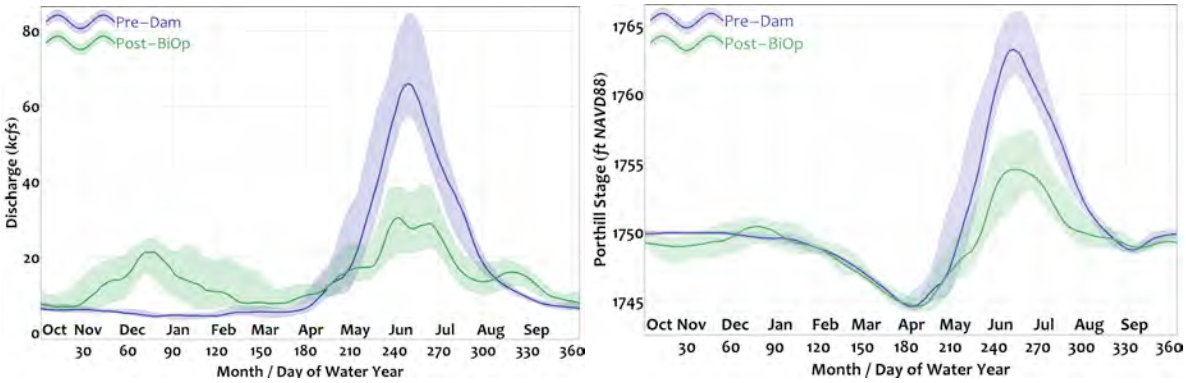


Figure 2-11. Governing boundary conditions by DWY for pre-dam, post-BiOp at the Porthill USGS Station #12322000.

These figures illustrate a reduction in median annual peak flows of approximately 50%, which also corresponds to lower peak Kootenay Lake elevations as represented by a nearly 10 foot reduction in river stage at Porthill, ID in the June to July time period. Also notable are higher flows and corresponding lake levels during the fall drafting period when dam operations are traditionally governed by power generation. The combination of additional Libby Dam flow and regulated Kootenay Lake levels during this period has resulted in departure of the channel hydraulics and corresponding geomorphic response. An increase in variability around the median values for both discharge and stage is observed for post-dam conditions. Pre-dam variability

generally only occurred on the rising and falling limbs of the annual peak and can be attributed to pre-dam subbasin processes, whereas the post-dam variability is fairly consistent for the entire water year and can be attributed to operational modes and constraints of Libby Dam and Kootenay Lake. Model simulations were used to compare pre-dam and post-BiOp hydraulic regimes. For the modeling work for this project, median seasonal peak discharges of 65kcfs and 30kcfs were selected as bankfull channel discharge surrogates representing the historical and contemporary conditions, respectively. Downstream median peak backwater elevations of 1763 feet (for the 65kcfs event) and 1754 feet (for the 30kcfs event) were selected to coincide with the surrogate bankfull discharge values.

The valley slope flattens abruptly by over an order of magnitude between the Braided Reaches and the Straight Reach. The slope transitions from 0.0005 ft/ft near RM 158 in the middle of the Braided Reach 1, to 0.00005 ft/ft at RM 152 in the Straight Reach (Figure 2-12).

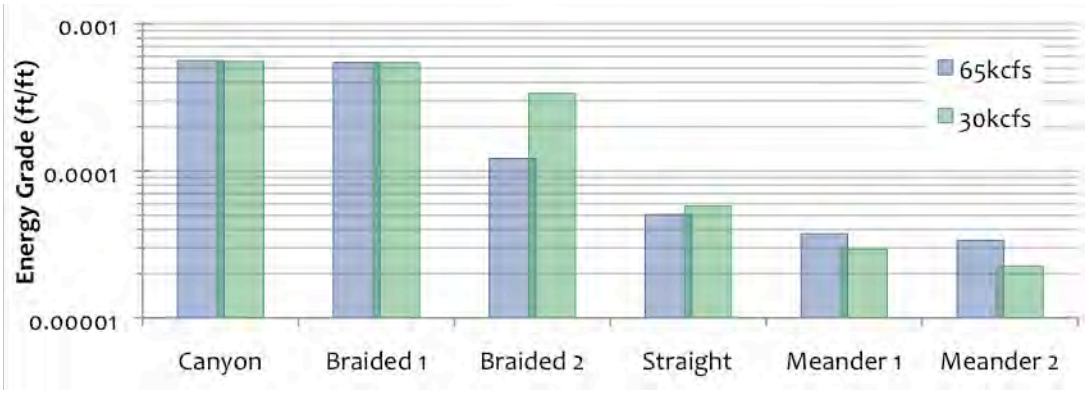


Figure 2-12. Departure in bankfull energy grade by reach for pre-dam (65 kcfs) versus post-BiOp (30 kcfs).

As a result of such mild slopes through the project reaches, the upstream extent of the Kootenay Lake backwater effect can extend over 50 miles upstream from Porthill, seasonally fluctuating over a range of six river miles between the Straight Reach and Braided Reach 1. The surrogate bankfull energy grade for median lake levels at 30kcfs exceeds that of 65kcfs in Braided Reach 2 and the Straight Reach, and as such influences channel hydraulics. A summary of mean bankfull hydraulic departure by reach for the pre-dam and post-BiOp hydrologic regimes is shown in Table 2-6. Post-BiOp hydraulic variables (depth, velocity and shear stress) generally have lower values relative to the pre-dam period.

Table 2-6. Summary of mean bankfull hydraulic departure for pre-dam and post-BiOp regimes.									
Reach/Param	Hydraulic Depth *(ft)*			Velocity *(ft/sec)*			Shear Stress *(lbf/ft²)*		
	65kcfs	30kcfs	% Change	65kcfs	30kcfs	% Change	65kcfs	30kcfs	% Change
Canyon	20.9	5.8	-24%	7.0	4.9	-30%	0.63	0.44	-31%
Braided 1	16.8	12.0	-29%	6.5	4.5	-31%	0.55	0.38	-31%
Braided 2	20.5	10.8	-47%	2.9	2.9	-1.5%	0.13	0.19	40%
Straight	31.1	23.6	-24%	3.4	2.5	25%	0.09	0.06	-29%
Meander 1	31.4	23.9	-24%	3.1	2.2	-29%	0.07	0.04	-41%
Meander 2	35.2	27.6	-22%	3.0	2.0	-35%	0.07	0.04	-48%
** Assumes Water-surface elevation at Porthill (USGS Sta#12322000) of 1763 for 65kcfs and 1754 for 30kcfs*									

The departure in bankfull hydraulic depth by reach is shown in Figure 2-13. Both hydrologic regimes are characterized by the general trend of increasing mean depth in the downstream direction, partially as a result of the backwater influence, and also due to the transition from a braided channel type in the upstream Braided Reaches to entrenched channel conditions in the Meander Reaches. The largest estimated change in mean hydraulic depth occurred in the Braided 1 and 2 reaches with nearly 30% and 50% reductions in depth between the pre-dam and post-BiOp conditions. There has also been a 25% reduction in mean hydraulic depth between the two periods in the Straight and Meander reaches.

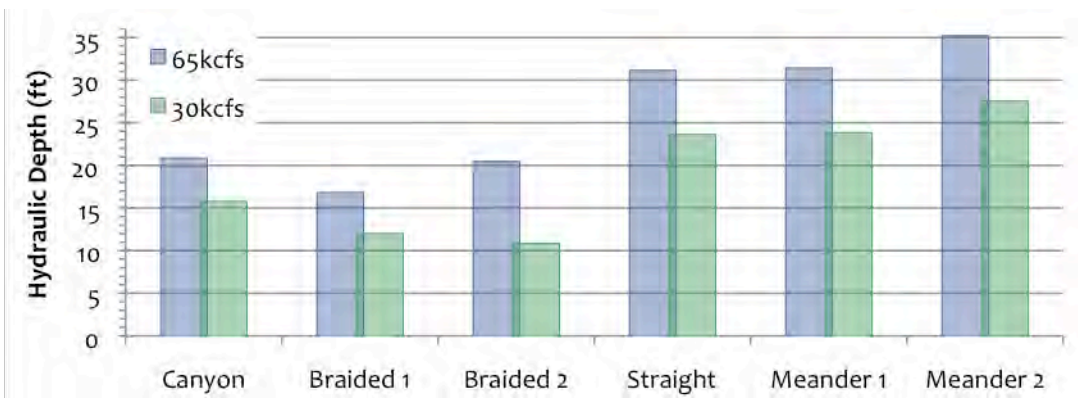


Figure 2-13. Departure in bankfull hydraulic depth by reach for pre-dam (65 kcfs) versus post-BiOp (30 kcfs) regimes.

The temporal response of hydraulic depth to departure in discharge and backwater boundary conditions in the Braided Reaches is plotted in Figure 2-14 below. In the Braided Reaches, pre-dam mean annual peaks for hydraulic depth generally correlate with pre-dam discharge around mid-June indicating a diminished influence from Kootenay Lake backwater which is not present year-round and does not extend upstream of Braided Reach 2. Under the post-BiOp hydraulic regime, median values for hydraulic depth have been reduced by one-third in Braided Reach 1, and one-half in the Braided Reach 2. Between RM 152 and RM 157, the Libby Dam BiOp recommends intermittent depths of 16.5 ft to 23.0 ft or greater during peak augmentation flows for Kootenai sturgeon migration and spawning habitat.

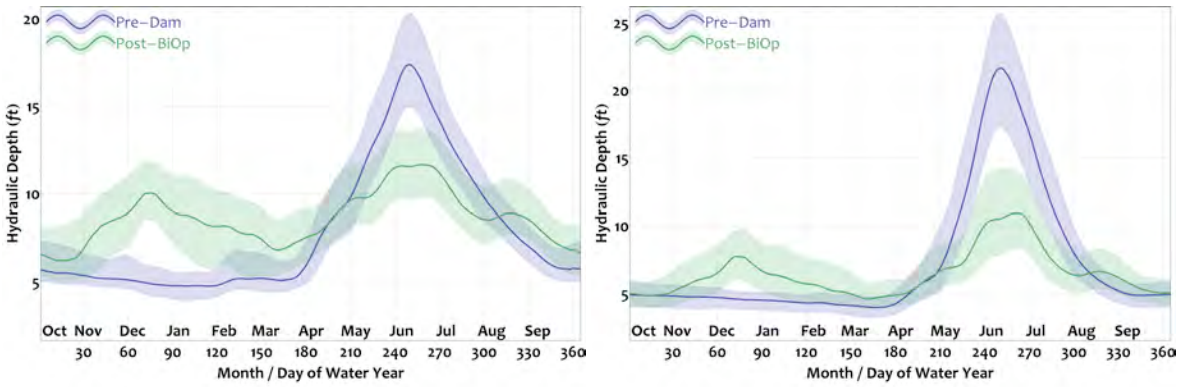


Figure 2-14. Hydraulic depth by DWY for pre-dam versus post-BiOp in the Braided Reaches 1 and 2.

Analysis completed for this project suggests a 30% reduction in bankfull channel velocity from the pre-dam to post-BiOp condition in all reaches except the Braided Reach 2, where pre-dam and post-BiOp velocities were nearly equal, averaging less than 3 ft/sec as shown in Figure 2-15. In the Canyon Reach and Braided Reach 1, post-BiOp bankfull discharge velocities were estimated between 4 ft/sec and 5 ft/sec, while downstream in the Meander Reach, bankfull velocities averaged just over 2 ft/sec. Libby Dam BiOp (USFWS 2006) recommends that water velocities during the spawning period should exceed 3.3 ft/sec in over 60% of the reach characterized by rock substrate between RM 152 and RM 157 to provide habitat conditions believed to be important for Kootenai sturgeon spawning and egg survival.

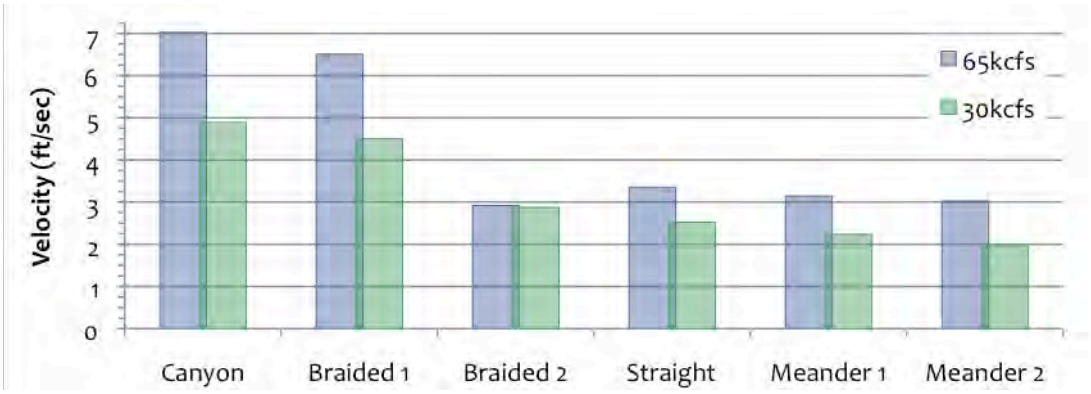


Figure 2-15. Departure in bankfull discharge velocity by reach for pre-dam (65 kcfs) versus post-BiOp (30 kcfs) regimes.

Boundary shear stress departure between the pre-dam and post-BiOp hydraulic regimes was less than 50% for all reaches. In Braided Reach 2, the greater than 100% increase in post-BiOp energy grade slope resulted in a 40% increase in shear stress (Figure 2-16). The increase in shear stress in Braided Reach 2 is due to the less extensive Kootenay Lake backwater associated with the post-BiOp period. Regardless of this significant increase, the general trend of decreasing energy with decreasing river mile still dominates. This shear stress trend contributed to the depositional channel regime under both pre-dam and post-BiOp hydraulic regimes.

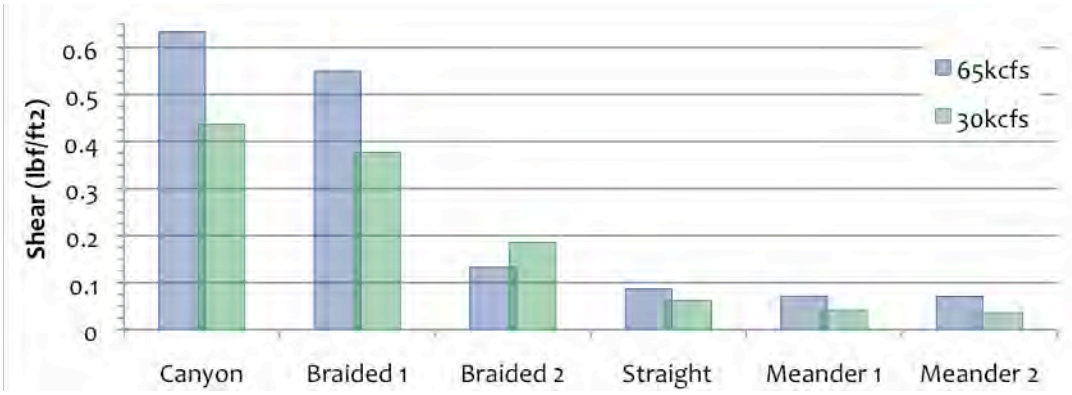


Figure 2-16. Departure in bankfull boundary shear stress by reach for pre-dam (65 kcfs) versus post-BiOp (30 kcfs) regimes.

This abrupt transition in available shear and corresponding depositional response is also illustrated by comparing the temporal plots between the Braided 1 and 2 reaches. In Braided Reach 1, both pre-dam and post-BiOp hydraulic responses suggest that shear stress generally correlates with discharge. This result indicates there is a higher correlation of hydraulic response with Kootenai River discharge versus the Kootenay Lake backwater influence as the backwater effect is not present year-round in Braided Reach 1 (Figure 2-17, left figure).

Conversely, in the downstream Braided Reach 2, less separation between the pre-dam and post-BiOp median shear stress is evident throughout the entire water year (Figure 2-17, right figure). Additionally, there is a dampening of hydraulic effects around the spring peak for both pre-dam and post-BiOp regimes. The overall similarity of median shear values in the Braided Reach 2 for both regimes (just above 0.2 lbf/ft^2) indicates the hydraulic response is more strongly tied to the channel geometry and Kootenay Lake backwater than the Kootenai River discharge.

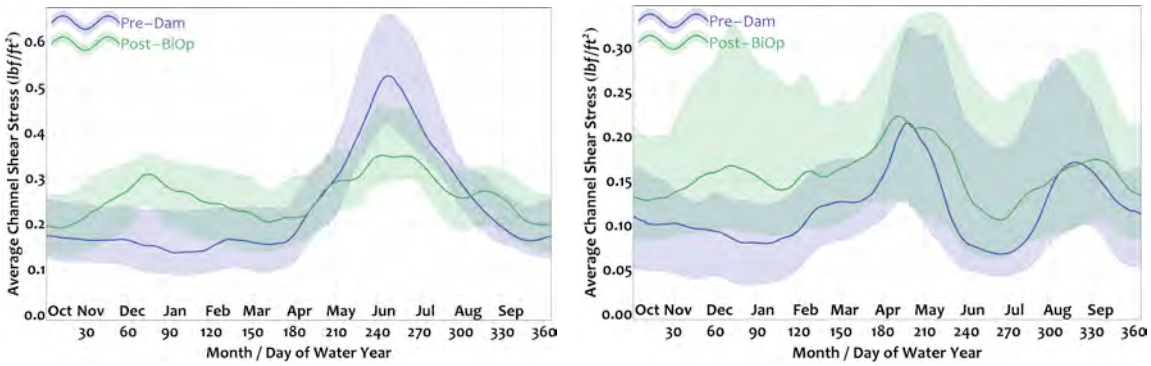


Figure 2-17. Boundary shear stress by DWY for pre-dam versus post-BiOp regimes in the Braided Reach 1 (left) and Braided Reach 2 (right).

In Braided Reach 2, on the rising limb of the spring peak in late April (approximately DWY 200) a less frequent peak in hydraulic response occurred during both pre-dam and post-dam regimes. This effect is generally on a declining trend by the June peak (approximately DWY 250) due to the combined effects of the over-widened braided geometry and backwater as Kootenay Lake refills.

Downstream from RM 151 in the Meander Reaches, the pre-dam regime was characterized by a seasonal peak in both velocity and shear in June in response to seasonal peak flows (Figure 2-18). In the post-BiOp era, this seasonal peak in hydraulic response was essentially dampened to just above 2.0 ft/sec within a consistent range of variability throughout the entire water year.

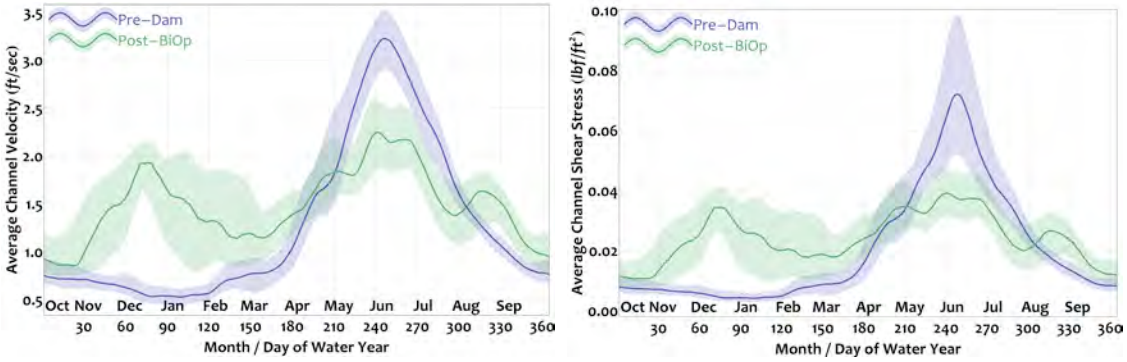


Figure 2-18. Annual trends of velocity (left) and shear stress (right) for pre-dam versus post-BiOp regimes in Meander Reach 1.

In contrast to the Straight and Braided reaches, the Meander Reaches are not characterized by the short-term peaks in hydraulic response coincident with the rising limb between April and June (DWY 200-250). This condition may suggest that for the Meander Reaches during the post-dam period, any potential increases in hydraulic response on the rising limb were sufficiently dampened by the more persistent backwater effects of Kootenay Lake. Post-BiOp hydraulic response in the Meander Reaches is characterized by higher velocity and shear during the fall and early spring drafting period (October - March) similar to other upstream reaches.

In summary, the general change in hydraulic response within the project area resulting from the dam-altered regime is dependent upon the combined effect of both Libby Dam discharge and Kootenay Lake level. The altered hydraulics are characterized by reduced median spring peak flows and increased median flows for the remainder of the year. In essence, spring runoff peaks are lower and base flows are higher in the post-BiOp period compared to the pre-dam period. In the Braided Reaches, where the hydraulic response is seasonally influenced by the Kootenay Lake backwater effect, the combination of larger flows with high lake levels can actually dampen the hydraulic response (i.e., velocity and shear stress) as compared to moderate flows and lake levels. Below RM 151, the Straight and Meander reaches are influenced by the Kootenay Lake backwater effect year round and follow a general trend of decreasing magnitude of hydraulic response with river mile. Additional examples of alteration in hydraulic response are presented in Appendix A, including rating tables and evaluation of frequency duration departure for select hydraulic parameters. Because of departure in channel hydraulics and the resulting changes in channel morphology, we have identified ***river response to altered hydraulics as a limiting factor for morphology***.

2.4.2 Altered Sediment Transport

Since its completion in 1972, and full operation beginning in 1974, Libby Dam (upstream of the project area) has altered both the supply and transport characteristics of the pre-dam sediment regime in the project area. Lake Koocanusa, the reservoir formed by Libby Dam, has a surface

area over 70 square miles with a length extending over 90 miles. Lake Koocanusa effectively traps virtually all of the sediment originating from the upper 46% of the 19,300 square mile subbasin (Tetra Tech 2004). During the design of the Libby Dam Project, the USACE estimated the catchment upstream of Libby Dam would generate an annual suspended-sediment load of 1.48 million tons per year, over 90% of which would be trapped in Lake Koocanusa under average flow conditions. The USACE estimates that during peak spring flows, roughly 12% of this suspended sediment load passes through the dam (USACE 1971). Due to the extensive length and depth of Lake Koocanusa, 100% of coarse-grained sediment (> 2 mm) generated by the upper Kootenai subbasin is likely trapped by the reservoir (Barton 2004; Burke 2006).

This disruption in downstream sediment delivery is reflected in measurements of suspended-sediment load collected between 1966 and 1984 in Meander Reach 2 near Copeland, ID (Sta#12318500, RM 124) as shown in Figure 2-19 on the following page. Calibrated estimates of mean daily suspended-sediment load reveal that median suspended sediment loads coincident with spring runoff between May and August (DWY 210-340) were reduced by an order of magnitude from over 10,000 tons per day to under 1,000 tons per day in the post-dam era. Conversely, median suspended sediment loads for the first half of the water year (October - May) are thought to be about six times higher under the post-dam regime, an increase of around 50 tons per day to 300 tons per day. This increase in suspended sediment loads is due to fall hydropeaking operations, which increase shear stress 300% in the upstream Braided Reach. Hydropeaking provides sufficient energy to selectively transport fine material smaller than 2 mm that is present in depositional features and poorly vegetated banks upstream of the Meander Reaches.

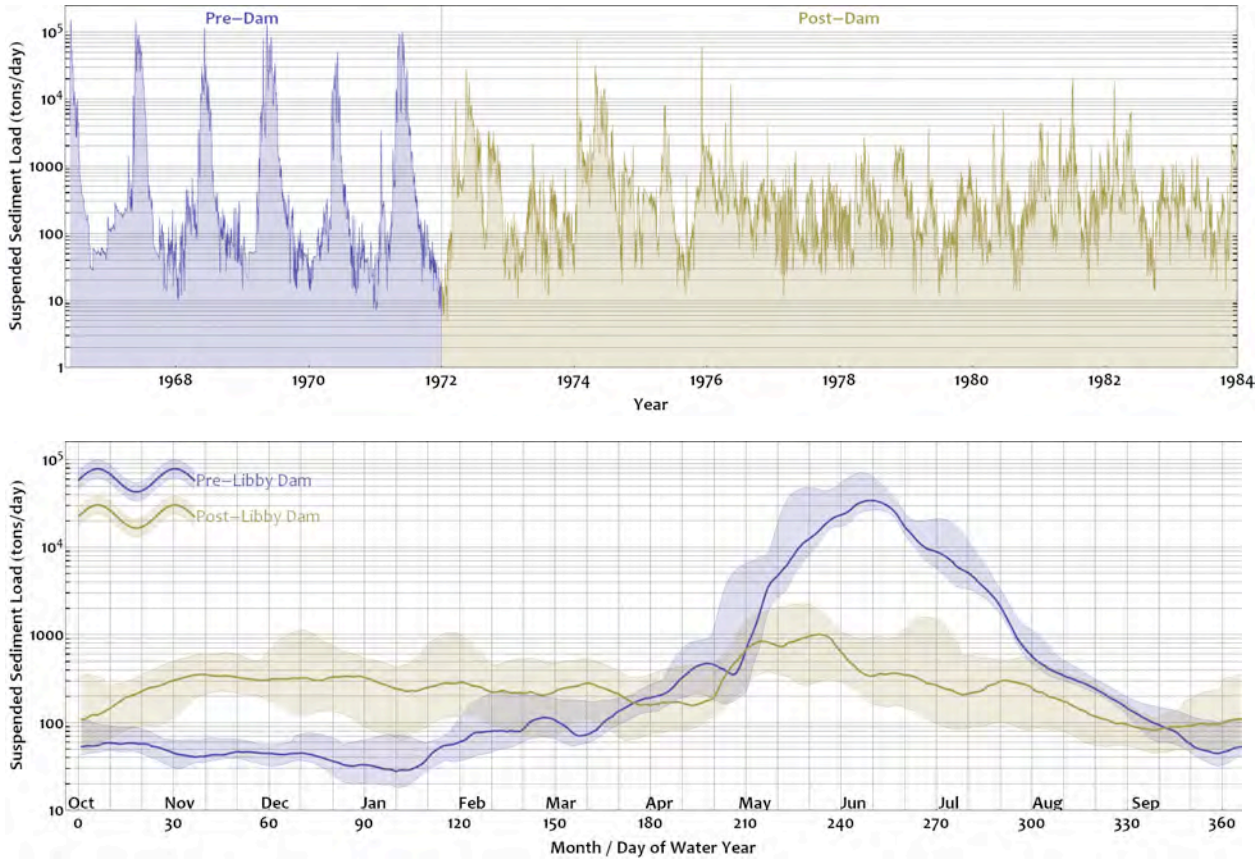


Figure 2-19. Historical suspended-sediment load: Kootenai River near Copeland, ID (Sta #12318500) in Meander Reach 2 from 1968 through 1984.

The project area is also affected by the abrupt decrease in valley slope as the Kootenai River enters the Purcell Trench at the top of the Braided Reach 1 and the backwater effect from Kootenay Lake below RM 158 (Berenbrock 2005; Burke 2006; Wildland Hydrology 2008). As described in Section 2.3, the backwater typically extends through the Straight Reach and into the lower Braided Reaches during spring runoff when Kootenay Lake is elevated. The backwater decreases the energy gradient through the affected reaches, reducing stream power and limiting the ability of the river to transport coarse bedload from upstream reaches.

Figure 2-20 displays the maximum particle size that can be transported using a standard incipient motion Shield's criterion for the pre-dam and post-BiOp regimes. For both regimes, the overall reduction in available transport competence is reflected as the mobile particle size decreases from coarse gravels (coarse grain 16mm - 32mm) in Braided Reach 1 to medium gravels (medium grain 8mm - 16mm) in Braided Reach 2 to very fine gravels (very fine grain 2mm - 4mm) in the Straight Reach and very coarse sands (very coarse grain 1mm - 2mm) in Meander Reach 1. Of particular importance is the observed difference in sediment transport competency between regimes. In general, the post-BiOp regime mobilizes smaller particles during the spring and summer (DWY 180-300) and larger particles during the fall and winter (DWY 1-180) as a result of hydropeaking operations at Libby Dam. This additional transport competence results in the

mobilization of select finer fractions during times of the year when sediment transport may not have occurred historically.

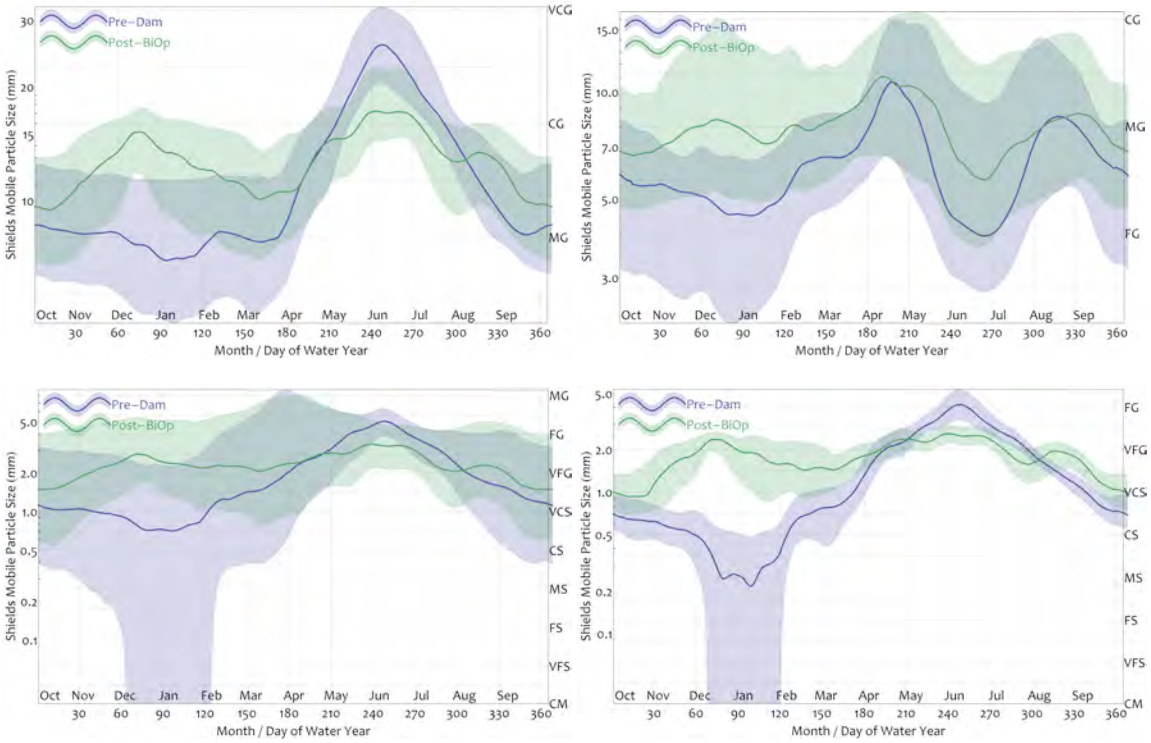


Figure 2-20. Maximum mobile particle size and inner quartile range for the pre-dam and post-BiOp regimes for the Braided 1 reach (top left), Braided 2 reach (top right), Straight reach (bottom left), Meander 1 reach (bottom right) for median hydraulic conditions.

Compared to pre-dam conditions, spring runoff transport competency under the post-dam regime was reduced by approximately two-thirds or one grain size class. In Braided Reach 1, spring transport competency was reduced from coarse gravel to medium gravel, while in Meander Reach 1 it was reduced from very fine gravel to very coarse sand. One notable exception to this trend is in Braided Reach 2, where the mobile particle size is nearly equal between pre-dam and post-BiOp regimes as a result of the reduced backwater influence during spring runoff. Nonetheless, this decrease in transport competency for larger size classes under the post-dam regime is thought to have sustained a slight bias for the selective transport of fines, which propagates in the downstream direction as overall available slope and energy decrease. This shift is also reflected in the gradation of the channel bed material between the project reaches as illustrated in Figure 2-21.

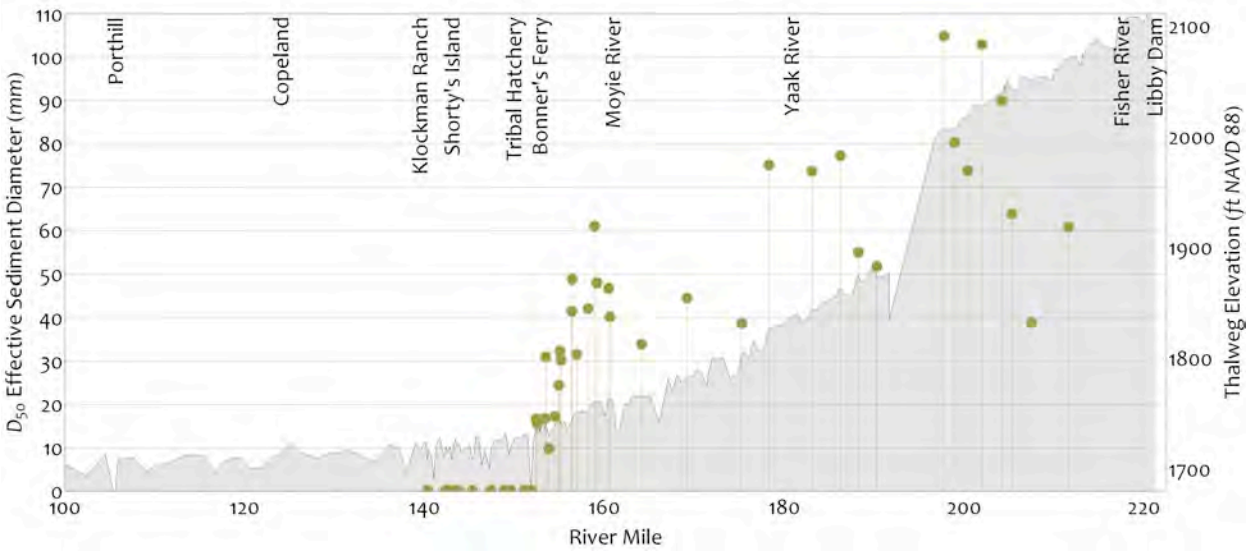


Figure 2-21. D50 particle size of bed sediment by river mile (after Burke 2006).

Upstream of RM 162 in the Canyon Reach, the Kootenai River is characterized by alternating confined and semi-confined sub-reaches with channel slopes exceeding 0.05%. The channel surface is generally made up of coarse gravel and cobbles (D_{50} less than 32 mm) with a moderate degree of armoring, supporting both pool-riffle and armored plane-bed morphology (Burke 2006). Downstream from RM 158, the Kootenai River exits the confined planform of the Canyon Reach, with a significant increase in width-to-depth ratio and the formation of multiple low-flow channels in response to an abrupt loss of slope as the river enters Braided Reach 1. Under both pre-dam and post-dam regimes this slope transition created a depositional environment, especially for larger size classes of sediment. The streambed through Braided Reach 1 is composed primarily of gravel and cobble bars coarser than 2 mm, which are generally thought to provide a suitable substrate for Kootenai sturgeon spawning, incubation, and early life stages. The coarse fraction of the channel bed continues to decrease through Braided Reach 2 which is seasonally influenced by the Kootenay Lake backwater, transitioning from very coarse gravel to very fine gravel as shown in Figure 2-22 and Figure 2-23.

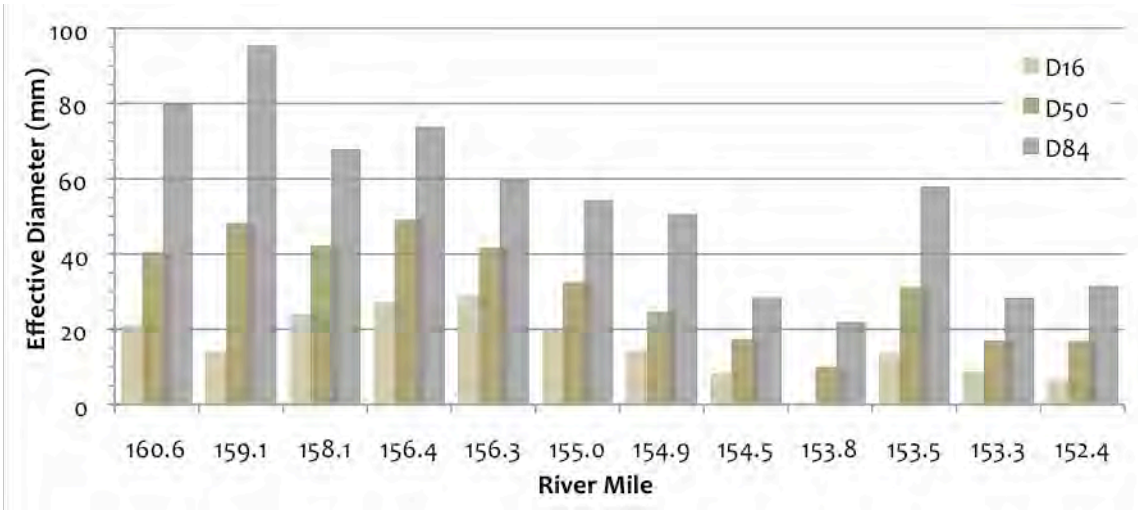


Figure 2-22. Effective diameters of surface layer sediment through the Braided Reaches, from USGS Pebble Count and Shovel Data collected from 2002-2008.

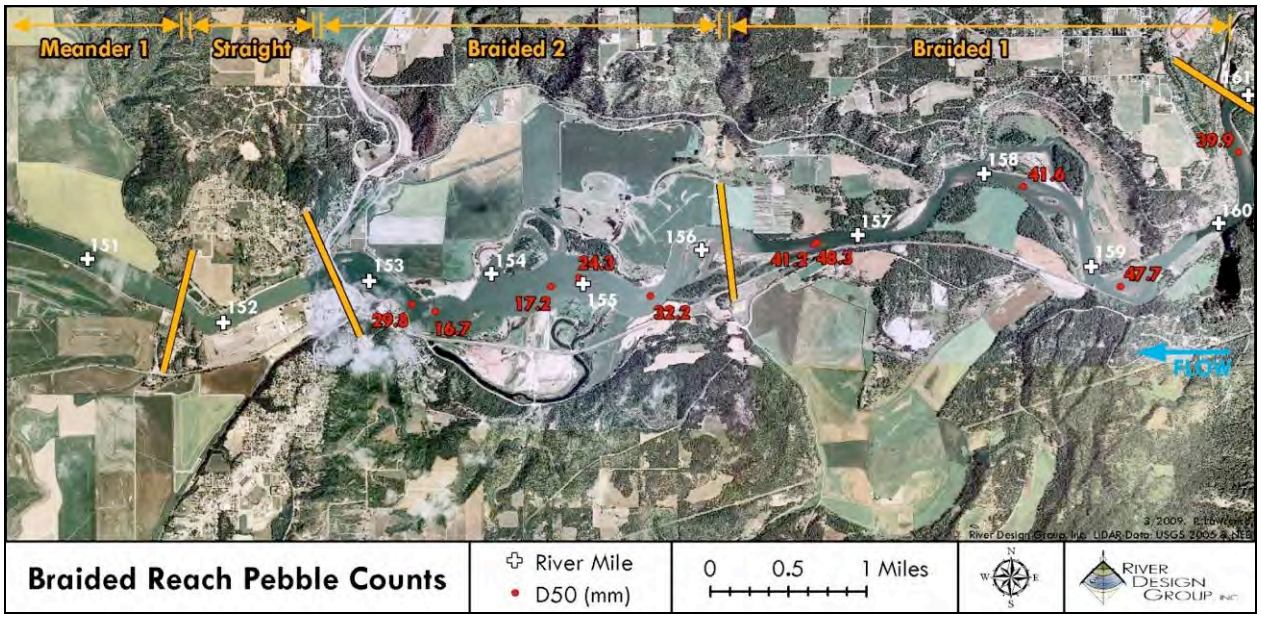


Figure 2-23. D50 Surface Pebble Counts in the Braided Reaches.

At the top of the Straight Reach, core samples collected by the USGS near the channel center at the HWY 95 bridge crossing, indicated that there are gravel deposits extending over 100 feet below the riverbed. Upstream of Ambush Rock, core samples were found to consist primarily of gravels and cobbles with increasing sands near the banks. Less than one river mile downstream, core samples collected near Ambush Rock indicate the presence of a geologic contact where the deep gravel and cobble is replaced by a thick lacustrine clay and silt layer about 15 feet below the streambed overlain by a discontinuous gravel cobble and sand layers (Barton 2004). Through the Straight Reach (below RM 152), the Kootenai River continues the trend of downstream fining, transitioning to a sand veneer over coarser patches of gravel and cobble. It is thought that under

the pre-dam regime, coarser patches in the Straight Reach were annually washed clean of the overlying sand prior to the descending limb of the hydrograph.

Further downstream in the Meander Reaches where the backwater influence is present year-round and the energy grade slope averages less than 0.00003 ft/ft, the Kootenai River channel bed is composed primarily of medium to fine sand, which is thought to be unsuitable bed material for spawning. Coring samples reveal that the geologic conditions downstream from the Straight Reach are dominated by lacustrine clay-silt deposits overlain by sand varying in thickness between 3 feet and 36 feet. Fine sediment, particularly in the Meander Reaches has accumulated to the extent that seasonal dunes with heights that cyclically fluctuate three to six feet per year (Barton 2004) are formed. As shown in Figure 2-24, channel substrates in Meander Reach 1 are composed of medium sands (<0.5 mm) and finer material. However, underwater videography taken during the 2006 high-flow season indicated that a few lenses of coarse material exist throughout the reach (Figure 2-50 in Section 2.6).

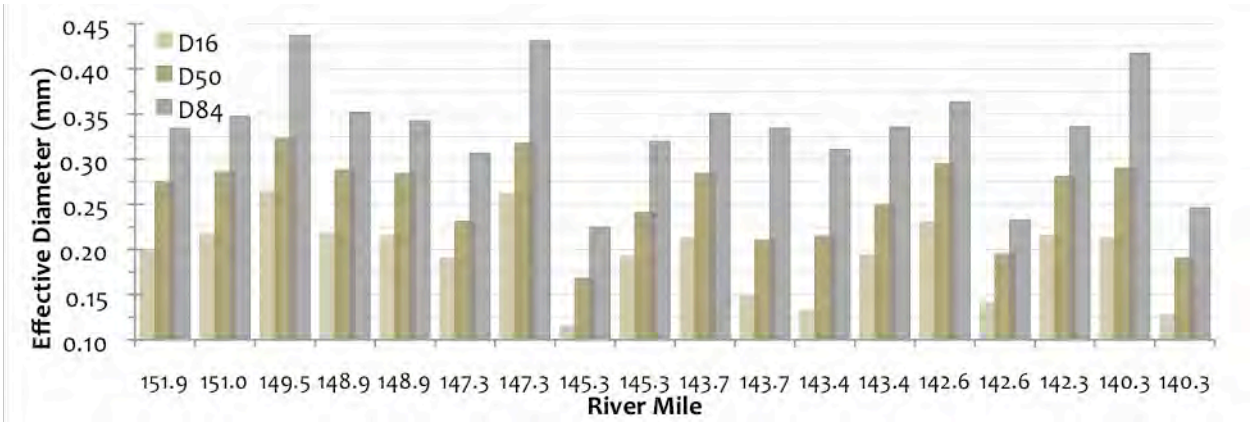


Figure 2-24. Effective diameters for subsurface Dredge Samples in Meander Reach 1 (Berenbrock 2005).

Despite the reduction in sediment supply caused by the trapping of sediment at Libby Dam, fine sediment delivery from the remainder of the catchment and tributaries is thought to have changed in the post-dam era as a result of watershed disturbances from river and floodplain management. To clarify the extent of this impact and address the potential implications on habitat restoration actions, efforts are underway to estimate the sediment supply derived from the watershed upstream of the project area as well as the sediment supply derived from within the project area. These efforts will be used to inform future decisions about the feasibility of habitat restoration, however the results of this analysis were not available for inclusion in this Master Plan.

In support of the development of limiting factors, approximately 500 sediment load measurements in the project area were assembled from historical and recent datasets for the post-dam era. Of these measurements, over 80% were suspended load, with the remainder made up of bedload samples. In general, the most reliable samples were those collected by the USGS over 16 days during water year 2008 at three stations (Figure 2-25). These samples were collected from a boat at discharges up to 47 kcfs. Related efforts are currently underway to estimate the annual supply of sediment derived from tributaries located between the dam and the project area, and from bank erosion in the project area (Section 2.4.5).

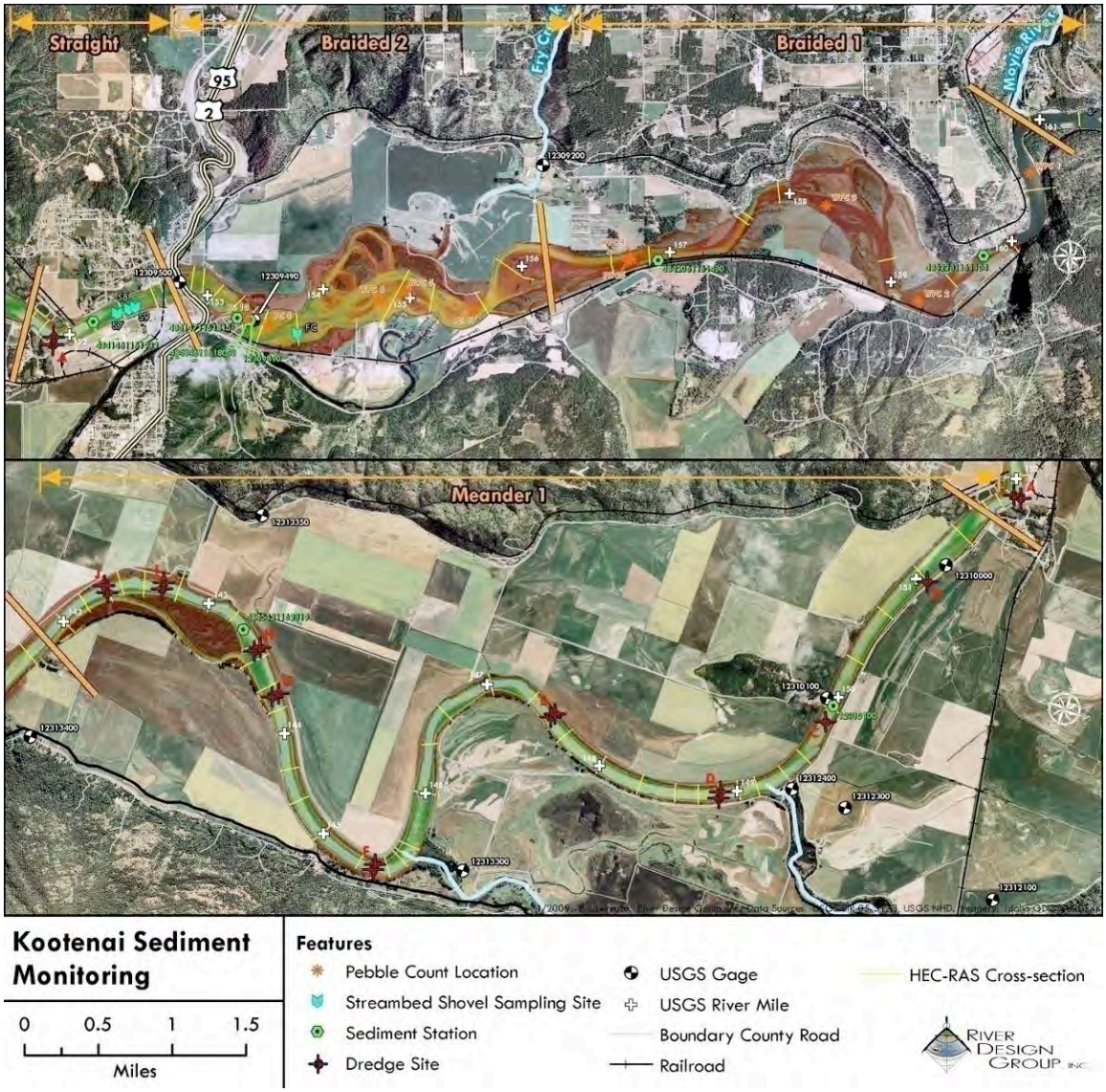


Figure 2-25. Sediment sampling stations in the study reach.

The 2008 bedload and suspended sediment measurements were used to complete a preliminary estimate of sediment transport and supply in project area. The purpose of the preliminary analysis was to support the development of limiting factors. Additional data collection and analysis will be necessary during the design phases in order to inform future decisions related to project feasibility and development of specific designs. Measurements were taken at three locations in the project area. For the purposes of this Master Plan, measurements from the upstream sampling site (RM 159) are assumed to represent the sediment supply entering the project area from the watershed. Measurements from the middle sampling site (RM 153) are assumed to represent the sediment supply near the downstream end of the Braided Reaches and within the backwater influence of Kootenay Lake. Measurements from the downstream sampling site (RM 143) are assumed to represent the sediment supply at the downstream end of

Meander Reach 1. Figure 2-26 shows the 2008 sampling events overlain on the 2008 water year hydrograph.

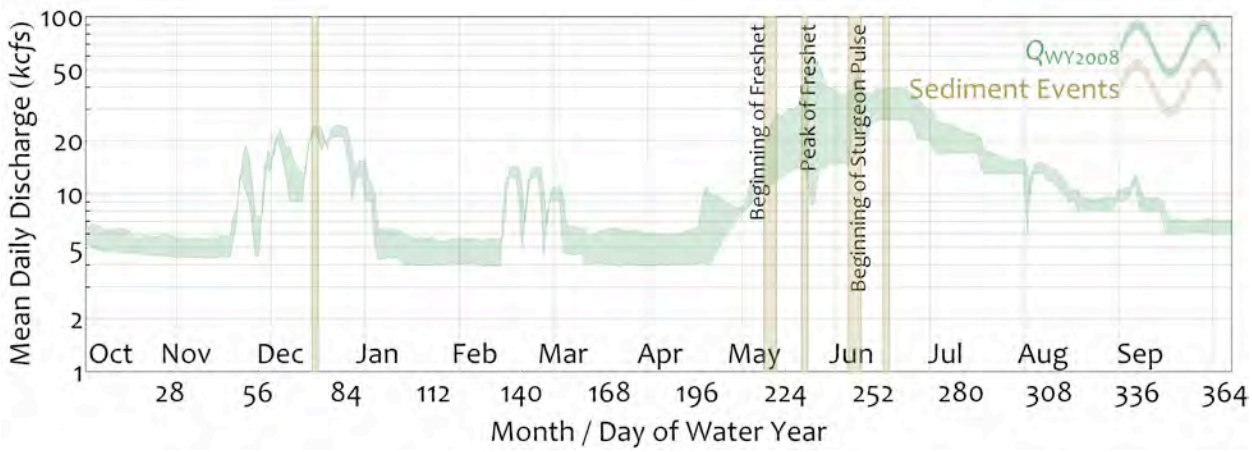


Figure 2-26. Hydrograph at Porthill (USGS #12322000) and Libby Dam (USGS #12301933) with sediment sampling events for water year 2008.

Preliminary results for estimates of the bed material load (Figure 2-27), which includes bedload and the sand fraction (> 0.0625mm) of the suspended load, indicate that bed material load increases through the Braided Reaches and decreases through Meander Reach 1. Under equilibrium transport conditions, sediment load and sediment supply are equal, suggesting that sediment is recruited from within the Braided Reaches and deposited in the Meander Reaches. There are no major tributaries in the Braided Reaches, therefore, the supply is presumed to come from the channel banks and bed. Because of the loss of floodplain connection in the Meander Reaches, the only place for sediment to deposit is on the channel bed or the infrequent, small bars.

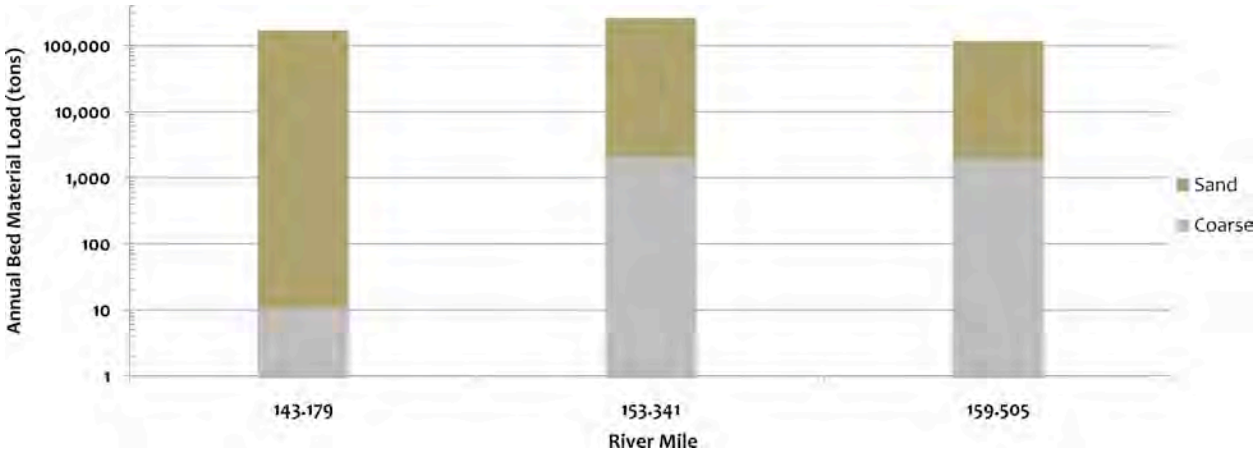


Figure 2-27. Estimated annual bed material load for water year 2008.

Another observation gleaned from the preliminary sediment sampling results is the low proportion of coarse bedload (gravel and cobble) measured. On average, coarse bedload accounted for less than 2% of the total sediment load measured at the upstream sampling site. Measured transport rates for coarse bed material load were roughly an order of magnitude less

than the transport rate of the bed material load sand fraction, falling by another order of magnitude near the Shorty's Island sampling site. Two possible explanations are offered to explain the low proportion of coarse bedload in the measured sediment samples.

The first explanation is that coarse bedload could have been under-sampled due the inherent difficulty of sampling from the boat in higher flow conditions. To help characterize the upstream sediment contributions from the catchment, the USGS sampled five tributaries of the Kootenai River comprising about two-thirds of drainage basin between Libby Dam and the Idaho/Montana Border during Spring 2008 (Holnbeck et al. 2008). Preliminary suspended sediment results indicate that these five streams alone may contribute over 10,000 tons/day of bedload to the Kootenai River during the spring peak flow. Zelch (2003) concluded that tributary deltas downstream of Libby Dam have increased in size due to storage of tributary bedload. Whether tributary sediments are stored in the tributary deltas or transported downstream to the project area is unknown and will be investigated further in subsequent phases of this project.

The second explanation for the low proportion of bedload sampled is that measurements are representative of supply and the Kootenai River upstream of the project area is unable to mobilize sources of coarse bedload. In natural gravel bed systems, bedload is typically mobilized at flows approaching mean annual peak flow, which in the Kootenai River would have historically been 65kcfs. If the Kootenai River is not capable of breaking up the existing bed armor and mobilizing large quantities of coarse bedload at flows of less than 65kcfs, it could be concluded that delivery of coarse bedload to the project area is low for all flow levels except for very large flood events in the post-dam era. Future data collection and analysis will be completed during design phases in order to refine the understanding of coarse bedload supply to the project area. Additional information regarding historical and current sediment sampling efforts is presented in Appendix B.

In summary, sediment transport in the project area is affected by a reduction in sediment supply from the watershed due to sediment trapping at Libby Dam and changes in sediment transport compentence and capacity due to altered hydraulics. The effects of altered sediment tranport have implications for aquatic habitat including: 1) reduced supply of suitable spawning substrate delivered to the project area, and 2) increased embeddedness of coarse substrate with sand and finer sediment. The implications for aquatic habitat are discussed in more detail in Section 2.6, Aquatic Habitat Limiting Factors. Not only does altered sediment transport affect aquatic habitat, but it also affects channel morphology and vegetation processes. Because variations in sediment-transport regimes have a profound effect on river behavior, we have identified ***river response to altered sediment-transport as a limiting factor for morphology*** in the Kootenai River. The Kootenai River's response to altered sediment transport, altered hydaulics and river management constraints is described in more detail in the following section.

2.4.3 Altered Morphology

Altered flow and sediment regimes have influenced the morphology of the Kootenai River. The following sections discuss the changes in the river morphology within the project area. Table 2-7 presents a summary of valley type, historical stream type, and existing stream type by reach (Wildland Hydrology 2008). Valley and stream type descriptions are summarized in Appendix E. Figure 2-28 presents a graphic of the existing stream types by reach.

Table 2-7. A summary of valley type, historical stream type, and existing stream type by reach.			
Reach Name	**Valley Type**	**Historical Stream Type**	**Existing Stream Type**
Braided 1	Terraced Alluvial Valley	Meandering/Braided	Meandering/Braided
Braided 2	Terraced Alluvial Valley	Braided	Braided
Straight	Structurally-Controlled Valley	Entrenched	Entrenched
Meander 1	Glacio-lacustrine Valley	Meandering	Entrenched
Meander 2	Glacio-lacustrine Valley	Meandering	Entrenched
Tributaries	Structurally-controlled Glaciated Valleys and Alluvial Fans	Entrenched/Confined	Entrenched/Confined

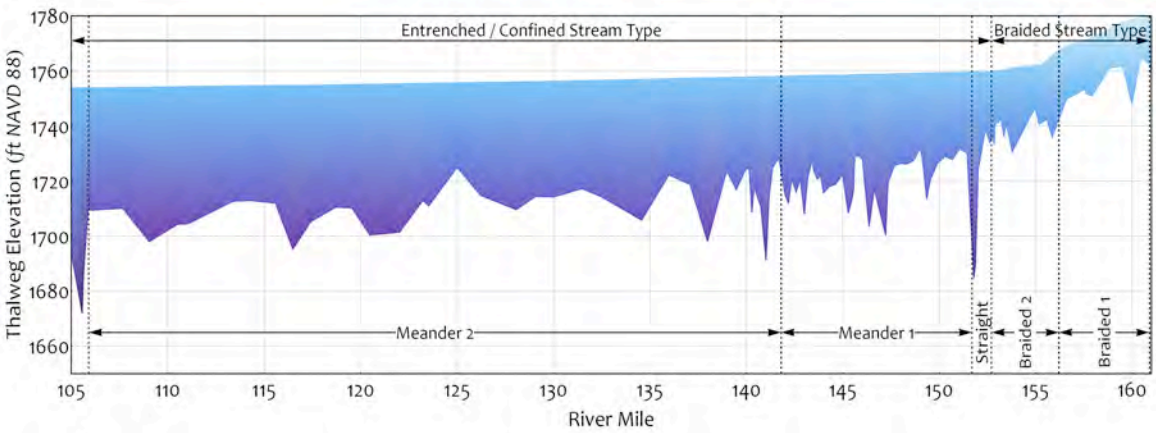


Figure 2-28. The distribution of existing condition stream types by reach. The graph also illustrates the 30 kcfs water-surface elevation through the project area.

2.4.3.1 Historical Aerial Photograph Interpretation and Planform Departure

An historical aerial photograph analysis was conducted to evaluate morphological trends from 1862 through 2006 in the majority of the project area reaches. While the Kootenai River's planform has varied over time by reach, post-dam changes have been within the range of adjustments that occurred in the pre-dam period (Tetra Tech 2004). It should be noted, however, that natural systems have wide ranges of variability and the causes of the adjustments may be attributed to different factors as discussed in later sections. The channel has been most dynamic in Braided Reach 2 upstream of Bonners Ferry. Overall, observed adjustments in planform are related to direct land use impacts, floodplain modifications, and changes in the hydraulic and sediment-transport characteristics of the project area. Table 2-8 summarizes percent change in channel plan form metrics for the project area from the 1862-1865 (General Land Office) maps, 1934 and 2006 aerial photos. The analysis was not performed for the Straight Reach due to its confined and stable configuration over the analysis period.

Table 2-8. Percent change in channel planform indices for the Kootenai River Project Area using the Government Land Office (GLO) maps, 1934 and 2006 air photos. The percent change compares 2006 values relative to the GLO values.

Parameter[1]	1862-1865 GLO Value	1934 Value	2006 Value	Percent Change
Braided 1				
Meander Length (ft)	5,642	6,143	5,668	0.5
Belt Width (ft)	1,729	1,259	1,597	-7.6
Radius of Curvature (ft)	1,660	1,466	1,581	-5.0
Bankfull Width (ft)	669	600	547	-22.3
Braided 2				
Meander Length (ft)	6,721	6,962	6,593	-1.9
Belt Width (ft)	4,445	3,024	2,985	-32.8
Radius of Curvature (ft)	2,713	1,508	1,578	-71.9
Bankfull Width (ft)	875	1,414	1,021	14.3
Meander 1				
Meander Length (ft)	13,868	13,728	13,686	-1.3
Belt Width (ft)	6,695	910[2]	910[2]	-86.4
Radius of Curvature (ft)	3,551	3,727	3,804	6.7
Bankfull Width (ft)	544	630	660	17.6
Meander 2				
Meander Length (ft)	6,199	6,402	6,429	3.6
Belt Width (ft)	4,070	2,256[2]	2,256[2]	-44.6
Radius of Curvature (ft)	1,551	1,585	1,591	2.5
Bankfull Width (ft)	584	586	636	8.2

1. An illustration of planform parameters is provided in Appendix E.
2. 1934 and 2006 meander belt width is defined as the distance between the levees.

Braided Reaches

The Kootenai River downstream from the Moyie River confluence enters a wide valley with decreasing gradient. The river is characterized by sediment deposition and lateral migration. These factors, with the corresponding changes in valley type and decreasing slope, have induced a braided river morphology that likely represents the historical form since the Holocene period (Wildland Hydrology 2008). Channel morphology in Braided Reach 2 has been and continues to be influenced by the Kootenay Lake backwater. Several studies have evaluated channel change over time including the Kootenai Flats Erosion Study (USACE 1983) and the USGS study by Barton et al. (2005). Both of these studies confirmed that the channel in the Braided Reaches has shifted its position over time (Wildland Hydrology 2008). As shown in Figure 2-29, the Braided Reaches are characterized by a dominant channel with secondary channels, extensive sediment deposition, and a meandering channel pattern.

Figure 2-29. The existing morphology of Braided Reach 1 (left) and Braided Reach 2 (right) is characterized by a dominant channel, active secondary channels, sediment deposition, and lateral migration.

Several major channel adjustments are noted in aerial photo series. The USGS study by Barton et al. (2005) indicated that the river in Braided Reach 2 shifted approximately 1,968 ft (600 m) between 1928 and 1958. Between 1934 to 1992, the dominant channel avulsed in response to meander migration and sediment deposition. This gradual process of sediment accretion, outer band erosion and meander cutoff development was likely exacerbated by vegetation removal that reduced bank strength and resistance to erosion. The geomorphic process described above is demonstrated in the drawing and photos presented in Figure 2-30, which compare the 1862-1865, and 1934 channel alignments and planforms to the 1992 and 2004 river positions. Presently, the relict channel scrolls maintain some degree of hydrologic connectivity with the main channel and provide flood relief and backwater habitat, particularly during high flows and periods when the Braided Reach is subject to backwater from Kootenay Lake. This example of a channel succession scenario appears to be a common geomorphic process in the Braided Reaches.

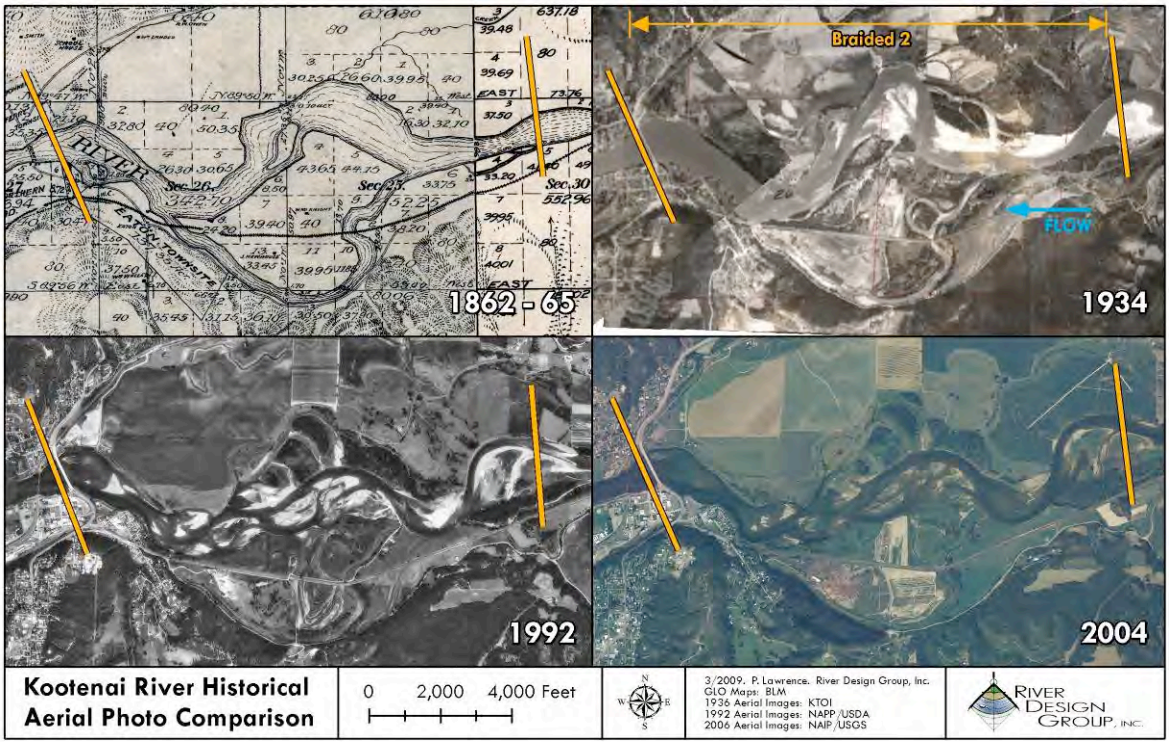


Figure 2-30. Comparison of channel migration trends from 1862-2004 in Braided Reach 2. A major channel avulsion occurred between 1934 and 1992. A pronounced side channel has been gradually disconnected from the system over time due to hydrologic changes and construction of the BNSF railway.

Meander Reaches

The Meander Reaches are generally a sand-bed stream type that is confined by levees. The Kootenai Flats Erosion Study (USACE 1983) evaluated rates of channel migration at 32 bends in the Meander Reaches. Two periods were evaluated including 1928–1968, and 1968–1992. The USACE study concluded that only two meander bends had major changes and the rest had experienced minor lateral channel migration (as presented in Tetra Tech 2004). This same USACE study suggested that in Meander Reach 1, about 100 to 200 feet of lateral bend migration occurred between 1928 and 1968 (pre-dam period), whereas between 1968 and 1983 (post-dam period after 1972), only minor rates of bend migration were observed (Tetra Tech 2008). Similarly, in Meander Reach 2, from 1928 to 1968 most bends reflected up to 100 to 300 feet of lateral adjustment, compared to only three bends with approximately 200 feet of adjustment from 1968-1992. A neck cutoff also occurred between 1968 and 1992 in Meander Reach 2 resulting from over 400 feet of lateral down-valley channel migration (Tetra Tech 2008) (Figure 2-31).

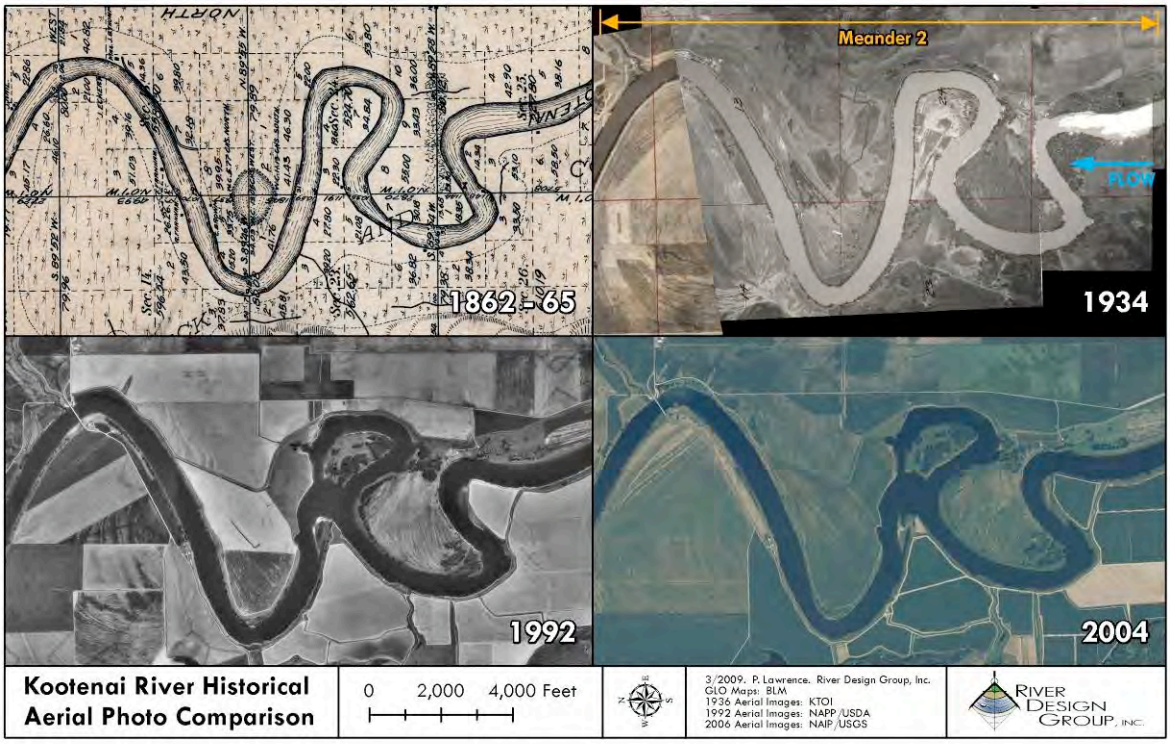


Figure 2-31. Comparison of channel migration trends from 1862-2004 in Meander Reach 2. An active neck cutoff is visible as the channel erodes the lower one-third of the bend in the center of the photo. The oxbow maintains hydrologic connectivity with the dominant channel.

While rates of meander bend migration appear to have moderated since Libby Dam closure, the most significant alteration to the channel planform has been the reduction in meander belt width due to the lateral constraints imposed by levees on the Meander Reaches. In Meander Reach 1, the meander belt width decreased from an average of 6,695 ft in 1862-1865 to 910 feet in 1934, a reduction of 86.4%. Similarly, values in Meander Reach 2 decreased from 4,070 feet in 1862-1865 to 2,256 feet in 1934, a 44.5% reduction. Since the locations of the levees have remained relatively unchanged through the air photo record, existing meander belt width values are assumed to be very similar to 1934 values, although minor increases have resulted from levee erosion and subsequent channel migration (Figure 2-31). Loss of boundary roughness provided by woody riparian vegetation and confinement of flood flows to the active, entrenched channel (Figure 2-32) contribute to levee erosion and bank migration.

Figure 2-32. Existing levees in Meander Reach 1. The levees are subject to erosion due to loss of boundary roughness and lack of resistance to flow (left photo). Stabilization efforts are ongoing in the Meander Reach and typically include rock armoring and placement of tree revetments (right photo). Levee erosion is a source of sediment to the Kootenai River in the Meander Reach.

As shown in Figure 2-33, reach-averaged meander belt width has decreased in all four of the primary reaches. The greatest reduction has occurred in Meander Reach 1 and Meander Reach 2, with a corresponding 86.4% and 44.6% change from 1862 to 2006.

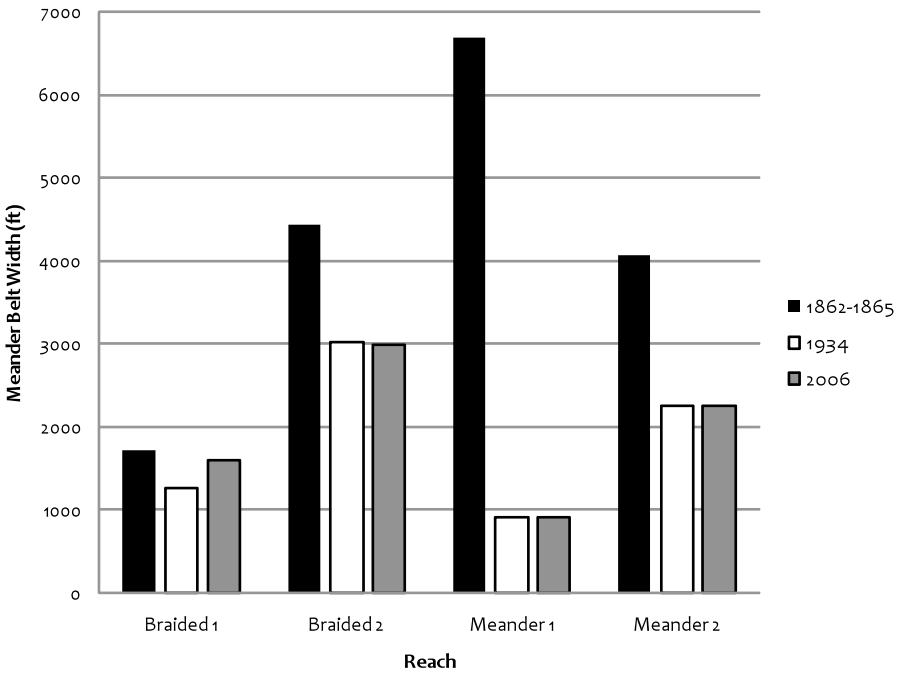


Figure 2-33. Comparison of reach-averaged meander belt width values from 1862-1865, 1934 and 2006. Floodplain constraints and infrastructure have decreased the channel belt width in the four primary reaches of the project area.

Summary of Historical Aerial Photo Analysis

Analysis of historical narrative, maps and aerial photographs confirms that the Kootenai River from the Moyie River downstream to Canada has undergone widespread change since the valley was first settled. Vegetation clearing, construction of transportation corridors and levee systems, agriculture and other subbasin development activities have altered the landscape within which the Kootenai River interacts. A temporal pattern of channel planform adjustment was observed in response to anthropogenic and natural disturbances through the period of record studied. To understand the Kootenai River's response to disturbance more clearly, additional investigations were completed to evaluate the morphological departure from historical conditions.

2.4.3.2 Channel Cross-section and Longitudinal Profile Departure

This section provides a summary of changes in channel morphology in the project area, in terms of cross-section and longitudinal profile. Limited data is available to fully evaluate reach-scale changes in the longitudinal profile and cross-section dimensions over time. Tetra Tech (2004) compared channel cross-sections from 1929 (USGS), 1956 (USACE) and 2002 (USACE Seattle District office) and overlaid these with historical thalweg profile data from 1929 (USGS 1937), 1950 (USACE), and 2002 (USGS 2004) to evaluate if cross-sections indicated that significant sediment deposition had occurred. In general, the studies found that the mean channel bed elevations through the project area have not changed significantly suggesting that neither aggradation nor degradation of the bed profile has occurred. In addition, recent underwater videography taken by USGS indicates that deep pools on outer bends in the Meander Reaches have thalwegs that are scoured deep into lacustrine clay layers and remain relatively free of sand and fine sediment (G. Barton, USGS, personal communication, 2009).

Results from hydraulic modeling were used to evaluate departure in cross-section hydraulics for pre-dam and post-BiOp flow regimes. For the modeling, mean annual peak discharges of 65kcfs and 30kcfs were selected as bankfull channel discharge surrogates representing the pre-dam and post-BiOp flow conditions, respectively. Downstream mean annual peak backwater elevations of 1763 ft (for the 65kcfs event) and 1754 ft (for the 30kcfs event) were selected to coincide with the surrogate bankfull discharge values. Due to a lack of historical topographic data, existing channel topography was used for all modeling scenarios in order to gain a conceptual understanding of the magnitude of the changes.

As shown in Table 2-9, hydraulic radius, flow area and width-to-depth ratio have changed significantly when comparing pre-dam and post-BiOp hydraulic regimes. Channel width-to-depth ratio has changed most significantly in Braided Reach 2, increasing by 85% from the pre-dam to post-dam period (Figure 2-34). A consequence of this departure is the loss of channel and floodplain connection at mean annual peak flow in all reaches. Figure 2-35 and Figure 2-36 illustrate the loss of floodplain connection by reach in a longitudinal profile and cross-sections. Loss of floodplain connection has widespread implications for ecological and biological processes as described in subsequent sections in this chapter. From a morphological perspective, loss of floodplain connection results in a lack of semi-permanent over-bank storage areas for water and fine sediment. As such, a greater proportion of sediment is stored more temporarily within the active channel. Because of these effects, ***loss of channel and floodplain connection is identified as a limiting factor for morphology***.

Table 2-9. Summary of mean bankfull hydraulic departure for pre-dam and post-dam regimes.									
Reach	Hydraulic Radius (*ft*)			Flow Area (ft^2)			W/D Ratio		
	65kcfs	30kcfs	% Change	65kcfs	30kcfs	% Change	65kcfs	30kcfs	% Change
Canyon	19.8	15.0	-24%	9,523	6,546	-31%	24.00	30.56	27%
Braided 1	16.5	11.8	-28%	10,097	6,755	-33%	37.55	50.04	33%
Braided 2	20.1	10.7	-47%	24,747	11,828	-52%	63.83	118.34	85%
Straight	29.7	22.5	-24%	19,632	12,523	-36%	22.25	28.32	27%
Meander 1	30.3	23.1	-24%	20,475	13,329	-35%	21.71	24.62	13%
Meander 2	33.7	26.6	-21%	21,556	15,388	-29%	18.10	21.41	18%
** Assumes Water-surface Elevation at Porthill (USGS Sta#12322000) of 1763 for 65kcfs and 1754 for 30kcfs*									

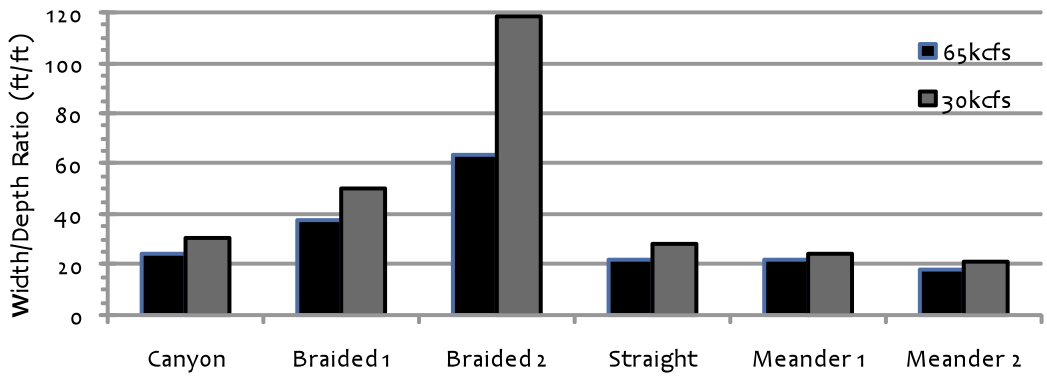


Figure 2-34. Comparison of channel width-to-depth ratios in the project reaches based on pre-dam and post-BiOp hydraulic regimes. Reach averaged width-to-depth ratios have increased in all reaches, most notably by 85% in Braided Reach 2 in the post-BiOp era.

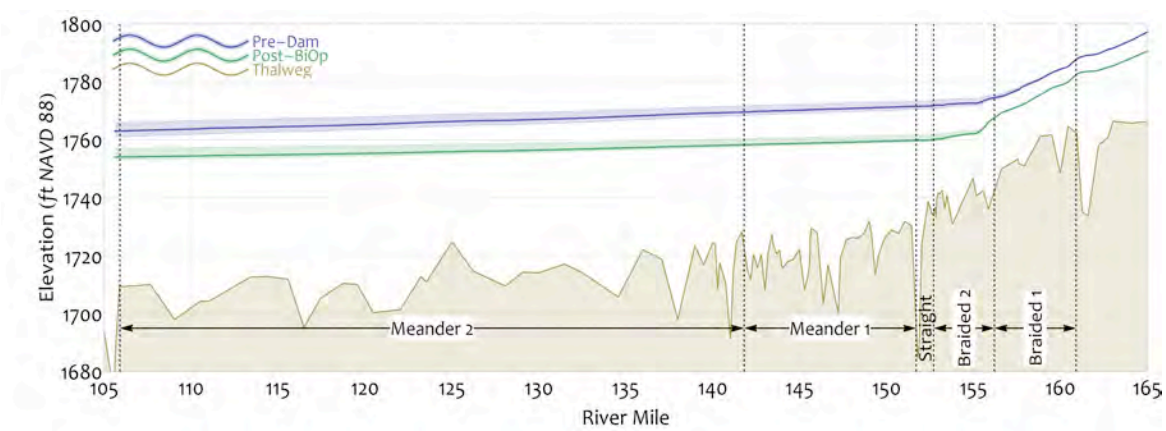


Figure 2-35. Comparison of mean annual peak water surface elevations for pre-dam (65kcfs) and post-BiOp (30kcfs) flow regimes. The difference between the two water surfaces is approximately seven to ten feet.

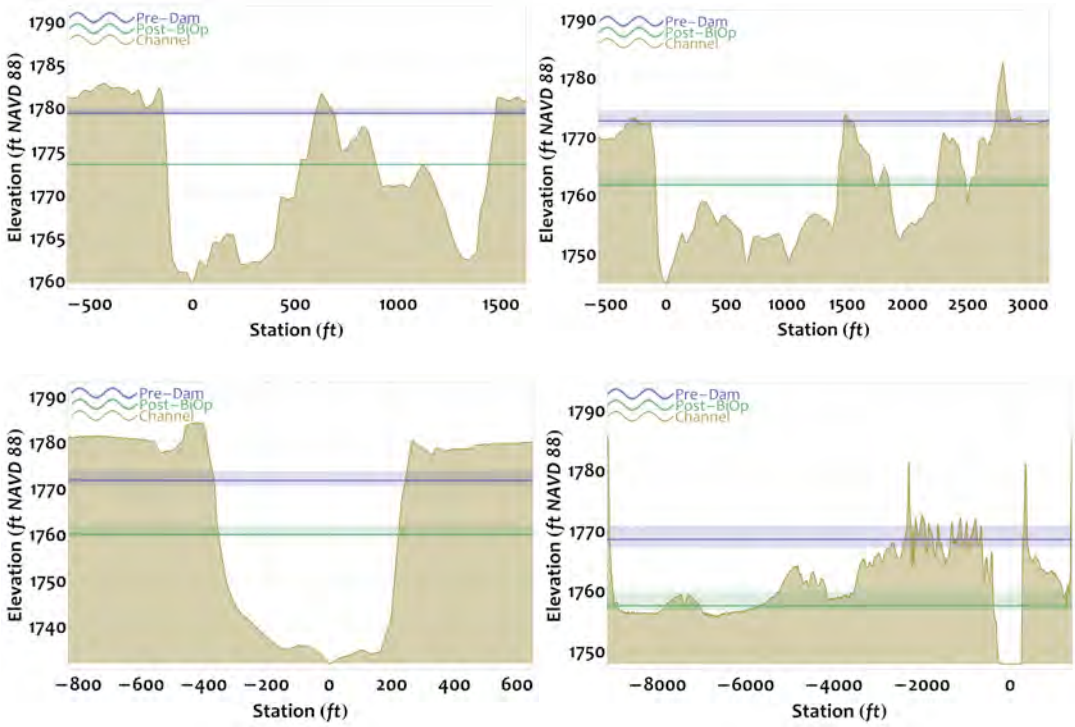


Figure 2-36. Select cross-sections with pre-dam (65kcfs) and post-BiOp (30kcfs) mean annual peak discharge water surface elevations for Braided Reach 1 RM 158.2 (top left), Braided Reach 2 RM 154.2 (top right), Straight Reach RM 152.3 (bottom left), Meander Reach 1 RM 136.5 (bottom right). Lower water surface elevations in the post-dam era combined with levees have resulted in a loss of floodplain connection in all reaches.

2.4.3.3 Bank Erosion

Streambank stability in the Kootenai River has been impacted by river and floodplain management, the loss of native bank vegetation, and the river's response to altered hydraulics and sediment transport. The net effect of these impacts is land loss and sediment loading. Annual streambank erosion rates for the Kootenai River were predicted and validated using the Bank Assessment for Non-point source Consequences of Sediment (BANCS) model (Wildland Hydrology 2006). The BANCS model uses two bank erosion estimation tools including the Bank Erosion Hazard Index (BEHI) and near-bank stress (NBS) ratings. The combination of the BEHI and NBS ratings were used to derive annual streambank erosion rate estimates in the project area. Erosion rates were predicted based on these two estimation tools, and validated through repeated surveys of bank study sites established in the project area. Appendix E includes additional information on the BANCS model.

Historically, in the Meander Reaches, streambank heights, which were naturally upwards of 25 ft higher than the base flow water-surface, were built up over millennia by annual floods that deposited fine sediment. Constructed dikes and levees have further increased bank heights relative to the river and adjacent floodplain. Combined with altered hydraulics and the effects of the Kootenay Lake backwater, these high streambanks do not the support dense, woody riparian vegetation that historically would have helped maintain streambank integrity. Throughout much of the Meander Reaches, native cottonwoods, willows and other native shrubs are absent, and fluctuating water depths, combined with few available areas for substrate deposition, present

very limited opportunities for these species to colonize naturally. Because of this, most streambanks in the Meander Reaches are vegetated with herbaceous plant species that contribute little rooting strength to banks. Appendix C includes a more detailed description of vegetation conditions along the Kootenai River's streambanks.

Ramping rates associated with fall hydropeaking at Libby Dam (Figure 2-11) combined with the variable downstream backwater effect from Kootenay Lake, are thought to have contributed to bank erosion. Cyclical bank saturation and de-saturation following rapid drawdowns causes poorly drained saturated banks to exhibit increased pore water pressure, which decreases bank strength and can exacerbate bank erosion.

2.4.3.4 Bank Erosion by River Reach

As part of the development of this Master Plan, bank erosion rates and streambank sediment yields were predicted for each project reach of the project area (Table 2-10, Figure 2-37 and Figure 2-38). On a reach-specific basis, bank erosion rates differ from the Braided Reaches to the Meander Reaches. Sediment yield predictions were based on bank erosion and sediment yield data collected on streams in Colorado (Wildland Hydrology 2008) and from data collected at discrete bank erosion modeling sites on the Kootenai River within the project area.

Table 2-10. Comparison of predicted (Colorado) and measured (Kootenai) bank erosion rates for Kootenai River reaches.					
Reach	Colorado		Kootenai		% Difference (tons/yr)
	tons/yr	tons/ft/yr	tons/yr	tons/ft/yr	
Braided 1	20,719	0.35	19,438	0.33	-6.2
Braided 2	57,429	1.29	46,785	1.05	-18.5
Straight	3,126	0.27	3,625	0.31	-15.9
Meander 1	55,863	0.54	61,256	0.59	9.6
Meander 2	237,228	0.61	309,225	0.80	-30.3

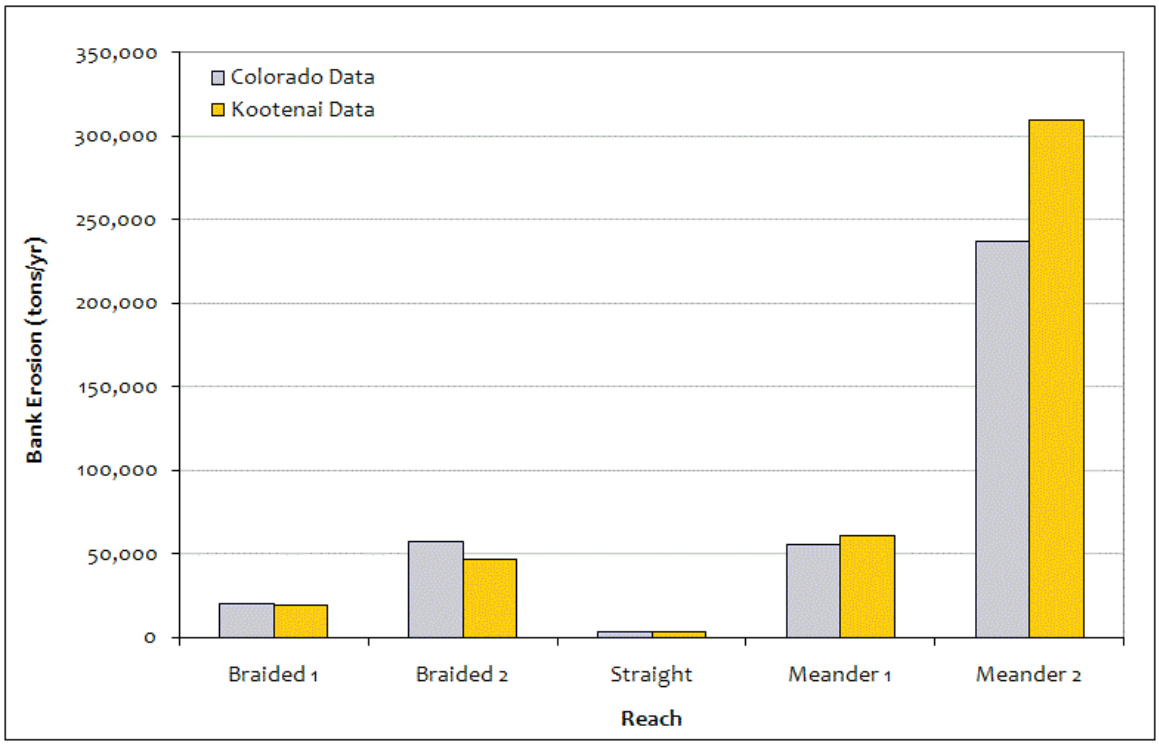


Figure 2-37. Comparison of predicted and measured bank erosion rates for the Kootenai River project area by reach (Wildland Hydrology 2008).

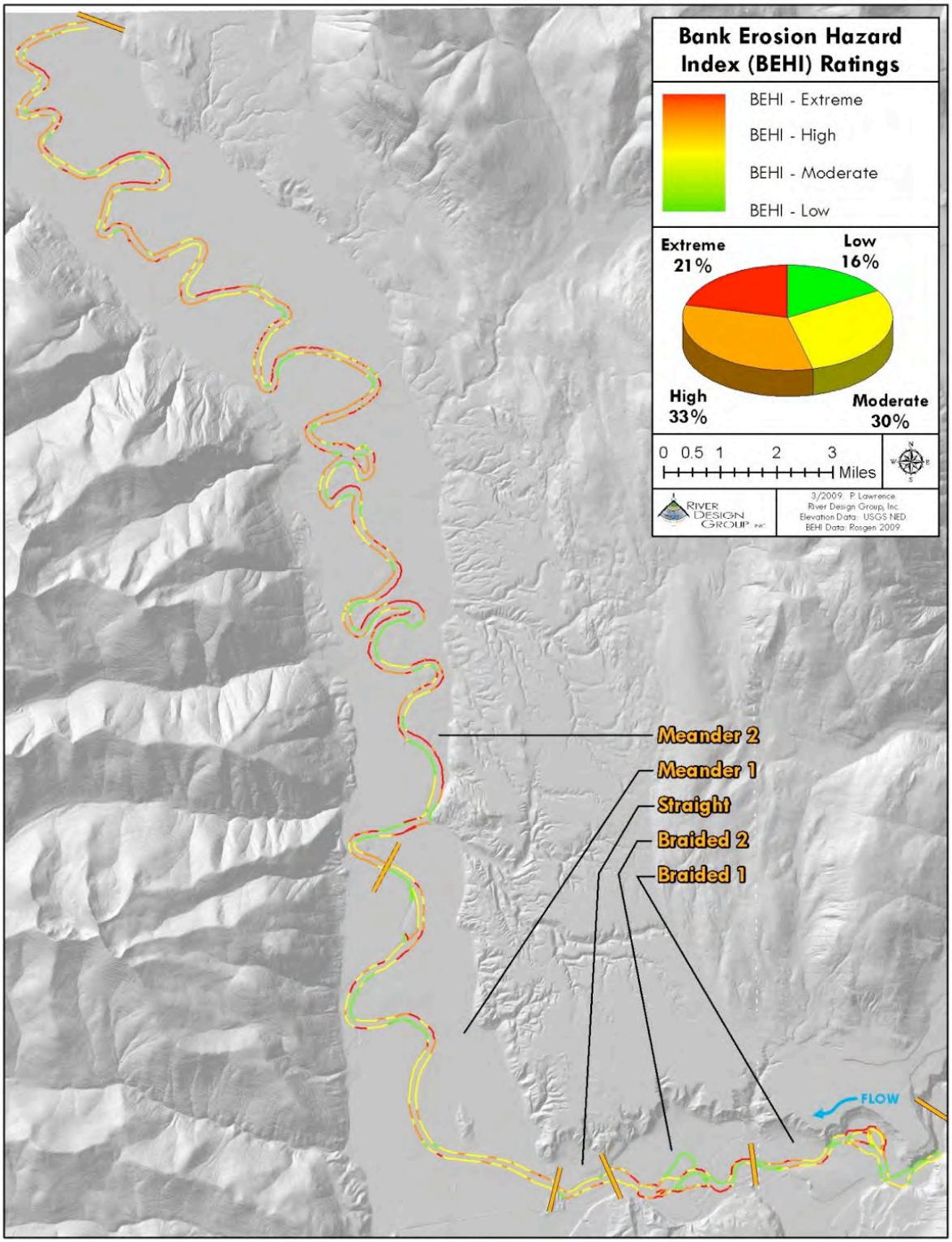


Figure 2-38. Existing condition bank erodibility hazard indices (BEHI) in the project area. The map categorizes streambanks by BEHI rating including low, moderate, high and extreme.

Braided Reaches

Bank erosion measurements completed in 2008 by USGS and Wildland Hydrology suggest the greatest bank erosion rates occur in Braided Reach 2 (Table 2-10). Prediction level bank erosion models (Wildland Hydrology 2008) suggest that 103,153 ft (total bank length) of streambank in the Braided Reach contribute 78,148 tons/yr, or 0.76 tons/ft/yr. Measured data indicate approximately 66,223 tons/yr, or 1.38 tons/ft/yr, a difference of approximately 15.3%. On a per linear foot basis, sediment generated from streambank erosion is three times higher in Braided Reach 2 than Braided Reach 1. BEHI predicted data suggest Braided Reach 2 contributes approximately 5,536 tons of sediment per mile per year compared to an estimated measured value of 6,336 tons.

Straight Reach

Streambank erosion rates in the Straight Reach are the lowest of the three reaches due to bedrock outcrops and extensive bank stabilization for scour and flood protection (Wildland Hydrology 2008). Based on measured data, the Straight Reach through Bonners Ferry produces approximately 3,625 tons/yr for 11,670 ft of streambank, or 0.31 tons/ft/yr, the lowest values of the project reaches (Table 2-10). Both streambanks in the Straight Reach are diked to prevent flooding in Bonners Ferry. Infrastructure protection measures and bedrock outcrops prevent lateral channel migration in the reach.

Meander Reaches

The Meander Reaches are characterized by considerable streambank erosion with estimated erosion rates of 0.59 tons/ft/year in Meander Reach 1 and 0.80 tons/ft/year in Meander Reach 2 (Table 2-10). Based on bank erosion data in Meander Reach 1 and Meander Reach 2, approximately 370,481 tons/yr from 489,953 ft of streambank is contributed to the system (Wildland Hydrology 2008).

In summary, bank erosion and sediment loading have always played a role in the morphology of the Kootenai River. However, observed disturbances in the project area including river and floodplain management, loss of bank vegetation, altered hydraulics, and altered sediment transport are thought to have changed the rates at which these processes occur relative to undisturbed conditions. Measured data suggest that bank erosion in the project area is a significant source of sediment to the Kootenai River. When compared with the estimated annual bedload supply (Figure 2-27), bank erosion accounts for approximately 15 to 30% of the total bedload supply. Data indicate that the highest bank erosion rates occur in Braided Reach 2, and correspond with the highest measured rates of sediment supply at RM153.3. As discussed previously, fine sediment loading has implications for aquatic habitat such as increasing the embeddedness of coarse spawning substrate with sand and finer sediment. In addition, bank erosion and associated rates of channel migration, if accelerated, could cause excessive disturbance and have negative effects on aquatic habitat and ecological processes. Moreover, bank erosion and land loss is a costly problem that affects river stewardship as well as river and floodplain management. For these reasons, ***reduced channel boundary roughness*** and ***bank erosion are identified as limiting factors for morphology***.

2.5 Vegetation Limiting Factors

Human activities have caused significant losses in riparian and wetland areas or substantially impaired riparian, wetland and overall floodplain functions along the lower Kootenai River since

the early 1900s (USEPA 2004). Some of the most serious impacts have come from the following anthropogenic activities: water impoundment and diversion; river diking, flood control and channelization; dam construction and operation; wetland draining and associated reduction of native species dependent on wetlands (including beavers); livestock grazing; urban and suburban development; clearing of land for agriculture; road building; and recreation.

This degradation impaired key riparian and floodplain wetland ecological functions, including sediment filtering, streambank building, water storage, aquifer recharge, dissipation of stream energy, nutrient retention, and fish and wildlife habitat.

The primary effects of these activities to riparian and wetland communities and overall floodplain ecosystem function include:

- Direct loss of riparian vegetation resulting in reduced floodplain and streambank stability;
- Loss of habitat and habitat connectivity both along the river and between the river and tributary systems and the river and uplands;
- Loss of natural sources of river and floodplain nutrient, organic matter and large woody debris inputs; and altered temperature regimes;
- Alterations to hydrologic and sediment regime resulting in interrupted patterns of vegetation succession;
- Loss of floodplain connectivity resulting in elimination of low velocity back water and side channel habitat;
- Loss of wetland acres and corresponding wetland function including primary production, potential sturgeon rearing habitat, wildlife and waterfowl habitat;
- Increased competition and species diversity due to the introduction and spread of non-native and invasive plant species.

The above effects have led to the following primary factors limiting restoration of riparian vegetation in the Kootenai subbasin:

- Lack of surfaces that support riparian vegetation recruitment;
- Lack of vegetation on outer banks;
- Frequent scour or deposition of alluvial surfaces;
- Altered hydroperiod;
- Invasive weeds;
- Lack of native plant diversity and seed sources; and
- Lack of nutrient sources for primary productivity and limited carbon storage.

These effects and limiting factors are described in more detail in the following sections.

2.5.1 Altered Riparian Vegetation

Riparian and wetland plant communities within the Kootenai subbasin historically would have been formed, maintained and distributed according to a variety of naturally occurring controls.

At the broadest scale, these controls would have included geology, valley geomorphology and soils. The most influential of these controls were likely related to fluvial processes that resulted in highly variable surface water/groundwater interactions, frequent flood disturbance cycles, creation and erosion of streambanks and floodplain surfaces, and significant biological feedback loops such as beaver influences, seed dispersal mechanisms, and a high frequency exchange of nutrients and organic matter.

Early photographs and artistic renderings show a multi-storied riparian system with shrubs, cottonwoods, and several conifer species (Jamieson and Braatne 2001). Very tall, large diameter white pine (*Pinus monticola*) appear to be present in many of the old photos and paintings available in Kootenai Tribe's archives, indicating that much larger wood than is currently present may have been a part of this system. General Land Office notes from between 1894 and 1898 indicate abundant marshy land, rich alluvial soils, three- to four-foot diameter cottonwoods, shrubs and several types of emergent wetlands (KTOI and MFWP 2004).

The following general structural groups of plant communities were likely present along the lower Kootenai River and within the Kootenai River floodplain prior to European settlement (interpreted from Egger et al. 2007 and Hansen et al. 1995):

- Early successional phases of cottonwood and willow would have occurred on point bar features and deposition/scour areas within the broader floodplain.
- Later successional phases of cottonwood and willow would have occurred further from the channel and along abandoned meander scrolls. Mature cottonwood stands also likely occupied extensive areas of the floodplain outside of natural levees.
- Herbaceous emergent wetlands dominated by various sedge, rush, grass and forb species would have been present in floodplain depressions, and along backwater or other open water features such as abandoned oxbows or floodplain depressions.
- Riparian areas dominated by alders (*Alnus* species), birch (*Betula* species), hawthorne (*Crataegus* species) and other hydrophytic species would have occurred along side channels, tributary streams, and in transitional areas between low floodplain surfaces and low terrace features.
- Early successional stages of pine (*Pinus* species) and cedar (*Thuja* species) would have been present in higher elevation areas of the floodplain not subject to frequent flooding, scour, or high water. These plant communities typically would occur as an understory component in pole or mature cottonwood stands.
- Later successional phases of various conifer species would develop over time on terrace features or drier microsites in the floodplain. Understory species would consist of a mix of shrubs, grasses and forbs.
- Drier grassland and shrub communities may have occupied portions of sand levees adjacent to the river.

Historical and current land uses within the Kootenai subbasin have altered the native plant communities. Riparian vegetation has been reduced by livestock grazing, clearing for agriculture and development or logging; interruption or alteration of natural flood processes; and diking. Nearly complete elimination of the deciduous riparian forest has occurred in the lower reaches of the Kootenai River below Bonners Ferry through diking and conversion to agriculture.

Approximately 50,000 acres of lowland floodplain and 23,000 acres of ephemeral and perennial wetlands have been converted into agricultural row crop and pastureland (Richards 1997). Jamieson and Braatne (2001) found that human impacts to the floodplain were much more extensive below Libby Dam where much of the river is diked and most of the floodplain is now farmland.

The loss of riparian and floodplain vegetation has reduced streambank protection and flood water filtering and retention. These functions support formation of new habitats and surfaces that are necessary for early successional plant species to establish, store flood waters and maintain late season flows. Loss of riparian vegetation has also significantly affected plant and wildlife diversity in the lower Kootenai subbasin.

Grassland and Farmland are the primary cover types in the project area, illustrating the extensive conversion of floodplain areas to drier sites. A vegetation study associated with evaluating ecosystem losses from Libby Dam operations (Egger et al. 2008) included collection of detailed plant community data for select reaches of the lower Kootenai River, regional reference stream reaches and reference reaches upstream of Libby Dam. These data show the predominance of grassland vegetation types and also distinct differences in riparian and floodplain plant community diversity and distribution between the Meander and Braided reaches (Figure 2-39). The primary differences are the lack of cottonwood and willow communities in the Meander Reaches and the predominance of Great Plains cottonwood (*Populus deltoides*) in the Meander Reaches compared with black cottonwood (*Populus trichocarpa*) being dominant in the Braided Reaches. The Braided Reaches generally supports a more diverse assemblage of riparian plant communities due to a larger overall floodplain area that is still subject to annual overbank flows. Some mature cottonwood forests within the Braided Reaches were probably established before the construction of Libby Dam. While these areas are no longer connected with the current river channel, they do support diverse, multi-storied plant communities with a native shrub understory. Within the Meander Reaches, riparian vegetation consists of cottonwood forests and shrub-dominated communities that are currently restricted to small linear bands on or within the levees and on mid-channel islands.

Table 2-11. Existing vegetation communities and other cover types within select reaches of the Kootenai River in the project area, reference reaches on the Kootenai River upstream of Libby Dam, and on other regional streams (Egger et al. 2008).

Vegetation and other Cover Types used by Egger	Lower Kootenai-Meandering	Lower Kootenai Braided	NF Reference Site	Elk River	Upper Kootenai Reference-Wasa	Upper Kootenai Reference--Fenwick
Vegetation community/cover type percent cover by reach						
River	21.44	12.52	11.07	15.77	20.77	34.8
Creek	0	0	0.34	0	0.31	0
Still water	0.43	0.75	1.57	0.90	0	0
Gravel bar or sandbar without vegetation	0.44	0	4.99	5.74	2.08	4.33
Pioneer vegetation –gravel bar	0	0.74	2.61	1.44	0.25	0
Pioneer vegetation-sand bar	0.46	0.14	0	0.29	0.88	0.22
Sandbar willow	0	0.49	0.50	0.18	1.14	2.72
Black cottonwood shrub	0	0.59	0.29	8.34	0	0
Black cottonwood-willow shrub	0	0.22	7.49	1.88	0	0
Hawthorn shrub	0.56	1.11	0	0	0	0
Grassland/willow shrub	0.0	0.25	0	0	0.91	0
Snowberry shrub/grassland	3.01	0	0	1.66	0	1.8
Mountain alder/willow shrub	0	0	0.13	1.82+1	0	1.24
Drummond willow/reed grass	0	0	1.32	0	0	0
Water birch/shrub	0	0	0	0	0.95	3.35
Yellow willow shrub	0	0	0	0	0	2.28
Sedge reed	0	0.21	0	0	0	0
Reed canarygrass	0.13	1.11	0	1.49	0	0
Cattail reed	18.15	0	0	0	0	0
Spike rush reed	0	0	0	0	1.77	0
Black cottonwood/dogwood	0	0.31	14.74	0	2.31	2.51
Black cottonwood/snowberry	0	2.77	1.38	12.52	0.72	0
Black cottonwood-spruce	0	2.82	0	3.92	4.87	0
Black cottonwood-grassland	0.33	1.23	2.16	12.41	0	0
Great plains cottonwood/snowberry	5.94	2.12	0		0	0
Great plains cottonwood/shrub	0.45	0	0		0	0
Aspen forest/dogwood	0	0.29	0		23.49	25.68
Black cottonwood/reed canarygrass	1.55	0.42	0			0
Aspen forest/snowberry	0	0.38	0			4.74
Spruce forest	0	1.58	15.81	6.41	16.42	0
Spruce forest/aspen	0	0	1.59	0	1.94	3.12
Spruce forest/black cottonwood	0	0	5.35	1.52	0.78	0
Red cedar/Black cottonwood forest	0.77	0.78+0.99	1.13	12.92	0	0
Lodgepole pine	0		22.08	0	0	0
Ponderosa pine	0		0	0	0.6	8.49
Grassland, dry	14.04	7.93	2.65	1.64	7.97	0
Grassland, fresh	13.17	16.13	1.26	7.34	11.84	1.21
Farmland	19.13	43.14	0	0	0	
Street railway	19.13	0.96	1.53	0		3.52
Bank protection	0	0	0	0.79		

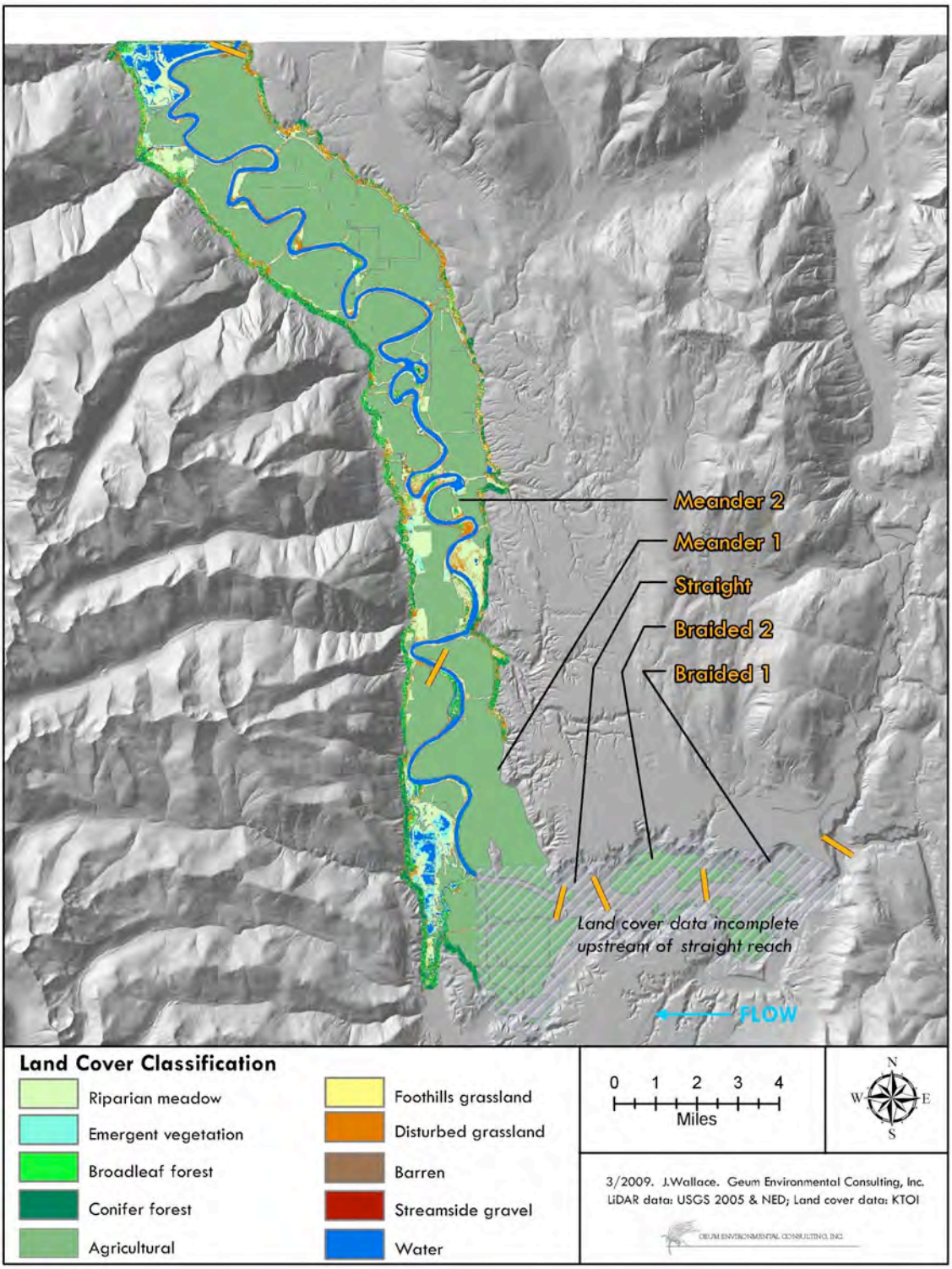


Figure 2-39. Vegetation and land cover types in the Kootenai River project reach (KTOI 2009).

The loss of riparian and floodplain vegetation contributes to reduction of the overall productivity of the lower Kootenai River system by reducing the amount of organic inputs reaching the river

and being deposited in floodplain environments where they decompose and fuel primary and secondary production. The loss of riparian vegetation has also led to a decline in the amount of large, instream woody debris, which directly impacts trout populations in the Kootenai River (USFWS 2002). Riparian vegetation loss can contribute to increased summer water temperatures by reducing overhanging cover, although this effect is more significant in smaller channels.

Succession within existing mature cottonwood stands, evidenced by the lack of a shrub understory and younger age classes or tree species, is also limited in the project area. Plant community succession appears to be hindered by a number of factors including lack of seed sources and land management including grazing and extensive agricultural operations. In general, early successional pioneer vegetation, such as willows and cottonwoods, is lacking in the project area. The lack of these plant communities is an indication of altered hydrologic and sediment-transport regimes resulting from the presence and operation of Libby Dam. Various studies have surveyed young cottonwood stands in the Kootenai River downstream from Libby Dam (Jamieson and Braatne 2001; Egger et al. 2007). These studies have found that seed germination is occurring, and young cottonwood are present, but location, species composition and age class structure differ significantly between the Braided and Meander Reaches. Various studies have identified areas in the Braided Reaches with extensive floodplains supporting a range of young aged-class black cottonwoods (Jamieson and Braatne 2001; Egger et al. 2007; Geum Environmental Consulting 2008) (Figure 2-40 and Figure 2-41). The age classes of these stands may indicate that they became established after initiation of increased spring flow releases from Libby Dam or as a result of more gradual ramping of tiered sturgeon flows that has occurred in the last decade. Young cottonwood stands are very rare in the Meander Reaches and consist almost entirely of Great Plains cottonwood (*Populus deltoides*). Additional observations of cottonwood recruitment are summarized in Appendix C.

Figure 2-40. Typical distribution of cottonwood stands on levees in the Meander Reaches (left photo). The right photo shows colonization of Great Plains cottonwood on sandbar surfaces in distinct linear banks likely tied to Libby Dam reservoir flow releases.

Figure 2-41. Young age classes of black cottonwood (left photo) and sandbar willow (right photo).

As described above, the altered riparian plant community has affected the ecosystem's ability to stabilize soils and streambanks and recolonize floodplain areas, therefore ***lack of vegetation on outer banks*** and ***lack of native plant diversity and seed sources are identified as limiting factors for riparian plant communities***.

2.5.2 Altered Hydrologic and Sediment Regime

The physical effects of the construction and operation of Libby Dam include alterations to the flow of water and sediment-transport downstream, which have resulted in significant changes to floodplain processes dependent upon natural variations in the hydrologic and sediment-transport regimes. Modifications to the timing, periodicity and magnitude of the hydrograph directly affect the processes that form and maintain floodplain plant communities. These alterations have affected riparian and wetland plant community composition throughout the project area.

Several ecological processes depend upon natural flood events, including nutrient transport, deposition and scour, seed dispersal, and ground water recharge. The altered hydrologic and sediment-transport regime has mostly eliminated nutrient and sediment exchange between the river and the floodplain. Polzin (1998), Marotz et al. (2000), and Burke et al. (2008) have documented the loss of cottonwood recruitment due to flood manipulation. Many existing riparian forests lack seedlings, saplings and pole-sized trees because the floodplain surfaces required for colonization of new plants are no longer deposited due to the reduction in peak annual flood events. The Burke et al. (2008) investigation of the Kootenai River's pre-Libby Dam hydrograph found that the historical hydrograph showed a pattern consistent with seasonal mobilization of sediment. The cottonwood and willow recruitment period coincided with sediment mobilization, providing fresh fine sediment deposition on bars (Burke et al. 2008).

As described by Burke et al. (2008), the annual pattern of sediment mobility and vegetation colonization was disrupted by the regulation of the Kootenai River by Libby Dam. Regulated flows are maintained at higher levels throughout the year, though the mobility is limited to fewer sites due to lower magnitude flood events relative to the pre-dam era. Elevated flows that are sustained through fall and winter may scour successfully recruited seedlings from the preceding recruitment period (Burke et al. 2008). Moreover, the fact that sediment mobility is less evenly distributed over the project area, but for longer periods, suggests that while the locations with

larger grain sizes are not being scoured, the finer grained locations are being scoured more frequently (Barton 2004; Burke 2006).

Jamieson and Braatne (2001) made similar conclusions in their study of the impacts of flow regulation on Kootenai River riparian cottonwood forests. Jamieson and Braatne report that in relatively unaltered sections of the Kootenai River, regular flood events are resulting in cottonwood and willow recruitment. The Braided Reaches have dikes, but the river is able to migrate between them. In these reaches, Jamieson and Braatne (2001) found large stands of mature cottonwood and recruitment of new cottonwood stands that had occurred in recent years as a result of spring flow releases from Libby Dam. In the Meander Reaches, the Kootenai river is restricted by dikes for most of its length, and Jamieson and Braatne (2001) found little evidence that cottonwood and willow recruitment had occurred since construction of Libby Dam except on point bars forming below dikes where the dikes cut across the neck of meander loops. Although the study concludes that diking for agricultural use has severely restricted the hydrologic connectivity between the river and the floodplain, Jamieson and Braatne (2001) proposed that the operation of Libby Dam is the major factor affecting cottonwood recruitment. The survival of cottonwood recruits is unknown and is likely tied to subsequent years' flows and erosion processes. Snyder (2002) reported in her assessment that dikes were constantly being eroded and reshaped, which may affect cottonwood survival. Appendix C provides additional details about cottonwood and willow recruitment in the Meander Reaches.

Based on these studies and field observations documented in Appendix C, ***lack of surfaces that support riparian recruitment*** and ***frequent scour and deposition of floodplain surfaces were identified as limiting factors for riparian plant communities.***

2.5.3 Altered Floodplain Connectivity

Channelization, diking and altered flood regimes have all contributed to a large-scale reduction in available, connected floodplain for the Kootenai River to access within the project area. In addition, most of this floodplain area has been converted from native riparian and wetland complexes to agricultural cropland or pastureland (Figure 2-42). Natural levees were present in most of the project area due to the backwater effect created by Kootenay Lake and seasonal flooding of the Kootenai River. Despite the height of the natural levees, the Kootenai River regularly inundated the adjacent floodplain. Reduced floodplain connectivity is mainly due to the regulation of flows by Libby Dam and construction of levees.

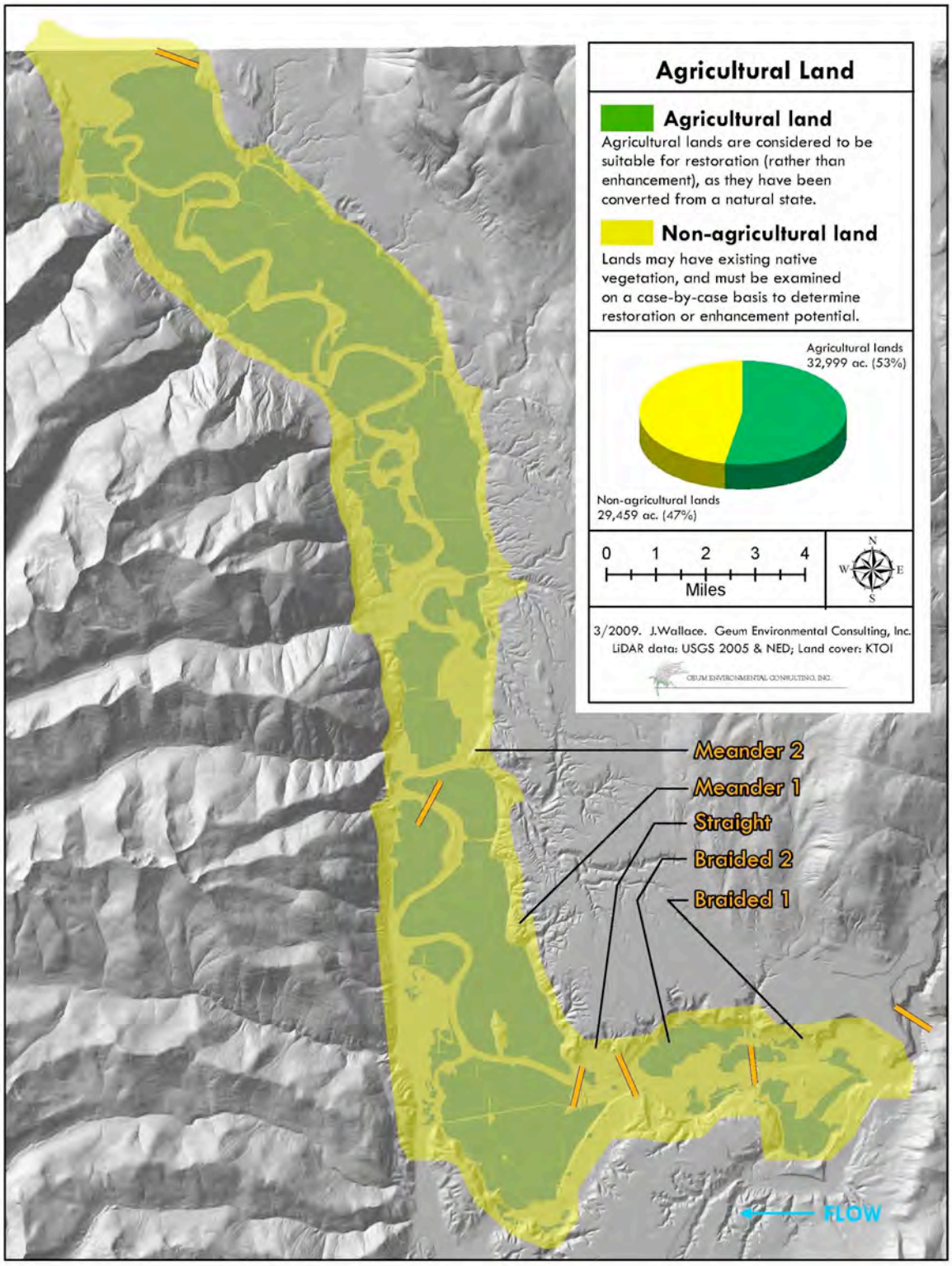


Figure 2-42. Distribution of agricultural and non-agricultural land in the Kootenai River project area.

Historically, plant communities were adapted to and dependent upon the free-flowing flood disturbance patterns of the Kootenai River and the connection between the river and floodplain. Over time, and under the pressure of the various anthropogenic disturbances, native plant communities have shifted from diverse, in both species and structure, to simple and ecologically static communities adapted to a steady environment resulting from fewer large disturbance events. Reduced floodplain connectivity, combined with a lower water table and reduced stream flows, has resulted in a shift from extensive, complex riparian and wetland communities to a predominance of agricultural fields and drier, flood intolerant plant communities along streambanks and many portions of the floodplain.

Based on these changes, ***altered hydroperiod was identified as a limiting factor for riparian plant communities.***

2.5.4 Altered Wetland Function

Before European settlement, the lower Kootenai subbasin experienced frequent floods, which formed approximately 22,000 acres of wetlands and associated riparian habitats (KTOI 2004). The alterations described in the previous sections affected wetland acres and function within the Kootenai River floodplain. In the lower Kootenai subbasin, approximately 50,000 acres of lowland floodplain and 23,000 acres of ephemeral and perennial wetlands in the U.S. portion of the Kootenai subbasin (Figure 2-43) have been converted to agricultural crop and pastureland (EPA 2004). Before European settlement, the lower Kootenai subbasin experienced frequent floods, which formed approximately 22,000 acres of wetlands and associated riparian habitats (KTOI 2004).

Table 2-12 lists the estimated wetland acres remaining by elevation above sea level in the lower Kootenai subbasin (McPhail and Baxter 1996). Some land in the project area was converted back to wetlands by the early 1990s in an area that is now managed as a wildlife refuge with managed wetland areas behind the dikes (Jamieson and Braatne 2001).

Table 2-12. National Wetlands Inventory (NWI) acres of wetlands in the lower Kootenai subbasin.

Lentic Environments	Total Acres	0-2,500 ft elevation	2,500-4,500 ft elevation	4,500+ft elevation
NWI-Palustrine	6,002.9	3,199.0	2,257.6	546.3
NWI-Lacustrine	1,044.0	635.1	303.8	105.9
Total	7,046.9	3,834.1	2,561.4	652.2
Riverine	5,040.1	4,755.2	2,846.3	0.0
Lotic Environments	Total Miles of Streams	Total Miles of Streams in 500-Year Floodplain	Total Miles of Streams in Upland Areas	
	1,897.9	164.2		1,733.7

Source: NWI as reported in KTOI 2004. Lentic and lotic inventories in Boundary County, Idaho.

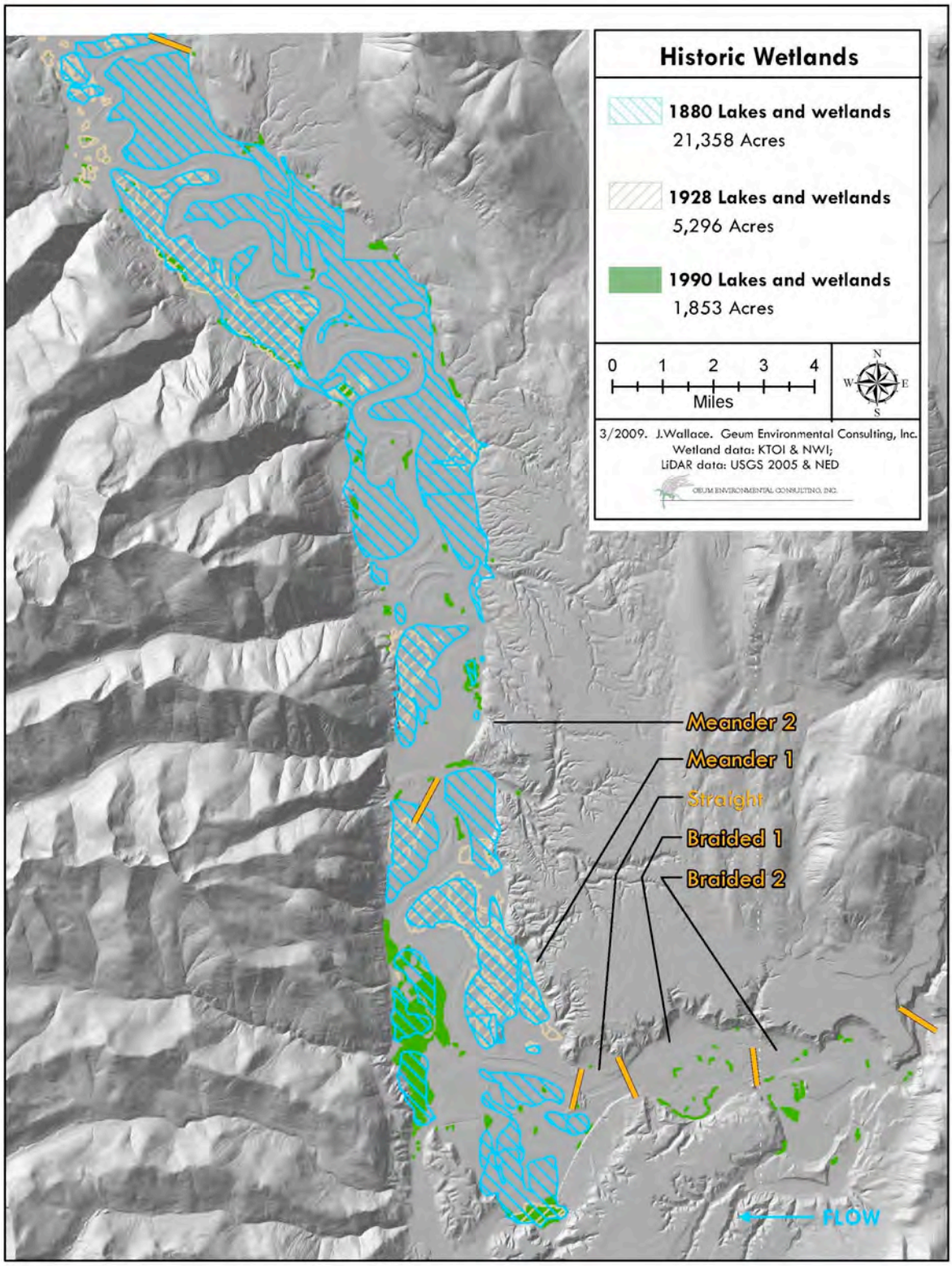


Figure 2-43. Time-series analysis of wetland change, 1890-1990 (Modified from USEPA 2004).

A study completed by Sieracki (2002) mapped approximately 265 miles of streams and ditches present in the 500-year Kootenai River floodplain within Boundary County, Idaho. Based on the 1928 USGS maps there were 182 miles of streams and ditches in the floodplain. Relative to the 1928 map, there has been an 83 mile increase in the length of floodplain channels over the past 75 years. The increase in channel length is due to a higher density of ditches that support agriculture; therefore, this increase does not represent an increase in functioning stream channel length within the floodplain. The more expansive channel and ditch network is used to distribute water to support agriculture, resulting in overall negative impacts on tributary conditions, floodplain function, and floodplain ecology.

Wetland systems in the lower Kootenai subbasin probably contributed substantially to the influx of carbon and nutrients to the Kootenai River. Wetland habitats rely on the nutrients and water recharge provided by high spring flows. Although natural levees and constructed dikes are present along much of the lower Kootenai River, the river often overtopped dikes and flooded agricultural lands. These flood events supplied nutrient inputs and created low velocity, backwater and side channel habitat (PWI 1999). These inputs have been reduced by the construction and operation of Libby Dam. Other wetland functions affected by anthropogenic activities include: reduced area and diversity of habitats for a wide range of species, loss of floodwater storage capacity, aquifer recharge and maintenance of base flows, and filtering of sediments, nutrients and other potential contaminants.

Based on these changes in wetlands, ***altered hydroperiod***, ***lack of nutrients for primary productivity*** and ***altered carbon balance were identified as limiting factors for riparian plant communities.***

2.5.5 Altered Species Composition

Humans have introduced several non-native grass and forb species within the riparian and floodplain areas of the lower Kootenai subbasin. Competition and reduced species diversity due to the introduction and spread of non-native and invasive species is a limiting factor that will need to be addressed to restore diverse, native riparian and wetland plant communities.

Extensive populations of non-native species, particularly reed canarygrass (*Phalaris arundinacea*) and common tansy (*Tanacetum vulgare*) are present along the river (KTOI and MFWP 2004). Other invasive forb species include spotted knapweed (*Centaurea maculosa*), Canada thistle (*Cirsium arvense*), and houndstongue (*Cynoglossum officinale*). Non-native grasses include quackgrass (*Agropyron repens*) and redtop (*Agrostis stolonifera*). A study of the vegetation composition on dikes along the Kootenai River below Bonners Ferry by Snyder (2002), showed out of 100 plant species identified, 61% of those were non-native and 39% were native. These non-native species reduce the value of the areas for wildlife habitat and can displace native plant species. Within the Meander reaches, aggressive grasses such as reed canarygrass appear to be colonizing similar depositional features as cottonwood seedlings (see Appendix C for additional discussion). The ability of reed canarygrass to spread rapidly, form dense root mats, and tolerate fluctuating water levels may be one factor limiting establishment of cottonwoods in these areas.

The abundance of aquatic macrophytes has increased in the post-dam environment. Eurasian watermilfoil (*Myriophyllum spicatum*) is present in the lower Kootenai River. The introduction of Eurasian watermilfoil can drastically alter a water body's ecology. Eurasian watermilfoil forms very dense mats of vegetation on the water-surface which can reduce oxygen levels in the water

and shade out of native aquatic vegetation. However, based on the habitat requirements of Eurasian watermilfoil, it is not expected to cover or colonize most of the river channel, with possible exceptions of near-shore or shallow, low velocity areas.

Based on the presence of non-native and invasive plant species, ***invasive plants have been identified as a limiting factor for riparian plant communities.***

2.6 Aquatic Habitat Limiting Factors

In developing the Kootenai River Habitat Restoration Project Master Plan, six Kootenai River aquatic focal species were considered: Kootenai sturgeon, burbot, bull trout, Columbia River redband trout, westslope cutthroat trout, and kokanee salmon. Each of these six aquatic focal species has been affected by anthropogenic activities within the river corridor and corresponding changes to the aquatic habitat.

This section provides a summary of the historical and current status of each species, an abbreviated overview of the life history of each species, and describes the species' habitat requirements, and the habitat factors thought to limit naturally self-sustaining populations of each species. Finally, this section includes a discussion of how broad ecosystem level changes have resulted in the current aquatic habitat limiting factors that are being addressed by this Master Plan.

Within the Kootenai River project area, the specific anthropogenic activities that have had the most direct effects on aquatic habitat include:

- River diking, flood control and channelization;
- Dam construction and operation;
- Land clearing, side channel and wetland filling for agriculture;
- Suburban and urban development;
- Road and railroad construction;
- Trapping and killing of beaver; and
- Introduction of non-native fish and plant species.

The primary effects of these activities to aquatic habitat include:

- Loss of backwater, side channel, and off-channel habitats resulting from river corridor simplification for flood control and agriculture;
- Disconnected floodplain tributaries due to infrastructure fish passage barriers;
- Floodplain tributary manipulation and land surface draining to facilitate agriculture;
- Altered hydrology influencing river hydraulics including hydraulic depth and water velocity, which influences fish movement and spawning migration timing;
- Dam operations influenced the thermal regime, which influences spawning migration timing and spawning success;

- Nutrient sequestration in Lake Koocanusa, disconnection of the river from the floodplain, and loss of riparian vegetation and wetlands disrupt primary productivity and undermine the basis of the food web;
- Coarse bedload trapping in Lake Koocanusa, lower shear stress and sediment competency in the project area, and fine sediment inputs affect sediment particle size distribution, availability of suitable spawning substrate, and embeddedness of coarse substrate;
- Absence of large wood from the channel and a diminished riparian forest have reduced large wood accumulations and loading to the river;
- Loss of wetland acres and corresponding wetland function including primary production have diminished potential sturgeon rearing habitat, wildlife and waterfowl habitat; and
- Aquatic habitat simplification due to introduced plant species (e.g., water milfoil) and encroachment of aquatic vegetation related to river management changes.

The above effects have led to the following primary factors limiting aquatic habitat in the Kootenai subbasin:

- Insufficient depth for Kootenai sturgeon migration;
- Insufficient velocity for successful Kootenai sturgeon spawning, incubation, and early life stages;
- Lack of coarse substrate for egg attachment;
- Lack of cover for juvenile fish;
- Lack of pool-riffle complexity;
- Simplified food web from lack of nutrients;
- Insufficient pool frequency;
- Lack of fish passage into tributaries;
- Lack of off-channel habitat for rearing; and
- Altered water quality.

These effects and factors are described in more detail in the following two sections, which link focal species to aquatic habitat limiting factors, and with altered ecosystem effects on aquatic habitat.

2.6.1 Overview Aquatic Focal Species

The following sections present information about the historical and current status, life histories, and habitat factors thought to limit naturally self-sustaining populations of the six aquatic focal species that were considered in developing this Master Plan (Kootenai sturgeon, burbot, bull trout, kokanee, Columbia River redband trout, and westslope cutthroat trout).

In addition to the above information, this section includes a summary table for each of the six species, of preferred habitat characteristics thought to meet the physical habitat requirements

and preferences for that species. This information was used to help guide the identification and conceptual development of restoration strategies and restoration treatments described in subsequent chapters of this Master Plan. The information presented in these tables was identified through a collaborative process incorporating expert opinions from regional co-managers and biologists. The process for developing and refining the information presented in these tables and additional information that was identified in the original tables is described in Appendix D along with additional details related to each of the tables.

2.6.1.1 Kootenai River White Sturgeon

The following information is drawn primarily from the Kootenai Subbasin Plan (KTOI and MFWP 2004); recent research papers and peer review publications; Kootenai Tribe publications, reports, and project proposals; and the Critical Habitat Revised Designation for the Kootenai River Population of the White Sturgeon (*Acipenser transmontanus*): Final rule (USFWS 2008).

Historical and Current Status

Relatively little is known about the historical status of Kootenai sturgeon in the Kootenai Subbasin (KTOI and MFWP 2004). Within the Kootenai River Subbasin, white sturgeon historically occupied an approximately 300 km (186.5 mile) reach, from Kootenai Falls (km 380.5) downstream to the north end of Kootenay Lake (km 17), and upstream into what is now Duncan Reservoir, as well all of the lake's West Arm (approx. 50 km or 31 miles) (KTOI and MFWP 2004).

Most white sturgeon populations in western North America are anadromous. Only the Kootenai River supports a naturally landlocked population. Kootenai Falls, Montana, and Bonnington Falls, British Columbia, are thought to have been migration barriers that isolated white sturgeon in a 270 km reach of the Kootenai River in Montana, Idaho, and British Columbia after recolonization following the most recent Pleistocene glacial period (Wisconsin), approximately 12,000 years BP (Alden 1953; Northcote 1973; Partridge 1983). During this glacial period, the outlet of the West Arm of Kootenay Lake was blocked by ice. This blockage formed glacial Lake Kootenay, which extended south into the area currently occupied by the Lake Pend Oreille system. It is believed that this connection with the large glacial lakes to the south permitted recolonization of the Kootenai region by fish species whose subsequent migration was blocked by Kootenai and Bonnington Falls (Alden 1953).

Consequently, this population adapted to specific local conditions in the Kootenai River headwater system. Kootenai sturgeon are active at cooler temperatures (Paragamian and Kruse 2001), spawn in different habitats (Paragamian et al. 2001), and have lower genetic diversity than other populations in western river systems (Bartley et al. 1985; Setter 1989; Setter and Brannon 1992; Anders et al. 2000; Anders 2002; Anders and Powell 2002; Rodzen et al. 2004). The range of this population extends from Kootenay Lake upstream 190 km to Kootenai Falls, but they are primarily found in the low gradient reach downstream from Bonners Ferry and in Kootenay Lake.

The Kootenai sturgeon was listed as endangered on September 6, 1994 (59 FR 45989) under the ESA and a recovery plan was completed in 1999 (UWFWS 1999). Within Canada, white sturgeon occur only in British Columbia and are divided into six populations, based on geography and genetics: the lower, mid and upper Fraser River, Nechako River, Columbia River, and Kootenay River. All populations were listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), but only the latter four are legally listed under the Canadian Species at Risk Act (SARA). Kootenay sturgeon are included in this group and are listed as

endangered under SARA. A recovery plan for white sturgeon is currently being developed under SARA and is scheduled for release in late 2009 or early 2010.

A hind-casted recruitment history generated with empirical data indicates that natural recruitment initially plummeting around 1950 to 1960 and has been largely suppressed or absent ever since. A few minor exceptions of limited year class production, but at levels insufficient for population viability and persistence, were observed during the early 1970s (Paragamian et al. 2005). Despite annual monitoring during recent decades, too few wild fish are captured to produce reliable recruitment estimates. The remnant population is currently distributed in a 250 km reach of the Kootenai River from the Bonners Ferry area downstream into and including all of Kootenay Lake.

Current population abundance is estimated to be approximately 500-1,000 adults, with the population decreasing by 50% in roughly 8 years, down from a reconstructed abundance estimate of approximately 8,000 adults in 1980 (Paragamian et al. 2005). The next 10-20 years will be a critical period for the future of sturgeon in the Kootenai River. There will be a significant bottleneck in spawner numbers as the wild population declines but hatchery fish are not yet mature. Kootenai sturgeon begin maturing around 30 years of age and so the first hatchery-reared fish from releases in the early 1990s will begin reaching maturity around the year 2020. In the interim, the wild population will reach critical low levels where normal population processes begin to break down on the final slide into extinction (the "extinction vortex" described by Gilpin and Soule 1986).

The Kootenai Tribe initiated a sturgeon conservation aquaculture program in 1989 as a stopgap measure designed to ensure preservation of an adequate demographic and genetic base for a healthy future population while adequate habitat restoration actions are implemented and have a chance to take effect. This conservation aquaculture program currently provides the only significant source of recruitment for the Kootenai River population.[4] The Tribe submitted a proposal to the NPCC (Kootenai River Native Fish Conservation Aquaculture Programs Master Plan) in July of 2009 proposing vital hatchery upgrades for the existing Tribal Sturgeon Hatchery near Bonners Ferry, and construction of a new hatchery facility near the confluence of the Moyie and Kootenai rivers that will provide additional rearing capacity for sturgeon and help to imprint fish on waters further upstream where suitable habitat currently is thought to exist.

[4] The Libby Dam BiOp specifically acknowledges the essential role of the Tribe's sturgeon aquaculture program in Reasonable and Prudent Action (RPA) Component 4, and directs the action agencies to provide funding to expand adult holding and spawning capability at the Tribal Sturgeon Hatchery (RPA Action 4.2) (USFWS 2006, clarified in 2008).

Life History

The longevity of Kootenai sturgeon (up to 100 years), lengthy maturation period (approximately age 30 in Kootenai females), and spawning periodicity (5 or more years in females) suggests that white sturgeon populations can persist through extended periods of unsuitable spawning conditions. This adaptation is particularly well suited to large, dynamic river systems where suitable combinations of habitat, temperature, and flow may not occur every year (Beamsderfer and Farr 1997).

Many Kootenai sturgeon are thought to spend part of their lives in Kootenay Lake in British Columbia and migrate upstream to spawn in the Kootenai River (USFWS 2008). Kootenai sturgeon have been described as having a unique two-step pre-spawning migration process, migrating first from the lower river and Kootenay Lake during autumn to staging reaches in the Kootenai River, then migrating in spring to the spawning reach near Bonners Ferry, Idaho (Paragamian et al. 2001; Paragamian et al. 2002).

White sturgeon are broadcast spawners and release demersal eggs (eggs that quickly sink to the bottom) that are initially adhesive upon exposure to water (Paragamian et al. 2001; Anders et al. 2002). Successful reproduction appears to depend on Kootenai sturgeon spawning over coarse bed material that supports egg viability, and where the free embryos that emerge from the eggs have appropriate habitat for development and protection from predators (USFWS 2008). Rocky substrates are thought to provide fixed surfaces for the attachment of the adhesive eggs during incubation and also to provide shelter for the "hiding phase" period following hatching in which free embryos seek cover from predators in the inter-gravel spaces (Brannon et al. 1985; Parsley et al. 2002).

Although there is little information specific to spawning substrates for Kootenai sturgeon, in other areas where white sturgeon are reliably reproducing and recruiting, the river bed at spawning sites typically consists of several miles of gravel, cobble, and boulder substrates that provide shelter and cover during this free embryo hiding phase (USFWS 2008).

White sturgeon spawn in fast-flowing water, and water velocity appears to act as a cue for spawning (USFWS 2008). White sturgeon spawning in fast-flowing water greater than or equal to 3.3 ft/s (1.0 m/s) may also experience reduced predation on eggs by limiting access of some predators to spawning and incubation areas (Brannon et al. 1985; Miller and Beckman 1996; Anders et al. 2002; Parsley et al. 2002).

Fast flowing waters also help to maintain the exposed rocky substrate essential for successful egg incubation and the free embryo hiding phase of the Kootenai sturgeon's reproduction cycle (USFWS 2008). Water depth is also thought to be an important factor in spawning site selection for the Kootenai sturgeon. The USFWS (2008) identified a minimum water depth of 23 ft (7 m) as a requisite for successful spawning in their 2008 revised critical habitat designation for Kootenai River white sturgeon.

Kootenai sturgeon appear to spawn within a fairly narrow range of water temperatures, from 47.3 to 53.6°F (8.5 to 12°C) (Paragamian et al. 2002). Paragamian and Wakkinen (2002) identify temperatures between 49.1 and 49.9°F (9.5 and 9.9°C), or roughly 50°F (10°C), as those at which spawning has the highest probability of occurring in the Kootenai River (USFWS 2008). Sudden drops of water temperature greater than 3.6°F (2.0°C) cause males to become reproductively inactive, thereby negatively affecting egg fertilization (Lewandowski 2004).

In the period following construction of Libby Dam, most Kootenai sturgeon appear to spawn over sandy substrates in the meander reach below Bonners Ferry (USFWS 2008). As previously described in this document, the meander reach has a low stream gradient, and substrates are composed primarily of sand and other fine materials overlying lacustrine clay (Barton 2003; Barton et al. 2004; USFWS 2008). Many of the eggs that are located in this reach are found drifting along the river bottom, covered with fine sand particles in sites without rocky substrate (Paragamian et al. 2001), and where mean water column velocities seldom exceeded 3.3 ft/s (1.0 m/s) (Paragamian et al. 2001; Barton et al. 2005; USFWS 2008).

Healthy sturgeon populations are generally characterized by age-frequency distributions that include large percentages of juveniles and sub-adults. Age and length distributions in such populations are stable and are skewed toward young fish. The lower Columbia River white sturgeon population is composed of > 95% sexually immature fish and this population also sustains an annual harvest of 50,000 fish (DeVore et al. 1999). The age and length of the Kootenai population are heavily skewed toward older fish; approximately 90% are age 25 and older (BPA 1997; Paragamian et al. 2005).

Habitat Requirements and Limiting Factors

In addition to demographic and genetic requirements, suitable physical habitat (abiotic) and ecological (biotic) conditions are required for viability and persistence of fish populations (KTOI and MFWP 2004). In particular, key ecological requirements for Kootenai River white sturgeon include, but are not limited to: suitable water quality, suitable hydraulic and thermal conditions, and predation and competition within ranges that collectively allow life cycle completion. Abiotic and biotic factors must be collectively suitable for completion of each specific life stage in the life cycle process, including: spawning, incubation, recruitment, juvenile and subadult rearing, sexual maturation and reproduction (KTOI and MFWP 2004).

Table 2-13 on the following page, presents a snapshot of preferred habitat characteristics based on empirical data, literature, and expert professional judgment (see Appendix D for additional detail). Consideration is given to habitat preference at each life stage and the relevant duration or seasonality for that life stage habitat requirement. Table 2-13 show the river reach used at each life stage, whether water temperature is a consideration, type of substrate preference, cover related factors, hydraulics, flow related considerations, and channel geometry considerations. Variables noted with an "X" in the table below are believed to be important to the specified Kootenai sturgeon life stage.

Table 2-13. Kootenai sturgeon life stage and preferred habitat characteristics based on empirical data, literature, and professional judgment.

Life Stage	Non-Reproductive Adult	Migrating Adult	Spawning Adult	Embryo	Free Embryo	Larva	Age 0+ Juvenile
Duration/ Seasonality	**Year Round**	**Jan to May**	**May to Jul**	**May to Jul**	**Jun to Aug**	**Jun to Aug**	**~ 65 days, Fall**
River Reach Used by Life Stage							
Canyon	X						
Braided Reach 1							
Braided Reach 2		X					
Straight Reach		X	X	X	X		
Meander Reach 1		X	X	X	X		
Meander Reach 2	X	X	X	X	X	X	
Tributaries							
Temperature							
Water Temperature			X		X		
Substrate							
Type of substrate			X	X	X		
Particle size distribution			X	X	X		
Longitudinal extent (length)			X	X	X		
Interstitial spaces				X	X		
Cover							
Depth/incident light					X		
Hydraulic cover			X		X	X	X
Large woody debris					X		
Bedforms				X			
Hydraulics							
Velocity variability	X	X	X	X	X	X	X
Boundary sheer stress				X	X		
Bedload transport				X			
Hydro operations							
Flow duration, frequency, and magnitude		X	X	X	X		
Channel geometry							
Habitat diversity	X			X			X
Depth	X	X			X		X
Channel stability				X	X		X
Floodplain							X
Connection with off-channel habitat						X	X
Connection with tributary habitat						X	X
Slope/gradient	X	X	X		X	X	X
Pool/riffle/run ratio; pool spacing	X	X	X		X	X	X

Self-sustaining natural populations of Kootenai sturgeon may be recruitment habitat limited, stock limited or both (Anders et al. 2002). River regulation and related and unrelated habitat alterations (e.g., changes in river morphology, loss of floodplain connectivity, loss of riparian habitat) have significantly compromised the quantity and quality of available habitat. Demographic stock limits and early life mortality also are limiting factors for Kootenai sturgeon. Early life mortality factors are thought to include: unfertilized eggs, egg suffocation, egg predation, predation of fry and fingerling, food limitations, and first over-winter mortality (Duke et al. 1999; USFWS 1999; Anders et al. 2002).

A number of factors are thought to account for the Kootenai sturgeon population's decline. However, at this time recruitment failure is generally recognized as the first bottleneck to Kootenai sturgeon survival and a range of recruitment failure hypotheses are most commonly cited as the reason for the Kootenai sturgeon's endangered status.

Decades of study have consistently indicated that recruitment failure most likely occurs during the embryo (incubation to early life) stages (Partridge 1983; Duke 1999; USFWS 1999; Paragamian et al. 2001; Anders et al. 2002; Paragamian et al 2005; KTOI 2008). Several hypotheses have been advanced to explain the relationships between river system changes and ongoing recruitment limitation and failure of Kootenai sturgeon.

These hypotheses are aggregated into time periods to delineate potential failure mechanisms prior to, and after, the completion of Libby Dam in 1972. Following is a summary of the major Kootenai sturgeon recruitment failure hypotheses.

Pre-Dam Hypotheses:

- Ecosystem Degradation Hypothesis – Recruitment failure is due to direct and indirect cascading effects of habitat alteration and loss of the natural floodplain (e.g., reduced nutrient and food availability, altered competition and predation, and reduced habitat quality and availability) (Anders et al. 2002).
- Imprinting/Homing Failure Hypothesis – Kootenai sturgeon no longer migrate upstream from Bonners Ferry into what appears to be suitable spawning, incubation, and early rearing habitats, because fish that historically spawned in these reaches (possibly as far upstream as the "sturgeon hole" at the base of Kootenay Falls) no longer exist.
- Riparian Habitat Loss Hypothesis – Widespread collapse of resident white sturgeon populations is due primarily to the loss of flooded riparian vegetation, which might provide critical incubation and early rearing conditions (Coutant 2004).
- Stock Limitation Hypothesis – Insufficient broodstock remain in the population to produce enough early life stages to compensate for total additive mortality in the post-development Kootenai River.

Post-Dam Hypotheses:

- Flow Reduction Hypothesis – Recruitment failure has resulted from the effects of flow regulation on spawning and early rearing conditions (Paragamian et al. 2001).
- Sand Invasion Hypothesis – Post-dam hydraulics and erosion contribute to sand invasion and accumulation in the braided and meander reaches (assumed to be detrimental to spawning, incubation, and possibly survival of free embryos).

- Scour Hypothesis – Spawning historically occurred in present spawning locations, however reduced flood flows and stream power resulting from operations of Libby Dam have generally failed to clean the hard substrates of sediment or sand cover as would have occurred under historical flow conditions.
- Upstream Migration Barrier Hypothesis – Some number of Kootenai sturgeon historically migrated upstream past Bonners Ferry to spawn in the braided and/or canyon reaches but post-dam habitat features now restrict or prohibit that historical upstream migration.
- Shifted Hydraulic Cue Hypothesis – Prior to levee construction and dam operation, hydraulic conditions that served as spawning cues may have existed further upstream (in the braided reach). Today, similar hydraulic conditions may now exist downstream (in the meander reach) in the current spawning reach due to channel constriction from the enhanced levees.
- Olfactory Spawning Location Shift Hypothesis – Pheromones and chemical odorants produced by females (held in captivity to spawn at the Tribal Sturgeon Hatchery near Bonners Ferry) are released into the river via hatchery effluent and may be influencing the location where Kootenai sturgeon currently spawn (i.e., influencing the sturgeon to not migrate further upstream to spawn).

The breadth of the recruitment failure hypotheses suggest the Kootenai sturgeon population is affected by multiple factors rather than a single or relatively small number of conditions. Due to the range of factors that have been linked to the declining population, addressing recruitment failure within the urgent time frame dictated by the population's decline will require an ecosystem-level approach that goes beyond merely modifying how Libby Dam is operated or focusing restoration actions on a single habitat component like depth, flow or spawning substrate.

2.6.1.2 Burbot

Information in this section is drawn primarily from the Kootenai Subbasin Plan (KTOI and MFWP 2004) and the Kootenai River/Kootenay Lake Burbot Conservation Strategy (KVRI 2005).

Historical and Current Status

Although the abundance of the West Arm Kootenay Lake burbot population prior to 1967 was estimated at 200,000 (Ahrens and Korman 2002), historical abundance of Kootenai River and Kootenai Basin burbot populations remains largely unknown (KVRI 2005).

Historically, burbot were distributed throughout the Kootenai subbasin; however, their natural distribution does not appear to have been contiguous. Although burbot existed in numerous adjacent watersheds in British Columbia (e.g., Arrow Lakes, Columbia River, Slocan Lake), burbot in the Kootenai system were historically isolated from those watersheds by the impassable Bonnington Falls, located downstream from Nelson, B.C. and now inundated between dams. This geographic isolation is thought to have occured post-glacially about 10,000-12,000 years ago (Alden 1953; Northcote 1973). Kootenai Falls in Montana was reported to be a natural upstream barrier to burbot passage. However, burbot and burbot fisheries historically existed upstream from Bonnington and Kootenai falls, and burbot can successfully move downstream through this upstream migration barrier. Numerous dams (e.g. Cora Linn, 1931; Duncan, 1967; and Libby, 1972) have further restricted the distribution and movements of Kootenai Subbasin burbot.

The largest burbot concentrations were believed to have inhabited the Balfour area near the inlet to Kootenay Lake's West Arm, and to a lesser extent seasonally inhabited the Kootenai River from Kootenay Lake to Kootenai Falls. Based on empirical reproductive data collected from fisheries, at least two distinct burbot stocks likely existed in Idaho and British Columbia. One was a lacustrine population in Kootenay Lake, the other a fluvial or adfluvial population in the Kootenai River. Temporal and geographic reproductive isolation appears sufficient to infer reproductive isolation (Martin 1976; Hammond and Anders 2003).

The Kootenai River and Kootenay Lake once provided popular and important sport, subsistence, and commercial burbot fisheries, and may have provided one of the most robust burbot fisheries in North America (Paragamian and Hoyle 2004). Tribal elders report that ling (burbot) were extremely abundant in the Kootenai River in Idaho and were a main staple for the Tribe in the late winter/early spring months. The Kootenai Tribe relied heavily upon this important subsistence fishery and tribal members were very adept at using weirs and traps.

In 1993, IDFG in coordination with other partners implemented a program to assess burbot abundance, distribution, size, reproductive success, and movement, and to identify factors limiting burbot in the Kootenai River in Idaho and British Columbia. A total of only 17 burbot were caught in 1993 (CPUE of one burbot/33 net days) and 8 in 1994 (CPUE of one burbot/111 net days). Only one burbot was captured between Bonners Ferry and the Montana border, with no evidence of reproduction in Idaho. Cooperative sampling in the British Columbia river reach suggested that burbot were only slightly more abundant in the lower river. Telemetry studies indicate that the existing population is transboundary (Paragamian 2000).

When it became clear that the burbot fishery was at risk of failing, regional managers took measures to reduce exploitation by reducing creel limits and implementing fishery closures, but none of these measures restored the fishery (Paragamian et al. 2000). Examples of stock rebound in overexploited burbot populations with fishery restrictions or closures have been documented, although habitat was generally intact in such cases (Paragamian et al. 2000). Since they began monitoring the movement, habitat use, and spawning behavior of burbot in 1993, IDFG has not found evidence of successful spawning or recruitment in Idaho.

Kootenai River native burbot were proposed for ESA listing in 2000. However, the USFWS determined that the population was not eligible for listing because it does not comprise a Distinct Population Segment. Rather than listing burbot as threatened or endangered under the ESA, the Kootenai Valley Resource Initiative Burbot Subcommittee[5], in coordination with the USFWS and other stakeholders proposed the Kootenai River drainage as a "pilot project" to develop, implement, and evaluate a Conservation Strategy for Lower Kootenai River Burbot in lieu of an ESA listing.

[5] The Kootenai Valley Resource Initiative (KVRI) was formed under a Joint Powers Agreement (JPA) between the Kootenai Tribe, the City of Bonners Ferry, and Boundary County, dated October 2001. Under the JPA, the KVRI is empowered to foster community involvement and development to restore and enhance the resources of the Kootenai Valley. The KVRI membership and its partners include the Kootenai Tribe, who initiated the process, federal, state, and provincial fisheries and water regulatory agencies, regional city and county governments, private citizens, landowners, environmental advocacy groups, and regional representatives of business and industry. The KVRI Burbot Subcommittee was formed as a subset of the KVRI to pursue coordinated burbot conservation and management.

Currently, most burbot in the Kootenai River Subbasin exist in three separate lake systems: Koocanusa Reservoir in Montana, Duncan Reservoir in B.C., and Trout Lake in B.C. (figure 4.17). Little is known about the distribution of burbot in Koocanusa Reservoir and the upper Kootenai River upstream from the lake. Distribution of burbot in Duncan Reservoir and Trout Lake was addressed in Spence (2000), Neufeld and Spence (2001), Spence and Neufeld (2002), and Baxter et al. (2002a, 2002b). In addition, Bisset and Cope (2002) indicated that a viable burbot population exists in Moyie Lake based on a 2002 creel survey (KTOI and MFWP 2004). Kootenai River burbot are considered functionally extinct, a status that occurs when populations are so small they are unable to recover on their own, even if suitable habitat conditions exist or are restored (Paragamian et al. 2000; KVRI 2005).

Burbot is a culturally significant species to the Kootenai Tribe. As mentioned previously, the Tribe is submitting a proposal to the NPCC in July 2009 (Kootenai River Native Fish Conservation Aquaculture Programs Master Plan), to construct a new hatchery at the confluence of the Moyie and Kootenai rivers (Twin Rivers Hatchery) that in addition to providing for upgraded and expanded sturgeon conservation aquaculture facilities, would allow the Tribe to implement a conservation aquaculture program to reintroduce burbot into the lower Kootenai River and begin rebuilding the population using genetically and behaviorally similar stock from within the subasin (from Moyie Lake in British Columbia).

Life History

The burbot is the only true freshwater representative of the cod family, Gadidae (McPhail and Paragamian 2000). It normally completes its lifecycle in freshwater and rarely enters the sea, however, burbot have been documented in estuaries and brackish lagoons (Preble 1908, Percy 1975, Pulliainen et al. 1992).

Burbot that occur in the Kootenai River basin exhibit three life history strategies in several isolated groups. The first life history strategy is represented by the lower Kootenai River burbot population, which spends a portion of its life in the South Arm of Kootenay Lake, British Columbia, and then migrates up the Kootenai River during the winter months to spawn in the mainstem river or tributary streams in British Columbia or Idaho (adfluvial life form) (KTOI and MFWP 2004).

The second life history strategy is represented by burbot occurring further upstream in the Kootenai River above Kootenai Falls, which have a fluvial (riverine) life history (Paragamian et al. 1999). That is, they migrate within the river and to tributary streams for spawning. Burbot that occur in Lake Koocanusa are also considered to be fluvial, because they evolved with a fluvial life history prior to the construction of Libby Dam. This population is thought to be fluvial because it is currently unclear how readily burbot populations adopt a different life history strategy when faced with changing environmental conditions, and it does not appear appropriate to compare naturally occurring adfluvial populations of burbot to burbot that now have some adfluvial characteristics as the result of a human-created reservoir (KTOI and MFWP 2004).

The third life history strategy is represented by the only known lacustrine population in Kootenay Lake, which occurs in the North Arm of Kootenay Lake (Spence 1999). Prior to dramatic declines of burbot in Kootenay Lake, a population was believed to have spawned at the inlet of the West Arm of Kootenay Lake, but this population has completely collapsed and is now believed to be extirpated (Spence 1999; Baxter et al. 2002; Paragamian, pers. comm., 2000 from KTOI and MFWP 2004).

Burbot are cold water spawners during highly synchronized communal spawning periods, with reported optimal spawning and incubation temperatures from 0 to 4 °C (Bjorn 1940; Andersson 1942; Clemens 1951b; McCrimmon and Devitt 1954; Lawler 1963; Meshkov 1967; Chen 1969; Johnson 1981; Kouril et al. 1985; Sandlund et al. 1985; Breeser et al. 1988; Boag 1989; Arndt and Hutchison 2000; Evenson 2000). Eggs are thought to drift in the water column and lodge in interstitial spaces in the substrate.

Burbot life span varies geographically, and northern populations generally contain older fish than southern populations (McPhail and Paragamian 2000). Maximum ages recorded in northern populations ranged from 20 to 22 years (Hatfield et al. 1972; Nelichik 1979; Guinn and Hallberg 1990).

The Kootenai River Burbot Conservation Committee's Conservation Strategy (http://www.kootenai.org/documents/FinalBurbotCS-3-2-05.pdf) provides a comprehensive review of burbot life history and habitat requirements and behaviors of all burbot life stages (KVRI 2005).

Habitat Requirements and Limiting Factors

In most waters of the Kootenai subbasin, with the possible exception of Duncan and Trout lakes in British Columbia, and Montana waters, the extremely low numbers of remaining burbot appear to currently pose a greater risk to their continued existence than does any combination of key ecological correlates or non-demographic limiting factors (KTOI and MFWP 2004).

Burbot spawn in rivers, streams, and lakes. In rivers, burbot spawn in low velocity areas, in main channels, or in side channels behind deposition bars (Breeser at al. 1988, Sorokin 1971). Preferred river substrate appears to be fine silt, sand, or gravel. In lakes, spawning usually occurs over near-shore shallows (1.5-10 m deep) or over shallow offshore reefs and shoals (Clemens 1951b, McCrimmon 1959, Johnson 1981, Boag 1989). However, there is some indication of spawning in deep water in the Great Lakes (Clemens 1951b). Lake substrate is usually sand, gravel, or cobbles and is relatively free of silt (McCrimmon and Devitt 1954, Chen 1969, Sorokin 1971, Boag 1989).

Paragamian (1995) described habitat in the Kootenai and Goat rivers used during the spawning period. In the Kootenai River, burbot were rarely found in less than 6 meters of water, but maximum depth ranged from 1-30 meters where fish were sampled. Substrate in most locations was composed of silt or sand. In the lower Goat River, where spawning was thought to have occurred, the habitat was described as silt and sand substrate with water depths less than 3 meters. In the North Arm of Kootenay Lake, burbot spawning was associated with cobble and boulder substrate in 0.5 to 1.5 meter depths (Spence 1999). In Duncan Reservoir, Spence and Neufeld (2002) observed a concentration of burbot during the spawning period at the mouth of Glacier Creek. In Trout Lake, Baxter et al. (2002b) observed fish concentrations at the mouths of small creeks entering the lake; there was no observed utilization of the larger tributaries entering the lake. During winter and early spring when Trout Lake was frozen, these creek mouths were the only ice-free areas.

The Kootenai Subbasin Plan (2004) states that it seems likely that the existing post-development, post-dam environmental conditions can provide little restorative value to these remnant stocks or populations; and that restoration of native burbot populations to include natural recruitment and stable size and age class structures is unlikely to occur without improvement of current ecological conditions and restoration of ecological functions.

Burbot managers and researchers, with help from Libby Dam operators, have tried experimental alterations of Libby Dam discharge operations in order to help restore natural production. Monitoring of initial experimental discharge reductions during the historical burbot spawning season (December-March) failed to provide evidence of any natural spawning or recruitment in the Idaho portion of the Subbasin (KTOI and MFWP 2004). This may be due to extreme stock limitation (i.e., too few burbot may be left to measure a response to experimentally reduced discharge regimes, or to provide observable experimental treatment effects), or to other effects. However, Kozfkay and Paragamian (2002) found drought conditions of the winter of 2000-2001 provided ideal conditions for burbot movement and documented spawning of burbot through weight changes in recaptured fish and a limited number of postspawn biopsies.

Table 2-14 presents a summary of preferred habitat characteristics based on empirical data, literature, and expert professional judgment (see Appendix D for additional detail). Consideration is given to habitat preference at each life stage and the relevant duration or seasonality for that life stage habitat requirement. Variables noted with an "X" in the table below are believed to be important to the specified burbot life stage.

Table 2-14. Burbot life stage and preferred habitat characteristics based on empirical data, literature, and professional judgment.

Life Stage	Non-Reproductive Adult	Migrating Adult	Spawning Adult	Embryo (N/A)	Free Embryo (N/A)	Larva	Age 0+ Juvenile
Duration/ Seasonality	**Year Round**	**Fall to Winter**	**Dec to May**	**N/A**	**N/A**	**Jun to Aug**	**~ 65 days, Fall**
River Reach Used by Life Stage							
Canyon	X	X	X				
Braided Reach 1							
Braided Reach 2							
Straight Reach		X	X				
Meander Reach 1		X	X				
Meander Reach 2							
Tributaries		X	X			X	X
Temperature							
Water Temperature	X	X	X			X	X
Substrate							
Type of substrate		X	X			X	
Particle size distribution			X			X	X
Longitudinal extent (length)			X				
Interstitial spaces						X	X
Cover							
Depth/incident light	X	X	X				
Hydraulic cover			X			X	X
Large woody debris	X	X	X			X	X
Bedforms							
Hydraulics							
Velocity variability	X	X	X			X	X
Boundary sheer stress							
Bedload transport							

Table 2-14. Burbot life stage and preferred habitat characteristics based on empirical data, literature, and professional judgment.							
Life Stage	**Non-Reproductive Adult**	**Migrating Adult**	**Spawning Adult**	**Embryo (N/A)**	**Free Embryo (N/A)**	**Larva**	**Age 0+ Juvenile**
Duration/ Seasonality	**Year Round**	**Fall to Winter**	**Dec to May**	**N/A**	**N/A**	**Jun to Aug**	**~ 65 days, Fall**
Hydro operations							
Flow duration, frequency, and magnitude		X	X				X
Channel geometry							
Habitat diversity	X					X	X
Depth	X	X	X				
Channel stability	X	X	X			X	X
Single vs. braided, meander	X	X	X				
Connection with off-channel habitat						X	X
Connection with tributary habitat	X	X	X				
Slope/gradient	X	X	X			X	X
Pool/riffle/run ratio; pool spacing	X	X	X				

At this point, no single factor appears responsible for the collapse of the Kootenai River burbot population. Rather, a combination of overharvest, habitat loss and alteration due to levee constructions, impoundment, river regulation, and additive ecosystem degradation appears have contributed to burbot population loss through recruitment limitation and failure (KVRI 2005).

The Kootenai Subbasin Plan identifies the following possible interrelated Kootenai subbasin conditions that likely resulted in limiting factors that have contributed to the collapse of the Kootenai native burbot population:

- Increased winter river flow and velocities;
- Increased winter water temperature;
- Degradation of floodplain tributary channels or tributary disconnection from the river;
- Loss and degradation of in-river and off-channel habitats;
- Reduction in nutrient and food availability and biological productivity at all trophic levels;
- Kootenay Lake flood control;
- Overharvest; and
- Altered ecological community composition.

Conservation strategies for burbot identified in the KVRI burbot Conservation Strategy (2005) and the Kootenai Subbasin Plan include: habitat restoration, flow and temperature manipulation, spring management of Kootenay Lake levels, nutrient restoration, and use of donor stocks, captive broodstock and conservation aquaculture.

2.6.1.3 Bull Trout

Information in this section is drawn almost entirely from the Kootenai Subbasin Plan (KTOI and MFWP 2004).

Historical and Current Status

Historically, bull trout were one of six native salmonid species distributed throughout the Kootenai River drainage (KTOI and MFWP 2004).

The historical importance of Kootenai Falls as a barrier to fish movement is unknown, although recent radio telemetry information indicates that this series of falls is traversed by adult bull trout at certain flows. If this was the case, this bull trout population likely included migratory fish from Kootenay Lake in British Columbia as well as Kootenai River fish, which may have moved freely throughout the drainage (KTOI and MFWP 2004). Resident bull trout may have been present (KTOI and MFWP 2004). If upstream passage did not occur over Kootenai Falls, the bull trout population in the Kootenai Drainage upstream was isolated at this point, likely resulting in one-way gene flow downstream (KTOI and MFWP 2004). Libby Dam is currently a barrier blocking upstream migration as there are no fish ladders at the dam. Therefore, any bull trout that are entrained at Libby dam cannot return upstream to their natal streams to spawn.

Little quantitative information exists regarding historical bull trout abundance downstream from Kootenai Falls in Montana or Idaho (KTOI and MFWP 2004). The valleys of the lower Kootenai were developed for agriculture during the late 19th and early 20th century, and the habitat for bull trout was negatively impacted prior to the collection of substantive fishery data. The lack of information is a major gap in our knowledge of the drainage (KTOI and MFWP 2004). Suckley (1861) reported collecting a bull trout from the Kootenay River, but the exact location of this collection is unknown.

Bull trout are currently widely distributed through the lower Kootenai River, from Libby Dam downstream to Kootenay Lake in British Columbia (KTOI and MFWP 2004). Spawning and rearing by migratory adults occur in tributaries draining portions of British Columbia, Idaho, and Montana. These migratory fish spend their adult lives in Kootenay Lake or the Kootenai River (KTOI and MFWP 2004).

In the final ESA listing rule for bull trout, five subpopulations were recognized within the Kootenai River Subbasin (USFWS 1998). These included three portions of the mainstem system: 1) Upper – upstream from Libby Dam, 2) Middle – from Libby Dam downstream to Kootenai Falls, and 3) Lower – downstream from Kootenai Falls through Idaho to the United States/Canada border.

The two disconnected subpopulations (referred to as disjunct by the Montana Bull Trout Scientific Group), in Bull Lake and Sophie Lake, were considered separate subpopulations (KTOI and MFWP 2004). At the time of listing, all Kootenai River bull trout subpopulations were considered to have unknown status and population trend, and the Sophie Lake subpopulation was considered to be at risk of stochastic extirpation due to its single spawning stream and small population size.

The U.S. Forest Service lists bull trout as a sensitive species, primarily to emphasize habitat protection. The Idaho Panhandle National Forests have named bull trout as Management

Indicator Species (MIS) in their Forest Plan to guide stream and riparian management and to monitor progress toward achieving Forest Plan objectives (KTOI and MFWP 2004).

In British Columbia, bull trout are listed as an intermediate priority candidate species (COSEWIC 2003). The British Columbia Conservation Data Centre has blue-listed bull trout in British Columbia, which means they are a species considered to be vulnerable or of special concern because of characteristics that make them particularly sensitive to human activities or natural events (BC Ministry of Sustainable Resource Management 2003).

The Kootenai Tribe consider bull trout a sensitive species and an important cultural resource.

Life History

Bull trout populations in the Kootenai may exhibit one of three life history forms: resident, fluvial, or adfluvial. Resident bull trout generally spend their entire life cycle in small headwater streams. Fluvial and adfluvial bull trout spawn in tributary streams where the juveniles rear from one to four years before migrating to either a river system (fluvial) or a lake/reservoir system (adfluvial) where they grow to maturity (Fraley and Shepard 1989; KTOI and MFWP 2004). All three life history forms are present in the Kootenai subbasin.

Adfluvial bull trout mature at four to seven years of age and may spawn every year or in alternate years (KTOI and MFWP 2004). Adfluvial fish grow larger in size and have higher average fecundities than fluvial or resident stocks.

Bull trout are fall spawners, typically migrating to spawning areas during August and early September, primarily in third and fourth-order streams. In some systems, bull trout have been observed moving into spawning tributaries during high spring runoff, giving them access to habitat that becomes inaccessible later in the year when flows are lower (Pratt and Huston 1993).

Eggs hatch after 100 to 145 days of incubation (Heimer 1965; Allan 1980; Weaver and White 1984). Fry remain in the gravel for another 65 to 90 days until yolk sac absorption is complete; parr marks develop and actual feeding begins while fry are still in the gravel. Fry emerge from gravels in early spring, usually April (Shepard et al. 1984). Bull trout generally reach lengths of about one inch (25 to 28 mm) before filling their air bladders and emerging from the stream bed (Shepard et al. 1984).

Juvenile bull trout live near the stream bottom for the first two years of life using pockets of slow water within swift stream reaches (Pratt 1984b; Shepard et al. 1984). Unembedded cobble and boulders, and dispersed woody debris are commonly used forms of cover. Juvenile bull trout typically rear close to spawning areas, usually in middle to upper stream reaches. Juvenile bull trout may migrate from natal streams during the summer or fall of their second or third growing season (Ringstad 1976; Oliver 1979; Shepard et al. 1984; Pratt 1996). Time spent migrating from natal streams to the Kootenai River has not been studied, but Goetz (1991) reported that juvenile out migrants move downstream quickly in other stream systems (KTOI and MFWP 2004).

Habitat Requirements and Limiting Factors

Bull trout are considered good indicators of aquatic ecosystem health. They have relatively strict habitat requirements. They require high quality, cold water; high levels of shade, undercut banks, and woody debris in streams; abundant gravel in riffles with low levels of fine sediments;

stable, complex stream channels; and connectivity among and between drainages (USFWS 2002). These requirements make them a good indicator of the health of an aquatic environment. Because bull trout use the entire aquatic system in the subbasin, impacts in any single component can potentially affect bull trout (KTOI and MFWP 2004).

Table 2-15 presents a summary of preferred habitat characteristics based on empirical data, literature, and expert professional judgment (see Appendix D for additional detail). Consideration is given to habitat preference at each life stage and the relevant duration or seasonality for that life stage habitat requirement. Variables noted with an "X" in the table below are believed to be important to the specified bull trout life stage.

Table 2-15. Bull trout life stage and preferred habitat characteristics based on empirical data and literature.

Life Stage	Migrating Adult	Spawning Adult	Embryo	Alevins	Fry	Fingerling	Juvenile
Duration/ Seasonality	**Summer-Fall**	**Sep to Oct**	**Winter**	**Early Spring**	**Spring**	**Summer-Winter**	**Year-round**
River Reach Used by Life Stage							
Canyon	X						X
Braided Reach 1	X						X
Braided Reach 2	X						X
Straight Reach	X						X
Meander Reach 1	X						X
Meander Reach 2	X						X
Tributaries	X	X	X	X	X	X	X
Water Quality							
Water temperature	X	X	X	X	X	X	X
Dissolved oxygen	X	X	X	X	X	X	X
Turbidity/suspended sediment	X	X	X	X	X	X	X
Nutrient availability	X	X	X	X	X	X	X
Other WQ factors	X	X	X	X	X	X	X
Substrate							
Type of substrate	X	X	X	X	X	X	X
Particle size distribution	X	X	X	X	X	X	X
Longitudinal extent (length)		X	X	X			X
Interstitial spaces		X	X	X	X	X	X
Cover							
Depth/incident light	X	X			X	X	X
Canopy/shade	X					X	X
Undercut banks	X	X			X	X	X
Hydraulic cover	X					X	X
Large woody debris	X	X			X	X	X
Bedforms	X						
Hydraulics							
Velocity	X	X	X	X	X	X	X
Velocity variability	X	X	X	X	X	X	X
Boundary sheer stress	X	X	X	X	X	X	X
Lateral sheer	X	X	X	X	X	X	X

Table 2-15. Bull trout life stage and preferred habitat characteristics based on empirical data and literature.							
Life Stage	**Migrating Adult**	**Spawning Adult**	**Embryo**	**Alevins**	**Fry**	**Fingerling**	**Juvenile**
Duration/ Seasonality	**Summer-Fall**	**Sep to Oct**	**Winter**	**Early Spring**	**Spring**	**Summer-Winter**	**Year-round**
Roughness	X		X	X	X	X	X
Bedload transport	X	X	X	X	X		X
Hydrology							
In-channel groundwater/surface water interaction			X				
Flow duration, frequency, and magnitude	X	X	X	X	X	X	X
Channel geometry							
Habitat diversity	X						X
Depth	X	X			X	X	X
Channel stability	X	X					
Single vs. braided/meander	X	X			X	X	X
Connection with off-channel habitat					X	X	X
Connection with tributary habitat	X	X			X	X	X
Slope/gradient	X	X	X	X	X	X	X
Pool/riffle/run ratio; pool spacing	X	X			X	X	X

Bull trout in the Kootenai River have been impacted by habitat degradation, altered hydrology and river hydraulics related to flow ramping, habitat fragmentation (e.g., tributary barriers, dams) and degradation (e.g. agriculture and logging), gas supersaturation due to reservoir spill, and a diminished prey base related to suppressed kokanee production caused by nutrient depletion. This risk to the bull trout population is elevated due to the small number of available core areas (Quartz, Pipe and Libby Creek drainages) available due to fragmentation caused by Libby Dam. Dam operations are considered a very high risk to the continued existence of the Kootenai subbasin population of bull trout (KTOI and MFWP 2004).

The Kootenai Subbasin Plan (2004) states that habitat attributes considered most important to resident salmonids (when averaged across all HUCs) are high temperature, riparian conditions channel stability, and fine sediment, in that order. In the regulated mainstem, they are altered flows, riparian condition fine sediment and channel stability (KTOI and MFWP 2004).

2.6.1.4 Kokanee

Information in this section is drawn primarily from the Kootenai Subbasin Plan (KTOI and MFWP 2004).

Historical and Current Status

Pre-dam population levels of kokanee are unknown. There are currently six populations of kokanee in the Kootenai River Subbasin in Idaho, Montana, and British Columbia. Native

kokanee in the Kootenai subbasin are found downstream from Kootenai Falls in Montana. All populations upstream from Libby Dam, in Lake Koocanusa and elsewhere were introduced, and are not considered native.

Kokanee are the non-anadromous or land locked form of sockeye salmon found in the large lake systems throughout the entire Columbia River Basin (McPhail and Carveth 1992). In British Columbia they are indigenous in all drainages except the Peace River drainage. They overlap the distribution of sockeye salmon in British Columbia, but are also found in lakes that are now cut off to sockeye as a result of human interventions, the best example being the upper Columbia River system. Morphologically, kokanee and sockeye are identical and are considered to be the same species (*Onchorynchus nerka*) (KTOI and MFWP 2004).

Kokanee in the Kootenai subbasin have been isolated for at least 10,000 years due to a natural barrier located on the lower Kootenay River at Bonnington Falls approximately 20 km upstream from the confluence with the Columbia River (Northcote 1973). Discrete natural populations are currently found in Trout, and Kootenay lakes, and Duncan reservoir, whereas the Moyie and Koocanusa reservoir kokanee populations are naturalized from hatchery introductions.

Duncan Dam, which was completed in 1967, isolated Kootenay Lake kokanee from those inhabiting the Duncan Reservoir. A major waterfall on the lower Moyie River in Northern Idaho prevents fish movement to Moyie Lake. Kootenai Falls in Montana serves as a barrier to all upstream movement of kokanee. However, kokanee introductions into the Lake Koocanusa in the 1970s have resulted in an extension of their distribution to the very upper reaches of the Upper Kootenay River and tributaries.

Native kokanee salmon runs in lower Kootenai River tributaries in Idaho have experienced dramatic population declines during the past several decades (Ashley and Thompson 1993; Partridge 1983). The kokanee that historically spawned in these tributaries inhabited the South Arm of Kootenay Lake in British Columbia. Native kokanee are considered an important prey item for white sturgeon and also provided an important fishery in the tributaries of the lower Kootenai River (Partridge 1983; Hammond, J., B.C. MELP, per. comm. 2000 from KTOI and MFWP 2004).

Kokanee runs into North Idaho tributaries of the Kootenai River that numbered into the thousands of fish as recently as the early 1980s have now become "functionally extinct" (Anders 1993; KTOI, unpublished data). Since 1996, visual observations and redd counts in five tributaries found no spawners returning to Trout, Smith, and Parker Creeks, while Long Canyon and Boundary Creeks had very few kokanee returns.

A series of kokanee stream restoration activities lead by the Kootenai Tribe appear to be contributing to recent increases in spawner counts in Long Canyon and Parker creeks (KTOI and MFWP 2004). More recently, kokanee eyed-eggs have been planted in various South Arm and Kootenai River tributaries within Idaho and British Columbia in an effort to stimulate natural production. The Kootenai Tribe began planting eyed-eggs (Meadow Creek stock, North Arm Kootenay Lake) in Idaho tributaries in 1997. The number of eggs planted each year depended on the availability of Meadow Creek broodstock. For example, no eggs were available for out-planting during 2000 to 2002. The number of eyed-eggs planted increased significantly beginning in 2003. Progeny from the 2003 plant were expected to return to spawn in 2007. Although kokanee eggs have been planted in South Arm (British Columbia) tributary streams as early as 1929 (Andrusak et al. 2004), recent efforts were not initiated until 2005. Adults resulting

from these recent egg plants are not expected to return to British Columbia streams until 2009 (P. Anders, Cramer Fish Sciences, personal communication, 2009).

The 2007 return was the first year expected from the larger eyed-egg plants initiated in 2003, and likely benefited from South Arm and Kootenai River nutrient additions. In 2004, about twice as many eggs were planted in Idaho tributaries, and a corresponding increase in spawners was observed in 2008 (P. Anders, Cramer Fish Sciences, personal communication, 2009).

Life History

Most kokanee populations found in the large lakes of British Columbia migrate up tributary streams to spawn, usually in September. Information and documentation of shore spawning kokanee in British Columbia has been quite limited, but recent investigations have identified several shore spawning populations that were previously unknown.

Kokanee prefer low gradient streams for spawning, and while some will utilize streams that have gradients of 1% to 5%, they generally will select the lower gradient sites. Most often kokanee that ascend larger rivers will utilize the side channels for spawning with the exception being in a regulated stream system where spawning coincides with lower flows, e.g., Mabel Lake kokanee in the middle Shuswap River (KTOI and MFWP 2004).

Most kokanee in the southern interior large lakes such as Arrow, Okanagan, Slocan and Kootenay spawn from late August to early October with the peak of spawning around the third week of September. Kokanee in the West Arm of Kootenay Lake spawn quite early, commencing in mid-August and completed by mid-September. The South Arm of Kootenay Lake kokanee spawn earlier than their northern counterparts, usually from mid-August to mid-September whereas Lardeau River kokanee spawn in the latter part of September until late October (KTOI and MFWP 2004).

It is generally understood that kokanee fry move immediately to open waters after emergence from spawning areas, whether from tributaries or beach spawning sites. This rapid dispersion of fry to the open water is consistent with many anadromous sockeye populations. There are well-documented examples of sockeye fry undergoing rapid and intricate dispersion patterns into nursery lakes upon emergence (McCart 1967; McDonald and Hume 1984).

Once in the limnetic area, both kokanee and sockeye feed primarily on zooplankton, especially copepods and cladocerans (KTOI and MFWP 2004).

The West Arm of Kootenay Lake kokanee behave differently than most studied kokanee populations. The fry move from the natal streams and associate themselves with the shoreline for the first two months before moving to open water within the West Arm (KTOI and MFWP 2004). Benthic organisms, aquatic insects and littoral zooplankton are consumed in addition to pelagic zooplankton. As the summer advances, the fry move off shore and utilize macrozooplanktors and mysids (KTOI and MFWP 2004).

Kokanee likely provided forage for much of the historically present lower Kootenai River fish assemblage. Adfluvial rainbow trout, bull trout, sturgeon and burbot that occupied Kootenay Lake certainly relied on kokanee for forage (KTOI and MFWP 2004). It is most likely that Kootenai burbot and sturgeon also targeted on spawning kokanee when they migrated into tributary streams in the Kootenai Basin.

Kootenai sturgeon in Kootenay Lake appear to move to the mouth of the Lardeau River to prey on staging kokanee prior to their upriver spawning migration. Loss of these spawning migrations as a potential food source very likely had significant impacts on these two species. Moreover, kokanee were an important component of the diet of Native Americans and First Nations peoples in the U.S. and Canada. This traditional food source remains culturally important to the Kootenai Tribe of Idaho and the Lower Kootenay First Nation Bands in southeastern British Columbia (KTOI and MFWP 2004).

Habitat Requirements and Limiting Factors

The magnitude of the effects of Duncan Dam and Libby Dam on kokanee populations is substantial. These impacts included: changes in physical habitat; spawning, incubation and early rearing success; and nutrient and food availability for later rearing and maturation (KTOI and MFWP 2004; Ericksen et al. 2009).

Table 2-16 presents a summary of preferred habitat characteristics based on empirical data, literature, and expert professional judgment (see Appendix D for additional detail). Consideration is given to habitat preference at each life stage and the relevant duration or seasonality for that life stage habitat requirement. Variables noted with an "X" in the table below are believed to be important to the specified kokanee life stage.

Table 2-16. Kokanee life stage and preferred habitat characteristics based on empirical data and literature.

Life Stage	Migrating Adult	Spawning Adult	Embryo	Alevins	Fry	Fingerling	Juvenile
Duration/ Seasonality	**Late Summer to early Fall**	**Mid-Aug to Sep**	**Winter**	**Early Spring**	**Spring**	**Summer to Winter**	**Year-round**
River Reach Used by Life Stage							
Canyon	X						
Braided Reach 1	X						
Braided Reach 2	X						
Straight Reach	X						
Meander Reach 1	X						
Meander Reach 2	X						
Tributaries	X	X	X	X	X	X	X
Water Quality							
Temperature	X	X	X	X	X	X	X
Dissolved oxygen	X	X	X	X	X	X	X
Turbidity/suspended sediment	X	X	X	X	X	X	X
Nutrient availability	X	X	X	X	X	X	X
Other WQ factors	X	X	X	X	X	X	X
Substrate							
Type of substrate		X	X	X	X	X	X
Particle size distribution		X	X	X	X		
Longitudinal extent (length)		X	X	X			
Interstitial spaces		X	X	X			
Cover							
Depth/incident light	X	X			X	X	X
Large woody debris					X		

Table 2-16. Kokanee life stage and preferred habitat characteristics based on empirical data and literature.							
Life Stage	**Migrating Adult**	**Spawning Adult**	**Embryo**	**Alevins**	**Fry**	**Fingerling**	**Juvenile**
Duration/ Seasonality	**Late Summer to early Fall**	**Mid-Aug to Sep**	**Winter**	**Early Spring**	**Spring**	**Summer to Winter**	**Year-round**
Hydraulics							
Velocity	X	X	X	X	X	X	X
Velocity variability	X	X	X	X	X	X	X
Boundary sheer stress	X	X	X	X	X	X	X
Lateral sheer	X	X	X	X	X	X	X
Hydrology							
In-channel groundwater/surface water interaction			X	X			
Flow duration, frequency, and magnitude		X	X	X	X		
Channel geometry							
Depth		X			X		
Channel stability		X					
Single vs. braided, meander		X			X		
Connection with off-channel habitat					X		
Connection with tributary habitat		X			X		
Slope/gradient		X	X	X	X		
Pool/riffle/run ratio; pool spacing					X		

Based on an analysis of stream habitat conducted as part of the Kootenai Subbasin Planning effort in 2004, of the eleven stream habitat attributes considered key to resident salmonids, the most degraded for kokanee trout in tributaries in the U.S. portion of the subbasin (when averaged across all the tributary HUCs) are pollutants, altered thermal regime, channel stability, and fine sediment, in that order. In the regulated mainstem they are altered hydrograph, altered thermal regime, fine sediment, and channel stability (KTOI and MFWP 2004).

2.6.1.5 Columbia River Redband Trout

The following sections summarize Columbia River redband trout (redband trout) historical and current population status, habitat requirements, and limiting factors affecting the population. The information in this section focuses primarily on the Kootenai River and Kootenay Lake population. Most of the following information is taken directly from the Kootenai River Subbasin Assessment (KTOI and MFWP 2004).

Historical and Current Status

Redband trout of the Columbia River basin (*Oncorhynchus mykiss gairdneri*) are a subspecies of the rainbow trout evolutionary line (*Oncorhynchus mykiss*) native to the Fraser River Basin and Columbia River Basin east of the Cascade Mountains to barrier falls on the Pend Oreille, Spokane,

Snake and Kootenai rivers (Allendorf et al. 1980; Behnke 1992). They are also native to Kootenay Lake, British Columbia and the Kootenai River in Idaho and Montana. For years, the upper distribution of redband trout in the Columbia River Basin was believed to extend upstream to Kootenai Falls, which was considered a barrier falls (Allendorf et al. 1980; Chapman and May 1986), but it is now thought the barrier was not Kootenai Falls, but one that existed in geologic time near the present day Libby Dam or Fisher River (Hensler et al. 1996). Genetic surveys also indicate that Columbia River redband trout were not just found in headwater reaches as they are now, but were native to low-gradient valley-bottom streams throughout the Kootenai River drainage (Muhlfeld 1999). This range contraction may have occurred in response to past and present land use and fishery management practices.

Region 1 of the US Forest Service lists Columbia River redband trout as a sensitive species. The USFWS was formally petitioned to consider the Kootenai River population of Columbia River redband trout as an endangered species under the ESA on April 4, 1994. However, the petition was dismissed due to lack of information. Concern has arisen in recent years that Columbia River redband trout in the Kootenai River basin are at high risk of extinction (Muhlfeld 1999).

On the Idaho Panhandle National Forest, little is known about the status of Kootenai-drainage Columbia River redband trout populations. In all but five of the 6-field HUCs in the Idaho portion of the Kootenai, the Columbia River redband trout status is described by the USFS as "presence unknown". In three HUCs, redbands are known to be present but their population status is unknown, and in two they are present but depressed.

Based on genetic analyses in Montana, populations of Columbia River redband trout have been identified in Callahan Creek, the East Fork Yaak River and its tributaries, the Yaak River (downstream from Yaak Falls), the North Fork Yaak River, and tributaries to Libby Creek and the upper Fisher River (including the Pleasant Valley Fisher, East Fisher River drainages) (Allendorf et al. 1980; Leary et al. 1991; Huston 1995; Hensler et al. 1996; Knudsen et al. 2002). Currently, unintrogressed Columbia River redband trout populations are restricted to headwater reaches. Columbia River redband trout inhabiting Callahan Creek and the upper Yaak drainage are isolated into two separate regions by Yaak River Falls, a falls-chute barrier located 4 km from the mouth of Callahan Creek and a barrier falls located in the lower East Fork of the Yaak River.

In Idaho, genetics studies have documented Columbia River redband trout in the Boulder, Boundary, and Deep creek drainages, and North and South Callahan Creeks (Sage 1993, 1995; Leary 1997; Knudsen et al. 2002). Spawning and rearing habitat in several Idaho tributaries has been lost or is now inaccessible to fluvial Columbia River redband trout due to anthropogenic factors (Partridge 1983). These streams include, but are not limited to, Caboose, Cow, Debt, and Twenty-Mile creeks.

Life History

A variety of life history strategies can be found among Columbia River redband trout. Anadromous stocks (which are known commonly as steelhead) historically migrated to the middle and upper Columbia River drainage, but this range probably became more restricted when barriers formed during the last (Tahoe stage) glacial advance (Behnke 1992). There are presently redband trout populations isolated from anadromous influence, such as in Kootenay Lake and the Kootenai River upstream. An adfluvial form, the Kamloops redband trout of Kootenay Lake, British Columbia, has a piscivorous diet and therefore grows quite large and exhibits an advanced size at sexual maturity. Kamloops redband trout spawn in Kootenai River

tributaries in Montana and Idaho but do not migrate upstream from Kootenai Falls (Huston 1995). Fluvial stocks occupy large rivers and spawn in smaller tributaries. Resident forms complete their entire life cycles in smaller tributaries and headwater areas. The Kootenai River drainage supports all three life histories (Downs 1999, 2000; Muhlfeld et al. 2001b; Walters and Downs 2001; Knudsen et al. 2002). The different redband trout life history forms are indistinguishable using meristic counts, coloration patterns, or allozyme data (Knudsen et al. 2002).

Habitat Requirements and Limiting Factors

Seasonal habitat requirements of Columbia River redband trout in the Kootenai River drainage in Montana were investigated during 1997 and 1998 (Muhlfeld 1999; Hensler and Muhlfeld 1999; Muhlfeld et al. 2001a; Muhlfeld et al. 2001b). Summer results demonstrated that juvenile (36-125 mm) and adult (> 126 mm) Columbia River redband trout preferred deep microhabitats (>0.4 m) with low to moderate velocities (< 0.5 m/s) adjacent to the thalweg. Conversely, age-0 (<35mm) Columbia River redband trout selected slow water (< 0.1 m/s) and shallow depths (< 0.2 m) located in lateral areas of the channel. Age-0, juvenile and adult Columbia River redband trout strongly selected pools and avoided riffles; runs were used generally as expected (based on availability) by juveniles and adults and more than expected by age-0 Columbia River redband trout.

At the macrohabitat scale, a multiple regression model indicated that low-gradient, mid-elevation reaches with an abundance of complex pools were critical areas for the production of Columbia River redband trout. Mean reach densities ranged from 0.01-0.10 fish/m2. During the fall and winter period, adult Columbia River redband trout occupied small home ranges and found suitable overwintering habitat in deep pools with extensive amounts of cover in headwater streams. In Basin Creek, adult Columbia River redband trout began spawning (e.g., redd construction) during June as spring flows subsided following peak runoff. Columbia River redband trout generally selected redd sites in shallow pool tailout areas (mean depth = 0.27 m; range: 0.20-0.46) with moderate water velocities (mean velocity = 0.50 m/s; range: 0.23-0.69 m/s) dominated by gravel substrate.

Table 2-17 presents a summary of preferred habitat characteristics based on empirical data, literature, and expert professional judgment (see Appendix D for additional detail). Consideration is given to habitat preference at each life stage and the relevant duration or seasonality for that life stage habitat requirement. Variables noted with an "X" in the table below are believed to be important to the specified Columbia River redband trout life stage.

Table 2-17. Columbia River redband trout life stage and preferred habitat characteristics based on empirical data and literature.

Life Stage	Migrating Adult	Spawning Adult	Embryo	Alevins	Fry	Fingerling	Juvenile
Duration/ Seasonality	**Winter to Spring**	**Mar to Apr**	**Mar to May**	**Apr to May**	**May to Jun**	**Summer to Winter**	**Year-round**
River Reach Used by Life Stage							
Canyon	X						
Braided Reach 1	X						
Braided Reach 2	X						
Straight Reach	X						
Meander Reach 1	X						
Meander Reach 2	X						
Tributaries	X	X	X	X	X	X	X
Water Quality							
Temperature	X	X	X	X	X	X	X
Dissolved oxygen	X	X	X	X	X	X	X
Turbidity/suspended sediment		X	X	X	X		
Nutrient availability	X	X	X	X	X	X	X
Substrate							
Type of substrate	X	X	X	X	X	X	X
Particle size distribution	X	X	X	X	X	X	X
Longitudinal extent (length)		X	X	X			
Interstitial spaces		X	X	X		X	X
Cover							
Depth/incident light	X	X			X	X	X
Canopy/shade	X					X	X
Undercut banks	X					X	X
Turbidity/suspended sediment	X					X	X
Hydraulic cover	X					X	X
Large woody debris	X				X	X	X
Hydraulics							
Velocity	X	X	X	X	X	X	X
Velocity variability	X	X	X	X	X	X	X
Boundary sheer stress	X	X	X	X	X	X	X
Lateral sheer	X	X	X	X	X	X	X
Hydrology							
In-channel groundwater/surface water interaction			X	X			
Flow duration, frequency, and magnitude	X	X	X	X	X	X	X
Channel geometry							
Depth	X	X			X	X	X
Channel stability		X					

Table 2-17. Columbia River redband trout life stage and preferred habitat characteristics based on empirical data and literature.							
Life Stage	**Migrating Adult**	**Spawning Adult**	**Embryo**	**Alevins**	**Fry**	**Fingerling**	**Juvenile**
Duration/ Seasonality	**Winter to Spring**	**Mar to Apr**	**Mar to May**	**Apr to May**	**May to Jun**	**Summer to Winter**	**Year-round**
Single vs. braided, meander	X	X	X	X	X	X	X
Connection with off-channel habitat					X	X	X
Connection with tributary habitat	X	X			X	X	X
Slope/gradient	X	X	X	X	X	X	X
Pool/riffle/run ratio; pool spacing	X	X			X	X	X

Columbia River redband trout populations have been impacted by degraded riparian condition, fine sediment, high water temperatures, and channel instability in tributary habitat to the Kootenai River (KTOI and MFWP 2004). In the mainstem Kootenai River, limiting factors include altered hydrograph and thermograph due to Libby Dam, degraded riparian condition, and fine sediment. Fish passage barriers that restrict Columbia River redband trout spawning migrations are also considered to be a limiting factor. Recent concern has arisen that Kootenai River Basin Columbia River redband trout populations are at a high risk of extinction due to hybridization with non-native coastal rainbow trout, habitat fragmentation, and stream habitat degradation (Perkinson 1993; Muhlfeld 1999).

2.6.1.6 Westslope Cutthroat Trout

The following sections summarize westslope cutthroat trout historical and current population status, habitat requirements, and limiting factors affecting the population. The information included in this section focuses primarily on the Kootenai River and Kootenay Lake population. Most of the following information is taken directly from the Kootenai River Subbasin Assessment (KTOI and MFWP 2004).

Historical and Current Status

The westslope cutthroat trout is one of fourteen subspecies of cutthroat trout native to interior regions of western North America. Although the extent of its range is not precisely known, the historical range of the westslope cutthroat is considered the most geographically widespread among the 14 subspecies of inland cutthroat trout (Behnke 1992). It is believed they inhabited all major drainages west of the Continental Divide (Leary et al. 1991). Shepard et al. (2005) estimates they historically occupied 2,640 miles of stream in the Upper Kootenai, Fisher, Yaak, Lower Kootenai, and Moyie drainages.

In June of 1997, the USFWS was petitioned to list the westslope cutthroat trout as threatened and designate critical habitat. In 1998, the USFWS published a notice of a 90-day finding that the petition provided substantial information indicating that the requested action may be warranted and immediately began a comprehensive status review for westslope cutthroat trout. In 2002, based on the results of the status review, the USFWS determined that the westslope cutthroat trout was not likely to become a threatened or endangered species within the foreseeable

future. That determination was challenged by the petitioners and in 2003, the agency reevaluated their finding and again concluded that the subspecies does not warrant listing as a threatened species under the ESA because abundant, stable, and reproducing populations of westslope cutthroat remain well distributed throughout its historic range. (The USFWS listing determination is provided at the following link: http://www.thefederalregister.com/d.p/2003-08-07-03-20087.)

Region I of the U.S. Forest Service lists westslope cutthroat trout as a sensitive species. The state rank for both Montana and Idaho is S2, which means the species is considered imperiled because of rarity or because of other factors, demonstrably making it very vulnerable to extinction throughout its range. In the Idaho portion of the Lower Kootenai watershed, stocks of westslope cutthroat trout are known to occur in 33 stream reaches. Data indicate westslope cutthroat trout stocks are strong or predicted to be strong in two HUCs and depressed or predicted depressed in the remaining 31 HUCs (KTOI and MFWP 2004). Twenty-five years of population estimates reveal a population decline for westslope cutthroat trout in the Kootenai subbasin (Hoffman et al. 2002). Severe declines in westslope cutthroat trout abundance in Koocanusa Reservoir tributaries have been measured since the early eighties in population index streams (Marotz et al. 1998).

Life History

Westslope cutthroat trout usually mature at 4 or 5 years of age and spawn entirely in streams, primarily small tributaries. Spawning occurs between March and July, when water temperatures warm to about 10 C (50 F) (Trotter 1987; Behnke 1992). Natal homing, the return of adult fish to spawning areas where they were produced, is believed to occur in westslope cutthroat trout.

Three westslope cutthroat trout life-history types (resident, fluvial, and adfluvial) are recognized (Trotter 1987; Behnke 1992). Resident fish spend their lives entirely in the natal tributaries; fluvial fish spawn in small tributaries but their resulting young migrate downstream to larger rivers where they grow and mature; and adfluvial fish spawn in streams but their young migrate downstream to mature in lakes. After spawning in tributaries, adult fluvial and adfluvial westslope cutthroat trout return to the rivers or lakes (Behnke 1992). All three life-history types occur within the Kootenai subbasin (Marotz et al. 1998).

Westslope cutthroat trout feed primarily on macroinvertebrates, particularly immature and mature forms of aquatic insects, terrestrial insects, and, in lakes, zooplankton (Liknes and Graham 1988). These preferences for macroinvertebrates occur at all ages in both streams and lakes. Westslope cutthroat trout rarely feed on other fishes (Liknes and Graham 1988; Behnke 1992).

Growth of individual westslope cutthroat trout, like that of fish of other species, depends largely upon the interaction of food availability and water temperature. Resident westslope cutthroat trout usually do not grow longer than 30 cm (12 inches), presumably because they spend their entire lives in small, coldwater tributaries. In contrast, fluvial and adfluvial westslope cutthroat trout often grow longer than 30 cm (12 inches) and attain weights of 0.9-1.4 kg (2-3 pounds). Such rapid growth results from the warmer, more-productive environments afforded by large rivers, lakes, and reservoirs (Trotter 1987; Behnke 1992).

Habitat Requirements and Limiting Factors

Like bull trout, westslope cutthroat trout are often considered an indicator of the health of the aquatic ecosystem. Both species require high quality, cold water and clean gravel for spawning, and both species do best in complex habitats, much of which is created by large woody debris. Proximity to cover is an important component of spawning habitat. Adult westslope cutthroat trout are strongly associated with pools and cover (McIntyre and Riemen 1995).

Historically, habitats of westslope cutthroat trout ranged from cold headwater streams to warmer, mainstem rivers (Behnke 1992). Today, remaining stocks of westslope cutthroat trout occur primarily in colder, headwater streams (Liknes and Graham 1988). Westslope cutthroat trout may exist in these streams not because the thermal conditions there are optimal for them, but because nonnative salmonid competitors like brook trout cannot exploit these cold, high-gradient waters (Griffith 1988; Fausch 1989).

Table 2-18 presents a summary of preferred habitat characteristics based on empirical data, literature, and expert professional judgment (see Appendix D for additional detail). Consideration is given to habitat preference at each life stage and the relevant duration or seasonality for that life stage habitat requirement. Variables noted with an "X" in the table below are believed to be important to the specified westslope cutthroat trout life stage.

Table 2-18. Westslope cutthroat trout life stage and preferred habitat characteristics based on empirical data and literature.

Life Stage	Migrating Adult	Spawning Adult	Embryo	Alevins	Fry	Fingerling	Juvenile
Duration/ Seasonality	**Winter to Spring**	**Mar to May**	**Mar to Jun**	**May to Jul**	**May to Jul**	**Summer to Winter**	**Year-round**
River Reach Used by Life Stage							
Canyon	X						X
Braided Reach 1	X						X
Braided Reach 2	X						X
Straight Reach	X						X
Meander Reach 1	X						X
Meander Reach 2	X						X
Tributaries	X	X	X	X	X	X	X
Water Quality							
Temperature	X	X	X	X	X	X	X
Dissolved oxygen	X	X	X	X	X	X	X
Turbidity/suspended sediment	X	X	X	X	X	X	X
Nutrient availability	X	X	X	X	X	X	X
Other WQ factors	X	X	X	X	X	X	X
Substrate							
Type of substrate	X	X	X	X	X	X	X
Particle size distribution	X	X	X	X	X	X	X
Longitudinal extent (length)		X	X	X			
Interstitial spaces		X	X	X	X		X
Cover							
Depth/incident light	X	X			X	X	X
Canopy/shade	X	X			X	X	X
Undercut banks	X	X				X	X

Table 2-18. Westslope cutthroat trout life stage and preferred habitat characteristics based on empirical data and literature.

Life Stage	Migrating Adult	Spawning Adult	Embryo	Alevins	Fry	Fingerling	Juvenile
Duration/ Seasonality	**Winter to Spring**	**Mar to May**	**Mar to Jun**	**May to Jul**	**May to Jul**	**Summer to Winter**	**Year-round**
Turbidity/suspended sediment		X					
Hydraulic cover	X	X				X	X
Large woody debris	X	X			X	X	X
Hydraulics							
Velocity	X	X	X	X	X	X	X
Velocity variability	X	X	X	X	X	X	X
Boundary sheer stress	X	X	X	X	X	X	X
Lateral sheer	X	X	X	X	X	X	X
Hydrology							
In-channel groundwater/surface water interaction		X	X				
Flow duration, frequency, and magnitude	X	X	X	X	X		
Channel geometry							
Habitat diversity	X	X			X	X	X
Depth	X	X			X	X	X
Channel stability	X	X					
Single vs. braided, meander	X	X			X	X	X
Connection with off-channel habitat		X			X	X	X
Connection with tributary habitat	X	X			X	X	X
Slope/gradient	X	X	X	X	X	X	X
Pool/riffle/run ratio; pool spacing	X	X			X	X	X

Habitat factors considered to be most limiting to westslope cutthroat trout populations in the US portion of the Kootenai subbasin include degraded riparian condition, fine sediment, channel instability and lack of habitat diversity (KTOI and MFWP 2004). The Montana Chapter of the American Fisheries Society identified the following factors as the primary reasons for the decline of westslope cutthroat trout: overexploitation, genetic introgression and competition from non-native fish species, and habitat degradation. Fish passage barriers that restrict westslope cutthroat trout spawning migrations also negatively affect the species.

2.6.2 Altered Ecosystem Effects on Aquatic Habitat

Considering only one life stage of a single focal species, it might be possible to identify a single habitat component that could be restored to address that species and life stage. However, when considering all life stages of all focal species, it is apparent that aquatic species depend on

functioning aquatic habitat that is supported by a diverse, functioning river and floodplain ecosystem.

The following sections outline how river management has led to limiting factors that impact focal species' aquatic habitat. Because Kootenai sturgeon are greatly impacted by the identified limiting factors, and because recovery of Kootenai sturgeon is an important regulatory and practical driver of this Master Plan, the following discussion emphasizes relationships between Kootenai sturgeon and altered habitats. However, the Tribe believes that addressing the factors that limit naturally self-sustaining populations of Kootenai sturgeon by restoring ecosystem function in the Kootenai River will also benefit other native focal species identified and discussed in this Master Plan.

The following excerpt is from the Kootenai sturgeon critical habitat designation (USFWS 2008) explaining Kootenai sturgeon spawning habitat conditions since the closure of Libby Dam.

> Since the construction of Libby Dam, most Kootenai sturgeon spawn over sandy substrates in the Meander Reach below Bonners Ferry. The Meander Reaches have a low stream gradient, and substrates are composed primarily of sand and other fine materials overlying lacustrine clay (Barton 2003, p. 45; Barton et al. 2004, pp. 1, 18–21). Many of the eggs that are located in this reach are found drifting along the river bottom, covered with fine sand particles in sites without rocky substrate (Paragamian et al. 2001, p. 26), and where mean water column velocities seldom exceeded 3.3 ft/s (1.0 m/s) (Paragamian et al. 2001, Table 2, p. 26; Barton et al. 2005, Table 3). The sandy substrate in the current spawning sites in the Kootenai River differs from the rocky substrate that occurs in successful white sturgeon spawning sites elsewhere in the Columbia River Basin (Paragamian et al. 2001, pp. 28–29; Parsley et al. 1993, Table 2, p. 220 and Figure 6, p. 222; Parsley and Beckman 1994, pp. 812–827; Kock et al. 2006, pp. 134–135, 139 and references therein).

River management has affected the historical hydrograph by regulating river flow. As reviewed in Section 2.4, Libby Dam operations have decreased peak flows by approximately half. Diminished spring flows equate to shallower water depths and lower velocities in the Master Plan project area. Some regional sturgeon experts have proposed that the shallower channel is a behavioral passage barrier for Kootenai sturgeon migrating from the Meander reaches to the Straight and Braided reaches where coarser channel bed material is located (P. Anders, Cramer Fish Sciences, personal communication, 2009). Figure 2-44 illustrates river depths through the project area associated with pre-dam discharge of 65kcfs, the approximate pre-dam bankfull discharge. Figure 2-45 shows river depths in the post-dam era using a revised post-dam bankfull discharge of 30kcfs. The 1,763 ft elevation of the Kootenai River at Porthill was selected to represent the pre-dam bankfull discharge downstream boundary condition as it was the median river elevation associated with the 65kcfs pre-dam discharge based on the historical record. Because water surface elevations at gaging stations on Kootenay Lake and the Kootenai River through the backwater extent have similar patterns and are generally linearly correlated although with different elevations (Berenbrock 2005), river stage recorded at the Porthill gage was used as a surrogate for backwater conditions. The 1,754 ft elevation of the Kootenai River at Porthill was used for the post-dam 30kcfs bankfull event downstream boundary condition as that elevation was the median post-BiOp elevation associated with a 30kcfs discharge.

Because Kootenai sturgeon spawning activities correspond to rising streamflows and water temperature associated with spring runoff (Paragamian and Kruse 2001), the 65kcfs (1,840 cms) discharge used to represent the pre-dam bankfull flood event most likely would have elicited a Kootenai sturgeon spawning response based on observations presented in Paragamian and Kruse (2001). Additionally, Kootenai sturgeon have been observed in spawning areas at flows exceeding the modeled post-dam 30kcfs (850 cms) bankfull discharge event (Paragamian and Kruse 2001). Female Kootenai sturgeon abandoned spawning areas when flows dropped to between 24kcfs (700 cms) and 11kcfs (300 cms). Although discharge has been reported as an important spawning cue, water temperature is also an important condition influencing Kootenai sturgeon spawning (Paragamian and Kruse 2001). Shallower depths through the upstream project reaches may cause Kootenai sturgeon to return to the deeper Meander Reaches where they spawn over finer sediment, resulting in poor embryo survival.

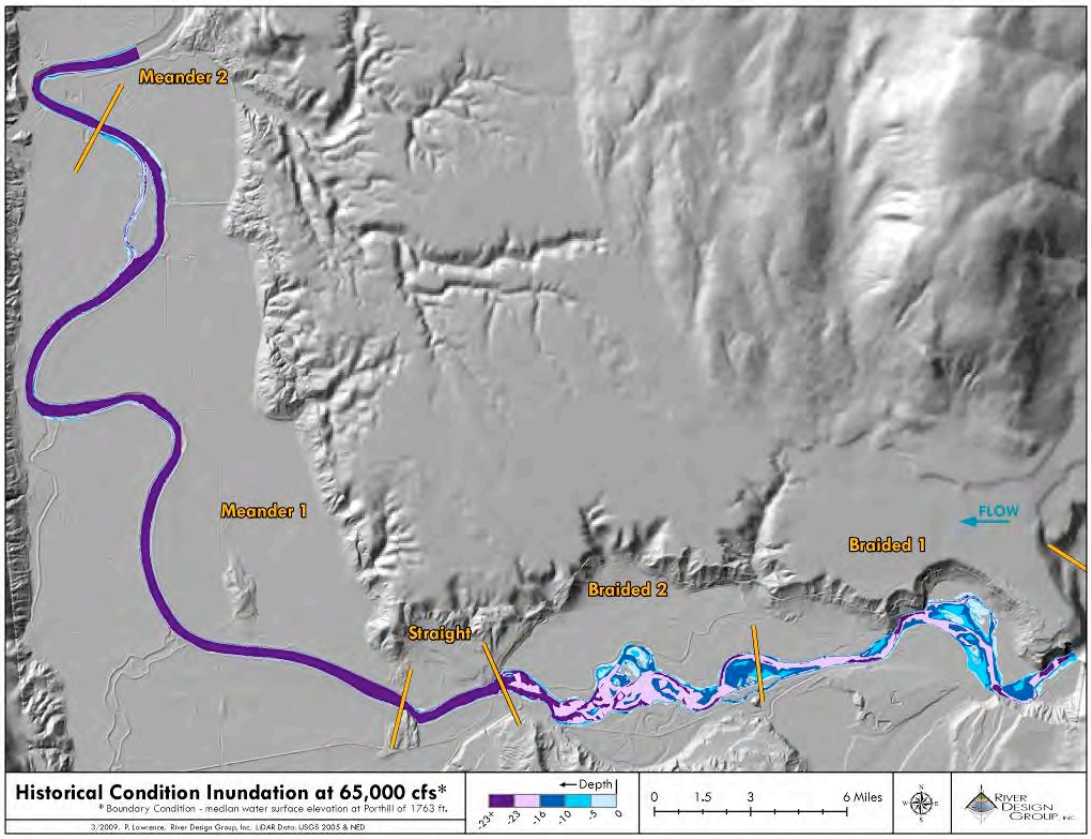


Figure 2-44. River channel depths associated with a discharge of 65kcfs (pre-dam mean annual peak flow. River depths exceeding 23 ft (Kootenai sturgeon BiOp spawning habitat depth target) are located throughout the Straight and Meander reaches. Shallower depths characterize the Braided Reach.

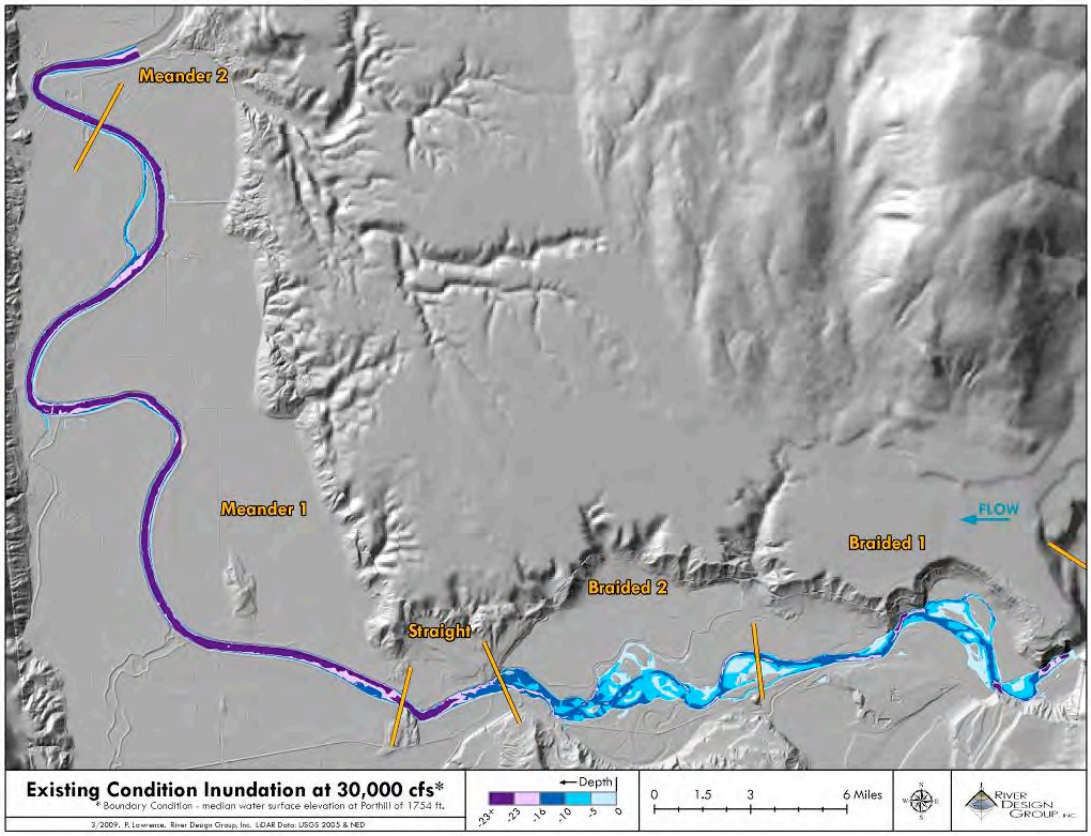


Figure 2-45. River channel depths associated with a discharge of 30kcfs (post-dam mean annual peak flow). River depths exceeding 23 ft (Kootenai sturgeon BiOp spawning habitat depth target) are located in the downstream half of the Straight Reach and throughout the Meander Reach. Shallower depths characterize the Braided Reach and upstream half of the Straight Reach.

Data presented in the above depth figures were used to quantify pre-dam (65kcfs) and post-dam (30kcfs) mean annual peak flow depths to evaluate changes in mainstem habitat with river management. Channel depths were delineated into five depth categories to compare the two eras. Based on the Libby Dam BiOp as revised (USFWS 2006, clarified in 2008), it is suggested that channel depths exceeding 23 ft in the project area will provide favorable depths for migrating and spawning Kootenai sturgeon.

Table 2-19 summarizes mean annual peak flow channel depths for the pre-dam period. Table 2-20 includes information for the post-dam period. Figure 2-46 includes the percentages of the depth categories for each project reach by period.

In general, there has been an increase in the percentage of shallow depth categories and a decrease in deeper depth categories from the pre-dam to post-dam eras. The Straight Reach and Braided Reach 2 have experienced the greatest reduction in channel depths exceeding 23 ft suggesting a downward trend in preferred Kootenai sturgeon spawning habitat depths based on the guidance provided in the Libby Dam BiOp (USFWS 2008). This change in channel depths may be important for Kootenai sturgeon spawning as Kootenai sturgeon have been observed abandoning spawning areas following rapid decreases in flow (Paragamian and Kruse 2001).

Alternatively, such observations could simply be natural post-spawning behaviors consistently observed for post-spawned females (Anders 1991; Apperson and Anders 1990, 1991).

Table 2-19. Pre-dam channel thalweg depths (ft) and percentage of reach length for five channel depth categories based on 65 kcfs discharge.

Channel Depth Categories (ft)	Braided Reach 1		Braided Reach 2		Straight Reach		Meander Reach 1		Total
	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)
0-5	0	0.0	0	0.0	0	0.0	0	0.0	0
5-10	0	0.0	0	0.0	0	0.0	0	0.0	0
10-16	1445	7.0	0	0.0	0	0.0	0	0.0	1445
16-23	12420	60.2	2619	15.7	0	0.0	0	0.0	15039
23+	6772	32.8	14079	84.3	5817	100.0	51148	100.0	77816
Total	**20637**	**100**	**16698**	**100**	**5817**	**100**	**51148**	**100**	**94,300**

Table 2-20. Post-dam channel thalweg depths (ft) and percentage of reach length for five channel depth categories based on 30 kcfs discharge.

Channel Depth Categories (ft)	Braided Reach 1		Braided Reach 2		Straight Reach		Meander Reach 1		Total
	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)
0-5	316	1.5	0	0.0	0	0.0	0	0.0	316
5-10	1258	6.1	458	2.7	0	0.0	0	0.0	1716
10-16	10796	52.3	7542	45.2	0	0.0	0	0.0	18338
16-23	5609	27.2	7847	47.0	2412	41.5	97	0.2	15965
23+	2658	12.9	851	5.1	3405	58.5	51051	99.8	57965
Total	**20637**	**100**	**16698**	**100**	**5817**	**100**	**51148**	**100**	**94300**

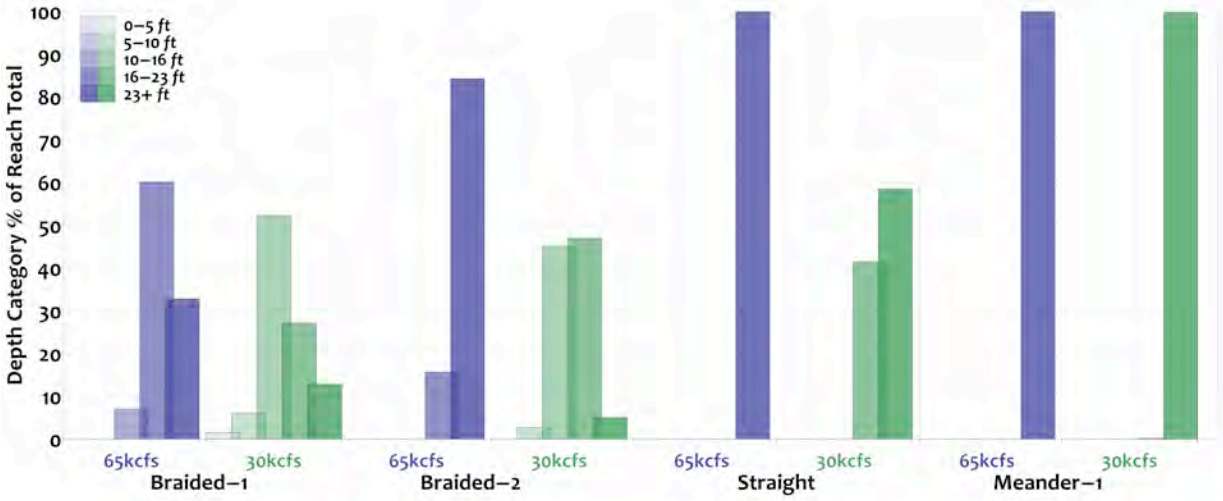


Figure 2-46. A comparison of channel depth categories in the project reach for the pre-dam mean annual peak flow (65kcfs) and post-dam mean annual peak flow (30kcfs). The proportion of shallower depth categories increases from the pre-dam to post-dam periods. Meander Reach 1 exhibits the least amount of change due to the consistent presence of the Kootenay Lake backwater.

Based on changes in depth, ***insufficient depth for Kootenai sturgeon migration has been identified as an aquatic habitat limiting factor***.

In addition to depth, water velocity and turbulence are reported to be important cues for Kootenai sturgeon spawning site selection (Paragamian et al. 2001). Due to the diminished flows as well as changes in the extent of the Kootenay Lake backwater, areas of the channel with sufficient water velocity and turbulence are thought to be less common in the post-dam era relative to the pre-dam period (Paragamian et al. 2001). Additionally, the frequency of higher velocities in the vicinity of coarse bed substrate is further limited in the post-dam era (Paragamian et al. 2001). Figure 2-47 illustrates the distribution of water velocities in the project area during the pre-dam period based on an average historical bankfull discharge of 65kcfs. Figure 2-48 presents water velocities in the project area during the post-dam period based on a bankfull discharge of 30kcfs. A comparison of the two figures illustrates the contraction in channel length with water velocities exceeding 3.3 fps, the velocity value reported as a requirement for successful sturgeon spawning in the Libby Dam BiOp (USFWS 2006, clarified in 2008). Historically, much of Braided Reach 1, the Straight Reach, and the Meander Reaches maintained bankfull velocities in excess of 3.3 fps. River regulation has reduced water velocities to the extent that bankfull water velocities are now limited to Braided Reach 1, a portion of Braided Reach 2, and the most upstream extent of the Straight Reach.

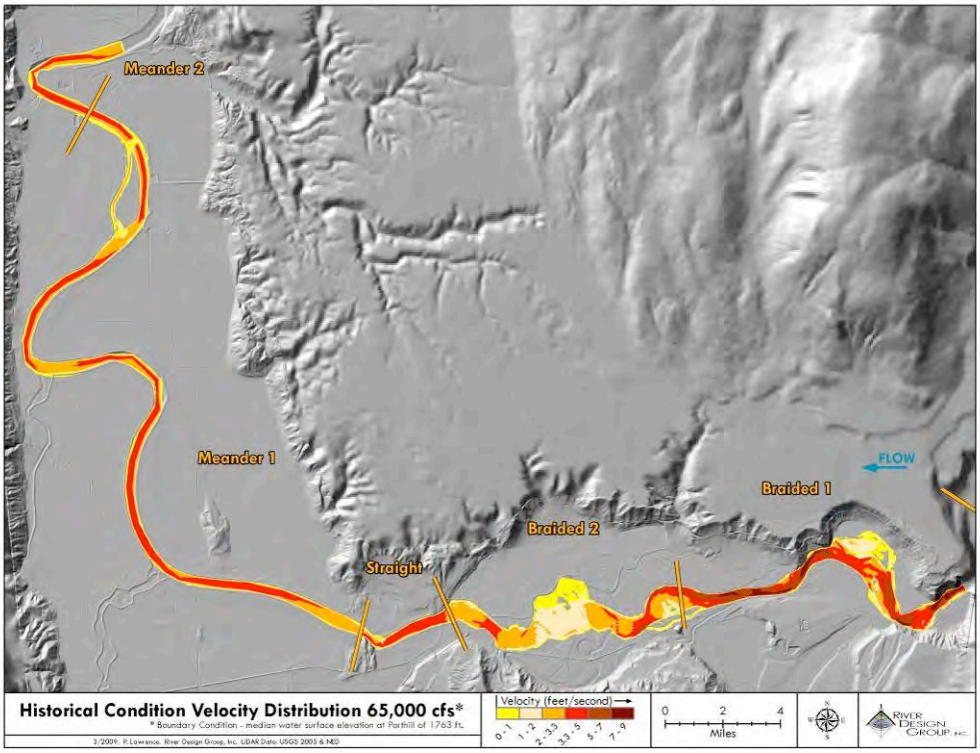


Figure 2-47. Water velocities associated with a discharge of 65kcfs (pre-dam mean annual peak flow). Velocities exceeding 3.3 fps (Kootenai sturgeon BiOp spawning habitat velocity target), shown in red or darker colors, are located throughout the Straight and Meander reaches, and sporadically through the Braided Reach. The lowest range of velocities is in Braided Reach 2 due to the broad channel cross-section.

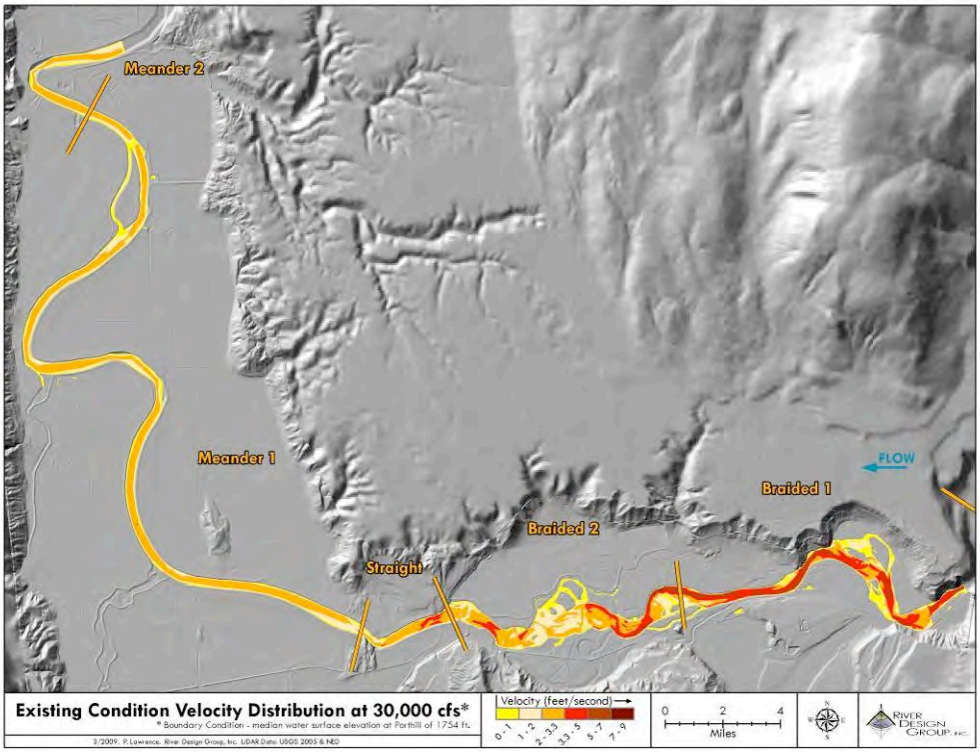


Figure 2-48. Water velocities associated with a discharge of 30kcfs (post-dam mean annual peak flow). Velocities exceeding 3.3 fps (Kootenai sturgeon Libby Dam BiOp spawning habitat velocity target), shown in red or darker colors, are limited to portions of the Straight and Braided reaches.

Data presented in the above velocity distribution figures were used to quantify average pre-dam (65kcfs) and post-dam (30kcfs) bankfull discharge velocities to evaluate changes in mainstem habitat with river management. Water velocities were delineated into seven velocity categories. Based on the Libby Dam BiOp (USFWS 2008), velocities 3.3 fps or greater in the project area are believed to provide velocities suitable for Kootenai sturgeon spawning, although most sturgeon spawning in the Kootenai River likely occurs over a considerably lower velocity range (P. Anders, Cramer Fish Sciences, personal communication, 2009).

Table 2-21 summarizes bankfull water velocities for the pre-dam period. Table 2-22 includes velocity data for the post-dam period. Figure 2-49 includes the percentages of the velocity categories for each project reach by period. In general, there has been an increase in the percentage of lower water velocity categories and a decrease in higher water velocity categories from the pre-dam to post-dam eras. The Straight Reach and Meander Reach 1 have experienced the greatest reduction in water velocities exceeding 3.3 fps, suggesting a downward trend in preferred Kootenai sturgeon spawning habitat velocities according to the Libby Dam BiOp (USFWS 2006, clarified in 2008).

Table 2-21. Pre-dam water velocities (fps) in the thalweg and percentage of reach length for seven velocity categories.

Velocity Categories (ft/s)	Braided Reach 1		Braided Reach 2		Straight Reach		Meander Reach 1		Total
	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)
0-1	0	0.0	0	0.0	0	0.0	213	0.4	213
1-2	64	0.3	2461	14.7	0	0.0	94	0.2	2619
2-3.3	0	0.0	5301	31.7	266	4.6	7740	15.1	13307
3.3-5	3269	15.8	6480	38.8	5551	95.4	43101	84.3	58401
5-7	8066	39.1	2456	14.7	0	0.0	0	0.0	10522
7-9	8502	41.2	0	0.0	0	0.0	0	0.0	8502
9-11.1(max)	736	3.6	0	0.0	0	0.0	0	0.0	736
Total	**20637**	**100**	**16698**	**100**	**5817**	**100**	**51148**	**100**	**94300**
Total ≥3.3 ft/s	**20573**	**99.2**	**8936**	**53.5**	**5551**	**95.4**	**43101**	**84.3**	**78161**

Table 2-22. Post-dam water velocities (fps) in the thalweg and percentage of reach length for seven velocity categories.

Velocity Categories (ft/s)	Braided Reach 1		Braided Reach 2		Straight Reach		Meander Reach 1		Total
	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)	%	Length (feet)
0-1	38	0.2	0	0.0	0	0.0	455	0.9	493
1-2	0	0.0	638	3.8	0	0.0	451	0.9	1089
2-3.3	623	3.0	5879	35.2	4221	72.6	50242	98.2	60965
3.3-5	5354	25.9	6281	37.6	1596	27.4	0	0.0	13231
5-7	14622	70.9	3161	18.9	0	0.0	0	0.0	17783
7-9	0	0.0	739	4.4	0	0.0	0	0.0	739
9-11.1(max)	0	0.0	0	0.0	0	0.0	0	0.0	0
Total	**20637**	**100**	**16698**	**100**	**5817**	**100**	**51148**	**100**	**94,300**
Total ≥3.3 ft/s	**19976**	**96.8**	**10181**	**60.9**	**1596**	**27.4**	**0**	**0**	**31753**

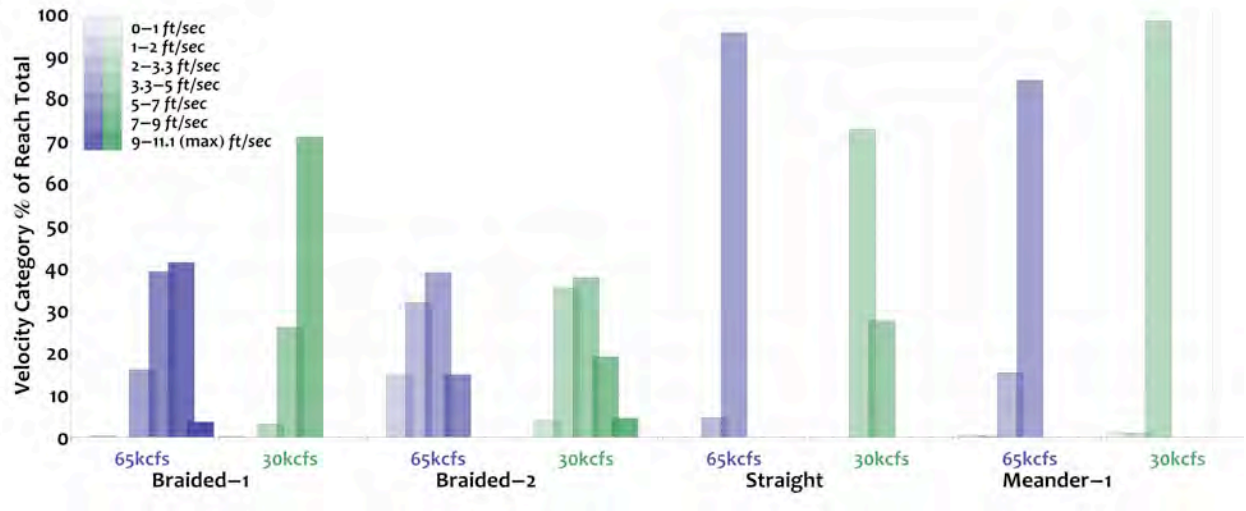


Figure 2-49. A comparison of water velocities in the project reaches for the pre-dam (65 kcfs) and post-dam (30 kcfs) mean annual peak flows.

Based on changes in velocity, ***insufficient velocity for Kootenai sturgeon spawning has been identified as an aquatic habitat limiting factor***.

Post-dam changes in hydraulics that have caused reduced depths and velocities have also resulted in finer channel bed sediments. Figure 2-50 displays a sediment facies map for portions of the project area. The sediment composition is based on coring data and underwater videography completed by USGS. Although areas of coarser bed material are found in the Meander Reaches, embeddedness of coarse substrate with finer material has occurred. Finer bed materials are reported to negatively affect Kootenai sturgeon embryos (Koch et al. 2006). An explanation of how sediment transport has changed in the project area is included in Section 2.4.

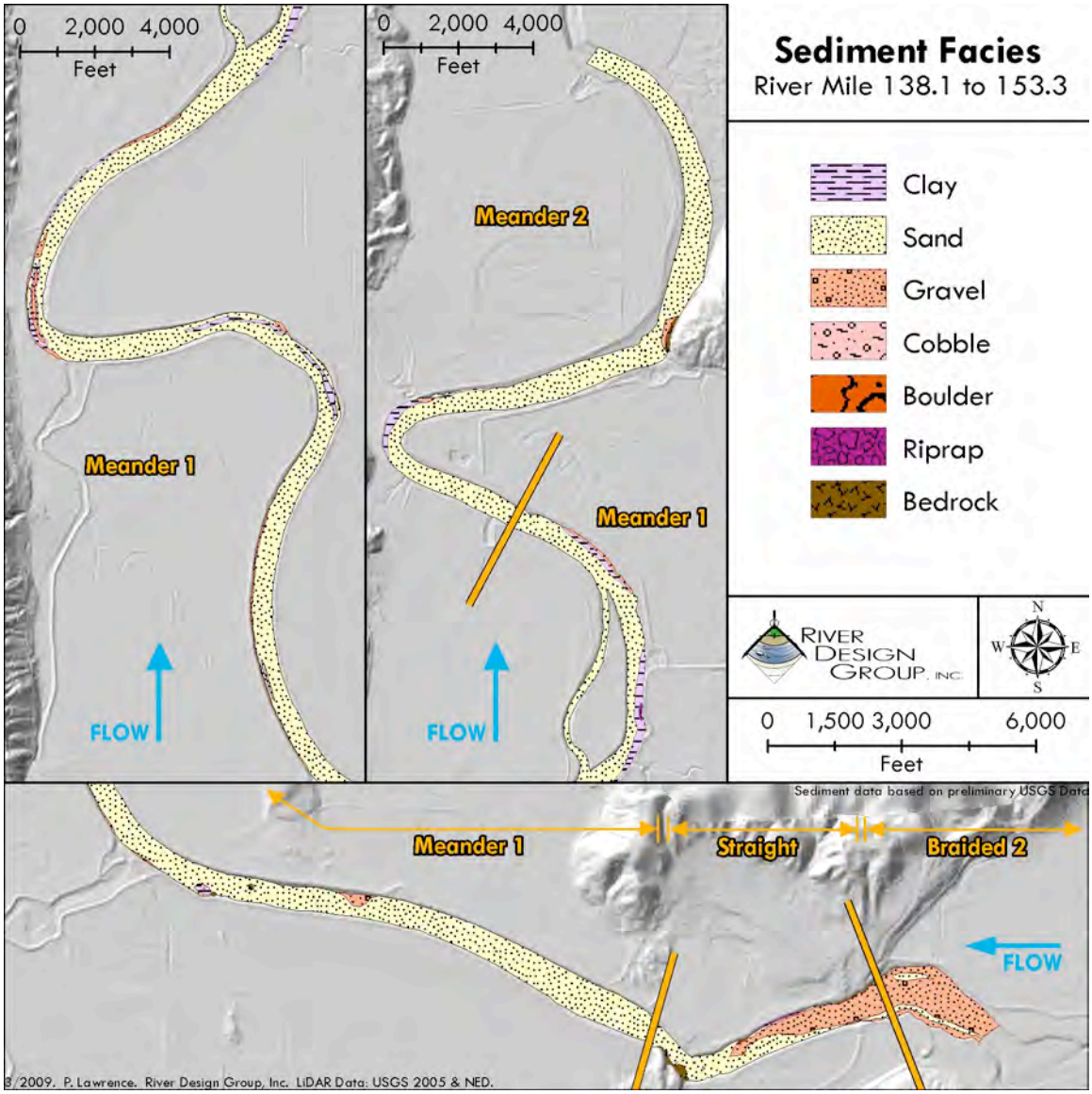


Figure 2-50. Existing condition channel bed materials in the project area. Coarse substrate suitable for spawning has become increasingly embedded with finer substrate.

Based on changes in substrate composition, ***lack of coarse substrate for egg attachment has been identified as an aquatic habitat limiting factor***.

While water depth, velocity, and substrate are important indicators of Kootenai sturgeon spawning habitat conditions, it is the combined presence of sufficient water depth, higher water velocities, and coarse channel substrate that forms the range of conditions reported to be required for successful Kootenai sturgeon spawning and embryo survival (USFWS 2008).

While changes in hydraulics have affected depth, velocity and substrate, these changes have also resulted in less complex aquatic habitat in terms of pool and riffle distribution. Habitat suitability maps were completed for the project area to evaluate the distribution of pool and riffle habitat in the project area. Areas within the channel with maximum depths that exceeded twice the

mean reach depth were delineated as pools. Areas of the channel with depths less than twice the mean reach depth were delineated as riffle habitat. Figure 2-51 displays the distribution of pool and riffle habitats in the project area. Pool habitat is currently less common in the Braided Reaches, accounts for over half of the Straight Reach, and defines slightly over a third of the mainstem habitat in the Meander Reaches. Riffle habitat dominates the Braided and Meander reaches and accounts for less than half of the Straight Reach (Table 2-23). An explanation of how channel morphology has changed from the pre-dam era to the present time is included in Section 2.4.

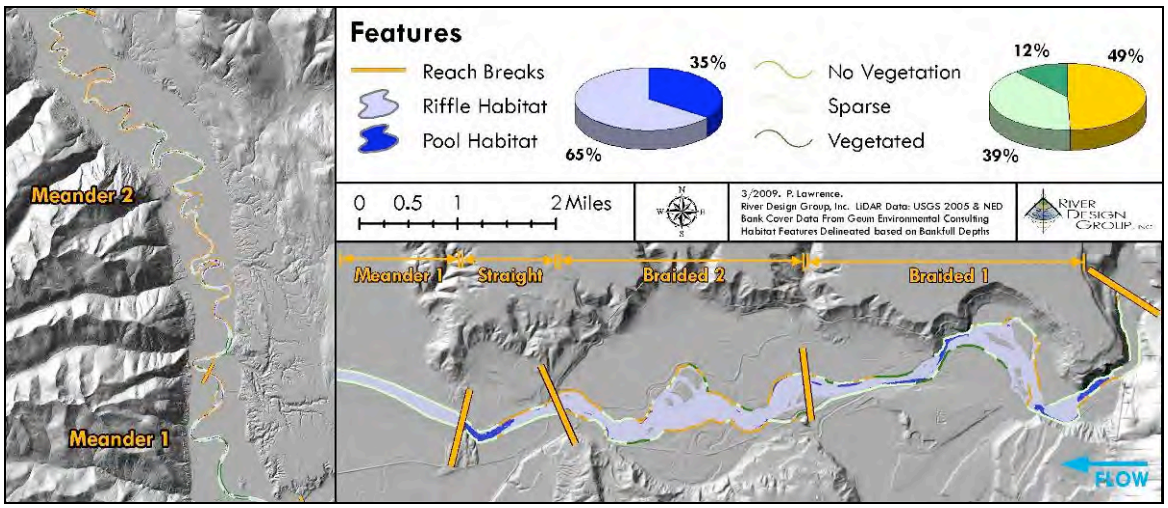


Figure 2-51. The distribution of pool and riffle habitats in the project reaches based on thalweg depth relative to mean depth. Thalweg depths exceeding twice mean depth are considered to be pool features.

Table 2-23. Pool and riffle habitat unit lengths and the percentage of the habitat unit's portion of each reach within the Master Plan project area.

Reach	Pool Length		Riffle Length		Total
	Length (ft)	% of Reach	Length (ft)	% of Reach	(mi)
Braided 1	8,897	43.1	11,736	56.9	3.9
Braided 2	1,678	10.1	15,006	89.9	3.2
Straight	3,307	56.8	2,517	43.2	1.1
Meander 1	18,636	36.5	32,492	63.5	9.7
Meander 2	67,209	35.8	120,402	64.2	35.5
Total	**99,727**	**35.4**	**182,152**	**64.6**	**53.4**

Based on changes in pool/riffle habitat distribution in some reaches, ***lack of pool-riffle complexity*** and ***insufficient pool frequency have been identified as aquatic habitat limiting factors***.

Nutrient fluxes in the Kootenai subbasin have also changed over time in response to extensive levee construction, transitions in land uses, operation and then closure of fertilizer production facilities and mines, and construction and operation of Libby Dam. Reduced nutrients have simplified the food web in the Kootenai River (Holderman and Hardy 2004; Holderman et al. 2009b). Nutrient sequestration in Lake Koocanusa and loss of over 50,000 acres of historical floodplain habitat diversity and productivity are cited as primary reasons for diminished nutrient loads downstream from Libby Dam (Snyder and Minshall 1996; Anders et al. 2002). As described in Section 2.5, conversion of native vegetation to agricultural crops and invasive plant species has reduced primary productivity in the floodplain, likely resulting in diminished nutrient inputs to the river.

Altered water quality directly affects biological productivity at all trophic levels, and may decrease food availability for fish including Kootenai sturgeon. Decreased prey availability for some life stages of sturgeon, and a possible reduction in the overall carrying capacity for the Kootenai River and Kootenay Lake to sustain populations of Kootenai sturgeon and other native fishes may be a significant limiting factor. A limited food supply for young-of-year fish could contribute to increased mortality rates, either through starvation or through increased predation mortality, because young of the year would spend more time feeding, thereby exposing themselves to higher predation risk. Based on these factors, ***simplified food web from lack of nutrients has been identified as an aquatic habitat limiting factor***.

Water quality conditions have varied over the period of Euro-American settlement in the Kootenai River drainage. In the late 1800s through 1974 (Libby Dam closure), agriculture, mining, logging, pulp mill operations, and development contributed sediment, nutrients, and mining-related metals to the Kootenai subbasin. The delivery of these materials to the river network degraded water quality. Agriculture, urban runoff, and wastewater treatment discharge to the river continue to influence water quality.

Channel bed sediment contamination by heavy metals and other chemicals likely affects benthic fishes like Kootenai sturgeon and burbot inhabiting the Kootenai River. Georgi (1993) noted that the chronic effects on wild sturgeon spawning in "chemically polluted" water and rearing over contaminated sediments, in combination with bioaccumulation of contaminants in the food web, is possibly reducing the successful reproduction and early-age recruitment to the Kootenai

sturgeon population. Results from a contaminant study performed in 1998 and 1999 showed that water concentrations of total iron, zinc, and manganese, and the PCB Arochlor 1260 exceeded suggested environmental background levels (Kruse 2000). Increased exposure to copper and Arochlor 1260 significantly decreased survival and incubation time of white sturgeon embryos and could be a potentially significant additional stressor to the white sturgeon population.

However, the high sturgeon fertilization and hatch rates in the hatchery, often exceeding 90%, along with consistent post-release, in-river survival rates of 60% during the first year at large, and 90% during all subsequent years among age 1 and older fish (Ireland et al. 2002; KTOI 2008) do not support an acute toxicity explanation for sturgeon limitation at the population level.

Flow regulation at Libby Dam has led to typically warmer water temperatures in the winter and cooler water temperatures in the summer (Partridge 1983). Changes in the thermal regime have affected the focal species by influencing seasonal behavior patterns, most notably spawning cues for Kootenai sturgeon (Paragamian et al. 2001) and burbot (KTOI and MFWP 2004), as well as the potential to influence young-of-year over-wintering energy expenditure (B. Kynard, BK RiverFish, personal communication, 2009). Figure 2-52 illustrates the average thermal regime for the pre-dam and post-dam periods.

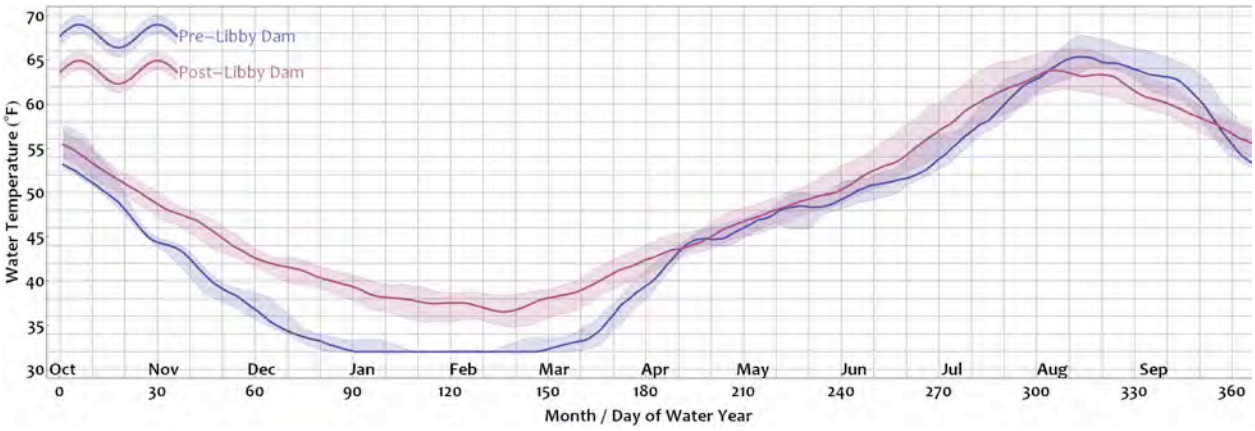
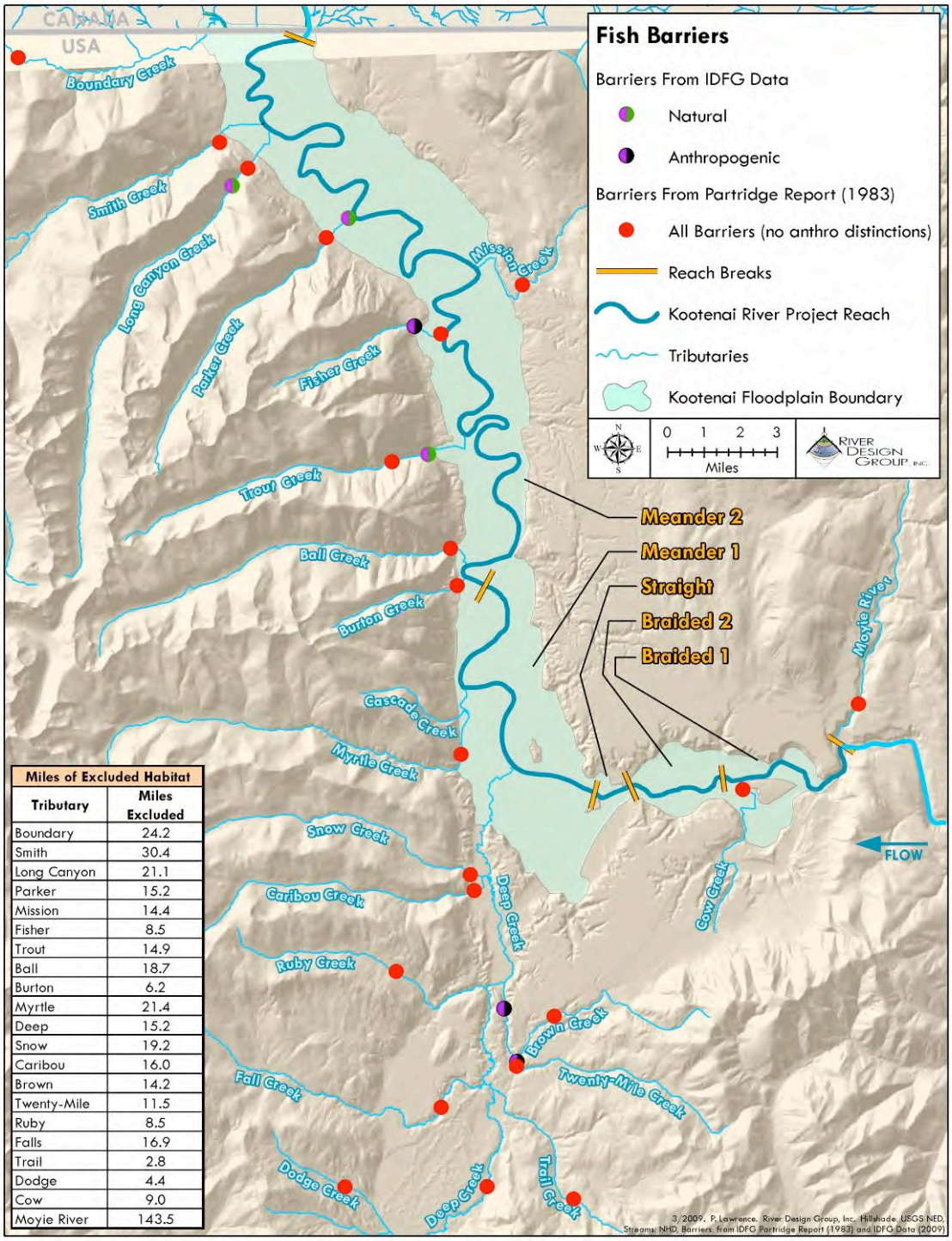


Figure 2-52. Average pre- and post-dam water temperature for the Kootenai River at Porthill (USGS Station #12322000).

Based on factors related to contaminants and changes in the thermal regime, ***altered water quality has been identified as an aquatic habitat limiting factor***.

Tributary connectivity with the Kootenai River is influenced by channel modifications, coarse bedload deposition in tributary deltas, and human infrastructure. Channel modifications including straightening, relocations, and dredging have affected tributary connectivity. Altered sediment-transport and deposition patterns have caused aggradation of sediments in the deltas of many tributaries to the Kootenai River upstream of the project area (KTOI and MFWP 2004). As a result, many of these deltas have become barriers to fish passage, especially at low flows. Other tributaries are impacted by both natural and anthropogenic fish passage barriers including natural falls and road crossings, respectively (Figure 2-53). Tributaries serve as important spawning and rearing habitat for many of the focal fish species, especially native trout and kokanee salmon.



Miles of Excluded Habitat	
Tributary	Miles Excluded
Boundary	24.2
Smith	30.4
Long Canyon	21.1
Parker	15.2
Mission	14.4
Fisher	8.5
Trout	14.9
Ball	18.7
Burton	6.2
Myrtle	21.4
Deep	15.2
Snow	19.2
Caribou	16.0
Brown	14.2
Twenty-Mile	11.5
Ruby	8.5
Falls	16.9
Trail	2.8
Dodge	4.4
Cow	9.0
Moyie River	143.5

Figure 2-53. Recognized fish passage barriers on tributaries to the Kootenai River project area. Barriers include both natural barriers like waterfalls, as well as human barriers such as road crossings. Many barriers are located at the transition from the valley floor to steeper forested reaches.

Based on this information about fish barriers in tributaries, ***lack of fish passage into tributaries has been identified as an aquatic habitat limiting factor***.

As described in Section 2.2 and 2.5, the aboriginal floodplain of the Kootenai River was modified to reduce flooding and optimize agriculture. Filling of floodplain wetlands and side channels, removal of large woody debris, and displacement of native riparian vegetation have simplified the floodplain ecosystem and resulted in the loss of off-channel habitat that likely supported life stages of some focal species in at least some years.

Removal of large woody debris, displacement of riparian vegetation, and filling of off-channel habitats has diminished cover habitats for juvenile fish rearing. Historically, the Kootenai River floodplain was a complex environment characterized by the mainstem river, backwater channels, and seasonal wetlands. Juvenile fish reared in floodplain tributaries and the mainstem would have inhabited shallow complex off-channel habitats influenced by vegetation and large wood. Flood protection measures and agricultural practices filled these habitats, creating a simplified mainstem river with little habitat complexity. Figure 2-54 illustrates the distribution of vegetation cover in the Kootenai River project area. The "No Vegetation" category dominates bank vegetation conditions. Table 2-24 presents descriptive statistics for the project area vegetation cover categories. Limited streamside vegetation equates to both short-term and long-term aquatic and riparian cover as vegetation that would recruit to a mature riparian forest is not currently present on the Kootenai River's floodplain.

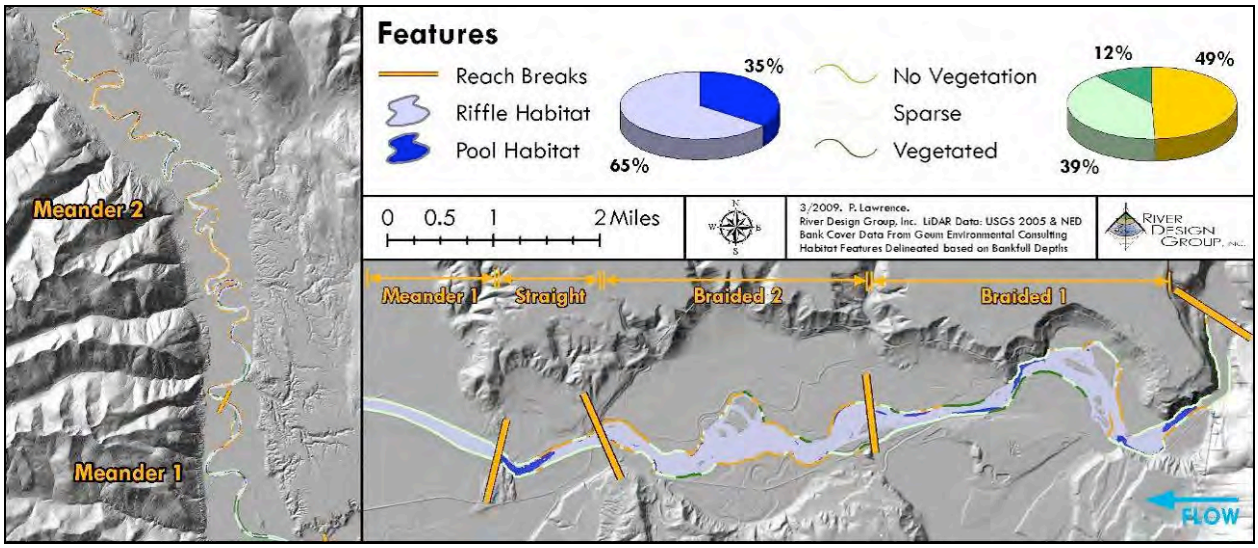


Figure 2-54. The distribution of bank vegetation cover conditions are presented as a proxy for streambank cover.

Table 2-24. Kootenai River bank cover conditions for the Master Plan project reach.							
Reach	**No Bank Cover**		**Sparse Bank Cover**		**Dense Bank Cover**		**Total**
	Length (ft)	% of Reach	Length (ft)	% of Reach	Length (ft)	% of Reach	(mi)
Braided 1	9,216	19.4	31,602	66.4	6,792	14.3	9.0
Braided 2	18,991	60.1	9,204	29.1	3,428	10.8	6.0
Straight	3,151	27.1	8,189	70.3	302	2.6	2.2
Meander 1	25,039	26.4	45,755	48.3	23,936	25.3	17.9
Meander 2	204,134	60.0	110,110	32.4	25,834	7.6	64.4
Total	**260,530**	**49.6**	**204,860**	**39.0**	**60,292**	**11.5**	**99.6**

Levees simplify the floodplain by restricting flood flows to the main channel. Similarly, flood water confinement to the channel reduces the overall productivity of the river-floodplain system as the shallow water habitats that are created on the floodplain during high flows are excluded by the levee network. Therefore, levees have reduced access to backwater and off-channel habitats which historically provided diverse microhabitats, food sources, and resting areas for fish in the Kootenai subbasin. Decreased floodplain-channel connectivity has resulted in fewer off-channel habitats in the system.

In-filling of gravel and fine gravel substrates with sand is reported to have reduced hiding habitat for free embryos and larval stage Kootenai sturgeon. Channel bed material simplification has decreased rearing habitat diversity and extent. Based on changes in the floodplain, loss of bank vegetation and construction of levees, and sand intrusion into interstitial spaces in the channel bed materials; ***lack of cover for larval and juvenile fish*** and ***lack of off-channel habitat for rearing have been identified as limiting factors for aquatic habitat***.

Development activities in the Kootenai subbasin dating to the early 1900s led to river corridor and aquatic habitat degradation. Extractive land uses affected the river ecosystem by disrupting river and floodplain functions; contributing sediment, nutrients, and contaminants to the river; and either erecting barriers in floodplain channels or impairing habitat in tributary streams. Further, over-fishing of Kootenai sturgeon and other focal species diminished the abundance of Kootenai River fish populations. The closure of Libby Dam in 1974 altered river hydraulics, sediment-transport, and river morphology resulting in additional adverse changes to the river ecosystem. Nutrients, water quality, and the thermal regime have also been affected by dam management. Combined with the ecosystem degradation that occurred prior to Libby Dam closure, river regulation has accentuated the ecosystem's departure from pre-European settlement river corridor conditions. The aforementioned conditions have created a suite of limiting factors that affect aquatic habitat in the project area.

2.7 Summary

In summary, the limiting factors presented in this chapter describe how human activities have affected the Kootenai River ecosystem in the project area. Limiting factors are defined as physical, biological, and ecological conditions that limit ecosystem sustainability and resiliency, negatively influence Kootenai sturgeon and other focal species, and affect the local social, cultural, and economic conditions. The detailed limiting factors analysis highlights how the Kootenai River ecosystem has been influenced largely by river and floodplain management. The

following chapter, Restoration Strategies, Treatments, and Habitat Actions (Chapter 3), proposes a hierarchical approach to overcoming the limiting factors through the implementation of habitat actions. The restoration "toolbox" approach is designed to apply specific restoration treatments to address limiting factors in each reach of the Kootenai River project area.

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.

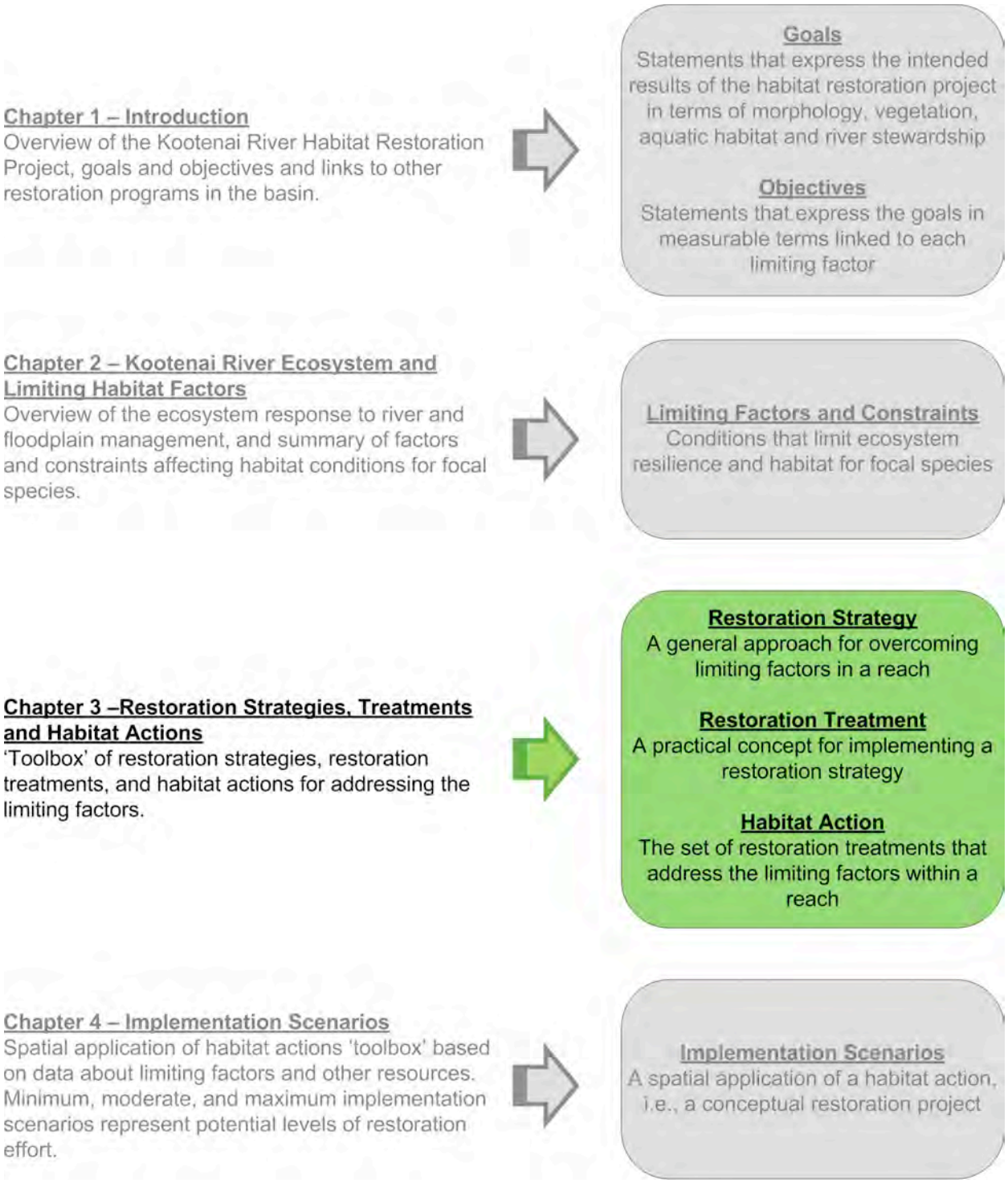


Figure 3-1. Relationship of Chapter 3 to Master Plan components in chapters 1, 2 and 4.

- ***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.

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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

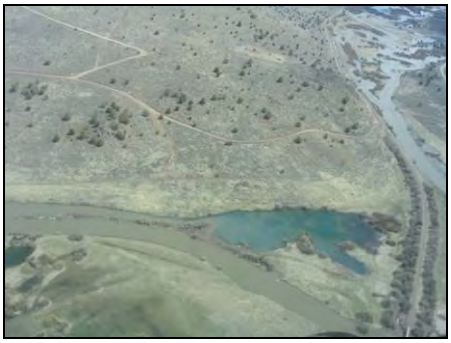
Floodplain excavation will contribute to overall restoration within the Meander Reaches by creating topographically diverse surfaces adjacent to the river that can be accessed by average peak flows, supporting riparian vegetation and facilitating the exchange of floodplain nutrients between the river 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.

4 Habitat Action Implementation Scenarios

Chapter 4 describes a range of conceptual implementation scenarios that quantify varying levels of restoration effort. Implementation scenarios, as defined for this Master Plan, are the spatial application of a habitat action. To develop implementation scenarios, data about limiting factors and other natural resource components were used to create maps that illustrate a range of spatial extents for which a habitat action could be applied to address the limiting factors in that reach using a specific set of criteria.

This chapter presents a synthesis of information from chapters 2 and 3. Chapter 2 describes the Kootenai subbasin and identifies specific limiting factors relative to morphology, riparian vegetation, and aquatic habitat. Chapter 2 also identifies river and floodplain management constraints. Chapter 3 includes descriptions of restoration strategies and treatments that were selected to address the limiting factors, and also includes an analysis of the capacity of each restoration treatment to address specific limiting factors. As described in Chapter 3, restoration treatments are combined to form a habitat action for each project reach. This chapter synthesizes information from chapters 2 and 3 by presenting implementation scenarios, which are spatial applications of habitat actions.

4.1 Overview

Habitat actions are applied to each reach by analyzing the spatial extent of limiting factors and other available spatial data about existing resources. Some limiting factors, such as those related to flow velocity and channel depth, have been mapped using bathymetry and hydraulic models, as described in Section 2.4. This makes it possible to identify areas in the river channel where velocity and depth result in unsuitable habitat based on accepted thresholds such as those identified in the Libby Dam BiOp for Kootenai sturgeon (USFWS 2006, clarified in 2008). Other limiting factors, such as the lack of sufficient areas with hydroperiod suitable to support wetland vegetation, can be inferred based on presence of drainage infrastructure, agricultural land use, and scarcity of hydrophytic vegetation in the floodplain. Spatial data about some of these factors exist as GIS layers and were combined as a restoration suitability analysis to identify areas that have a high potential for restoration.

This chapter includes a discussion about how available data were used to develop criteria to guide where habitat actions would be applied within each reach. For each reach, a minimum, moderate and maximum habitat action implementation scenario is described. This range of scenarios was selected because it makes it possible to provide a conceptual illustration of the degree of changes that may result from restoration and the range of estimated costs that would be associated with different levels of effort.

It is important to understand that the implementation scenarios presented in this chapter do not represent recommended sets of restoration treatments; rather, they are ways to illustrate low, medium and high levels of effort that can be translated into costs to help with program planning, development of a funding strategy, and other related activities. In addition, describing the minimum, moderate, and maximum ranges in terms of which limiting factors each scenario

would address makes it possible to understand ecological trade-offs related to choosing one level of effort over another.

The implementation scenarios described in this chapter provide an illustration of possible approaches to addressing the complex and interrelated factors limiting naturally self-sustaining populations of Kootenai sturgeon and other aquatic focal species. When specific restoration projects are selected and designed in subsequent phases of the Kootenai River Habitat Restoration Project, they will likely include mixes (or portions) of the implementation scenarios described in this Chapter.

4.2 Approach to Determining Spatial Extents of Habitat Actions

Within the Braided Reaches and Straight Reach, the spatial extent of habitat actions was determined by hydraulic and morphological limiting factors such as flow velocity, channel depth and bank erosion. Within these reaches, it is possible to increase both depth and velocity by excavating and dredging the channel and constructing floodplain surfaces.

Within the Meander Reaches, it is less feasible to address channel morphology (and related hydraulic and sediment-transport components) through direct restoration treatments due to the Meander Reaches' much larger scale, combined with the greater influence of constraints including levees, land ownership considerations, and the Kootenay Lake backwater effect. Therefore, in the Meander Reaches, the spatial extent of habitat actions is guided mainly by their ability to address floodplain connection, lack of specific instream habitat, bank instability, lack of nutrient inputs to the river, and lack of riparian vegetation and wetlands. In addition, other natural resource and land ownership data sets were used to determine the spatial extent of floodplain restoration in the Meander Reaches.

4.2.1 Limiting Factors Data Used To Support Spatial Extent of Habitat Actions

Habitat limiting factors are discussed in detail in Chapter 2; these limiting factors were linked to long-term, cumulative changes to the ecosystem that have occurred based on river management, land management and development within the project area. Data are available for a subset of these limiting factors in a spatial format that makes it possible to identify where limiting factors are present within different reaches. Methods and sources for each different type of data are described in Chapter 2. Table 4-1 below summarizes the presence of this subset of limiting factors by reach.

Within the Braided Reaches and Straight Reach, the majority of the channel is characterized by altered morphology, resulting in significant areas of low velocities and shallow depths. As described in Section 2.4, and appendices A, B and E, this altered channel morphology in combination with bank erosion has changed the available sediment supply within these reaches, and reduced the availability of sediment storage areas. Availability of sediment storage areas was considered, but not quantified when evaluating the spatial extent of habitat actions in the Braided Reaches for this Master Plan. Depending on the volume of sediment delivered to the Braided Reaches over time, an equivalent volume of floodplain storage areas can be constructed to offset the gradual decrease in sediment-transport capacity as the river flows downstream.

Quantification of sediment storage needs and the extent of habitat action implementation required to address this need will be evaluated during later design phases. This information, combined with information from other sections of this Master Plan describing how the upstream reaches affect downstream reaches, was used to help identify the spatial extent of restoration treatments that should be implemented in each reach in order to meet project goals and objectives. In areas selected for channel reconstruction, information about pool spacing and the relationship between pools and riffles was used to support the extent of restoration treatments related to instream habitat such as woody debris and substrate placement.

Streambanks with extreme, high and moderate Bank Erosion Hazard Index (BEHI) ratings are also present in all reaches. This information was used to determine the spatial extent of restoration treatments that address bank erosion. Related to BEHI, streambanks without vegetation or with sparse vegetation are also present in all reaches and this information was used to determine the extent of restoration treatments that address the lack of bank revegetation.

Examples of data related to BEHI, channel depth, flow velocity and instream habitat are shown on the following pages in Figures 4-1, 4-2, 4-3 and 4-4 respectively.

Table 4-1. Summary of available limiting factors data for instream habitat by reach.

Criteria		Braided Reach 1		Braided Reach 2		Straight Reach		Meander Reach 1		Meander Reach 2	
		Units	%	Units	%	Units	%	Units	%	Units	%
Velocity	less than 3.3 ft/s	661	3.2%	6,517	39.0%	4,221	72.6%	51,148	100.0%	N/A	N/A
Depth (at 30,000 cfs)	less than 16 ft	12370	59.9%	8,000	47.9%	0	0.0%	0	0.0%	N/A	N/A
	between 16 ft and 23 ft	5,609	27.2%	7,847	47.0%	2,412	41.5%	97	0.2%	N/A	N/A
	Greater than 23 ft	2,658	12.9%	851	5.1%	3,405	58.5%	51,051	99.8%	N/A	N/A
BEHI	Moderate (ft)	25,522	43.6%	9,976	22.7%	6,465	55.4%	53,420	53.2%	98,317	25.4%
	High (ft)	9,175	15.7%	7,034	16.0%	3,082	26.4%	20,629	20.5%	154,045	39.9%
	Extreme (ft)	7,138	12.2%	12,050	27.4%	398	3.4%	10,456	10.4%	78,071	20.2%
Pool Frequency	Average pool spacing (ft)	4,126	--	8,342	--	5,824	--	7,304	--	14,432	--
Number of Pools	Each	5	--	2	--	1	--	7	--	13	--
Pool Length	Length (ft)	8,897	43.1%	1,678	10.1%	3,307	56.8%	18,636	36.5%	67,209	35.8%
Riffle Length	Length (ft)	11,736	56.9%	15,006	89.9%	2,517	43.2%	32,492	63.5%	120,402	64.2%
Bank Vegetation	None (ft)	9,216	19.4%	18,991	60.1%	3,151	27.1%	25,039	26.4%	204,134	59.7%
	Sparse (ft)	31,602	66.4%	9,204	29.1%	8,189	70.3%	45,755	48.3%	110,465	32.3%

* N/A – data output from modeling is not available for Meander Reach 2.

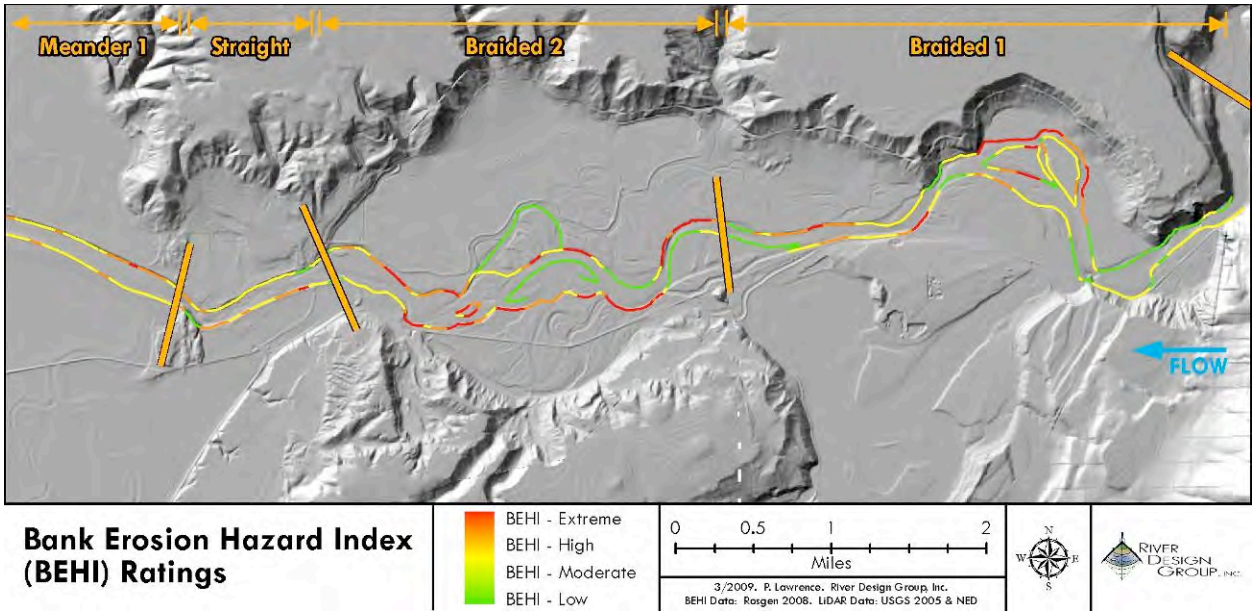


Figure 4-1. BEHI ratings in the Braided and Straight Reaches.

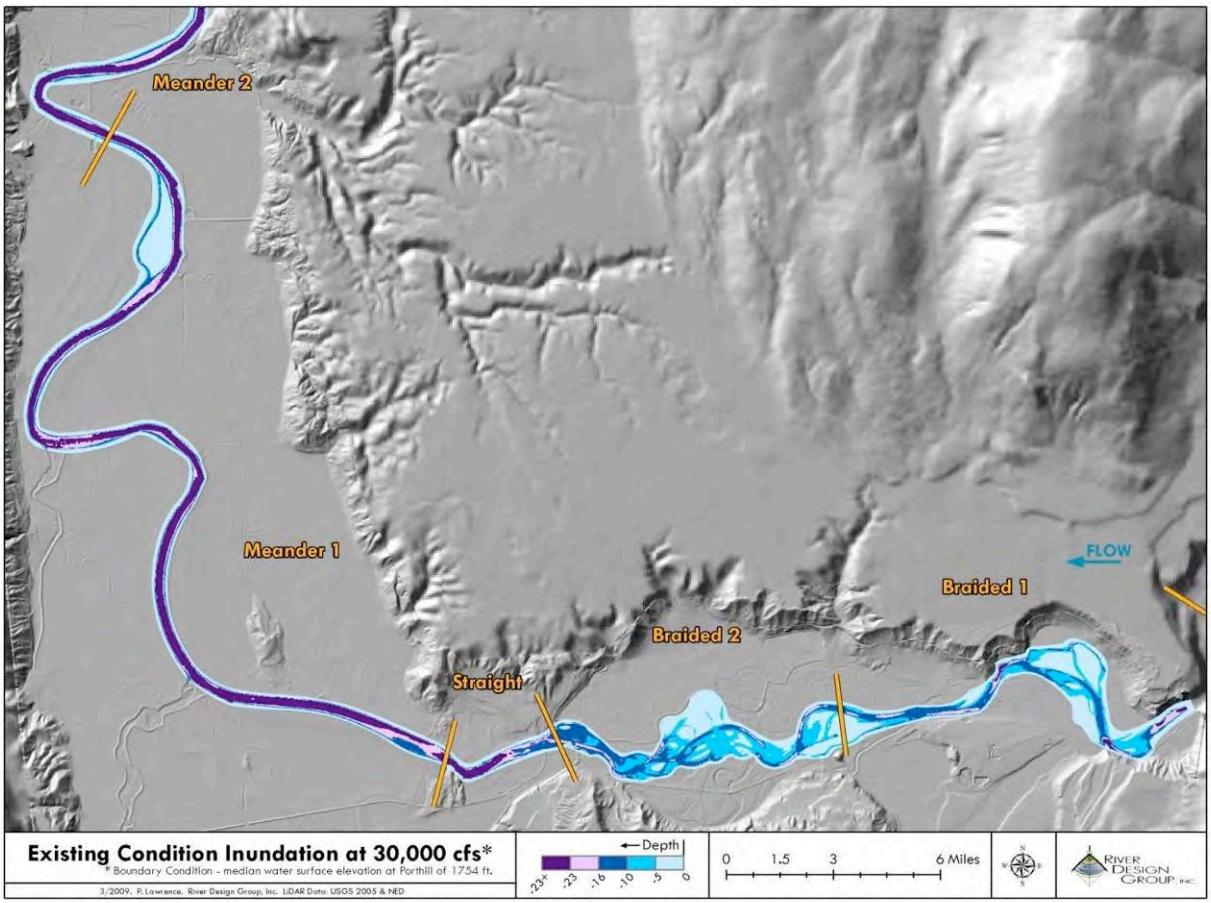


Figure 4-2. Channel depths throughout the project area (30,000 cfs) at bankfull discharge.

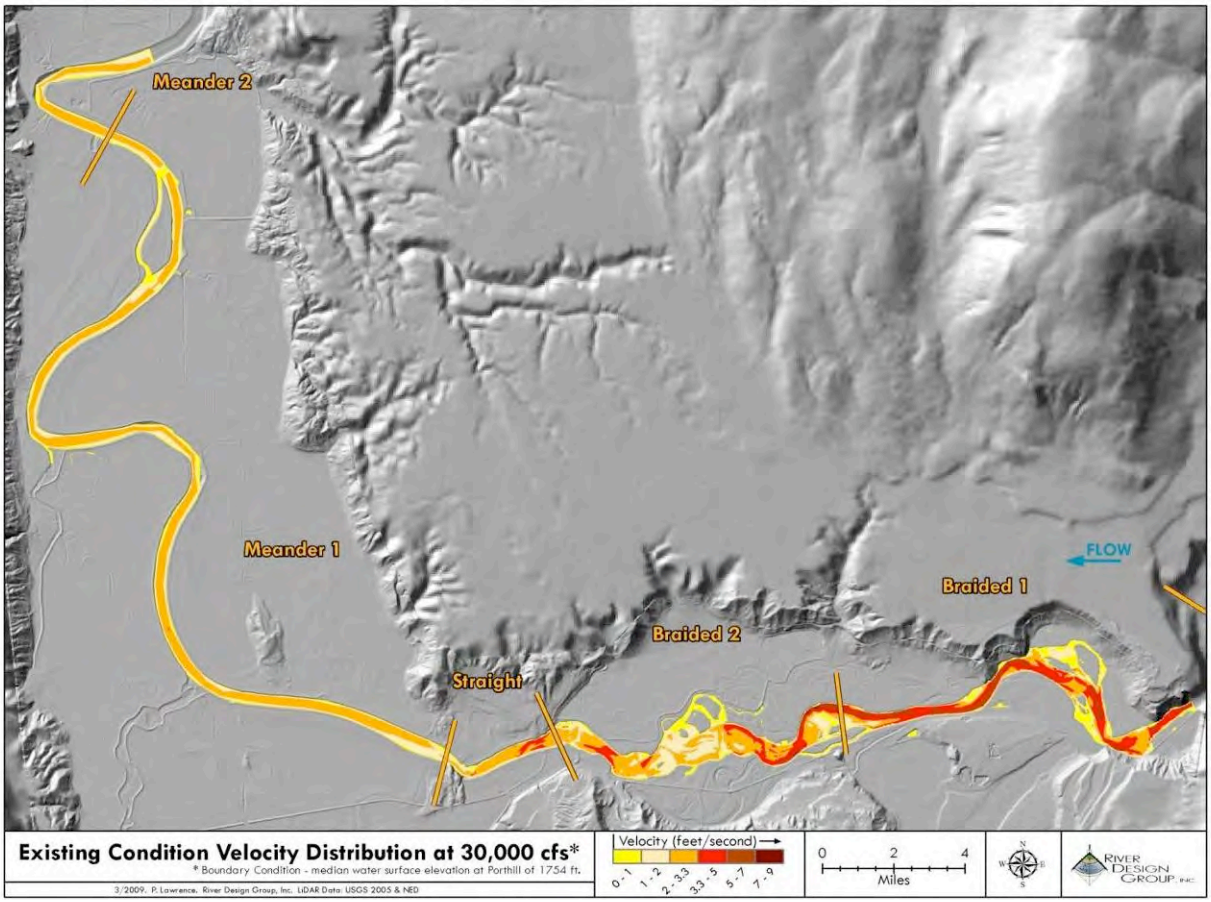


Figure 4-3. Channel velocities throughout the project area (30,000 cfs) at bankfull discharge.

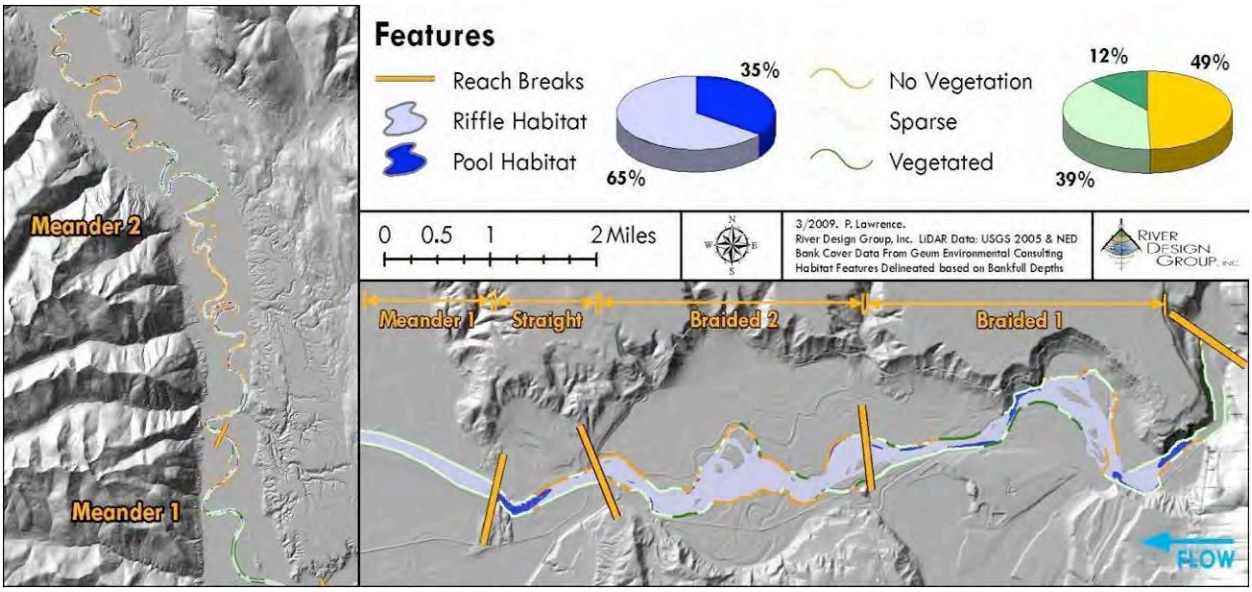


Figure 4-4. Distribution of riffle and pool habitat throughout the project reaches (30,000 cfs).

4.2.2 Restoration Suitability Analysis in Meander Reach Floodplain

In addition to data describing limiting factors, additional data sources were used to identify restoration opportunities in the Meander Reach floodplain. These data sources included:

- Floodplain elevation relative to river stage at 30,000 cfs;
- NRCS mapped hydric soils;
- Land cover classes, including vegetation, agricultural lands, water and substrate; and
- Broad land ownership and conservation status categories.

These data sources were combined into a restoration suitability analysis to identify broad restoration suitability classes within the floodplain in areas outside the levees. For the purpose of this Master Plan, a suitability analysis is defined as a tool for combining geographic information layers based on relevant thresholds to identify areas with combinations of attributes that are meaningful in a floodplain restoration context. To help identify areas where floodplain restoration treatments would be most likely to accomplish project objectives, existing spatial data sets related to soils, elevation, vegetation cover and land ownership or conservation status were compiled and classified based on attributes that indicate relative potential for either riparian and wetland restoration or native vegetation enhancement. A description of these data layers and how they were incorporated into the suitability analysis is provided in the following section.

Hydric Soils

Hydric soils indicate wetland and riparian restoration potential because they are, "saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation (USDA 2007)." The presence of hydric soils typically indicates the historical presence of wetlands, or sufficient hydroperiod to support riparian vegetation.

Hydric soils information was obtained through the USDA's Natural Resources Conservation Service (NRCS) soil data mart (http://soildatamart.nrcs.usda.gov/). This data provides physical and chemical properties for soil survey areas which are rendered in a geographic information layer as unique polygons. These polygons can be sorted or selected by any attribute for which data exists in the NRCS data mart.

For the purposes of this suitability analysis, soils are considered hydric if greater than 50% of the soils within a soil map unit are defined as such. Soil map units defined as non-hydric may include smaller areas of hydric soils (USDA 2006), and thus have potential for restoration, but would require examination on a case by case basis. Hydric soil map units are considered a higher potential for riparian and wetland restoration compared with non-hydric soil map units. Figure 4-5 shows hydric soils in the floodplain.

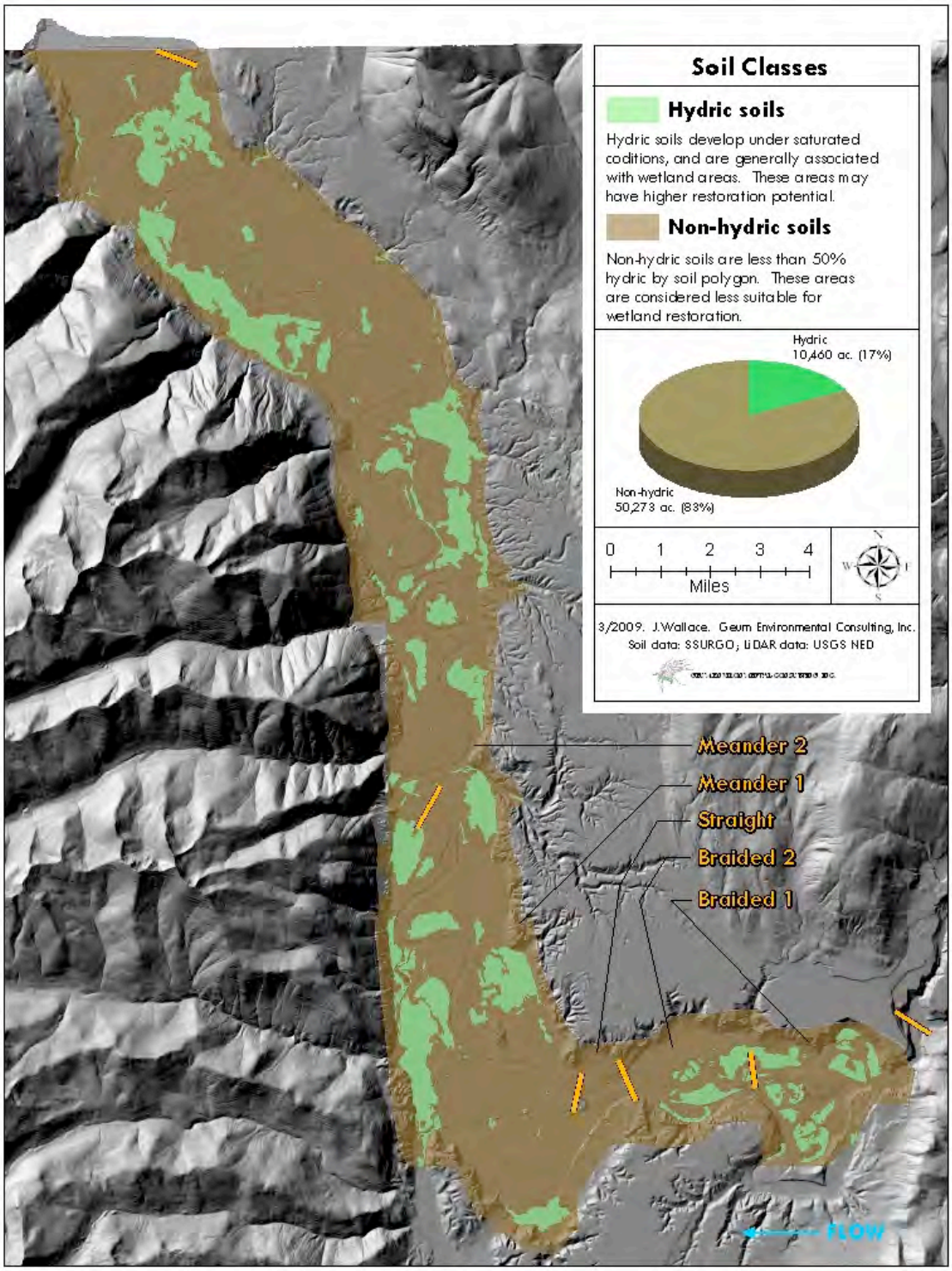


Figure 4-5. Areas with greater than 50% hydric component within a soil map unit.

Relative Elevation

Establishing and maintaining functional floodplain processes requires seasonal surface connection between the river and floodplain. For the Kootenai River, as discussed in previous sections, the average peak flows is estimated to be 30,000 cfs. In order to identify the areas which could potentially be accessed by these flows, elevation layers for both the floodplain surface and the surface of the channel at 30,000 cfs were compared.

A plane representing the elevation of the water-surface at 30,000 cfs stage (approximate river stage at peak flow) was interpolated at 10,000 ft intervals along the channel, using channel slope data, resulting in a total of 28 points from which to base the surface interpolation. Subtracting the existing floodplain elevations from the estimated 30,000 cfs surface produced a new surface, representing the estimated floodplain elevation relative to the 30,000 cfs river stage. These data reflect areas with elevations lower than 30,000 cfs flow as negative values (Figure 4-6).

For purposes of determining floodplain restoration potential, the new surface was separated into three categories linked to coarse estimates of plant community types each category could support: 1) above 30,000 cfs stage (estimated to have potential for upland vegetation); 2) zero to three feet below 30,000 cfs stage (estimated to have potential for riparian woody vegetation such as cottonwoods and willows); and 3) three to six feet below 30,000 cfs stage (estimated to have potential for hydrophytic vegetation and therefore wetlands). Figure 4-6 shows elevation categories related to potential plant hydroperiod regimes.

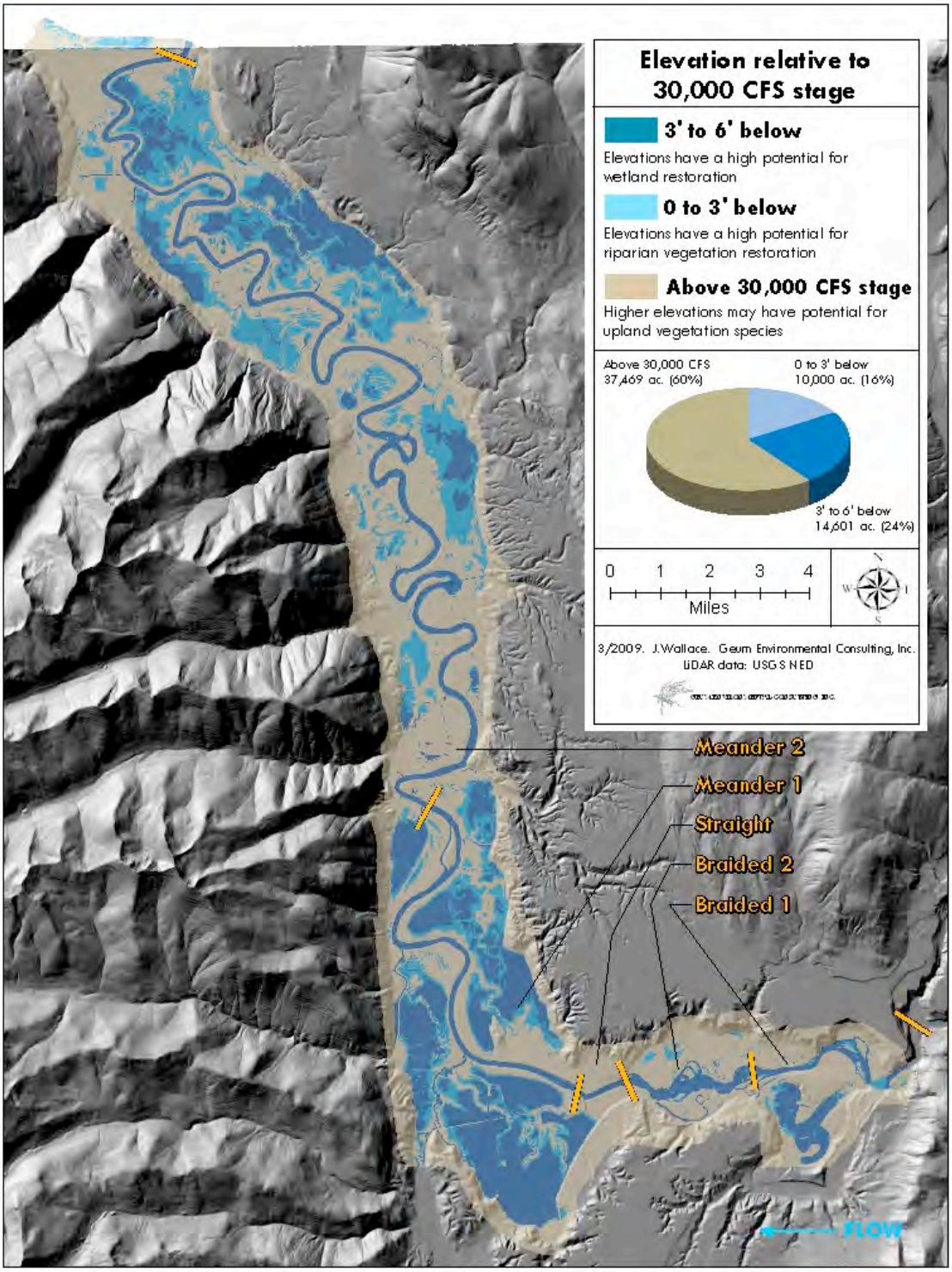


Figure 4-6. Floodplain elevation categories related to potential plant hydroperiod regimes. River stage is based on a water-surface elevation of 1754 at Porthill.

Land Cover

The Kootenai Tribe has developed a land cover classification of the Kootenai River floodplain using a combination of spectral information and aerial photo interpretation. This classification identifies ten vegetation cover types, which were then grouped into three broader categories relating to restoration potential. Standing water and exposed depositional areas were categorized as 'water'. If the cover type included substantial existing native vegetation, it was categorized as having 'enhancement' potential (i.e., a desired plant community is already present). All other cover types were identified as having 'restoration' potential (i.e., the potential to be converted to a desired plant community that would help meet project objectives). Table 4-2 shows how the original land cover types were grouped to support the suitability analysis. Figure 4-7 shows restoration and enhancement classes based on these groupings of cover types.

Table 4-2. Groupings of land cover types into categories to support floodplain restoration suitability analysis.

Enhancement	Restoration	Water
▪ Broadleaf forest ▪ Conifer forest ▪ Riparian vegetation Emergent vegetation	▪ Barren ▪ Foothills grassland ▪ Disturbed grassland ▪ Agricultural	▪ Water ▪ Streamside gravel

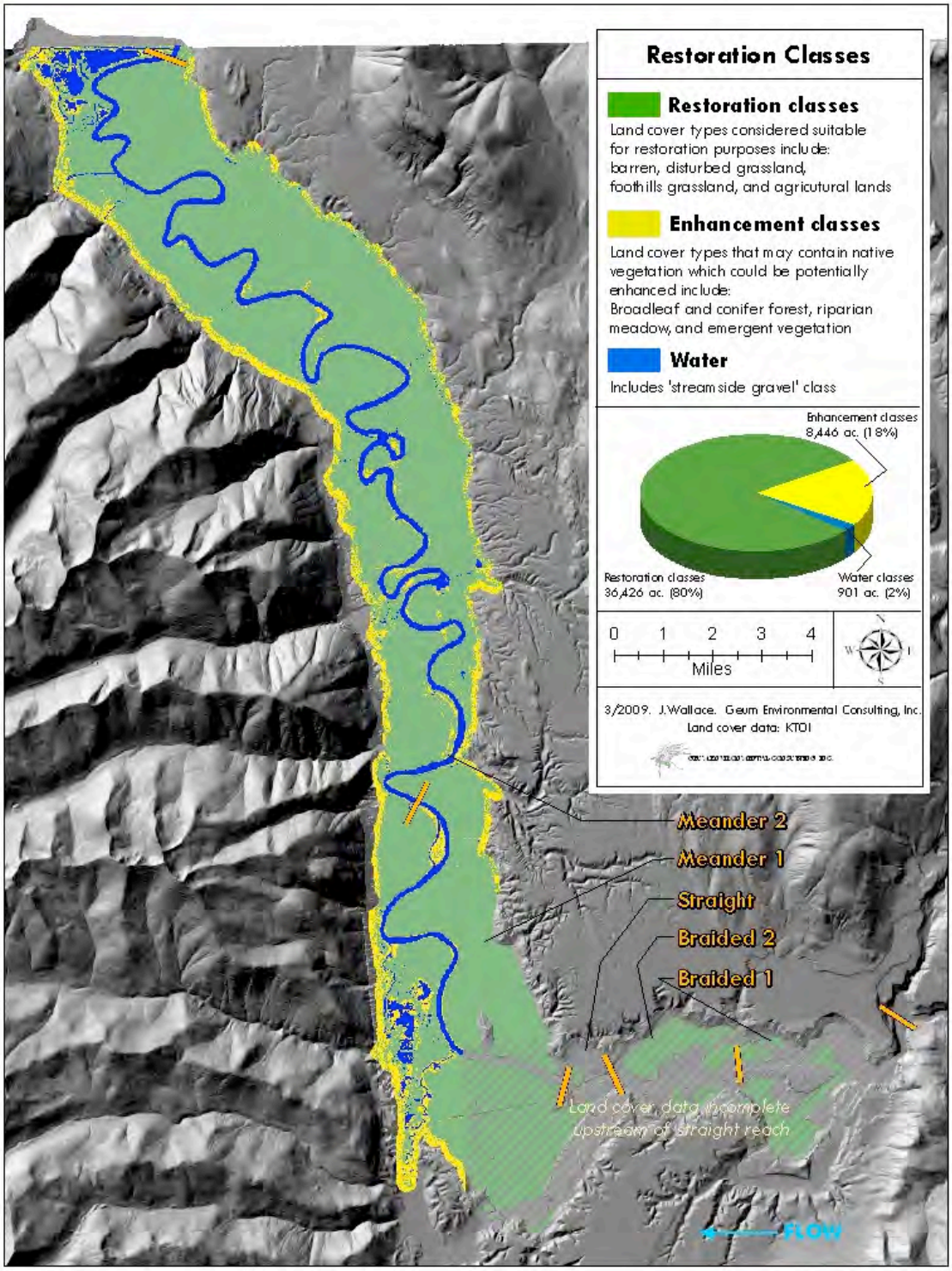


Figure 4-7. Native vegetation cover types (enhancement) and other cover types (restoration).

Ownership

Although land ownership does not have a direct ecological impact on restoration potential, the availability of lands for restoration purposes may depend on whether the land is publicly or privately owned. For this reason, land ownership does not influence the restoration suitability potential of an area in this analysis, but is included as a distinction between restoration suitability classes.

Land parcel data for this project was obtained from Boundary County public records. County, state, or federal government lands, or parcels identified as conservation lands through ownership or trust, are classified together as public/conservation lands. Lands owned by the Kootenai Tribe, or designated as U.S. Indian lands are classified as tribal land. All remaining lands are classified as private. Figure 4-8 shows the distribution of these lands in the project reaches.

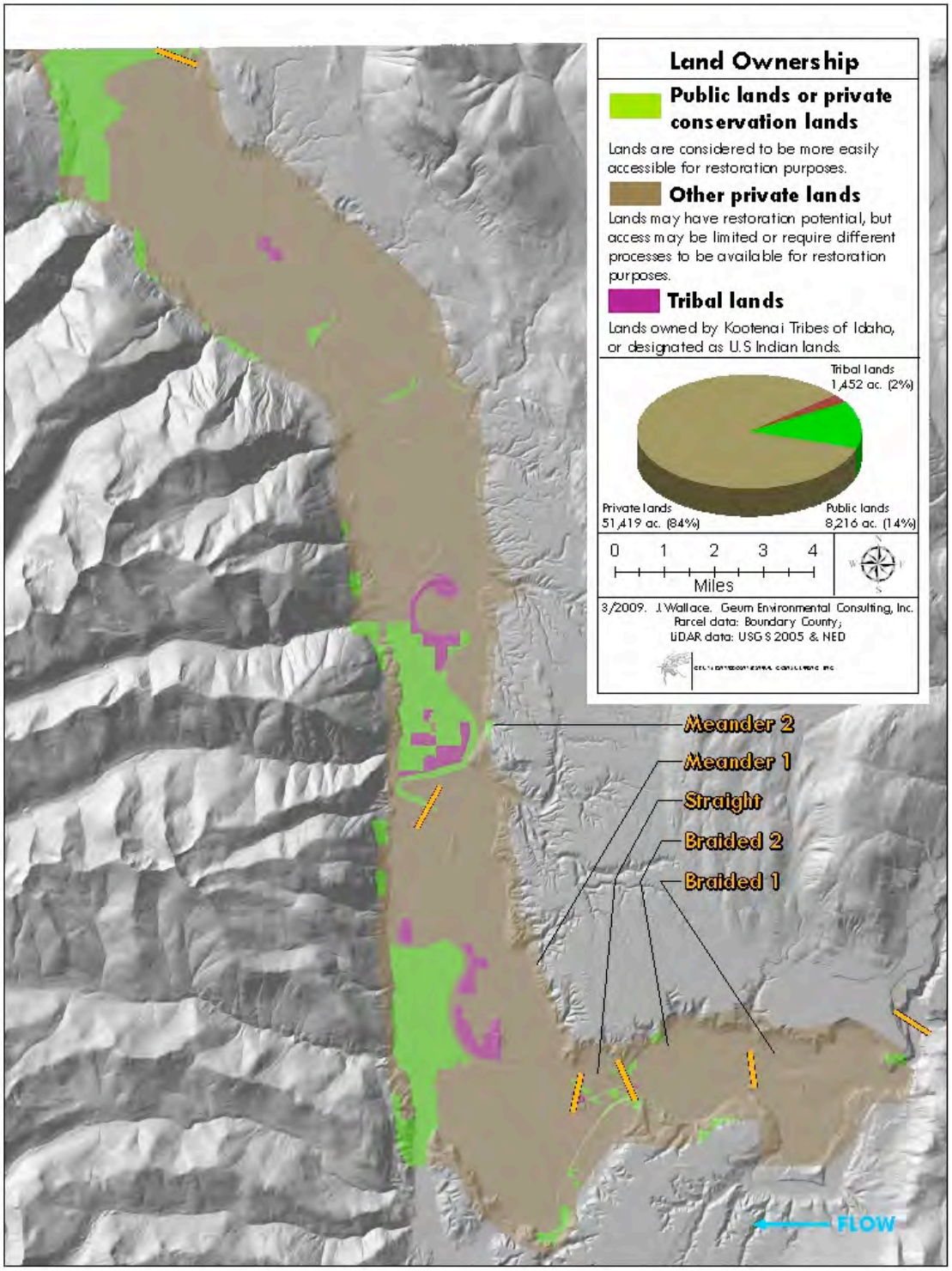


Figure 4-8. Public/ conservation lands and private lands in the project reaches.

Suitability Analysis Results

Suitability classes are differentiated initially by whether the land is publicly owned (or otherwise managed for conservation) versus privately owned. Within these two categories, areas are classified as having either high or moderate restoration potential based on the presence or absence of hydric soils. As described above, the distinction between suitability for wetland and riparian vegetation communities is based on relative elevation data. Areas that have pre-existing native vegetation cover types are classified as 'enhancement' areas because they could potentially be protected or enhanced as part of this project. Enhancement areas are also distinguished as being on either public or private lands. Restoration potential classes are summarized in Table 4-3, and the results of the floodplain restoration suitability analysis are shown in Figure 4-9.

Table 4-3. Floodplain restoration suitability categories and associated attributes.

Restoration Classes	Public or Conservation lands	Private Lands	0 to 3 ft below 30,000 cfs stage	3 to 6 ft below 30,000 cfs stage	Hydric soils	Agricultural or other non-native cover types	Native vegetation cover types
High Riparian Restoration Potential	X		X		X	X	
		X					
High Wetland Restoration Potential	X			X	X	X	
		X					
Moderate Riparian Restoration Potential	X		X			X	
		X					
Moderate Wetland Restoration Potential	X			X		X	
		X					
Enhancement							X

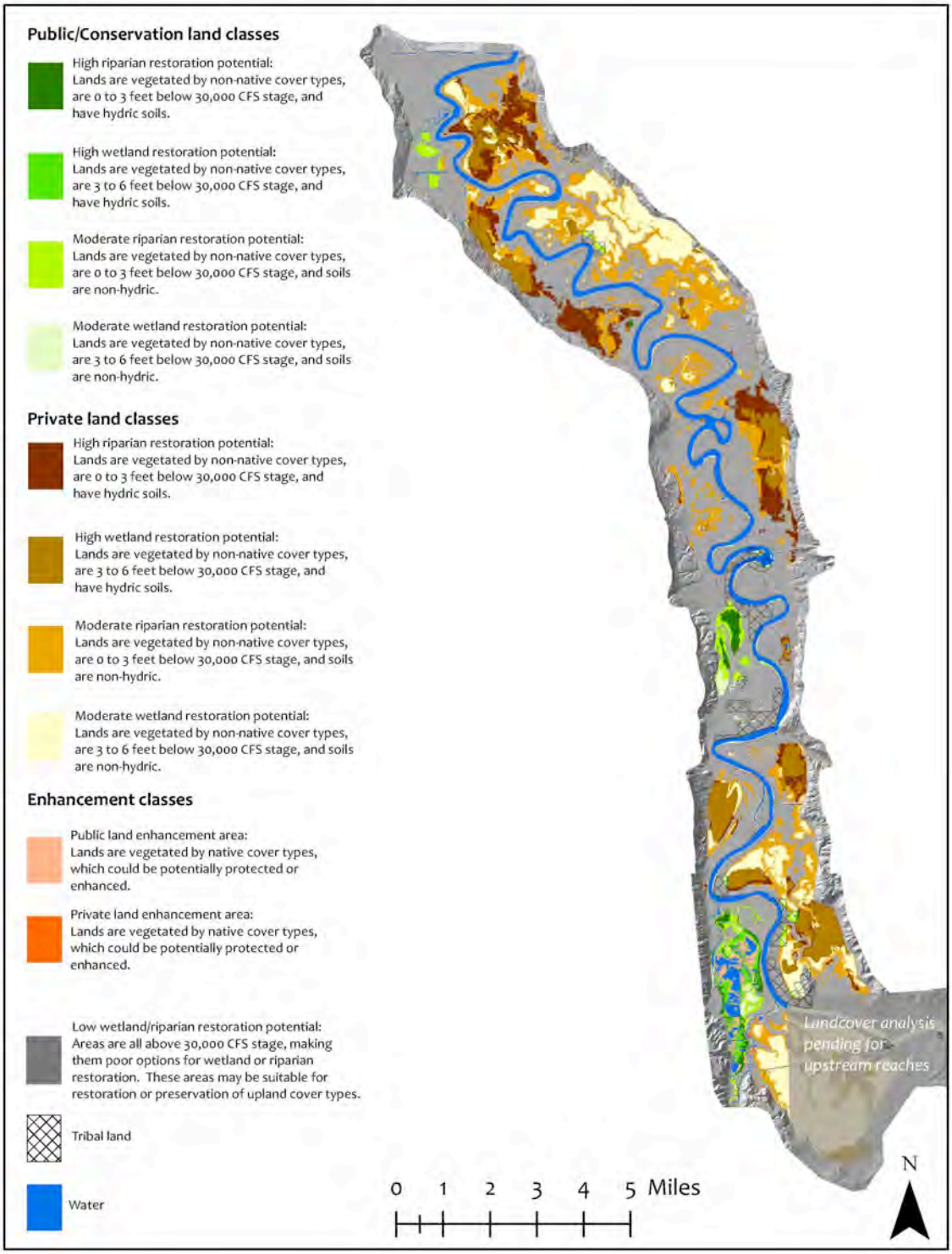


Figure 4-9. Floodplain restoration suitability analysis results for areas outside levees.

4.2.3 Other Analyses Used To Support Spatial Extent of Restoration Treatments

In addition to limiting factors data and other data used to support the floodplain suitability analysis, two additional analyses were completed to develop spatial extents of habitat actions. A conceptual channel was compared to the existing channel to estimate cuts and fills in the Braided Reaches and Straight Reach. Within the levees in the Meander Reaches, areas were identified where floodplain areas could be excavated adjacent to the channel. These analyses are described below.

4.2.3.1 Channel and Floodplain Cuts and Fills in Braided and Straight Reaches

To estimate volumes of material that might be excavated resulting from construction of a conceptual channel, a three-dimensional surface representing a simple, conceptual channel design was compared to the existing land surface and bathymetry using GIS raster analysis tools. Similarly, volumes of fill necessary to construct a floodplain were estimated by estimating the area of existing channel that would need to be filled based on the conceptual channel, and then using GIS to calculate the amount of material needed to fill from existing ground and bathymetry to the elevation associated with river stage at 30,000 cfs (an approximate constructed floodplain surface elevation). Secondary channel lengths were estimated along the conceptual channel quantify the restoration treatment related to secondary channels in the Braided Reach.

4.2.3.2 Floodplain Excavation within Levees

While levees follow the channel very closely in most areas within the Meander Reaches, there are some areas where levees cut between meanders, leaving large areas of land between the river and the levee on the inside of meander bends. Most of these areas are high relative to the peak flow river stage elevation (see Figure 2-2 in Section 2.2), and would require excavation to create surfaces that could support riparian or wetland vegetation. To quantify floodplain excavation adjacent to the river, areas within the levees were digitized in GIS, facilitating area calculations of potentially suitable surfaces. The existing ground elevation of these areas was compared to the elevation at 30,000 cfs river stage to estimate excavation volume for potential floodplain surfaces. To distinguish between moderate and maximum implementation scenarios, a median value of approximately 14,000 cubic yards of excavation per acre was selected. The moderate scenario includes identified floodplain excavation areas where excavation is less than 14,000 cubic yards per acres, while the maximum implementation scenario includes all identified floodplain excavation areas.

4.3 Implementation Scenarios

Based on limiting factors data, results of the floodplain restoration suitability analysis, and other methods described above, criteria were developed for each reach that represent a minimum, moderate and maximum restoration implementation scenario. Criteria are described by reach in this section, and restoration treatments are quantified for each implementation scenario by reach.

4.3.1 Braided Reach 1 Implementation Scenarios

While Braided Reach 1 has areas of flow velocities less than 3.3 ft/sec and shallow depths, these hydraulic components, combined with information about bank vegetation (Table 4-1) show that Braided Reach 1 is in a less impaired condition than Braided Reach 2 and the Straight Reach. For this reason, channel and floodplain reconstruction for the entire reach is only included as part of the maximum implementation scenario. The rationale for this is that the entire length of Braided Reach 1 must be reconstructed to address yet-to-be quantified sediment storage needs that would improve the likelihood of restoration success in downstream reaches. The moderate implementation scenario includes channel and floodplain reconstruction between RM 158 and 159 where extreme BEHI ratings and low velocities and depths are most concentrated. The amount of channel and floodplain reconstruction included as part of the moderate implementation scenario would also accommodate sediment storage needs, but to a lesser degree if future analyses indicate such actions do not contribute to restoration success in downstream reaches. Under these scenarios, quantities of cut and fill for channel and floodplain reconstruction are balanced, because it is probably neither feasible nor desirable to import or export large volumes of material to or from the project area.

Under the maximum implementation scenario, banks with extreme, high and moderate BEHI ratings would be treated; under the moderate scenario, banks with extreme and high BEHI ratings would be treated; and under the minimum scenario, only banks with extreme BEHI ratings would be treated. Quantities for instream structures are based on typical spacing of common structure types, like large wood placement, flow redirective structures, and alluvium (i.e., coarse bed material), that might be included as part of channel designs. For purposes of developing implementation scenarios, large wood would be located at specific sites throughout the project area including meander bends, areas of bank erosion or where new floodplain surfaces are to be stabilized. Placed alluvium would be located at the downstream end of pools. Instream structures and all other treatments would be implemented in conjunction with channel and floodplain reconstruction.

Under all scenarios, Libby Dam flow management and Kootenay Lake level management would be considered as part of subsequent design phases. Most of the length of Braided Reach 1 is not affected by the Kootenay Lake backwater, but flow depths and velocities (and other factors like floodplain connection) are limited at some times of the year by flow regulation at Libby Dam. For the purpose of developing these implementation scenarios, average peak flows were assumed to be 30,000 cfs. However, during the design process, different design flows will be evaluated in terms of additional benefits to habitat and in terms of feasibility related to existing Libby Dam operation, public safety and other factors. Restoration work associated with bank structures and channel and floodplain construction would require coordinating with landowners and infrastructure owners (e.g., railroad). Criteria for where this type of coordination would need to occur are linked to criteria for where those respective treatments would be implemented in the reach. Criteria are displayed in Table 4-4, which includes all restoration treatments that are part of the Braided Reach 1 habitat action.

Table 4-4. Braided Reach 1 criteria for minimum, moderate and maximum implementation scenarios.

Treatment	Restoration Treatment Explanation	Minimum Scenario	Moderate Scenario	Maximum Scenario
BR-A	Excavate and/or dredge the river to modify the channel geometry	None	Areas where velocity is less than 3.3 ft/s or depth is less than 16.5 ft/s (between RM 158 and 159)	Areas where velocity is less than 3.3 ft/s or depth is less than 23 feet
BR-B	Construct floodplain surfaces	No sediment storage needed	Portion of reach needed for sediment storage (between RM 158 and 159)	Entire reach needed for sediment storage
BR-C	Construct and/or enhance wetlands	None	Areas of floodplain construction	Areas of floodplain construction
BR-D	Construct and/or enhance secondary channels	None	Areas of floodplain reconstruction	Areas of floodplain reconstruction
BR-E	Revegetate the floodplain	None	Areas of floodplain reconstruction	Areas of floodplain reconstruction
BR-F	Install bank structures (bank structures, bioengineering)	BEHI = Extreme	Areas of channel reconstruction and BEHI = Extreme and High	Areas of channel reconstruction and BEHI=Extreme, High and Moderate
BR-G	Install instream structures (habitat, river training, grade control)	None	Areas of channel reconstruction (between RM 158 and 159)	Areas of channel reconstruction
KR-A	Manage the discharge from Libby Dam	To be determined	To be determined	To be determined
KR-B	Manage the backwater from Kootenay Lake	No backwater effect in this reach	No backwater effect in this reach	No backwater effect in this reach
KR-C	Manage land use practices	Coordinate with landowners where bank structures (BR-F) apply	Coordinate with landowners where bank structures (BR-F) apply and for river and floodplain work between RM 158 and 159	Coordinate with landowners where bank structures (BR-F) apply And with all landowners for river and floodplain work
KR-D	Manage for impacts from or to infrastructure	Coordinate with infrastructure owners where bank structures (BR-F) apply	Coordinate with infrastructure owners where bank structures (BR-F) apply and for river and floodplain work between RM 158 and 159	Coordinate with infrastructure owners where bank structures (BR-F) apply and for river and floodplain work in entire reach

Based on implementation scenario criteria for Braided Reach 1, Table 4-5 shows quantities of each restoration treatment that would result from minimum, moderate and maximum scenarios.

Table 4-5. Braided Reach 1 restoration treatment quantities by implementation scenario.					
Treatment	**Restoration Treatment Explanation**	**Unit**	**Min**	**Mod**	**Max**
BR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	0	5,280	20,630
		Cu yds (cut)	0	527,063	1,723,682
BR-B	Construct floodplain surfaces	Acres	0	71	115
		Cu yds (fill)	0	527,063	1,723,682
BR-C	Construct and/or enhance wetlands	Acres	0	36	55
BR-D	Construct and/or enhance secondary channels	Ft	0	10,072	13,135
BR-E	Revegetate the floodplain	Acres	0	71	115
BR-F	Install bank structures (bank structures, bioengineering)	Ft	7,138	16,313	41,835
BR-G	Install instream structures (habitat, river training, grade control)	Units	0	10	35
KR-A to KR-D	Project-scale management treatments	These treatments will be applied as needed and quantified if necessary in later design phases.			

4.3.2 Braided Reach 2 Implementation Scenarios

Braided Reach 2 has been identified (see Section 2.4) as the most significant sediment source in the project area, accounting for approximately 43% of banks that have either extreme or high BEHI ratings. In addition, 90% of Braided Reach 2 has depths less than 16 feet and velocities less than 3.3 feet per second. Pools represent less than 10% of instream habitat within Braided Reach 2. Based on limiting factors mapping, unsuitable instream habitat is distributed throughout the reach. Moreover, based on preliminary sediment-transport analyses (Appendix B), it is likely that the entire floodplain area of Braided Reach 2 would be needed to store sediment delivered to the reach. For these reasons, channel and floodplain reconstruction for the entire reach is included as part of all three implementation scenarios. The analyses completed in support of this Master Plan suggest that for ecosystem restoration to be successful under any scenario, it is necessary to restore the entire length of Braided Reach 2. Under all scenarios, quantities of cut and fill for channel and floodplain reconstruction are balanced, because it is probably neither feasible nor desirable to import or export large volumes of material to or from the project area.

As with Braided Reach 1 and all other reaches, under the maximum implementation scenario, banks with extreme, high and moderate BEHI ratings would be treated; under the moderate scenario, banks with extreme and high BEHI ratings would be treated; and under the minimum scenario, only banks with extreme BEHI ratings would be treated. Quantities for instream structures are based on typical spacing of common structure types, like large wood placement, flow redirective structures, and alluvium, that might be included as part of channel designs. For

purposes of developing conceptual implementation scenarios, the spacing of large wood and flow redirective structures is assumed to be one bankfull width between structures on outer meander bends, while placed alluvium would be located at the downstream end of pools. Instream structures and all other treatments would be implemented in conjunction with channel and floodplain reconstruction.

Under all scenarios, Libby Dam flow management and Kootenay Lake level management would be considered as part of subsequent design phases. The entire length of Braided Reach 2 is affected by the Kootenay Lake backwater during some part of each year, and flow depths and velocities (and other factors like floodplain connection) are limited at some times of the year by flow regulation at Libby Dam. As in Braided Reach 1, for the purpose of developing these implementation scenarios, average peak flows were assumed to be 30,000 cfs at a backwater elevation of 1754 feet at Porthill. However, during the design process, different design flows and backwater elevations will be evaluated in terms of additional benefits to habitat and in terms of feasibility related to existing Libby Dam operation, public safety and other factors. Restoration work associated with bank structures and channel and floodplain construction would require coordinating with landowners and infrastructure owners (railroad, highway, levees, pumping station). This type of coordination would need to occur throughout Braided Reach 2 because all three implementation scenarios include channel and floodplain reconstruction throughout the entire reach. Criteria are displayed in Table 4-6, which includes all restoration treatments that are part of the Braided Reach 2 habitat action.

Table 4-6. Braided Reach 2 criteria for minimum, moderate and maximum implementation scenarios.

Treatment	Restoration Treatment Explanation	Minimum Scenario	Moderate Scenario	Maximum Scenario
BR-A	Excavate and/or dredge the river to modify the channel geometry	Percentage of pool habitat less than 40%	Areas where velocity is less than 3.3 ft/s or depth is less than 16.5 ft/s	Areas where velocity is less than 3.3 ft/s or depth is less than 23 feet
BR-B	Construct floodplain surfaces	Entire reach needed for sediment storage	Entire reach needed for sediment storage	Entire reach needed for sediment storage
BR-C	Construct and/or enhance wetlands	Areas of floodplain construction	Areas of floodplain construction	Areas of floodplain construction
BR-D	Construct and/or enhance secondary channels	Areas of floodplain reconstruction	Areas of floodplain reconstruction	Areas of floodplain reconstruction
BR-E	Revegetate the floodplain	Areas of floodplain reconstruction	Areas of floodplain reconstruction	Areas of floodplain reconstruction
BR-F	Install bank structures (bank protection, bioengineering)	Areas of channel reconstruction	Areas of channel reconstruction	Areas of channel reconstruction
BR-G	Install instream structures (habitat, river training, grade control)	Areas of channel reconstruction	Areas of channel reconstruction (between RM 158 and 159)	Areas of channel reconstruction
KR-A	Manage the discharge from Libby Dam	To be determined	To be determined	To be determined
KR-B	Manage the backwater from Kootenay Lake	To be determined	To be determined	To be determined
KR-C	Manage land use practices	Coordinate with landowners where bank structures (BR-F) apply and with all landowners for river and floodplain work	Coordinate with landowners where bank structures (BR-F) apply and with all landowners for river and floodplain work	Coordinate with landowners where bank structures (BR-F) apply and with all landowners for river and floodplain work
KR-D	Manage for impacts from or to infrastructure	Coordinate with infrastructure owners where bank structures (BR-F) apply and with all infrastructure owners for river and floodplain work	Coordinate with infrastructure owners where bank structures (BR-F) apply and with all infrastructure owners for river and floodplain work	Coordinate with infrastructure owners where bank structures (BR-F) apply and with all infrastructure owners for river and floodplain work

Based on implementation scenario criteria for Braided Reach 2, Table 4-7 shows quantities of each restoration treatment that would result from minimum, moderate and maximum scenarios.

Table 4-7. Braided Reach 2 restoration treatment quantities by implementation scenario.

Treatment	Restoration Treatment Explanation	Unit	Min	Mod	Max
BR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	16,669	16,669	16,669
		cu yds (cut)	1,527,334	1,527,334	1,527,334
BR-B	Construct floodplain surfaces	Acres	253	253	253
		cu yds (fill)	1,527,334	1,527,334	1,527,334
BR-C	Construct and/or enhance wetlands	Acres	133	133	133
BR-D	Construct and/or enhance secondary channels	Ft	13,688	13,688	13,688
BR-E	Revegetate the floodplain	Acres	253	253	253
BR-F	Install bank structures (bank protection, bioengineering)	Ft	12,050	19,083	29,059
BR-G	Install instream structures (habitat, river training, grade control)	Units	47	47	47
KR-A to KR-D	Project-scale management treatments	These treatments will be applied as needed and quantified if necessary in later design phases.			

4.3.3 Straight Reach Implementation Scenarios

The Straight Reach has been identified (see Section 2.4) as the reach where sediment generated from the upper Kootenai subbasin, and from within the project area, is transported through to the Meander Reaches and known Kootenai sturgeon spawning locations.

Channel reconstruction or installation of structures in the Straight Reach, combined with creating backwater areas where sediment can be deposited, would allow some of the sediment load to be intercepted before reaching the Meander Reaches.

Significant portions of the Straight Reach have depths and velocities that do not meet habitat suitability criteria for Kootenai sturgeon as identified in the Libby Dam BiOp. For this reason, channel and floodplain reconstruction for the entire length of the Straight Reach is included as part of the maximum implementation scenario because this would result in depths of 23 feet identified in the clarified Libby Dam BiOp (2008) throughout the reach.

For the moderate scenario, the large pool near Ambush Rock at the lower end of the reach would not be reconstructed, resulting in approximately half of the reach being excavated and dredged. For the minimum scenario, the channel would not be dredged or excavated, but structures would be used to concentrate flows toward the center of the channel, result in some natural deepening of the channel. These structures would also be included as part of the maximum and moderate scenarios because they would help maintain the constructed channels.

As with all other reaches, under the maximum implementation scenario, banks with extreme, high and moderate BEHI ratings would be treated; under the moderate scenario, banks with extreme and high BEHI ratings would be treated; and under the minimum scenario, only banks with extreme BEHI ratings would be treated.

As described above, instream habitat structures in the Straight Reach would focus on directing the thalweg to concentrate flows, increase velocity, increase complexity, and promote channel scour for enhancing habitat in smaller pools. Large wood placement, placed alluvium, and flow redirective structures would promote sediment sorting and fine sediment would deposit in lower velocity channel margins. Large wood would be off-set from each other on both sides of the channel through the Straight Reach. All other treatments would be implemented in conjunction with channel and floodplain reconstruction.

Under all scenarios, Libby Dam flow management and Kootenay Lake level management would be considered as part of subsequent design phases. The entire length of the Straight Reach is affected by the Kootenay Lake backwater during some part of each year, and flow depths and velocities (and other factors like floodplain connection) are limited at some times of the year by flow regulation at Libby Dam. As in the Braided Reaches, for the purpose of developing these implementation scenarios and related conceptual channel dimensions, average peak flows were assumed to be 30,000 cfs at a backwater elevation of 1754 feet at Porthill. However, during the design process, different design flows and backwater elevations will be evaluated in terms of potential additional benefits to habitat and in terms of feasibility related to existing Libby Dam operation, public safety and other factors.

Restoration work associated with bank structures and channel and floodplain construction would require coordinating with landowners and infrastructure owners (city of Bonners Ferry, highway, levees). This type of coordination would need to occur throughout the Straight Reach because all three implementation scenarios include channel and floodplain reconstruction throughout the entire reach. Criteria are displayed in Table 4-8, which includes all restoration treatments that are part of the Straight Reach habitat action.

Table 4-8. Straight Reach criteria for minimum, moderate, and maximum implementation scenarios.

Treatment	Restoration Treatment Explanation	Minimum Scenario	Moderate Scenario	Maximum Scenario
SR-A	Excavate and/or dredge the river to modify the channel geometry	Percentage of pool habitat less than 40%	Areas where velocity is less than 3.3 ft/s or depth is less than 16.5 ft/s	Areas where velocity is less than 3.3 ft/s or depth is less than 23 feet
SR-B	Revegetate the riparian corridor and establish a riparian buffer	Bank vegetation = None	Bank Vegetation = None or Sparse	Bank Vegetation = None or Sparse
SR-C	Install bank structures (bank protection, bioengineering)	BEHI = Extreme	BEHI = Extreme and High and areas of channel reconstruction	Areas of channel reconstruction
SR-D	Install instream structures (habitat, river training, grade control)	Areas of channel reconstruction and unsuitable substrate	Areas of channel reconstruction and unsuitable substrate	Areas of channel reconstruction and unsuitable substrate
KR-A	Manage the discharge from Libby Dam	To be determined	To be determined	To be determined
KR-B	Manage the backwater from Kootenay Lake	To be determined	To be determined	To be determined
KR-C	Manage land use practices	Coordinate with landowners where bank structures (BR-F) apply and with all landowners for river and floodplain work	Coordinate with landowners where bank structures (BR-F) apply and with all landowners for river and floodplain work	Coordinate with landowners where bank structures (BR-F) apply and with all landowners for river and floodplain work
KR-D	Manage for impacts from or to infrastructure	Coordinate with infrastructure owners where bank structures (BR-F) apply and with all infrastructure owners for river and floodplain work	Coordinate with infrastructure owners where bank structures (BR-F) apply and with all infrastructure owners for river and floodplain work	Coordinate with infrastructure owners where bank structures (BR-F) apply and with all infrastructure owners for river and floodplain work

Based on implementation scenario criteria for the Straight Reach, Table 4-9 shows quantities of each restoration treatment that would result from minimum, moderate and maximum scenarios.

Table 4-9. Straight Reach restoration treatment quantities by implementation scenario.					
Treatment	**Restoration Treatment Explanation**	**Unit**	**Min**	**Mod**	**Max**
SR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	5,821	5,821	5,821
		Cu yds (cut)	0	218,356	436,713
SR-B	Revegetate the riparian corridor and establish a riparian buffer	Ft	0	3,151	11,340
SR-C	Install bank structures (bank protection, bioengineering)	Ft	398	3,480	9,944
SR-D	Install instream structures (habitat, river training, grade control)	Units	10	10	10
KR-A to KR-D	Project-scale management treatments	These treatments will be applied as needed and quantified if necessary in later design phases.			

4.3.4 Meander Reaches Implementation Scenarios

Criteria for Meander Reach 1 and Meander Reach 2 are the same, so this discussion addresses both reaches. Channel morphology within the Meander Reaches has been impacted by river and floodplain management as described in Section 2, but due to constraints related to levees, flood control, land ownership, scale and the Kootenay Lake backwater effects, it appears at this conceptual stage of design that channel reconstruction may not be feasible in these reaches. Therefore, none of the implementation scenarios include channel reconstruction. However, during the subsequent design phases it may become evident that some channel work is necessary and feasible in some portions of the Meander Reaches.

While channel work in the Meander Reaches is not included as part of these implementation scenarios, some areas of floodplain excavation are included between the channel and existing levees. No floodplain excavation is included as part of the minimum implementation scenario. When identifying floodplain areas that could be excavated to the 30,000 cfs river stage elevation, volumes of excavation and acres were calculated for each identified area as described above in Section 4.2.2.3. One logical way to compare these areas was to evaluate the volume of material required to create one acre of excavated floodplain surface. Based on this evaluation, 14,000 cubic yards per acre was identified as the approximate median value. To differentiate between the moderate and maximum implementation scenarios for floodplain excavation, all areas where excavation would be less than 14,000 cubic yards per acre were included as part of the moderate implementation scenario. The maximum scenario included all identified floodplain excavation areas.

These same floodplain excavation areas were used as areas for determining floodplain revegetation potential adjacent to the river, and were combined with data about bank vegetation. For the moderate implementation scenario, lengths of bank with no vegetation would be vegetated, and for the maximum implementation scenario, lengths of bank with no vegetation and sparse vegetation would be vegetated. As with all other reaches, under the

maximum implementation scenario, banks with extreme, high and moderate BEHI ratings would be treated; under the moderate scenario, banks with extreme and high BEHI ratings would be treated; and under the minimum scenario, only banks with extreme BEHI ratings would be treated.

Outside of the levees, riparian and wetland restoration is linked to the restoration suitability analysis described above in Section 4.2.2.1. Under the minimum scenario, no areas outside the levees would be restored; under the moderate scenario, high restoration suitability areas would be restored; and under the maximum scenario, high and moderate suitability areas would be restored. Secondary channels would be constructed or enhanced to connect suitable restoration areas to the main channel. Under the minimum scenario, no secondary channels would be constructed; under the moderate scenario, secondary channels would connect high restoration suitability areas to the river; and under the maximum scenario, secondary channels would connect high and moderate restoration suitability areas to the channel.

Proposed instream structures in the Meander Reaches include placement of large wood and alluvium (i.e., coarse bed material). Quantities for instream structures are based on typical spacing of common structure types that might be included as part of channel designs. For purposes of developing these implementation scenarios, the spacing for large wood is assumed to be one bankfull width between structures on outer meander bends. Large wood is proposed for tributary confluences in the Meander Reaches. Because most tributaries join the Kootenai River at a meander bend, additional large wood would be placed where tributaries join the main river along a straight section of the Meander Reaches. Coarse bed material treatments are proposed for the Shorty's Island portion of the reach as Kootenai sturgeon are known to spawn in this area. Potential treatment locations include the mile of river downstream from Ambush Rock and the two river miles through Shorty's Island. Instream structures and all other treatments would be implemented in conjunction with floodplain reconstruction actions or independently depending on floodplain treatment locations.

Under the minimum scenario, no instream structures would be placed in the Meander Reaches. Under the moderate scenario, instream structures such as alluvium capable of providing interstitial spaces < 3mm wide to accommodate protected sturgeon embryo incubation would be placed at documented spawning sites in Meander Reach 1. No wood would be placed in the Meander Reaches under the moderate scenario. Under the maximum scenario, alluvium would be placed at documented spawning sites in Meander Reach 1, and large wood would be placed at tributary confluences and at outside meander bends in Meander Reach 1 and Meander Reach 2.

Under all scenarios, Libby Dam flow management and Kootenay Lake level management would be considered as part of subsequent design phases. Kootenay Lake backwater affects the entire length of the Meander Reaches during most of each year. Combined with the levee system which confines rising water, the Kootenay Lake backwater effect results in several feet of water level fluctuation throughout the year. This results in early life stages of some riparian plant species such as cottonwood seedlings being submerged during the growing season at inappropriate times relative to their ecological adaptations. Flow depths and velocities are affected at some times of the year in the Meander Reaches by flow regulation at Libby Dam. Restoration work associated with bank structures, floodplain construction, riparian and wetland restoration and tributaries would require coordinating with landowners and infrastructure owners. Criteria for where this type of coordination would need to occur are tied to criteria for particular restoration treatments.

These criteria are displayed in Table 4-10, which includes all restoration treatments that are part of the Meander Reaches habitat action.

Table 4-10. Meander Reach 1 and 2 criteria for minimum, moderate, and maximum implementation scenarios.

Treatment	Restoration Treatment Explanation	Minimum Scenario	Moderate Scenario	Maximum Scenario
MR-A	Excavate and/or dredge the river to modify the channel geometry	None	Pending design	Pending design
MR-B	Excavate floodplain adjacent to the river	None	Surfaces inside levees where excavation < 14,000 cu yds/ acre	All identified surfaces inside levees
MR-C	Construct and/or enhance riparian areas and wetlands adjacent to the river	None	Surfaces inside levees where excavation < 14,000 cu yds/ acre	All identified surfaces inside levees
MR-D	Construct and/or enhance riparian areas and wetlands behind levees and connect to the river	None	Floodplain restoration suitability = High	Floodplain restoration suitability = High and Moderate
MR-E	Construct or enhance secondary channels adjacent to the river	None	Surfaces inside levees where excavation < 14,000 cu yds/ acre	All identified surfaces inside levees
MR-F	Construct or enhance secondary channels behind levees and connect to the river	None	Connect high restoration suitability areas to main channel	Connect high and moderate restoration suitability areas to main channel
MR-G	Revegetate the floodplain adjacent to the river	None	Surfaces inside levees where excavation < 14,000 cu yds/ acre Bank vegetation = None	All identified surfaces inside levees Bank vegetation = None or Sparse
MR-H	Install bank structures	BEHI = Extreme	BEHI = Extreme and High	BEHI = Extreme, High and Moderate
MR-I	Install instream structures	None	At documented spawning sites in Meander Reach 1	At documented spawning sites in Meander Reach 1, at tributary confluences, and at outside meander bends
MR-J	Tributary restoration	None	Remove barriers	Remove barriers Restore streams
KR-A	Manage the discharge from Libby Dam	To be determined	To be determined	To be determined
KR-B	Manage the backwater from Kootenay Lake	To be determined	To be determined	To be determined
KR-C	Manage land use practices	Coordinate with landowners where bank structures (BR-F) apply	Coordinate with landowners where bank structures (BR-F) apply and with all landowners for instream structure, tributary and	Coordinate with landowners where bank structures (BR-F) apply and with all landowners for instream structure, tributary and

Table 4-10. Meander Reach 1 and 2 criteria for minimum, moderate, and maximum implementation scenarios.				
Treatment	**Restoration Treatment Explanation**	**Minimum Scenario**	**Moderate Scenario**	**Maximum Scenario**
			floodplain work	floodplain work
KR-D	Manage for impacts from or to infrastructure	Coordinate with infrastructure owners where bank structures (BR-F) apply	Coordinate with infrastructure owners where bank structures (BR-F) apply and with all infrastructure owners for instream structure, tributary and floodplain work	Coordinate with infrastructure owners where bank structures (BR-F) apply and with all infrastructure owners for instream structure, tributary and floodplain work

Based on implementation scenario criteria for the Meander Reaches, Table 4-11 shows quantities of each restoration treatment that would result from minimum, moderate and maximum scenarios. No floodplain excavation is included in Meander Reach 1 because no significant areas are present within the levees.

Table 4-11. Meander Reach 1 restoration treatment quantities by implementation scenario.					
Treatment	**Restoration Treatment Explanation**	**Unit**	**Min**	**Mod**	**Max**
MR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	0	TBD	TBD
MR-B	Excavate floodplain adjacent to the river	Acres	0	0	0
		Cu yds (cut)	0	0	0
MR-C	Construct and/or enhance wetlands adjacent to the river	Acres	0	0	0
MR-D	Construct and/or enhance wetlands behind levees and connect to the river	Acres	0	2,242	7,844
MR-E	Construct or enhance secondary channels adjacent to the river	Ft	0	0	0
MR-F	Construct or enhance secondary channels behind levees and connect to the river	Ft	0	30,350	39,172
		Cu yds	0	76,445	117,893
MR-G	Revegetate the floodplain adjacent to the river	Ft	0	25,039	70,794
		Acres	0	0	0
MR-H	Install bank structures	Ft	10,456	31,085	84,504
MR-I	Install instream structures	Units	0	15	35
MR-J	Tributary restoration	Barriers	0	3	3
		Ft	0	0	34,102
KR-A to KR-D	Project-scale management treatments	These treatments will be applied as needed and quantified if necessary in later design phases.			

Based on implementation scenario criteria for the Meander Reaches, Table 4-12 shows quantities of each restoration treatment that would result from minimum, moderate and maximum scenarios.

Table 4-12. Meander Reach 2 restoration treatment quantities by implementation scenario.

Treatment	Restoration Treatment Explanation	Unit	Min	Mod	Max
MR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	0	TBD	TBD
MR-B	Excavate floodplain adjacent to the river	Acres	0	767	1,396
		cu yds (cut)	0	7,930,550	17,259,190
MR-C	Construct and/or enhance wetlands adjacent to the river	Acres	0	TBD	TBD
MR-D	Construct and/or enhance wetlands behind levees and connect to the river	Acres	0	3,690	10,456
MR-E	Construct or enhance secondary channels adjacent to the river	Ft	0	TBD	TBD
MR-F	Construct or enhance secondary channels behind levees and connect to the river	Ft	0	57,137	161,490
		cu yds (cut)	0	170,340	1,051,925
MR-G	Revegetate the floodplain adjacent to the river	Ft	0	204,134	314,599
		Acres	0	767	1,396
MR-H	Install bank structures	Ft	78,071	232,116	330,433
MR-I	Install instream structures	Units	0	0	126
MR-J	Tributary restoration	Barriers	0	13	13
		Ft	0	0	58,839
KR-A to KR-D	Project-scale management treatments	These treatments will be applied as needed and quantified if necessary in later design phases.			

4.4 Implementation Sequencing

The implementation scenarios described above are intended to present an illustration of a range of potential levels of restoration effort that represent spatial applications of habitat actions. These implementation scenarios are the basis for the development of cost estimates presented in Chapter 7. Actual Kootenai River Habitat Restoration Project implementation will be guided by designs that will be developed beginning in 2009. The following section describes in concept how the Kootenai River Habitat Restoration Project will be sequenced over time in terms of the reaches and restoration treatments described in these implementation scenarios.

Because the project area is large, because of funding limitations, and because of the Tribe's desire to implement the project within an adaptive management framework, the Kootenai Tribe anticipates that the restoration project will be completed in several sequences over a multi-year period. Kootenai River habitat restoration work will most likely begin at the upstream end of the

project area and generally proceed downstream. Most likely, restoration would be implemented in an order similar to that described on the following page, depending on which implementation scenario (or combination of pieces of implementation scenarios) is selected.

4.4.1 Example of minimum implementation scenario

The minimum implementation scenario encompasses the following:

- Braided Reach 1 – installation of bank structures and revegetation treatments in areas of extreme bank erosion;
- Braided Reach 2 – channel and floodplain reconstruction in the entire reach (along with other treatments that comprise the BR2 Habitat Action);
- Straight Reach – installation of bank structures and revegetation treatments in areas of extreme bank erosion; and
- Meander Reaches – installation of bank structures and revegetation treatments in areas of extreme bank erosion.

Work would likely proceed in the following order:

1. Bank structures and revegetation work in Braided Reach 1 would be implemented first to reduce sediment inputs into downstream reaches.
2. Channel and floodplain reconstruction in Braided Reach 2 would be phased over at least two years and implemented from upstream to downstream.
3. Bank structures and revegetation work would be integrated with channel and floodplain reconstruction in Braided Reach 2, so some of this work would occur as part of channel and floodplain construction, while other aspects focused on vegetation would be timed relative to plant dormancy and other biological considerations.
4. Bank structures and revegetation in the Straight Reach would be implemented following work in Braided Reach 2, however, it would be possible to implement work in this reach independently of other reaches due to the low risk of the channel shifting within the confined and armored reach.
5. Bank structures and related revegetation work in the Meander Reaches would be implemented on an opportunistic basis as agreements are reached with particular landowners. In general, this work in the Meander Reaches would probably occur after Braided and Straight reach work is substantially under way.

4.4.2 Example of moderate implementation scenario

The moderate implementation scenario encompasses the following:

- Braided Reach 1 – installation of bank structures and revegetation treatments in areas of extreme and high bank erosion, and channel and floodplain reconstruction (along with other treatments that comprise the BR1 Habitat Action) between RM 158 and 159;
- Braided Reach 2 – channel and floodplain reconstruction in the entire reach (along with other treatments that comprise the BR2 Habitat Action);

- Straight Reach – installation of bank structures and revegetation treatments in areas of extreme and high bank erosion and installation of instream structures in the upper half the reach (the lower half encompasses the deep pool at Ambush Rock); and
- Meander Reaches – installation of bank structures and revegetation treatments in areas of extreme and high bank erosion, floodplain excavation and revegetation inside the levees, instream habitat structure placement, floodplain restoration outside of the levees and removal of fish passage barriers on tributaries.

Work would likely proceed in the following order:

1. Bank structures and revegetation work, combined with channel and floodplain reconstruction between RM 158 and 159, in Braided Reach 1 would be implemented first to reduce sediment inputs into downstream reaches.
2. Channel and floodplain reconstruction in Braided Reach 2 would be phased over at least two years and implemented from upstream to downstream.
3. Bank structures and revegetation work would be integrated with channel and floodplain reconstruction in Braided Reach 2, so some of this work would occur as part of channel and floodplain construction, while other aspects focused on vegetation would be timed relative to plant dormancy and other biological considerations.
4. Structures and revegetation in the Straight Reach would be implemented following work in Braided Reach 2; however, it would be possible to implement work in this reach independently of other reaches due to the low risk of the channel shifting within the confined and armored reach.
5. Bank structures and related revegetation work in the Meander Reaches would be implemented on an opportunistic basis as agreements are reached with particular landowners. In general, this work in the Meander Reaches would probably occur after Braided and Straight reach work is substantially under way.
6. Other Meander Reach work inside the levees (e.g., floodplain excavation, instream structures) has the potential to be affected by sedimentation from upstream river work, so it would be started after Braided and Straight Reach channel and floodplain work is completed.
7. Floodplain restoration outside the levees would be implemented on an opportunistic basis as agreements are reached with particular landowners and other entities. This work would not be affected by upstream river work, so could be started at any time.
8. Removal of fish barriers along tributary streams is also independent of other river work, and could be implemented at any time.

4.4.3 Example of maximum implementation scenario

The maximum implementation scenario encompasses the following:

- Braided Reach 1 – channel and floodplain reconstruction (along with other treatments that comprise the BR1 Habitat Action) in the entire reach;
- Braided Reach 2 – channel and floodplain reconstruction in the entire reach (along with other treatments that comprise the BR2 Habitat Action);
- Straight Reach – channel and floodplain reconstruction in entire reach; and

- Meander Reaches – installation of bank structures and revegetation treatments in areas of extreme, high and moderate bank erosion; floodplain excavation and revegetation inside the levees; instream habitat structure placement; floodplain restoration outside of the levees; removal of fish passage barriers on tributaries and restoration of tributaries on the floodplain.

Work would likely proceed in the following order:

1. Channel and floodplain reconstruction throughout Braided Reach 1 would be implemented first to reduce sediment inputs into downstream reaches. This work would probably be phased over at least two years.
2. Channel and floodplain reconstruction in Braided Reach 2 would be phased over at least two years and implemented from upstream to downstream.
3. Bank structures and revegetation work would be integrated with channel and floodplain reconstruction in Braided Reach 2, so some of this work would occur as part of channel and floodplain construction, while other aspects focused on vegetation would be timed relative to plant dormancy and other biological considerations. Because channel work in these reaches would not occur until after Braided Reach 1 channel work is complete, some bank structures and revegetation work might be completed before channel work as a way to limit sediment inputs from Braided Reach 2.
4. Channel reconstruction in the Straight Reach would be implemented following work in Braided Reach 2 and would be phased over one or more years.
5. Bank structures and related revegetation work in the Meander Reaches would be implemented on an opportunistic basis as agreements are reached with particular landowners. In general, this work in the Meander Reaches would probably occur after Braided and Straight reach work is substantially under way. However, under the maximum scenario, some of the extreme and high BEHI rating banks might be restored while Braided and Straight Reach work is in progress.
6. Other Meander Reach work inside the levees (floodplain excavation, instream structures) has the potential to be affected by sedimentation from upstream river work, so it would be started after Braided Reaches and Straight Reach channel and floodplain work is completed, but this would be determined during the design process.
7. Floodplain restoration outside the levees would be implemented on an opportunistic basis as agreements are reached with particular landowners and other entities. This work would not be affected by upstream river work and could be started at any time.
8. Removal of fish barriers and channel restoration along tributary streams is also independent of other river work, so this work could be implemented at any time.

The above implementation sequencing discussion is conceptual and actual sequencing will be determined during the preliminary and final design phases as described in Chapter 9. The conceptual sequencing also helps to develop a conceptual timeline (Figure 4-10) that can be used to estimate time-sensitive elements of the costs such as economy of scale, cost escalation, and funding strategy.

As previously noted, the Kootenai River Habitat Restoration Project will likely take a number of years to complete the work. This will result in various restoration phases being implemented in

different reaches at different times. Funding availability and environmental compliance schedules will also influence implementation sequencing. This chapter has provided a basic rationale for identifying where work should occur and when. Subsequent design phases will consider specific actions and sequencing in greater detail with the recognition that the Kootenai River Habitat Restoration Project is a single endeavor with component parts that are all inter-linked and inter-dependent.

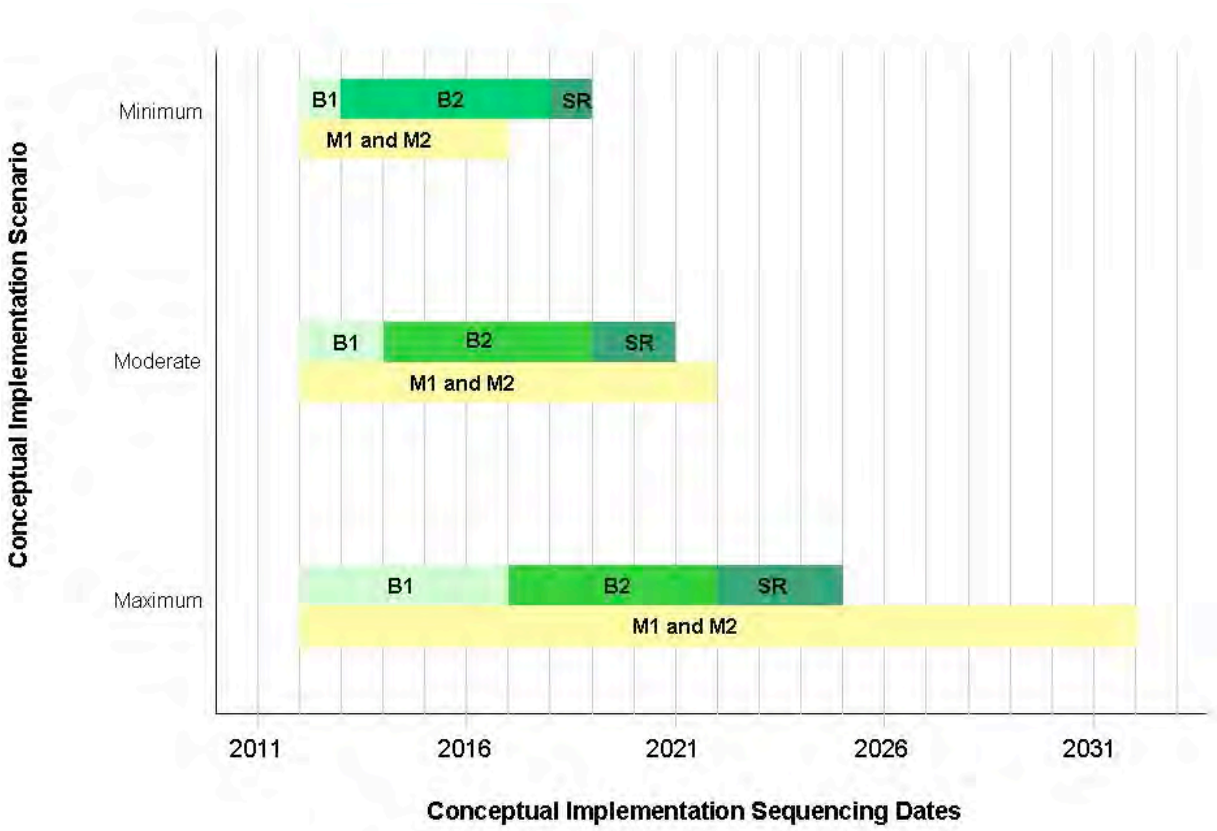


Figure 4-10. Conceptual implementation timeline related to minimum, moderate, and maximum implementation scenarios.

4.5 Summary

Implementation scenarios are spatial applications of habitat actions that link information about limiting factors and other resources to restoration treatments that have been proven to overcome those limiting factors in similar river systems. Implementation scenarios can be used for several purposes, including:

- Describing in a conceptual manner where restoration work is likely to happen in the project reach;
- Helping to identify a range of implementation costs that are tied to particular levels of effort at different locations (costs are described in Chapter 7) and helping to frame an appropriate funding strategy;

- Illustrating in a general way increased benefits to habitat and trade offs (including costs) associated with different levels of restoration effort;
- Describing a range of alternatives for evaluating potential restoration work relative to environmental compliance and permitting at a programmatic level; and
- Communicating the Kootenai River Habitat Restoration Project's scope and nature to the public and other stakeholders.

These implementation scenarios set the stage for design by providing a framework for identifying where restoration work should be completed. To make sure restoration work is achieving the purposes and goals described in this Master Plan, this restoration project will be designed and implemented in an adaptive manner. Just as data about limiting factors and other resources make it possible to develop meaningful implementation scenarios at a conceptual level, increasingly targeted data will be collected and analyzed to support the next phases of project design and implementation. Once portions of the project have been completed, these areas will be monitored to evaluate the degree to which restoration treatments are overcoming habitat limiting factors. These monitoring data will be fed back into the decision-making process and used to modify already-implemented portions of the Kootenai River Habitat Restoration Project if necessary, and to inform designs for future portions of the project. The following chapter describes the Adaptive Management and Monitoring program that will support the Kootenai River Habitat Restoration Project.

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5 Adaptive Management and Monitoring

This chapter describes the Adaptive Management and Monitoring program for the Kootenai River Habitat Restoration Project. The Adaptive Management and Monitoring program is a long-term decision-making framework that provides a formal way to incorporate effectiveness monitoring data related to specific restoration treatments, monitoring information from other related programs, and other new information that may become available. As part of later design phases, this adaptive management and monitoring program will be refined and tailored to address the specific restoration treatments and implementation scenarios that are selected.

5.1 Overview

The Adaptive Management and Monitoring program will be guided by the Kootenai River Habitat Restoration Project goals:

- Restore physical habitat by reducing the negative effects to river and floodplain ecological processes caused by river response to the altered landscape.
- Restore native vegetation by establishing stream bank and floodplain conditions that sustain plant community development processes.
- Restore aquatic habitat conditions that support sustainable populations for all life stages of native fish.
- Create opportunities for river and floodplain stewardship in the community.

The purpose of the Kootenai River Habitat Restoration Project Adaptive Management and Monitoring Plan is to provide a framework to:

- Evaluate the effectiveness of the implemented habitat actions in terms of achieving the project goals;
- Identify project maintenance needs;
- Identify any potential unforeseen negative impacts on infrastructure, public and private lands, flood control management, focal species, and habitat;
- Support decisions to modify restoration treatments; and
- Refine or modify restoration treatments that might be implemented in later phases of the project.

An important corollary purpose of the Adaptive Management and Monitoring Plan is to establish links to other existing adaptive management and monitoring programs. For example, it will be important to orchestrate effective coordination with the broader scale Kootenai River Adaptive Management Plan[1] monitoring associated with the Fish and Wildlife Service Biological Opinion

[1] In 2004, the Kootenai Tribe along with numerous scientific and management stakeholders participated in a multi-agency adaptive management workshop to develop a long-term adaptive management framework for the Kootenai River ecosystem. The resulting 20-year adaptive management framework included aquatic, riparian and

regarding the effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout and Kootenai Sturgeon Critical Habitat (Libby Dam BiOp) (USFWS 2006, clarified in 2008) as clarified, monitoring associated with the Kootenai Tribal Sturgeon Hatchery and the Tribe's aquaculture program, and the Kootenai River White Sturgeon Recovery Implementation Plan and Schedule (Kootenai Tribe of Idaho 2005), and other Kootenai subbasin fish and wildlife programs as partially listed in Section 1.1.4 of this Master Plan.

Because the Kootenai River Habitat Restoration Project focuses on overcoming limiting factors related to habitat, the Adaptive Management and Monitoring program will emphasize collection and evaluation of data that determines whether habitat goals and objectives are being achieved. As described in previous chapters, project goals and associated limiting factors are grouped into categories of morphology, riparian vegetation and aquatic habitat, and the project goals are based on these groupings. These limiting factors were selected because they can be most directly addressed by restoration treatments outlined in this Master Plan. Similarly, metrics related to morphology, riparian vegetation and aquatic habitat are most likely to be sensitive to changes resulting from restoration treatments. Therefore, the adaptive management and monitoring program includes metrics that link directly limiting factors, and these links are shown in Table 5-1. While one of the purposes of the Kootenai River Habitat Restoration Project, as described in Chapter 1, is to improve habitat for aquatic focal species, this adaptive management and monitoring program does not specifically include metrics related to the biological response in terms of focal aquatic species populations. This is because those metrics are being monitored as part of other, concurrent monitoring and evaluation programs. Because the links between habitat metrics and aquatic focal species are important, this Adaptive Management and Monitoring Plan specifically includes information about related monitoring and evaluation programs (see Table 5-3 and Section 5.5).

Chapter 2 (particularly Section 2.6 Aquatic Habitat Limiting Factors) describes the links between aquatic focal species and the limiting factors included in this Master Plan. Monitoring and evaluation activities conducted through other programs will provide links between the Kootenai River Habitat Restoration Project and biological response within the Kootenai River ecosystem. As the project moves into subsequent design phases, it will be necessary to develop formal mechanisms to ensure the social and cultural context is being considered adequately. Collectively, the information gathered through the coordinated adaptive management and evaluation programs will contribute to addressing and resolving data gaps associated with a broad range of ecosystem functions necessary for sturgeon and other aquatic focal species. In subsequent phases of the Kootenai River Habitat Restoration Project, this Adaptive Management and Monitoring program will be expanded and refined to explicitly define how these efforts will be coordinated so that a broad range of necessary data and information is effectively shared among the different programs.

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terrestrial/avian components and is described in the 2005 *Draft Kootenai River Adaptive Management Plan* (Walters et al. 2005).

5.2 Adaptive Management and Monitoring Program

The following sections describe the conceptual approach to the Kootenai River Habitat Restoration Project Adaptive Management and Monitoring program. As noted previously, the details of this program will be refined during the preliminary design phase of the project.

Adaptive management can be defined as incorporating the scientific method into a management framework to resolve specific problems. Adaptive management is based on the premise that informed, deliberate experimentation is the most reliable means of understanding and addressing complex problems in resource systems. Moreover, the adaptive management approach incorporates the development and comparison of alternative models based on multidisciplinary collaboration as the basis of management, experimental design, and monitoring of the resource system (Holling 1978; Walters 1986). This differentiates adaptive management from a more traditional trial-and-error or learn-as-you-go management approach (Hilborn 1992, Halbert 1993).

When applied to the large scale Kootenai River Habitat Restoration Project, adaptive management will provide a necessary framework for managing the entire restoration project, and linking it to related natural resource management programs. Adaptive management will encompass all stages of restoration, including planning and design, implementation, monitoring and maintenance.

A restoration design that incorporates adaptive management is the result of an interdisciplinary process that is focused on increasing knowledge about the ecosystem and its habitat, and how restoration treatments can overcome limiting factors. Knowledge is increased by collecting design-specific data, analyzing the data and applying information and experience gained from previous restoration projects; and from monitoring and evaluating the current project. Restoration design must be an iterative process that includes feedback loops that allow interpretations of monitoring results to serve as inputs in an ongoing process where designs are refined; it is not a linear process with a pre-determined or fixed end point. Figure 5-1 illustrates the restoration design process where information from early restoration phases feeds back into later phases of design and implementation (note that Figure 5-1 illustrates only the design process not the larger process that will be used to adaptively implement the project). This allows for project designs developed in later phases to incorporate effectiveness monitoring data from previous phases, resulting in the most effective restoration treatments being included as part of later restoration designs.

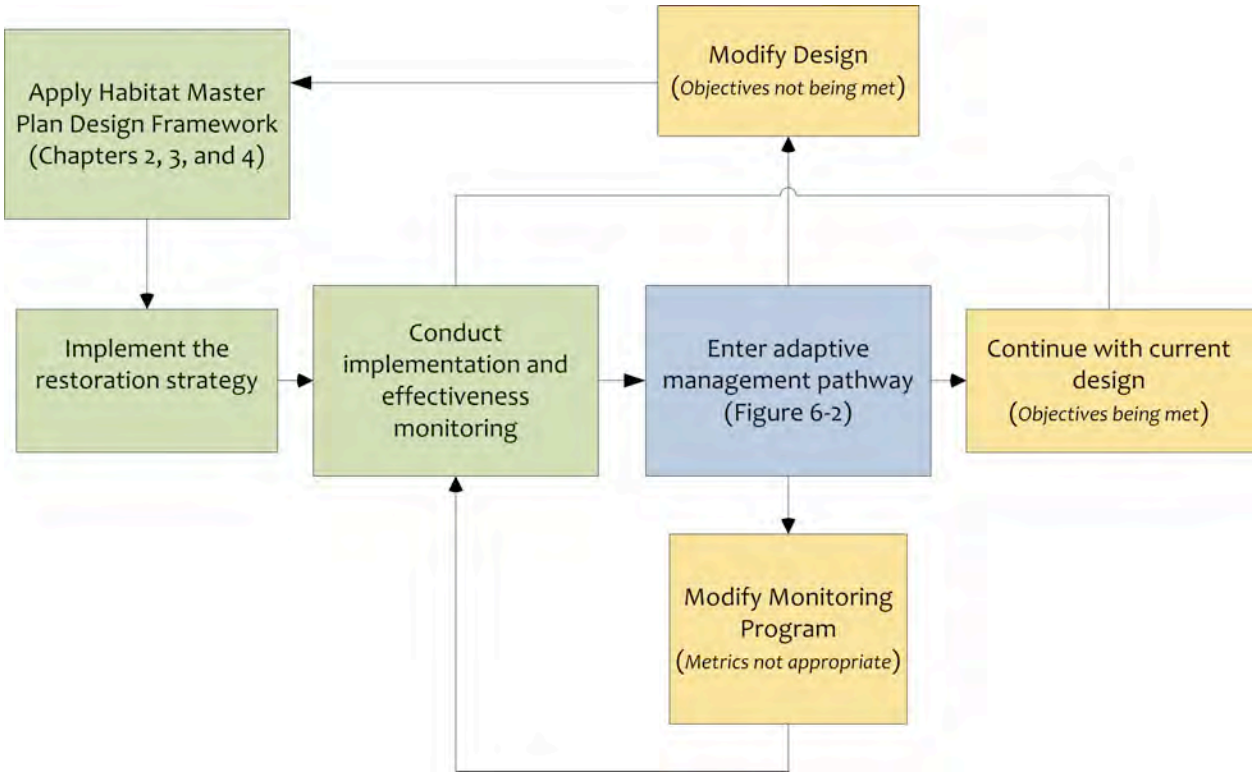

Figure 5-1. Restoration design process.

The Adaptive Management and Monitoring program provides a mechanism to make the design process adaptable and accountable, and to determine whether habitat restoration goals are being achieved. Table 5-1 illustrates how restoration goals are described in terms of limiting factors, restoration strategies and quantifiable objectives to support the adaptive management and monitoring program.

Following is a summary of the Adaptive Management and Monitoring program's components:

- **Goals** are described in terms of limiting factors related to morphology, riparian vegetation and aquatic habitat (and constraints related to river stewardship) that must be overcome to restore habitat; **restoration strategies** are identified to overcome limiting factors, and **objectives** are quantifiable ways to determine whether limiting factors are being addressed by treatments (see Chapter 3). In this document, some objectives include placeholders for thresholds that will be developed during the next phase of the design process and subsequently used to determine whether success criteria are being met.
- Once preliminary designs are completed for a project reach, **success criteria** will be developed based on either quantitative or qualitative criteria developed as part of the design. Success criteria provide a way to explicitly state and measure the expected outcomes of restoration treatments within both short-term and long-term time frames. Examples of success criteria are included in Table 5-2. The associated monitoring

program must include ways to measure these criteria in a manner that is quantifiable, repeatable and accurate.

- To accomplish this, **metrics** will be selected for each success criteria. Monitoring metrics are ways of measuring criteria; for example, size class distribution is a metric for sediment-transport and feet per year is a metric for lateral bank erosion. Proposed metrics are included in Table 5-1; these will be refined and potentially augmented during the preliminary design process.

Table 5-1. Limiting factors, strategies, objectives and metrics by four goal categories.			
Limiting Factors/ Constraints	**Restoration Strategy Components**	**Quantifiable Objectives [1]**	**Proposed Metrics**
Morphology			
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	▪ Construct a meandering gravel-bed channel with side channels in the Braided Reaches ▪ Construct a confined gravel-bed channel in the Straight Reach ▪ Excavate floodplain adjacent to the channel in the Meander Reaches	▪ Channel width ▪ Channel depth ▪ Channel slope ▪ Particle-size distribution
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	▪ Provide floodplain surfaces in the Braided and Straight Reaches that will store X tons of sediment over X years ▪ Provide river and floodplain sediment-transport conditions in the Braided and Straight Reaches that deposit X tons of sediment on the floodplains and less than X tons of sediment in the channel annually	▪ Change in volume and area of depositional surfaces ▪ Particle size distribution ▪ Scour and fill depth on point bars ▪ Channel width ▪ Channel depth
Loss of floodplain connection	Establish channel and floodplain connection at mean annual peak flow where feasible given constraints from river and floodplain management	▪ In the Braided and Straight Reaches, create X acres of new floodplain surfaces at elevations that correspond to river stage at 30,000 cfs ▪ In the Meander Reaches, connect X acres of floodplain surfaces at elevations that correspond to river stage at 30,000 cfs	▪ Channel profile ▪ Bank height ratio ▪ Observations of hydrologic connectivity

Table 5-1. Limiting factors, strategies, objectives and metrics by four goal categories.			
Limiting Factors/ Constraints	**Restoration Strategy Components**	**Quantifiable Objectives** [1]	**Proposed Metrics**
Accelerated bank erosion and reduced boundary roughness	Establish bank vegetation; increase channel roughness	▪ Within identified bank treatment areas, lateral bank migration is 0 ft per year for first five years while vegetation is becoming established ▪ Within identified bank treatment areas, less than 10% of bank length moves laterally less than 1 ft between years 5 and 10 ▪ Within identified bank treatment areas, less than 30% of bank length moves laterally less than 1 ft between years 10 and 20	▪ BEHI ratings ▪ Bank profiles ▪ Bank erosion rates
Riparian vegetation			
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	• In Braided Reach 1, create X acres of new floodplain surfaces • In Meander Reach 1, X acres of floodplain is (surface) connected to the river at 30,000 cfs including X acres with sand/gravel/cobble substrate • In Meander Reach 1, X acres of floodplain has hydrology in the rooting zone sufficient to support hydrophytic vegetation	• Hydrologic connectivity • Groundwater depth • Canopy cover of plants • Area and stability of depositional surfaces
Lack of outer bank vegetation	Establish bank vegetation	• Within identified bank treatment areas, X live willow and shrub stems per square foot on bank face by year 3 • Within identified bank treatment areas, 80% canopy cover of native shrubs by year 5	• Stem counts • Proportional abundance of native vegetation types • Canopy cover
Frequent scour/deposition of floodplain surfaces	Increase stability/longevity of floodplain surfaces	• Maximum x% change in footprint of point bars per year over three years (allows some movement, but not complete annual redistribution of point bars)	• Area of depositional features and change in position over time
Altered hydroperiod	Increase floodplain areas with appropriate elevation ranges relative to the water table to support native tree and shrub species	• Link this objective to a design table that represents proportional abundance of elevation patches per unit area	• Groundwater depth • Wetland indicator status of plant species

Table 5-1. Limiting factors, strategies, objectives and metrics by four goal categories.			
Limiting Factors/ Constraints	**Restoration Strategy Components**	**Quantifiable Objectives [1]**	**Proposed Metrics**
Invasive weeds	Reduce weed cover so weeds do not limit recruitment and establishment of native plant species	• Weed canopy cover is less than 10% by year five	• Canopy cover invasive species • Weed mapping
Lack of native seed sources	Establish nodes of diverse, native vegetation within the Straight Reach and Meander Reaches	• Link this objective to design plant pallets that include a list of species by layer and target density/canopy cover over short, medium and long-term timeframes	• Native plant species canopy cover and diversity as measured by number of species by life form
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	• Targets would be established for each project design	• Combination of vegetation metrics and other metrics from the Tribe's Operational Loss Assessment
Aquatic habitat			
Insufficient depth for Kootenai sturgeon migration preference	Provide depth conditions for normal Kootenai sturgeon migration and spawning behavior in Kootenai sturgeon migration reaches	• Provide intermittent depths of 16.5 to 23 ft or greater in 60% of the area of rocky substrate from RM 152 to RM157 during peak augmentation flows	• Channel depth • Libby Dam BiOp monitoring completed by others
Insufficient velocity for Kootenai sturgeon spawning preference	Provide velocity conditions for Kootenai sturgeon spawning and embryo/free-embryo incubation and rearing in Kootenai sturgeon spawning reaches	• Provide velocities of 3.3 ft/s and greater in approximately 60% of the area of rocky substrate from RM 152 to RM157 during post-peak augmentation flows	• Flow velocity • Libby Dam BiOp monitoring completed by others
Lack of coarse substrate for Kootenai sturgeon egg attachment and larval hiding	Provide substrate conditions for Kootenai sturgeon embryo/free-embryo incubation and rearing in Kootenai sturgeon spawning reaches	• Place coarse substrate (X mm) in approximately X miles of the Meander Reaches at the locations of known spawning behavior, general corresponding with pool tailout locations in Meander Reach 1	• Particle size measurements and distribution • Libby Dam BiOp monitoring completed by others
Lack of cover for juvenile fish	Increase instream and bank cover by constructing instream structures and establishing bank vegetation	• Create dense vegetation bank cover for approximately X% of the Braided Reaches, X% of the Straight Reach and X% of the Meander Reaches	• Canopy cover of bank vegetation and density of instream cover

Table 5-1. Limiting factors, strategies, objectives and metrics by four goal categories.			
Limiting Factors/ Constraints	**Restoration Strategy Components**	**Quantifiable Objectives [1]**	**Proposed Metrics**
Lack of pool-riffle complexity	Increase hydraulic habitat complexity by establishing ratios of pool and riffle habitat that are appropriate for the morphological setting	• Establish X% pool/glide habitat and X% riffle/run habitat in all reaches	• Pool and riffle habitat lengths by reach
Simplified food web from lack of nutrients	Increase nutrient availability	• Reference nutrient addition program and reference other goals/objectives aimed at increasing ecosystem productivity	• Combination of metrics and other Kootenai Tribe monitoring and evaluation metrics from Operational Loss Assessment
Insufficient pool frequency	Establish pool frequency that is appropriate for the morphological setting	• Establish pool frequency of one pool per unit length corresponding to 5 to 7 bankfull widths	• Pool spacing
Lack of fish passage into tributaries	Establish fish passage at known barriers on tributaries within the project area	• Remove fish passage barriers on tributaries	• Depth and velocity criteria for target species
Lack of off-channel habitat for rearing	Increase availability of off-channel habitat for native aquatic species	• Create X acres of off-channel habitat that is connected to the mainstem at X cfs. This could be linked to a design table that specifies how habitat should be distributed in terms of wetland systems/classes	• Area of off-channel habitat features • Observations in off-channel areas
Altered water quality	Identify and reduce point source pollutant inputs into Kootenai River and tributaries	• Identify specific opportunities to reduce pollutant inputs	• Turbidity • Chemical analysis
River stewardship			
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	• Verify that coordination is happening	• Documented coordination

Table 5-1. Limiting factors, strategies, objectives and metrics by four goal categories.			
Limiting Factors/ Constraints	**Restoration Strategy Components**	**Quantifiable Objectives [1]**	**Proposed Metrics**
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	• Verify that coordination is happening	• Documented coordination
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	• Verify that coordination is happening	• Documented coordination
Dam controlled nutrient regime	Develop habitat actions that are compatible with modified regimes and work with Libby Dam managers so operations support habitat restoration efforts	• Verify that coordination is happening	• Documented coordination
Floodplain land use	Coordinate with landowners and grazing lessees to explore development of grazing management plans that allow floodplain vegetation to develop	• Verify that coordination is happening	• Documented coordination
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	• Verify that coordination is happening	• Documented coordination
Levees and diking districts	Coordinate with diking districts and other affected parties to maintain, modify or remove levees to support channel, riparian and floodplain ecological processes according to specific habitat actions	• Verify that coordination is happening	• Documented coordination

Table 5-1. Limiting factors, strategies, objectives and metrics by four goal categories.			
Limiting Factors/ Constraints	**Restoration Strategy Components**	**Quantifiable Objectives [1]**	**Proposed Metrics**
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	• Verify that coordination is happening	• Documented coordination
Backwater influence from Kootenay Lake	Work with B.C. and other entities to explore and identify potential modifications to Kootenay Lake level management and design habitat actions that would complement those potential changes to Lake level management	• Reduce the backwater influence on X miles of river by lowering the backwater elevation by X feet during flows greater than X cfs	• Backwater elevation
Urban development adjacent to river	Design habitat actions that do not place urban infrastructure at risk, and create riparian buffers to separate city from river where possible by working with Bonners Ferry and landowners	• Establish riparian buffers for X feet of river frontage based on results of coordinating with landowners	• Documented coordination • Length of riparian buffer

[1] Where thresholds are not specified, they are indicated with an 'X' and will be developed during later design phases.

Table 5-2. Conceptual success criteria for adaptive management in the context of short-term and long-term time frames.		
Metrics	**Short-term success criteria* (0-15 years)**	**Long-term success criteria* (15+ years)**
Morphology		
Channel width/depth ratio	Channel dimensions are within 20% of design	Channel dimensions are within 20% of design
Hydrologic connectivity	Floodplain is accessed at flows > 30,000 CFS	Floodplain is accessed at flows > 30,000 CFS
Particle size distribution	Substrate meets distribution criteria by reach	Natural processes maintain appropriate particle size for design habitat
Bank erosion rates	Bank erosion <0.5 foot/yr	Bank erosion < 1 foot/yr
Lateral bank movement	Lateral bank movement < 0.5 foot/yr	Lateral bank movement < 1 foot/yr
Bank height ratio	BHR between 1.0 to 1.4	BHR between 1.0 and 1.4
Sediment volume	Floodplain surfaces in the Braided and Straight Reaches store X tons of sediment over X years	Floodplain surfaces in the Braided and Straight Reaches store X tons of sediment over X years
Scour and fill depth	Scour/fill depth is X feet/event by reach	Scour/fill depth is X feet/event by reach
Riparian vegetation		
Proportional abundance of native vegetation types	Floodplain vegetation types > 70% of target distribution	Floodplain vegetation types > 80% of target distribution
Canopy cover	Native species canopy cover > 80% of total	Native species canopy cover > 90% of total
Invasive species canopy	Invasive species < 20%	Invasive species < 10%
Stem counts	X live willows/sq ft by year 3	X live willows/sq ft by year XX
Groundwater depth	X acres of floodplain has sufficient root zone hydrology to support wetlands	X acres of floodplain has sufficient root zone hydrology to support wetlands
Hydrologic connectivity	X% of floodplain is accessed at flows > 30,000CFS	X% of floodplain is accessed at flows > 30,000CFS
Weed mapping	Weed canopy cover < 10% by year 5	Weed canopy cover does not increase above 10%
Point bar footprint	Max of X% change/yr over 3 years	Max of X% change/yr annually
Aquatic habitat		
Mean channel depth/velocity Particle size/distribution	Channel dimensions are within 20 % of design	Healthy channel is maintained by natural processes
Pool/riffle habitat length	Substrate meets distribution criteria by reach	Substrate meets distribution criteria by reach
Species population/ Proportional distribution	Habitat proportions are within 10% of design Increase in species diversity and population	Habitat proportions are within 10% of design Target species populations are healthy and naturally maintaining
Movement/migration	Barriers removed	Tributaries accessed by target species
Bank canopy cover	X% of banks in each reach have dense canopy cover	X% of banks in each reach have dense canopy cover
River stewardship		
Metrics are tied to degree of coordination and outcomes	Success criteria linked to amount and quality of communication with landowners and agencies	Success criteria tied to numbers of cooperative projects initiated

*Success criteria will be refined during subsequent design phases and may include biological components.

The conceptual success criteria described in Table 5-2 are split into short-term and long-term time frames. Short-term success criteria focus on whether specific restoration treatments and actions are responding as expected at the scale of the particular treatment or action. At this scale, thresholds that determine success are linked to quantitative criteria that will be developed during the design process. In some cases, long-term success criteria are similar to short-term success criteria, except different thresholds may be used to define success. For example, when restoring native vegetation to a recently disturbed surface, it is more likely that weeds will colonize that surface. As soils develop and native plants occupy more niches over the long-term, it is reasonable to set a lower threshold for weed cover in terms of how success is defined. In other cases, long-term success criteria may be broader and focus on whether limiting factors are being addressed and whether the ecosystem is responding to changes in habitat conditions caused by the restoration project. In addition to being different for different timeframes, some success criteria must be flexible due to the variable nature of a river and floodplain ecosystem. Because we define restoration as creating conditions that will sustain ecological processes, it is necessary to acknowledge that ecological processes are dynamic and will result in changes, particularly during the first few years after a project is constructed. For example, in the case of a constructed channel, some lateral erosion and deposition is desirable as the channel makes slight adjustments to local hydraulic and sediment-transport conditions. If success criteria for the short-term time frame are expressed as variation around a mean design value, this will allow room for natural adjustments without automatically triggering maintenance actions or unnecessary or inappropriate redesign.

Success criteria values and ranges represent expectations about how the ecosystem will respond to restoration treatments. Exceeding these values and ranges triggers a management response that is described in more detail in Section 5-4. Management responses may include reconsidering success criteria, increasing monitoring intensity, performing a maintenance action, or redesigning some aspect of the project. In practice, monitoring data should be reviewed both in the office and in the field by an adaptive management team consisting of experts and managers who represent the relevant scientific disciplines. Evaluating monitoring data in the context of the ecosystem makes it possible to observe ecological processes that are difficult to capture numerically. This contextual interdisciplinary review is necessary is necessary for the decision-making process described in Section 5-4 to be effective.

In addition to success criteria directed at habitat, additional criteria may be developed for biological populations as part of later design phases. As noted previously, it will be necessary to coordinate with other related restoration efforts like those described in the Draft Kootenai River Adaptive Management Plan (Walters et al. 2005) so appropriate links are made between habitat actions and other management programs aimed at restoring Kootenai sturgeon and other native populations.

5.3 Monitoring Program

This section describes the monitoring framework for the Kootenai River Habitat Restoration Project. The purpose of this section is to describe how monitoring data will be used to evaluate the success of the project and provide information to support the adaptive management decision-making process.

Three types of monitoring are necessary to establish the integrated monitoring program. These include baseline, implementation, and effectiveness monitoring.

- **Baseline** monitoring documents the pre-restoration condition.
- **Implementation monitoring** (also called as-built monitoring) documents the restoration project as completed.
- **Effectiveness monitoring** addresses whether project objectives are being met, determines maintenance needs, and provides inputs into decision pathways.

5.3.1 Baseline Monitoring

Baseline monitoring data include data collected to support development of this Master Plan, data that will be collected in the future to support subsequent design work, and other data collected as part of related projects. These data reflect the pre-restoration condition of habitat in the Kootenai River project area, and provide a basis for documenting changes that result from implementing restoration actions. Monitoring and adaptive management plans for specific projects will include a comprehensive list of data sets that apply to each project.

5.3.2 Implementation or As-built Monitoring

Once a project phase has been constructed, a detailed as-built survey will be conducted to document the completed restoration project. During the as-built survey, permanent monitoring stations will be established for the purpose of conducting effectiveness monitoring. The exact location of permanent monitoring stations will be determined as construction proceeds. Similar to construction, as-built documentation will occur in phases following completion of each project reach or phase.

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

- Detailed aerial (LiDAR), ground, and bathymetric topographic surveys of the channel and floodplain for use as base maps for project monitoring.
- Aerial photographs of the project reach.
- Ground photographs of the project reach.
- Longitudinal profile and channel cross-sections with as-built stationing.
- Channel substrate composition
- Resource-grade GPS surveys to create maps documenting revegetation treatment areas and vegetation cover type extents.
- Resource-grade GPS survey to create maps to document structure locations
- Resource-grade GPS surveys to create as-built wetland maps

5.3.3 Effectiveness Monitoring

Effectiveness monitoring is designed to measure progress toward achieving project goals and objectives in terms of success criteria, determine maintenance needs and provide input into determining whether the site exhibits a trajectory towards or away from achieving project goals and objectives. This monitoring effort will focus on collecting data necessary to calculate the

monitoring metrics established to quantify success criteria for the project. The following sections describe how the effectiveness monitoring plan will be developed and implemented including: monitoring methods, monitoring locations, level of effort, and monitoring schedule and frequency. More detailed adaptive management and monitoring plans will be developed during the preliminary and final design phases. How the data are collected for effectiveness monitoring, and how those data will be used to make decisions regarding project success, and determine corrective actions and maintenance needs is described in Section 5-4.

5.3.3.1 Monitoring Methods

Subsequent design phases will include specific monitoring methods that explain how each metric will be evaluated, and as noted above, additional metrics may be added. Methods may be included as an appendix that can be easily separated from the plan and used as a field reference. Specific monitoring methods will be determined for each phase of restoration depending on the specific restoration treatments that are implemented.

5.3.3.2 Monitoring Locations, Level of Effort, Timing and Frequency

Monitoring locations will be identified during the design phase and as the as-built survey is completed. The sampling intensity (level of effort) will be determined according to the parameter that is being measured and will vary depending on the particular monitoring method. Table 5-3 provides an example of the number of sampling sites, anticipated sampling locations, timing and sampling frequency for each monitoring metric.

Table 5-3. Example of potential monitoring sampling locations, effort, timing and frequency.

Example Metrics	Sampling Locations	Total Samples / Sampling Event	Timing	Scheduled Frequency*
Morphology				
Channel width/depth ratio	At cross-sections	Depends on Reach Length	After peak runoff	Years 1, 2, 3, 5, 10, 15, etc.
Hydrologic connectivity	Entire restoration area	One	During peak flow	Years 1, 2, 3, 5, 10, 15, etc.
Particle size distribution	All riffles and point bars and according to existing monitoring and evaluation efforts	Up to 5 per reach and per existing monitoring and evaluation efforts	After peak runoff	Years 1, 2, 3, 5, 10, 15, etc.
Bank erosion rates	Outer bends where bank stabilization structures are installed and at all channel cross-sections	Depends on Reach Length	After peak runoff	Years 1, 2, 3, 5, 10, 15, etc.
Lateral bank movement	Outer bends where bank stabilization structures are installed and at all channel cross-sections	Depends on Reach Length	After peak runoff	Years 1, 2, 3, 5, 10, 15, etc.
Bank height ratio	Points along longitudinal profile	Depends on Reach Length		Years 1, 2, 3, 5, 10, 15, etc.

Table 5-3. Example of potential monitoring sampling locations, effort, timing and frequency.				
Example Metrics	**Sampling Locations**	**Total Samples / Sampling Event**	**Timing**	**Scheduled Frequency***
Sediment volume	Entire floodplain surface	One	After peak runoff	Years 1, 2, 3, 5, 10, 15, etc.
Scour and fill depth	Point bars	3 to 5 per bar	After peak runoff	Years 1, 2, 3, 5, 10, 15, etc.
Riparian Vegetation				
Proportional abundance of native vegetation types	Entire project area	One	Growing season	Years 1, 2, 3, 5, 10, 15, etc.
Canopy cover	Sampling plots	Per monitoring plan	Growing season	Years 1, 2, 3, 5, 10, 15, etc.
Invasive species canopy	Sampling plots	Per monitoring plan	Growing season	Years 1, 2, 3, 5, 10, 15, etc.
Stem counts	All bioengineering structures	Per monitoring plan	Growing season	Years 1, 2, 3, 5, 10, 15, etc.
Groundwater depth	Within wetlands	Paired wells/wetland	Growing season	Years 1, 2, 3, 5, 10, 15, etc.
Hydrologic connectivity	Entire restoration area	One/Peak Flow Event	During peak flow	Years 1, 2, 3, 5, 10, 15, etc.
Weed mapping	Sampling plots	Per monitoring plan	Growing season	Years 1, 2, 3, 5, 10, 15, etc.
Point bar footprint	All point bars	One/Peak Flow Event	After Peak Flow	Years 1, 2, 3, 5, 10, 15, etc.
Aquatic Habitat				
Mean channel depth/velocity	At cross-sections	Depends on Reach Length		Years 1, 2, 3, 5, 10, 15, etc.
Particle size/distribution	At cross-sections	Depends on Reach Length		Years 1, 2, 3, 5, 10, 15, etc.
Pool/riffle habitat length	Entire length of longitudinal profile	Depends on Reach Length	After peak runoff	Years 1, 2, 3, 5, 10, 15, etc.
Species population/ Proportional distribution	Entire restoration area	Per related monitoring and evaluation efforts	Per existing protocols	Years 1, 2, 3, 5, 10, 15, etc.
Movement/migration	Tributaries TBD and in Kootenai River Mainstem	Per related monitoring and evaluation efforts	Per existing protocols	Years 1, 2, 3, 5, 10, 15, etc.
Bank canopy cover	At cross-sections	Depends on Reach Length	Growing season	Years 1, 2, 3, 5, 10, 15, etc.
Turbidity	Above and below project extents	Per related monitoring and evaluation efforts and specific	Peak runoff, release flows, construction protocol	Years 1, 2, 3, 5, 10, 15, etc.

Table 5-3. Example of potential monitoring sampling locations, effort, timing and frequency.				
Example Metrics	**Sampling Locations**	**Total Samples / Sampling Event**	**Timing**	**Scheduled Frequency***
		restoration plan		

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

5.4 Framework for Making Adaptive Management Decisions Based on Monitoring Data

Implementing large-scale ecosystem restoration requires building in mechanisms to address the uncertainty that is inherent within natural systems. To address this uncertainty, the Adaptive Management and Monitoring program includes a decision-making framework for interpretation of effectiveness monitoring data and other information that becomes available. To support this, the Kootenai Tribe will initiate efforts to identify and convene an interdisciplinary adaptive management and monitoring team for the Kootenai River Habitat Restoration Project prior to initiation of the preliminary design phase. This team will include representatives from key management agencies (co-managers), a range of necessary disciplines (e.g., fish and plant biologists, hydrologists, etc.) and other experts in the field of restoration. This team will coordinate to critically review monitoring data and other project-related information (in the office and in the field) so team members can interpret monitoring results in the context of developing ecosystem functions and processes. Through this framework, it will be possible to determine whether the implemented restoration actions(s) are meeting project objectives based on success criteria, which corrective measures may be necessary, whether maintenance is necessary, and whether monitoring methods and/or success criteria should be modified.

5.4.1 Interpreting Monitoring Results for Decision-Making

At a coarse scale, data generated during monitoring will point toward one of three conclusions related to whether project objectives are being met: 1) restoration project is meeting objectives, 2) restoration project is trending toward meeting objectives, or 3) restoration project is either not meeting objectives or trending toward not meeting objectives. The third conclusion may be reached for several reasons:

- Incorrect implementation of restoration action(s) or incorrect underlying restoration assumptions.
- Site conditions (e.g., anticipated hydrology not occurring, substrate does not support desired plant community).
- Non-project related factors (e.g., prolonged drought, other climatic variability, floods, invasive species and land use impacts).

- Insufficient time has elapsed since implementation (e.g., channel bed may not have become fully armored, flows have not been sufficient to move or deposit sediment, or hard-coated seeds may not have germinated).
- Ineffective monitoring program (e.g., inappropriate data collection methods, sampling regime, sampling locations not capturing variability, or data analysis).

The interdisciplinary adaptive management and monitoring team will interpret monitoring data, and conclusions about the success of restoration projects will be made using professional judgment in the context of this framework. Once a conclusion has been reached, the team will evaluate causes and uncertainties related to data interpretation, including ensuring that the monitoring data are appropriate and support conclusions, and that the correct conclusion has been reached. The adaptive management team will then identify the appropriate action related to that conclusion. Table 5-4 describes three types of monitoring data interpretations and related decisions and actions. Figure 5-2 outlines the decision-making framework that leads to one of the three data interpretations.

Table 5-4. Adaptive Management Decision-making Framework.

Interpretations of Monitoring Data	Decisions and Actions
Restoration project is meeting objectives based on values of success criteria	▪ Evaluate monitoring program (continue, reduce, eliminate some metrics, verify that metrics are appropriate)
Restoration project has not yet met objectives, but data appears to show trend toward meeting objectives	▪ Evaluate monitoring program (continue, reduce, modify, eliminate some metrics) ▪ Evaluate whether rates of progress toward objectives are appropriate ▪ Develop plan to address rate of progress if necessary ▪ Implement plan as new habitat action and evaluate within this framework
Restoration project appears that it will not meet objectives	▪ Evaluate causes ▪ Assess monitoring program to determine if appropriate data are being collected to determine and evaluate causes and effectiveness of restoration project or treatment ▪ Evaluate whether success criteria are appropriate ▪ Develop plan to address problems ▪ Implement plan and monitor results

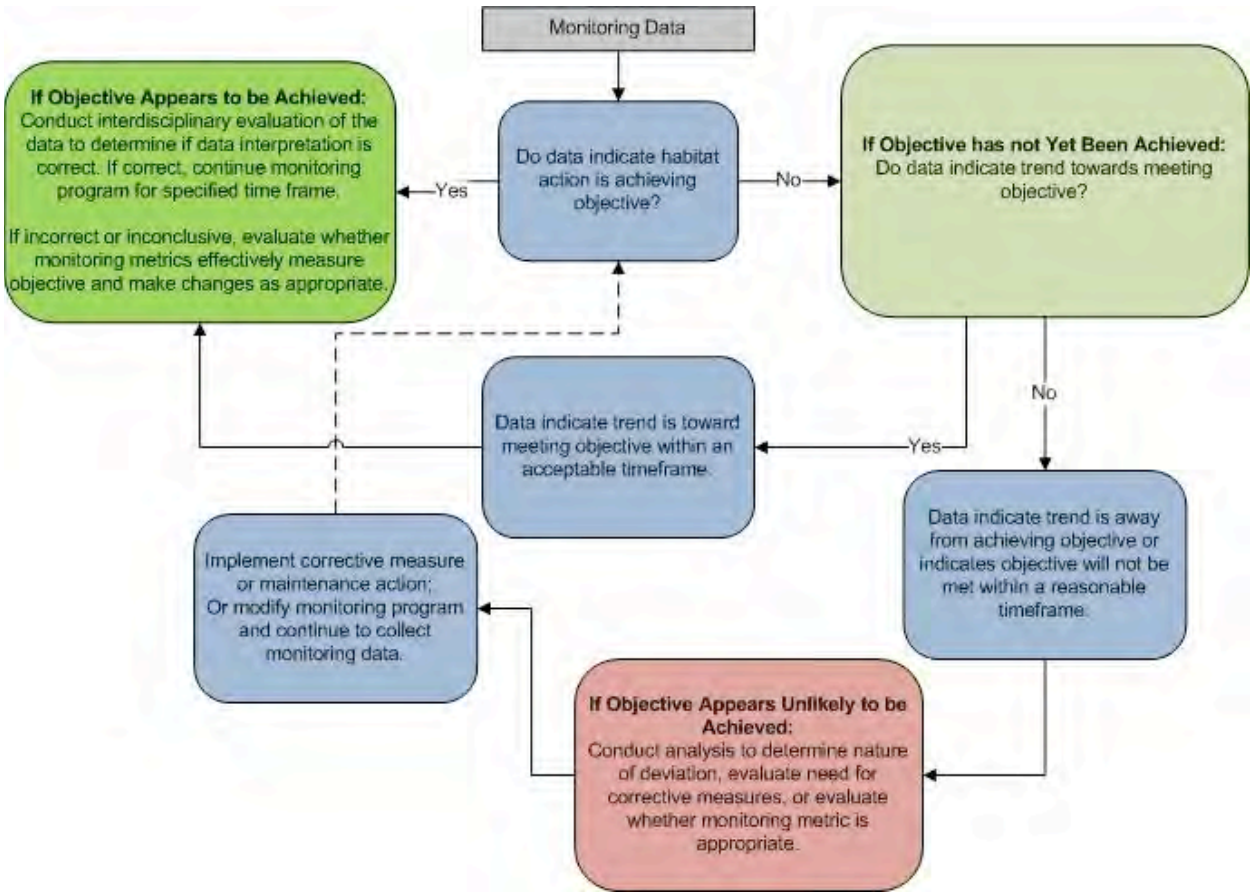

Figure 5-2. Adaptive management decision pathway

5.4.2 Interpreting Monitoring Results to Modify Future Restoration Designs

While effectiveness monitoring data will be used to evaluate and potentially modify restoration projects that have been designed and implemented, these data will also be used to guide restoration designs for subsequent project phases. One use of monitoring data may be to modify existing restoration treatments. For example, if a material used in a restoration treatment fails to withstand a high flow event that is within the design criteria for that treatment, a stronger or different material might be used in the design for later project phases. Alternatively, if a restoration treatment or combination of treatments does not appear to be addressing a limiting factor, future designs may adaptively replace that treatment with an entirely different treatment.

5.4.3 Interpreting Monitoring Results for Routine Maintenance Needs

In addition to monitoring project effectiveness, monitoring will be used to determine maintenance needs for the project, in addition to any unforeseen negative impacts on infrastructure. Some maintenance needs will occur annually regardless of monitoring results, such as watering planted material and controlling weeds; others will occur as a direct result of interpreting monitoring data or observations made during monitoring, such as repairing a

damaged structure. The decision framework shown in Figure 5-2 will be used to evaluate monitoring induced project maintenance needs.

5.4.4 Detecting Data Trends

Interpreting data and determining trends will be an important component of the Monitoring and Adaptive Management Plan due to the inherent variability and various timeframes associated with restoring altered ecological systems. Trend analysis requires evaluating data collected at specified intervals over a specified period in order to determine the magnitude and direction of change. The amount of data needed to conduct a trend analysis will depend on various factors, such as the type of data being collected or the expected response time. For some metrics, such as those that address plant community structure, a minimum of several years of data are typically needed to detect and characterize trends.

5.5 Links to Other Restoration and Monitoring Programs

While the Kootenai River Habitat Restoration Project will have its own monitoring program aimed at evaluating effectiveness of restoration actions in terms of objectives and time frames described in this document, several other monitoring and restoration programs have already been established through existing, related projects that make it possible to track biological and habitat components that may vary over longer time frames and larger geographic scales. As described above, the Adaptive Management and Monitoring Program associated with this Master Plan focuses on metrics that are sensitive to changes in habitat that result from restoration treatments. While that information will be most appropriate for evaluating how effective particular combinations of restoration treatments are at overcoming limiting factors, it will be necessary to link to information from other monitoring and evaluation programs to understand the effects of the Kootenai River Habitat Restoration Project on aquatic focal species populations and other ecological components of the ecosystem.

Monitoring will be closely linked to the Tribe's proposed conservation aquaculture program that will spawn, rear and release Kootenai River white sturgeon and burbot to the reaches of river targeted for habitat restoration. Habitat and population monitoring will be critical to guide the scale of aquaculture production at both the Kootenai River Hatchery and at the new Twin Rivers Hatchery. While the hatcheries may be successful at reintroducing fish to the river, a self-sustaining population is unlikely to be restored unless habitat is suitable to support all life stages.

Table 5-5 provides a summary of existing monitoring programs and associated data that are being collected, and that would be incorporated into the adaptive management decision-making process related to the Kootenai River Habitat Restoration Project. Much of the information contained within this table is drawn from more detailed descriptions of monitoring activities in both the Libby Dam BiOp (USFWS 2006), as clarified, and the *Kootenai River White Sturgeon Recovery Implementation Plan and Schedule* (Kootenai Tribe of Idaho 2005). A summary of these monitoring approaches and associated metrics is given below.

Biological Monitoring

Several agencies monitor Kootenai River White Sturgeon. Within Idaho, the Kootenai Tribe and Idaho Fish and Game (IDFG) track and measure population dynamics, movement patterns, spawning habits, and genetic variability. The British Columbia Ministry of Environment (BCMoE) is collecting analogous data in Kootenay Lake.

Population health and distribution are also being monitored for other focal fish species, including burbot, redband trout, bull trout, and westslope cutthroat trout. Monitoring of all focal fish species relies on combinations of gillnetting, seining, electrofishing, and snorkeling to generate population estimates. Movement and migration tracking is monitored through sonic/radio telemetry tagging.

Avian and mammal populations are also monitored throughout the Kootenai subbasin by a number of agencies. The Kootenai Tribe samples both terrestrial and aquatic invertebrates to record species composition, abundance, and richness as part of its Operational Loss Assessment project.

Integration of these biological data for Kootenai sturgeon and other fish, avian, mammalian and invertebrate species will provide community-based ecological baseline conditions against which to measure biological and ecological response to the habitat restoration project actions.

Hydrology monitoring

Channel depth, current velocity, and bank height have been measured by the U.S. Geological Survey (USGS) in order to understand the effects of managing flow from Libby Dam. Montana Fish Wildlife and Parks and the U.S. Army Corps of Engineers (USACE) monitor total dissolved gas (TDG) events associated with flow management at Libby Dam.

The Kootenai Tribe performs monthly water quality monitoring during the summer and water temperature data are collected by the USACE and USGS.

Off-channel/vegetation monitoring

Kootenai Tribe has recently established a 5-year interval bioassessment and survey of vegetation, canopy cover, and bank stability for riparian areas within the floodplain. These data are being used to develop food web and habitat suitability models. The Tribe is also performing tributary biological productivity evaluations and experimental nutrient additions in conjunction with IDFG and other collaborators in order to assess overall ecosystem health.

This combination of biological, hydrologic and vegetation monitoring will complement targeted effectiveness monitoring described in this chapter. An important preliminary task of the interdisciplinary adaptive management and monitoring team will be to better define how information from related monitoring and evaluation programs will be integrated into the Kootenai River Habitat Restoration Project.

Table 5-5. Related Monitoring and Evaluation Programs.

Ecosystem and Population Components	Monitoring Description/Methods	Monitoring Metrics [1]	Monitoring Location(s)	Lead Entity
White Sturgeon				
Population health	Gillnetting, beach seining, and snorkeling employed to generate population	Growth, survival, length, weight, condition factor, age class structure	Mainstem index sites	IDFG

Table 5-5. Related Monitoring and Evaluation Programs.				
Ecosystem and Population Components	**Monitoring Description/Methods**	**Monitoring Metrics [1]**	**Monitoring Location(s)**	**Lead Entity**
	estimates, locations, growth and mortality rates, age-class distribution			
	Gillnetting, setlining, angling to determine size and structure of population	Catch rate information	River and Lake	IDFG, BCMoE
Genetic variability	Mitochondrial DNA, nuclear, and DNA marker analysis	Variability, diversity, and genetic distance measures	System-wide	Kootenai Tribe
Migration/ Movement	Radio/Sonic telemetry of movement and timing. Emphasis on monitoring response to experimental flow increases	Locations, movement measures	Mainstem ID, MT, B.C.	IDFG
Spawning/Early life stages	Sample juveniles in order to monitor viability of released sturgeon. Sonic tracking to determine movement throughout system	Location, CPUE,	River and Lake	IDFG, Kootenai Tribe, MFWP, BCMoE
	Installation of artificial substrate mats. Monitor spawning conditions and response to flow alterations	Location, CPUE, flow, temperature, embryo stage	River, ID, MT	IDFG
Other Species				
Trout	Radio telemetry, drift nets, screw caps, snorkeling to monitor movement, tributary sources, habitat preferences	Locations, movement measures of habitat, depth, substrate, flow, temperature	River	IDFG
	Electrofishing, hoop netting population estimates, response to normative flow efforts, gamefish monitoring	Species abundance	MT below of Libby Dam, Koocanusa Reservoir; Westside tributaries in ID	IDFG, Kootenai Tribe, MFWP
Burbot	Generate population estimates, monitor movement, and perform chemical blood tests	Population abundance, PSD, recruitment magnitude and frequency	Kootenai and Goat rivers, B.C. Kootenai River, ID, Boundary and Deep creeks, ID	IDFG
	Monitor spawning and rearing of fluvial burbot	CPUE, with 1/2m net tows and light traps	River and tributaries, downstream from Libby Dam	IDFG, MFWP
Aquatic Invertebrates	Macroinvertebrate sampling and taxonomy, algal community composition	Standard macroinvertebrate sampling metrics	Libby, MT – Porthill, ID; Westside tributaries in ID	Kootenai Tribe
Mammals	Mammal population assessments are performed by state agencies throughout the Kootenai basin			MFWP, IDFG, Kootenai Tribe
Terrestrial Invertebrates	Terrestrial invertebrates sampled at ~60 sites from Libby Dam Tailrace to Porthill	Standard invertebrate metrics	500-year Kootenai River floodplain, MT & ID	Kootenai Tribe

Table 5-5. Related Monitoring and Evaluation Programs.				
Ecosystem and Population Components	**Monitoring Description/Methods**	**Monitoring Metrics [1]**	**Monitoring Location(s)**	**Lead Entity**
			Subset of 60 of the 160 bird sites (below); BPA mitigation sites	
Avian community	Avian data collected from Libby Dam Tailrace downstream to Porthill	Standard avian metrics	500-year Kootenai River floodplain, MT & ID; 160 sites	Kootenai Tribe
Vegetation community	Field surveys and aerial imagery assessments	Standard vegetation metrics	160 field sites and aerial imagery entire 500 year floodplain from Libby dam to ID/B.C. border 500-year floodplain; BPA mitigation sites	Kootenai Tribe
Vegetation community	Field surveys and aerial imagery assessments	Standard vegetation metrics	160 field sites and aerial imagery entire 500 year floodplain from Libby dam to ID/B.C. border 500-year floodplain; BPA mitigation sites	Kootenai Tribe
Hydrology				
Flow/Channel dynamics	Monitor and evaluate sturgeon larval abundance in response to flow change		Downstream from Libby Dam	IDFG
	Determine minimum flow for sturgeon spawning and rearing		Downstream from Libby Dam	IDFG
	Monitor permanent stream form and maintain sediment monitoring stations		Monitoring stations at Wigwam River, Grave Creek	MFWP
	Measure depth, velocity, bank elevation for use in development of Increased flow model. Substrate sampling		Downstream from Libby Dam	USGS/USACE
Water quality	Chemical analysis samples, staff gage, thermographs		Mainstem ID, MT,B.C.	
	TDG monitoring in response to increased flow events		Three areas in proximity to Libby Dam	MFWP/USACE
	Temperature monitoring		Mainstem, tributaries	USGS/USACE
	Water quality monitoring of nutrient levels, metal and chemical levels	NH_3, NO_2, SRP, TP, SRP, TN, NO_3+NO_4	Mainstem, tributaries	Kootenai Tribe
Off-Channel				
Tributary	Evaluate tributary biological productivity (algae, flora, fauna) to assess ecosystem	Chlorophyll biomass and accrual rates, algae, periphyton, phytoplankton,	Westside Kootenai River tributaries in ID	Kootenai Tribe

Table 5-5. Related Monitoring and Evaluation Programs.				
Ecosystem and Population Components	**Monitoring Description/Methods**	**Monitoring Metrics [1]**	**Monitoring Location(s)**	**Lead Entity**
Habitat	Evaluate biological conditions using HEP, HSE, IEI ranking	HEP, IBI, IEI	Kootenai and Columbia basins; BPA mitigation sites	Kootenai Tribe
	Monitor and evaluate integration of riparian/riverine floodplain food web models via RDRT/AEA	HEP, IBI, IEI	System-wide	Kootenai Tribe
	Map stream contours, assess bank stability, vegetation survey, canopy cover, bioassessments, staff-gage recalibration	HEP, Habitat (type, quality, relative abundance, value), stream morphology, migration rate, sediment-transport, morphology, sediment characterization	System-wide	Kootenai Tribe
Connectivity	Use biological productivity data to determine areas of necessary or potential floodplain connectivity	Trophic structure in floodplain and tributaries compared w/mainstem	Westside floodplain tributaries, BPA mitigation sites; system-wide	Kootenai Tribe

[1] Where metrics are not specified, they will be developed during later design phases.

To best utilize and share data among these related efforts, standard and accessible data storage and sharing tools are needed. The next section describes a data storage system that will be used to support the Adaptive Management and Monitoring program.

5.6 Data Storage

Monitoring data will be stored with the Kootenai Tribe or other designated entities in standard database(s). Data tables will be structured to avoid redundant data and to ensure consistent data formats among sampling events. Prior to the first sampling event, the interdisciplinary adaptive management and monitoring team will work together to develop consistent data naming conventions, table structures, and other coordination items that will facilitate data collection, transmission, sharing, and analysis.

Existing data management system

The Kootenai Tribe of Idaho Fish and Wildlife Monitoring Database was established in 2000 as a means of managing monitoring data collected through the 1994 Ecosystem Restoration Project, which covers approximately the same geographic area as the KRHRP. This online relational database may provide a template for the construction of a data management system capable of storing and synthesizing the volume of data that will need to be collected to support the Adaptive Management and Monitoring program.

The Tribe's database currently houses information pertaining to water quality and discharge levels, macroinvertebrate and algae, and the status of several fish species. A list of the data currently housed within this database is given in Table 5-6.

Table 5-6. Kootenai Tribe's Fish and Wildlife Database data and metrics.	
Category	**Monitored metrics**
Water	▪ Discharge ▪ Temperature ▪ Metals content ▪ Chemical content
Fish species	▪ Weight ▪ Length ▪ Effort ▪ (Rep, K)
Macroinvertebrate, algae species	▪ Taxonomic richness and abundance ▪ Community composition % ▪ Functional groups
Avian	▪ Species ▪ Common name ▪ Abundance ▪ Distance ▪ Direction ▪ Time ▪ Wind ▪ Sky ▪ Temperature
Invertebrates	▪ Abundance ▪ Class ▪ Order ▪ Family ▪ Common name ▪ Foraging guild ▪ Diet ▪ Foraging habitat ▪ Reproductive structure ▪ Trophic level

Monitoring data in the Tribe's database is searchable by several attributes including monitoring site, collection date, species, and monitoring metrics. Data can be listed, sorted, searched, censored, viewed and exported on a case-by-case basis for individual queries, or summarized in tabular or graphical form for a designated time frame.

In order to support the Kootenai River Habitat Restoration Project, the existing database will need to be modified or expanded so it can support the KRHRP. Specifically, the database and associated interface will need to accommodate data that evaluates channel morphology, riparian vegetation, aquatic habitat and potentially stewardship related actions.

If the design team determines that the existing database does not have an adequate structure to encompass and disseminate the body of information that will be collected through the KRHRP adaptive management and monitoring program, it will be necessary to construct a new data management system. For the system to be a useful tool for adaptive management, it will need to be easy to enter or import new data into the system quickly in formats that are compatible

and comparable with existing data. Ideal characteristics of the adaptive management data system include:

- Standard templates for data collection and data entry or import into the system;
- Automated integration of new data sets, including error checking and data validation rules;
- Integration of a spatial data component so effectiveness monitoring data can be readily displayed on maps and put into the context of restoration projects and associated as-built documentation;
- Built-in analysis functions to allow calculation of metrics based on raw data;
- Flexible query tools so the data management system can be used as a decision support tool;
- Database to store lessons learned from previous restoration projects that can be applied to future restoration design phases; and
- Managed levels of access so different functions are available to design team members, managers, interdisciplinary adaptive management and monitoring team members, other co-managers and potentially members of the public.

The data management system will be designed and built during the preliminary and final design phases so it is functional before the first restoration project begins.

5.7 Summary

The Adaptive Management and Monitoring Program outlined in this Master Plan is intended to be a starting point for developing more refined and targeted adaptive management and monitoring components during subsequent design phases.

Prior to preliminary design, an interdisciplinary adaptive management and monitoring team will be convened by Kootenai Tribe to further develop this program. Once specific restoration treatments and implementation scenarios are designed within the different project reaches as part of restoration project sequencing, effectiveness monitoring will be tailored to those treatments and scenarios.

Information from related monitoring and evaluation programs will be included as part of evaluating Kootenai River Habitat Restoration Project progress over time, and a data management system will be developed to store information so it is accessible and can be easily integrated.

In addition to supporting decisions about specific restoration treatments and implementation scenarios, data collected as part of the adaptive management and monitoring program will support reporting requirements related to environmental compliance, which includes permitting. The next chapter describes the environmental compliance and permitting components of the Kootenai River Habitat Restoration Project.

6 Environmental Compliance and Consultation

Various federal, state, and local environmental laws and administrative requirements will apply to the Kootenai River Habitat Restoration Project.[1] Chapter 6 provides an overview of anticipated environmental compliance and consultation requirements related to subsequent phases of the project. The applicability of each law, regulation, ordinance, or guideline, to this project is defined in this chapter. This information is not intended to be comprehensive; it is provided to identify major requirements that have the potential to substantially impact overall project feasibility, implementation timelines and costs, e.g., permits or processes requiring six months or more to complete.

Comprehensive permit requirements, schedule, and associated costs will be developed and refined in the preliminary and final design phases. Conceptual costs associated with environmental compliance are presented in Chapter 7. Table 6-1 provides a summary list of probable regulatory steps organized by category (i.e., water quality, instream work, planning approvals and construction).

6.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969, as amended (42 USC 4321 et seq.), requires federal agencies to assess and disclose the effects of a proposed action on the environment prior to funding, approving, or implementing the action.

An Environmental Impact Statement (EIS) that assesses environmental consequences of implementing the Kootenai River Habitat Restoration Project will be prepared to address NEPA requirements. The NEPA process will include formal public scoping and outreach with interested and potentially affected parties to present the proposed project and potential alternatives, and most importantly, to identify the key issues that will guide the environmental analysis.

Several important steps must be completed before NEPA can effectively be initiated. Because of the array of potential habitat restoration actions presented in this Master Plan, it will not be practical or likely possible, to develop detailed designs and perform necessary environmental evaluations of all of the actions identified in this plan within a timeframe that will meet the immediate project needs (i.e., 2012 target date to initiate the first phase of construction activities). Therefore, shortly after completion of this Master Plan, the Tribe in coordination with their agency partners, and with input from regional co-managers and other stakeholders, will identify immediate implementation priorities and associated habitat actions, as well as a process for prioritizing and sequencing subsequent project actions (see discussion of next steps in

[1] Tribal laws and administrative requirements are not detailed here, but will be addressed as the Tribe implements the Project.

Chapter 9). This phased approach will likely necessitate more than one NEPA process, with individual NEPA processes addressing independent project phases and/or groupings of actions.[2]

Each independent project phase or group of actions will be expected to provide significant biological and habitat benefits consistent with the goals and objectives presented in this Master Plan. Preliminary design of the initial project phase or grouping of habitat restoration actions will define the temporal and spatial scope of the treatments and will guide an environmental assessment team in determining the extent of natural and social resource effects that will be evaluated under NEPA. This information may reveal the need to collect additional baseline data to thoroughly examine the environmental effects of the first project phase or group of habitat treatments.

The NEPA process, beginning with scoping and ending with a Final EIS and Record of Decision, will be conducted under the supervision of the KTOI and BPA, with guidance from the USACE. A formal public scoping process will identify key issues of concern to agencies, organizations and the public that are relevant to the initial project phase or grouping of habitat treatments. Data collection will be completed and an environmental analysis of the effects of implementation of the identified project phase or grouping of habitat issues relative to specific scoping issues will be conducted.

At this time, the Tribe assumes that the Bonneville Power Administration (BPA) will be the lead agency on the NEPA effort. Additional cooperating agencies will be identified in the near term. Because the scope of the total habitat restoration project is extensive, the Tribe and BPA will conduct a robust analysis of cumulative effects in each NEPA undertaking. These effects analyses will link the potential independent habitat treatments, providing a larger-scale estimate of the overall benefits and risks of the restoration efforts.

6.2 Probable Regulatory Steps

Table 6-1 provides a summary list of probable regulatory steps organized by category, i.e., water quality, instream work, planning approvals and construction. In addition to these steps, if the proposed implementation scenario involves altering Kootenay Lake water management, consultation will be undertaken with British Columbia and the International Joint Commission through the appropriate forums.

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[2] In an earlier draft of this Master Plan the Kootenai Tribe suggested that given the nature of the conceptual framework presented in this Master Plan, a Programmatic EIS that considers the overall conceptual restoration framework and its effects would be more appropriate and efficient than a project-specific EIS that looks at specific effects of individual habitat actions or activities. The Tribe suggested that: 1) a programmatic approach would result in a baseline environmental analysis that would be referenced in future project-specific environmental documents; 2) implementation-level assessments would examine the environmental effects and design detail for specific restoration actions; 3) the magnitude of effects of individual restoration actions could vary greatly, therefore, subsequent NEPA documentation could range from Categorical Exclusions to Supplemental EIS' that tier off of the Programmatic EIS; and 4) a Programmatic EIS would be consistent with the adaptive management framework within which the project will be implemented. The Tribe's federal partners and members of the Kootenai Habitat Policy Team have indicated that they support a project-specific EIS approach, therefore that is the approach that has been presented in this Master Plan.

Table 6-1. Kootenai River Habitat Restoration Project general permitting schedule.					
Permit	**Data Needed**	**Expected Time to Receive**	**Required Submittal Date**	**Prerequisites**	**Notes**
Water Quality					
National Pollutant Discharge Elimination System (NPDES) General Construction Stormwater (U.S. Environmental Protection Agency)	Contractor contact info, project location description, water bodies that will be discharged to, construction dates, area of disturbance, ESA compliance info; prepare Stormwater Pollution Prevention Plan (SWPPP).	2 months	Prior to start of construction.	Section 401 from IDEQ	Submit one combined application for all sites with ground disturbance exceeding one acre.
Stormwater Pollution Prevention Plan	Describe ground disturbing activities, affected areas, location map, measures proposed to reduce erosion and sediment runoff, exact construction dates, measures to divert flows, post-construction storm water management measures, waste management measures, steps to keep vehicles clean, describe other possible pollution sources and control measures. Also, document compliance with ESA.	2 months	Submit after the NPDES is filed or at the same time.		Submit SWPPP to support the construction NPDES for sites disturbing one acre or more.
Water Quality Certification for Channel Modifications (Idaho Dept. of Environmental Quality)	Water quality parameters to be affected and to what extent. Exact construction timing and extent.	3-6 months	Once final alternatives for all work below ordinary high water mark (OHWM) or in wetlands has been defined.		Included with 404. Will define mixing zone within which some degradation can occur.
Instream Work					
USACE Section 404/10	Location description, water body, shoreline/zoning designation, parcel numbers, description of work in wetlands and below ordinary high water mark (OHWM), project purpose, potential effects on water bodies, construction period/phasing, any permanent structure below OHWM. Fill volume/area below OHWM, composition of fill material, material source, volume/area of excavation or dredging	1-2 years	Once final design for all below OHWM features is available. Info must include results of sediment core contaminant analysis from June 2007. Likely to require wetland delineation and mitigation plan.	Need Section 401 conditions and ESA determination before 404 can be issued	Submit one combined application for all sites with features below OHWM or affecting wetlands (includes 401 certification). Coordinate alternatives analysis with NEPA process.

Table 6-1. Kootenai River Habitat Restoration Project general permitting schedule.					
Permit	**Data Needed**	**Expected Time to Receive**	**Required Submittal Date**	**Prerequisites**	**Notes**
	below OHWM, list other approvals, total cost of project, federal funding, names/addresses/phone numbers of all adjacent property owners, possibly wetland delineation and mitigation plan.				
Dredged Material Management Plan (USACE)	If habitat restoration involves sediment dredging or channel maintenance dredging, a Sampling and Analysis Plan may be required by the USACE. Required information could include documentation of contaminant sources, chemical and biological processes affected by sediment exposure; identification of receptors of concern; and exposure pathways and potential responses.	75+ days	File with Section 10/404 application. Processed simultaneously with Section 401 and Stream Alteration Permit.	Analysis of potentially contaminated sediment.	Conduct early pre-consultation with the USACE to determine if this approval is needed. If so, initiate studies well in advance of submittal target.
Instream Alteration Permit (Idaho Dept. of Water Resources)	Same as for 404/10 permit. State standards for construction and instream features: IDAPA 37.03.07 (055-065). If other approaches or procedures are proposed, they must be described.	60 days	Submit as joint application for permit with Section 404. Allow at least 60 days.		Joint application with *USACE* permit.
Navigational Encroachment Permit (Idaho Dept. of Lands)	Basic application is same as above with additional form required for Idaho Dept. of Lands addressing riprap or structures (if in navigable waters).	30 days	Submit as part of Joint Application for Permit with Section 404.	Consent of adjacent land owners.	Required if plans include riprap or docks in navigable waters.
Boundary County Dept. of Land Conservation and Development – Floodway Development Permit	Development permit required for fill (Section 4.1-1) and approval required prior to altering or relocating a watercourse (Section 4.3-4). Flood capacity may not be diminished. Must demonstrate proof of permit application to Idaho Dept. of Water Resources for Stream Channel Alteration. If work would occur within Bonners Ferry, need to show proof that City has been notified. Also, must notify FEMA.	TBD	Consult with Boundary County and City of Bonners Ferry.		Must comply with FEMA standards for floodway development. Diminishment of floodway capacity is not allowed. See Boundary County Flood Damage Prevention Ordinance, Section 4.1-1 thru 4.3-4.
Planning Approvals					
NEPA Compliance and Record of Decision	Purpose and need, project description, project alternatives, environmental, cultural and socioeconomic analysis. Public scoping and	2 years.	Initiate NEPA compliance following Master Plan approval, selection of	Define and design implementation measures	Most significant review process, examining a range of environmental and

Table 6-1. Kootenai River Habitat Restoration Project general permitting schedule.					
Permit	**Data Needed**	**Expected Time to Receive**	**Required Submittal Date**	**Prerequisites**	**Notes**
	comments shape this process.		implementation priorities, and preliminary design.		social resource values.
USFWS Concurrence or Biological Opinion	Biological Assessment (BA) is a description of the proposed action, status of species and critical habitat, environmental baseline, effects analysis, determination of effects	6-12 months	Prepare and submit to the USFWS concurrent with the NEPA EIS.		BA needed for independent suite of implementation measures. Consultation to be tailored to final project proposal and NEPA schedule.
Section 106 Clearance	Evaluation of effects of actions on historical and archaeological resources and traditional cultural properties. Consult with tribes, Idaho State Historic Preservation Office (Bureau of Indian Affairs).	2-3 months		Define area of potential effect.	Submit survey results on National Register of Historic Places (NRHP) listed or eligible properties.
Boundary County Site Development Permit Application	All affected parcel numbers; describe land use, duration of work, vehicle trips/day and mitigation; site plan with property boundaries, topo, access, etc. Expect two public hearings.	TBD	Consult with Boundary County	Won't issue until Floodway Development Permit approval obtained.	Determines consistency with County Comp Plan.
Fugitive Dust Control (Idaho Dept. of Environmental Quality)	Define reasonable precautions to take, such as applying dust suppressants, reducing speed limits, etc.	N/A	Permit not required, but planning should include a Fugitive Dust Prevention/ Control Plan per IDAPA 50.01.01 Section 650-651.		No submittal required to IDEQ, but plan should be part of construction documents.
Construction					
Boundary County road and bridge permits	Location of proposed road access, proposed design, construction requirements, and drawing. Application to be signed by the owner of the land upon which the access is to be constructed. Must be prepared by a registered surveyor.	60 days	Approved SWPPP	Detailed design and surveys.	
Consult with Idaho Dept. of Transportation	If proposed habitat treatment could affect the I-95 bridge, design and mitigation information would be provided.	TBD	TBD	Detailed design and surveys.	Need for consultation to be determined.

6.3 Endangered Species Act

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. §§ 1531 et seq.), requires federal agencies to ensure that actions they authorize, fund or conduct are not likely to jeopardize the continued existence of any ESA-proposed or listed species or result in destruction or adverse modification of their designated critical habitat. Section 7(c) of the ESA requires that federal agencies consult with the USFWS and/or the National Marine Fisheries Service regarding endangered species. A Biological Assessment (BA) must be prepared if the USFWS determines that threatened or endangered species may occur in the vicinity of a proposed action. If the BA determines that the proposed project would likely adversely affect a listed species or result in destruction or adverse modification of critical habitat, then formal ESA Section 7 consultation is required. Under formal consultation, the USFWS will use the BA along with their own subsequent analysis as the basis of a Biological Opinion that will outline criteria to ensure the project does not further jeopardize the continued existence of an endangered species. The recently clarified Libby Dam BiOp addresses this proposed project; however, the scope and effect of proposed restoration actions were not considered in detail. The USFWS is likely to conclude that additional ESA compliance is necessary.

Endangered Species Act listed Kootenai River white sturgeon (endangered) and Columbia River bull trout (threatened) are present in the project area. As noted in Chapter 2, the USFWS designated the Kootenai River from RM 141.4 to RM 152.6 and RM 152.6 to 159.7 as sturgeon critical habitat (73 FR 39506). The lateral extent of critical habitat includes the river channel up to the ordinary high-water lines (as defined by the USFWS in 33 CFR 329.11) on each bank of the Kootenai River. No critical habitat for bull trout has been designated in the project area (70 FR 56211). Listed bull trout, sturgeon, and sturgeon critical habitat would be affected during habitat restoration actions. Even though the ultimate goal is to implement specific projects that would be beneficial to ESA listed sturgeon and bull trout, given the extent of likely restoration treatments described in previous chapters, a BA will be required and formal ESA Section 7 consultation with the USFWS may be necessary to ensure that negative effects from construction are minimized. The ESA Section 7 consultation would likely conclude with the issuance of a Biological Opinion by the USFWS.

Preparation of the BA would typically begin at the final design phase, which is the level of detail required by the USFWS to prepare a Biological Opinion. While a BA could be prepared within a month, preparation of a Biological Opinion by the USFWS can take as much as a year to complete due to factors such as a complicated multi-phased project and limited agency staff.

In addition, through the ESA consultation process, this project will be evaluated for consistency with the final recovery plan for Kootenai River white sturgeon (USFWS 1999) and for previously issued Biological Opinions with specific measures to protect sturgeon. The USFWS, Bureau of Reclamation, USACE, and BPA developed a Biological Opinion (BiOp) on Federal Columbia River Power System Operations in 2000 that recommended mitigation for Libby Dam operational effects on Kootenai River white sturgeon. Measures for sturgeon include implementing flow releases and a flood control approach to lessen the effects on sturgeon. In 2006, the USFWS Biological Opinion Regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat was published and was as clarified in 2008.

6.4 Clean Water Act

Uncontrolled water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law, commonly known as the Clean Water Act, is the principal federal law regulating water quality in waters of the United States. In addition, the Rivers and Harbors Act regulates activities affecting navigable waters of the United States.

Work within the Kootenai River, a navigable waterway, will be subject to Section 10 of the Rivers and Harbors Act, administered by the USACE. In addition, habitat restoration measures involving work within wetlands and rivers are generally subject to Section 404 of the Clean Water Act. Application is made jointly to the USACE for both approvals. Section 404 requires evaluation of activities involving discharges of dredged or fill material into waters of the United States, which includes the Kootenai River and its associated riparian wetlands and tributaries. Most elements of this project may meet the requirements of several Nationwide Permits (NWP), which authorize various types of habitat restoration activities. For example, NWP 27 authorizes many stream and wetland restoration activities. Non-conforming activities would require the lengthier individual 404 permit review process.

Section 10 and Section 404 permitting, administered by the USACE, also involve review by the Idaho Department of Environmental Quality (IDEQ), the agency responsible for local compliance with Section 401 of the Clean Water Act. IDEQ issues Water Quality Certifications for work within and near waters of the United States. This component ensures that the project meets state water quality standards. For some 404 permits, certain Tribes must also provide Section 401 approval. Issuance of a Section 401 Water Quality Certification means that the certifying agency/tribe anticipates there is a reasonable assurance that a proposed action can be conducted in a manner that would not violate applicable water quality standards.

If the project involves sediment dredging from the Kootenai River, another process could be triggered if these sediments are contaminated. Section 10 review could initiate an evaluation under the Northwest Regional Sediment Evaluation Framework (Corps of Engineers et al. 2006). If contamination is documented, the potential effects of dredging on physical, chemical and biological processes may need to be identified in a Dredged Material Management Plan. The intent of this process is to ensure that dredging and disposal don't expose species and habitats to concentrations of contaminants that cause adverse effects. It also seeks to limit the effects of suspended sediments on water quality.

Section 404 permitting can require a year or more for complex projects. IDEQ has 60 days from issuance of the public notice to grant or deny a Section 401 certification request, but the USACE can specify a longer or shorter time frame if necessary (not exceeding one year). Often times Section 404 and 401 permits and ESA consultation for these permit approvals are the most time consuming permit processes. Preparation of Section 404 and 401 permit applications typically begin at the final design stage, when the required level of construction detail is available. Facilitating regular involvement of USACE, IDEQ, and Kootenai Tribal staff through the final design stages could help to reduce the processing duration.

Section 402 of the Clean Water Act authorizes storm water discharges from construction activities exceeding a one-acre area. A National Pollutant Discharge Elimination System (NPDES) permit authorizes construction projects, providing notice is given to the authorizing agency and appropriate erosion control plans and measures are implemented. The Kootenai Tribe will be

required to prepare and implement a Storm Water Pollution Prevention Plan that would be overseen and approved by the IDEQ. Application would need to be made to the IDEQ when final project design is advanced. Pertinent information will include construction schedules and quantities and quality of potential discharge. Generally NDPES permitting does not cause undue delay in project implementation.

6.5 Federal National Historic Preservation Act

Federal funding of a project is considered an undertaking within Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended (P.L.89-665, 16 U.S.C. 470). Section 106 requires that every federal agency take into account how each of its undertakings could affect historic properties. Historic properties are districts, sites, structures and traditional cultural places and properties that are eligible for inclusion on the National Register of Historic Places (NRHP). The Kootenai Tribe will need to identify whether cultural resources are present within areas affected by restoration actions and if so, assess their eligibility for listing under the NRHP. Appropriate protective actions to take on NRHP eligible properties will be identified in consultation with the Idaho State Historic Preservation Office (SHPO).

A cultural resources survey and report of findings for the proposed undertaking must be submitted to the Idaho SHPO, and SHPO must provide concurrence before construction can be implemented. Such surveys may take considerable time, especially if sites are identified; therefore, the Kootenai Tribe's Cultural Resource Office intends to implement investigations and consultation as soon as specific project affected areas are identified. Depending on survey results, compliance with Section 106 of the NHPA may take several months to over one year.

6.6 Federal Farmland Protection Policy Act

The Farmland Protection Policy Act (7 U.S.C. 4201 et seq.) directs federal agencies to identify and quantify adverse effects of federal programs on farmlands. The intent of this Act is to minimize the number of programs that unnecessarily contribute to the conversion of agricultural land to non-agricultural purposes. Agriculture is a major economic base in Boundary County and restoration actions could affect agricultural lands within the Kootenai River Valley. For example, the Boundary County Comprehensive Plan recognizes and appreciates that farming and other agricultural practices are subject to special protection as stated in the Idaho Right to Farm Act, and that precedence in land use decisions should weigh in favor of agricultural pursuits. Agricultural issues will likely be important NEPA scoping issues, and Farmland Protection Policy Act compliance would be addressed in detail through the NEPA process. While compliance with this Act may take considerable time, evaluation can begin during preliminary design.

6.7 State Approvals

In addition to Section 401 Water Quality Certification by the IDEQ and NPDES permitting, implementing the habitat restoration project may require various other regulatory approvals from State of Idaho agencies. Permitting requirements will be verified during preliminary design and compliance initiated during the preliminary or final design phases as appropriate.

A stream channel alteration permit will be required for several potential proposed actions; this permit is issued by Idaho Department of Water Resources (IDWR) for stream crossings or streamside work conducted below the ordinary high water mark of a stream or river. This permit is applied for simultaneously with the Section 404 permit by using Idaho's Joint Permit Application process. Lands below the ordinary high water line are considered public trust lands and may be under the jurisdiction of the Idaho Department of Lands, which issues a Navigational Encroachment Permit. A state water permit may be needed if irrigation of plantings and restored riparian areas is proposed; however, alternatives could include paying a landowner for use of an existing water right. Gaining such state permits is not expected to cause undue delay in project implementation.

6.8 Boundary County Approvals

Boundary County approvals may include a site development permit to ensure consistency with the Boundary County Comprehensive Plan; a Floodway Development Permit to ensure that flood capacity is not diminished and to approve alternations in watercourses; as well as approvals to excavate or grade lands, for road and bridge access, etc. Special consideration and approval for actions on farm lands, especially lands designated as prime farmland under the County's Comprehensive Plan, may be needed. Permitting requirements will be verified during the preliminary design phase and approvals sought during the final design phase. Coordination with Boundary County and the City of Bonners Ferry throughout both design stages may improve permitting timeline efficiencies.

6.9 Summary

As the next phases of the Kootenai River Habitat Restoration Project mature, this environmental compliance and permitting framework will be refined into a detailed roadmap that ensures all required approvals are clearly understood and properly scheduled. Planning will initially focus on the long lead-time processes, particularly NEPA, which will further refine the final suite of treatments to be implemented. When implementation measures are clearly established, ESA compliance and in-water work approvals from the USACE will be pursued. Other identified steps will overlap with these long duration reviews.

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7 Estimated Costs

Chapter 7 presents estimated costs associated with the Kootenai River Habitat Restoration Project. This chapter includes an overview of the Kootenai Tribe's approach to developing cost estimates for this Master Plan, discussion of the cost categories used, identification of assumptions associated with each category and examples of costs by category, discussion of additional cost considerations, and estimated costs and cost considerations for implementation scenarios. Additional detailed supporting information for this chapter is presented in Appendix F.

7.1 Overview

Chapter 7 presents estimated costs associated with the conceptual habitat restoration approach defined in Chapter 1 and discussed in chapters 3, 4, and 5. The cost estimates contained in this chapter have been developed only to the conceptual level. Cost estimates will be further refined during the preliminary and final design phases when specific habitat restoration actions and priorities are identified.

Section 7.2 presents a summary of cost development methods for eight cost categories:

- Planning, coordination, data collection, and preliminary and final designs;
- Construction;
- As-built documentation and establishment of monitoring baselines;
- Post-construction effectiveness monitoring;
- Biological monitoring;
- Post-construction maintenance;
- Permitting and environmental compliance; and
- Land use management.

Section 7.2 also addresses land acquisition and leases, and costs applied to all cost categories. Section 7.3 describes additional cost considerations such as project sequencing, economy of scale, and cost escalation. Section 7.4 provides a summary of cost estimates for conceptual minimum, moderate and maximum implementation scenarios in the Braided Reaches, Straight Reach, and Meander Reaches.

7.2 Development of Cost Estimates

Since approaches to development of cost estimates can vary from project to project, this section describes the cost categories, approach to development of cost estimates, and assumptions and details associated with each cost category that were used in development of this Master Plan.

7.2.1 Approach to Development of Cost Estimates

The Tribe's approach to developing the cost estimates presented follows standard and accepted practices for a project of this type and size. The Tribe believes the level of certainty associated with the estimated costs presented in this chapter is appropriate to the conceptual phase of this project.

In general, development certainty around cost estimates depends on being able to break apart and define an organized scope of work to the smallest level of detail, and then to break down direct and indirect costs associated with each detail. Even in the early planning stages where work and deliverables may not be well defined, a formal and systematic approach can be followed to define work to the most accurate level possible. This is important to ensuring that general relationships between activities are well understood and critical activities are not overlooked, and thus left out of project cost estimates. The system of organizing a scope of work into components to which costs can be applied is called a "Work Breakdown Structure" (Haugan 2002; PMI 2004). This methodology is the basis for most standardized computer-based cost estimating programs and is the basis of cost development for the majority of cost categories and estimated costs described in this chapter.

To develop cost estimates for this project the Kootenai Tribe contracted with a major construction firm with extensive experience planning, estimating, and building projects of similar scope and scale. Representatives from this firm met in-person and by-phone with the Tribe's project planning and river design contractors on a number of occasions to review the proposed restoration treatments and implementation scenarios. They also visited the project area in order to view specific on-the-ground conditions, and develop a more thorough understanding of the proposed restoration treatments and implementation scenarios.

Based on this information, the construction firm provided estimated construction and construction related costs for the minimum, moderate and maximum implementation scenarios presented in Chapter 4 for each of the project reaches (i.e., Braided Reaches 1 and 2, Straight Reach, and Meander Reaches 1 and 2).

The conceptual costs for the minimum, moderate and maximum implementation scenarios for each project reach were then translated into unit costs (e.g., linear feet, cubic yards of cut, cubic yards of fill, acres, etc.) in order to provide a flexible and relatively accurate way to gage potential project costs by reach, scenario and treatment. This approach to development of unit costs based on actual construction estimates by reach and implementation scenario will help ensure that the initial identification of potential constraints, means and methods, estimates of economies of scale, and costs specific to the regional location of the project are considered (as opposed to applying gross unit figures from a similar project in a different locale and scaling up or down). The cost estimates presented in this chapter include direct and indirect costs for all cost categories.

As noted earlier in this document, the implementation scenarios presented in Chapter 4, and for which conceptual costs are presented in this chapter, represent illustrative examples of potential combinations of actions; they are not meant to be interpreted as wholesale recommendations. Specific actions and sequencing schedules will be developed in subsequent project phases and may contain different combinations of habitat treatments at different scales than those presented in Chapter 4. Likewise, the cost estimates that are presented in this chapter for

minimum, moderate and maximum implementation scenarios are provided for illustrative purposes only. However, in subsequent design phases the underlying unit costs used to develop the minimum, moderate and maximum implementation cost estimates for this Master Plan will provide the foundation to develop detailed specific cost estimates for the selected habitat actions.

7.2.2 Development of Costs by Category

This section describes the cost categories and provides a basis for costs developed in each category. The assumptions used in developing these cost estimates are presented along with the relative level of certainty associated with cost estimates for each category. In reviewing these estimated costs, it is important to understand that cost estimates can vary widely depending upon the cost category.

As noted previously, costs presented in this Master Plan are developed to the conceptual level. Costs are presented for each cost category for the Meander Reaches, Straight Reach and Braided Reaches implementation scenarios.

Costs estimates in all categories are presented in current (2009) dollars, which will provide a benchmark for future planning. As the project proceeds through preliminary and final design phases and as associated costs are refined, other cost considerations (Section 7.3) such as sequencing, economy of scale and inflation and escalation will also need to be considered.

As might be expected, the highest proportion of costs are associated with the construction cost category. The costs in other categories generally are based on the extent and scope of a specific implementation scenario. Because of the level of uncertainty associated with this conceptual planning stage, contingencies have been applied to each cost category. The contingencies vary depending on the specific cost category.

To help illustrate the basis for developing construction costs, Table 7-1 shows the moderate implementation scenario for Braided Reach 1 (from Chapter 4), including the associated restoration treatments, estimated units (e.g., linear feet, cubic yards of cut cubic yards of fill, acres), and number of given units for each treatment. An estimated lump sum cost for infrastructure mitigation was also included in the analysis for each reach.

Table 7-1. Braided Reach 1, treatments and units for a moderate implementation scenario.

Treatment	Treatment Name	Unit Description	No. Units
BR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	5,280
BR-A	Excavate and/or dredge the river to modify the channel geometry	Cu yds (cut)	527,063
BR-B	Construct floodplain surfaces	Acres	71
BR-B	Construct floodplain surfaces	Cu yds (fill)	527,063
BR-C	Construct and/or enhance wetlands	Acres	36
BR-D	Construct and/or enhance secondary channels	Ft	10,072
BR-E	Revegetate the floodplain	Acres	71
BR-F	Install bank structures (bank stabilization, bioengineering)	Ft	16,313
BR-G	Install in-stream structures (habitat, river training, grade control)	Units	10
KR-D	Mitigate for impacts from or to infrastructure	Lump Sum	1

Table 7-2 presents a summary of estimated costs by category for the Braided Reach 1 at a moderate treatment level. Subsequent tables in this section include breakdowns of cost

estimates by cost category for the Braided Reach 1 example (i.e., labor, direct costs, travel, equipment, supplies). Construction estimates are presented for each treatment by unit cost (i.e., cubic yard, acre). Underlying details for all cost categories are presented in the estimating templates contained in Appendix F. In Section 7.4, tables for each project reach show cost estimates including labor, direct costs, vehicles, travel, equipment, and supplies, for all categories except construction. The actual estimated construction costs for each treatment along with associated costs are provided as separate tables for each implementation scenario.

Table 7-2. Braided Reach 1, cost estimate summary (all cost categories), moderate implementation scenario.

Cost Estimation Category	Total Estimated Cost (2009 Dollars)	Associated Detailed Costs
Planning, coordination, data collection, preliminary and final design	$4,368,000	Cost from Table 7-3 and Appendix F-1
Construction	$22,508,000	Cost from Table 7-4 and Appendix F-2
As-built documentation and establishment of monitoring baselines	$222,000	Cost from Table 7-5 and Appendix F-3
Post-construction (effectiveness) monitoring	$136,000	Cost from Table 7-6 and Appendix F-4
Biological monitoring	$404,000	Cost from Table 7-7 and Appendix F-5
Post-construction maintenance	$675,000	Cost from Table 7-8 and Appendix F-6
NEPA (Environmental Impact Statement)	$657,600	Cost from Table 7-10 and Appendix F-7
Environmental compliance (permits)	$151,000	Cost from Table 7-9 and Appendix F-7
Management of land use practices	$301,000	Cost from Table 7-11 and Appendix F-8

7.2.2.1 Planning, Coordination, Data Collection, Preliminary and Final Design

The cost category titled "planning, coordination, data collection and preliminary and final design", presents costs associated with all activities that will occur during the interim, preliminary and final design phases. Cost included in this category include planning, coordination, data collection (as necessary to further refine designs and confirm feasibility), preliminary design and final design, and development of funding strategies. Contingencies are based on the level of certainty associated with each cost estimate and are applied to all costs.

Planning, Coordination, Data Collection, and Preliminary and Final Design Estimated Cost Assumptions

- Estimates are based on labor and direct costs generally associated with the scope of each implementation scenario.
- For this category, costs were estimated for a moderate scenario for representative reaches, then escalated or reduced based on the scope of each implementation scenario.
- Data collection and analysis, conceptual engineering, planning, and coordination conducted to date for this Master Plan are not included in these costs.
- Estimates for coordination, planning, sampling and data collection at the preliminary and final design stages are included. Estimates take into consideration the coordination with multidisciplinary technical teams and use technical reviewers at specific project milestones.

- The time frame used to develop estimates is fall 2009 through fall 2010 for preliminary planning and design phase activities and fall 2010 through summer 2011 for final planning and design activities.[1]
- Labor costs include resources for design, planning, coordination, related data collection and other fieldwork, incorporation of additional technical resources for the preliminary and final design phases, and project management.
- Estimated costs were cross-checked in three ways: 1) estimated hours and direct costs of specific tasks, 2) estimated resources for the specific time periods (annual), and 3) comparison of costs to the scope of the implementation scenario to which the costs apply.
- Estimated costs are based on 2009 dollars and will need to be escalated to the actual year in which they are incurred.
- A contingency of 20% has been applied.
- Assumed escalation for the planning and design cost category is 3% annually (see Section 7.3.3).

Table 7-3 provides an example of estimated costs associated with planning, coordination, data collection, preliminary and final design costs for Braided Reach 1 based on the moderate implementation scenario. Additional detailed information for Braided Reach 1 cost estimates is presented in Appendix F-1.

Table 7-3. Braided Reach 1, estimated planning, coordination, data collection, preliminary and final design costs, moderate implementation scenario.

Description	Total Estimated Cost (2009 Dollars)
Staff (payroll, fringe, indirect) and subcontractors	$3,301,000
Vehicles (fuel, insurance, lease, maintenance)	$12,000
Equipment, boats (fuel, maintenance, repair)	$20,000
Equipment, rent, lease	$14,000
Supplies (office, field, lab, other)	$44,000
Telephone, utilities	$6,000
Travel (mileage, lodging, per diem, auto rental, airfare)	$233,000
Insurance, other dues	$10,000
Subtotal	$3,640,000
Contingency (20%)	$728,000
Total	**$4,368,000**

7.2.2.2 Construction

Construction cost estimates for the minimum, moderate and maximum implementation scenarios were developed using standard construction cost estimating methods as mentioned in Section 7.1. Detailed conceptual construction estimates were developed for each reach and then

[1] This time frame is subject to change pending the Kootenai Tribe's identification of specific project milestones and target dates.

consolidated and summarized as units (e.g., linear feet, acres, etc.) for each implementation scenario. The costs of all construction activities and related general conditions and overhead for each treatment were combined to produce an estimated unit cost for each treatment in each reach. As previously noted, the construction estimators provided actual bid estimates for minimum, moderate, and maximum implementation scenarios for Braided Reaches 1 and 2, Straight Reach, and Meander Reaches 1 and 2, as defined in Chapter 4.

In addition to estimating costs for restoration treatments directly related to restoration activities, an estimated cost associated with mitigating for infrastructure impacts is presented as a line item in the construction category for each implementation scenario. There is a variety of existing infrastructure in the project area including water intakes, diversions, and discharge points; utilities (power transmission lines and natural gas lines); river gages; levees and diking; bridges; and roads (see Chapter 2 for more discussion about infrastructure). All of these infrastructure components will need to be considered during the preliminary and final design and implementation phases. While efforts will be made to avoid affecting existing infrastructure, it is possible that structures might need to be relocated, re-oriented, and/or acquired before restoration work can proceed.

Estimated Construction Cost Assumptions

- Cost estimates are based on quantities and areas provided in Chapter 4.
- All potential direct and indirect costs were considered.
- Lump sum unit costs were provided by subcontractors for several treatments including revegetation of wetlands and floodplains.
- Cost estimates were developed by breaking down and defining work based on descriptions of restoration treatments provided in Chapter 3.
- Costs estimates include all standard mark-ups, insurance, bonding, and other related costs which, would be incurred by project contractors.
- Costs are based on estimated work defined for an individual restoration treatment; however, it should be noted that all efficiencies that might be gained through combining activities among treatments could not be fully considered at this stage.
- Construction of restoration actions involving cut and fill work will be structured so that materials cut from one location will be used as fill in other locations to avoid potentially prohibitive costs of importing and exporting material.
- Estimates are based on current April 2009 costs.
- Costs estimates include a contingency built in by cost area (labor, overhead, materials, equipment, subcontractors, etc.)

Assumed escalation, for future planning, is 4% annually (see Section 7.3.3). Table 7-4 shows an example of the treatments, units, and cost estimates for a moderate treatment of Braided Reach 1. Additional, more detailed cost information for Braided Reach 1 is presented in Appendix F-2.

Table 7-4. Braided Reach 1, units and estimated construction costs, moderate implementation scenario.					
Treatment	**Treatment Explanation**	**Unit Description**	**No. Units (Moderate)**	**Est. Cost / Unit**	**Estimated Total Cost (2009 Dollars)**
BR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	5,280	N/A	N/A
		Cu yds (cut)	527,063	$13	$6,614,641
BR-B	Construct floodplain surfaces	Acres	71	N/A	N/A
		Cu yds (fill)	527,063	$10	$5,223,194
BR-C	Construct and/or enhance wetlands	Acres	36	$39,952	$1,438,282
BR-D	Construct and/or enhance secondary channels	Ft	10,072	$63	$637,558
BR-E	Revegetate the floodplain	Acres	71	$39,952	$2,836,611
BR-F	Install bank structures (bank stabilization, bioengineering)	Ft	16,313	$267	$4,350,188
BR-G	Install in-stream structures (habitat, river training, grade control)	Units	10	$119,413	$1,194,128
KR-D	Mitigate for impacts from or to infrastructure	Lump Sum	1	$213,802	$213,802

* N/A indicates estimate not provided in this unit, see alternate unit estimate for this treatment.

7.2.2.3 As-Built Documentation and Establishment of Monitoring Baselines

As-built surveys are intended to document the changes made as a result of implementing a specific restoration design. These surveys will be conducted following completion of each project sequence, and permanent monitoring stations will be established at that time. Data collected for as-built surveys will include aerial and ground photography, GPS surveys, and channel substrate and profile information. This category is assumed to be a one-time occurrence for each implementation scenario.

As-built Cost Estimate Assumptions

- Costs are based on labor and direct costs associated with each implementation scenario.
- As-built documentation is a one-time cost per implementation scenario.
- For this category, costs were estimated for a moderate scenario for representative reaches, then escalated or reduced based on the scope of each implementation scenario.
- Labor and expenses were estimated based on required expertise and activities described in Section 5.3.2.
- It is assumed that these costs would apply to each phase of construction for a specific reach.
- Estimated costs are based on 2009 dollars and will need to be escalated to the actual year in which construction is completed.
- The assumed escalation for this cost category is 3% annually (see Section 7.3.3).
- A contingency of 30% has been applied.

Table 7-5 shows a breakdown of the cost estimates by area for Braided Reach 1, moderate implementation scenario example. Additional, more detailed information for Braided Reach 1 is presented in Appendix F-3.

Table 7-5. Braided Reach 1, estimated as-built documentation and establishment of monitoring baselines costs, moderate implementation scenario.

Description	Total Estimated Cost (2009 Dollars)
Staff (payroll, fringe, indirect) and subcontractors	$120,000
Vehicles (fuel, insurance, lease, maintenance)	$3,000
Equipment, boats (fuel, maintenance, repair)	$2,000
Equipment, rent, lease	$4,000
Supplies (office, field, lab, other)	$16,000
Telephone, utilities	$3,000
Travel (mileage, lodging, per diem, car rental, airfare)	$19,000
Insurance, other dues	$3,000
Subtotal	$171,000
Contingency (30%)	$51,000
Total	**$222,000**

7.2.2.4 Post-Construction Effectiveness Monitoring

Monitoring will occur before and after construction takes place. Before construction, data will be collected to support design work and to establish a baseline for post-construction monitoring. After construction, monitoring will be focused on the effectiveness of restoration treatments.

Post- construction, or effectiveness, monitoring, as described in Chapter 5, will be linked to adaptive management and will measure progress toward achieving project goals and objectives (Section 5.3.3). Post-construction effectiveness monitoring will encompass many disciplines including hydrology, engineering, and biology and ecology. The disciplines involved in monitoring are the same disciplines that are involved in project planning and design. The results of post-construction effectiveness monitoring will be used to determine if changes are needed in the existing (already implemented) or planned (sequenced for later implementation) restoration actions. Post-construction effectiveness monitoring will also be used to determine project maintenance needs.

The level of effort associated with post-construction monitoring activities will vary according to the particular monitoring method used and the metric being monitored. Table 5-3 presents monitoring metrics with associated timing and scheduled frequency. Some parameters will be measured annually and some will be measured at an interval of several years.

Post-construction Effectiveness Monitoring Cost Estimate Assumptions

- Cost estimates are based on labor and direct costs specific to the scope of each implementation scenario.
- For this category, costs were estimated for a moderate scenario for representative reaches, then escalated or reduced based on the scope of each implementation scenario.

- Labor costs include specific resources and expertise (described in Table 5-3) to address the example effort.
- Estimated costs were cross-checked in three ways: 1) estimated hours and direct costs of specific tasks, 2) estimated resources for the specific time periods, and 3) comparison of costs to the scope of the implementation scenario to which the costs apply.
- It is assumed that the costs would include one monitoring cycle prior to implementation, followed by annual expenses after implementation; frequency would be as defined in Table 5-3.
- Estimated costs are based on 2009 dollars and will need to be escalated to the actual year completed.
- A contingency of 30% has been applied.
- Assumed escalation for this category is 3% annually (see Section 7.3.3).

Table 7-6 shows the costs associated with post-construction effectiveness monitoring for the moderate Braided Reach 1 implementation scenario example. Additional, more detailed cost information is presented in Appendix F-4.

Table 7-6. Braided Reach 1, estimated post-construction effectiveness monitoring costs, moderate implementation scenario.

Description	Total Estimated Cost (2009 Dollars)
Staff (payroll, fringe, indirect) and subcontractors	$73,000
Vehicles (fuel, insurance, lease, maintenance)	$2,000
Equipment, boats (fuel, maintenance, repair)	$3,000
Equipment, rent, lease	$3,000
Supplies (office, field, lab, other)	$8,000
Telephone, utilities	$2,000
Travel (mileage, lodging, per diem, car rental, airfare)	$12,000
Insurance, other dues	$2,000
Subtotal	$105,000
Contingency (30%)	$31,000
Total	**$136,000**

7.2.2.5 Biological Monitoring

Much of the biological monitoring efforts that will help determine the biological effectiveness of this program and will inform the adaptive management program, is being conducted through programs other than the Kootenai River Habitat Restoration Project (Section 5.5). Rather than duplicating these monitoring efforts as part of this project, the Kootenai Tribe plans to integrate biological monitoring data and other information gathered by the agencies and organizations through other processes, with information gathered as part of the pre- and post-construction monitoring proposed under this project, under the auspices of the project's Adaptive Management and Monitoring program.

Cost estimates provided for the biological monitoring category include data and information management, coordination among entities involved in monitoring, and incorporation of biological data into the Adaptive Management and Monitoring program. The Tribe assumes that additional Kootenai Tribe staff will be necessary to accomplish these functions. Costs associated with this category will also include coordination of an interdisciplinary adaptive management and monitoring team, and a Kootenai Tribe full-time program manager and assistant program manager.

Biological Monitoring Cost Estimate Assumptions

- Cost estimates are based on labor and direct costs associated with specific scopes for each implementation scenario.
- For this category, costs were estimated for a moderate scenario for the representative reaches, then escalated or reduced based on the scope of each implementation scenario.
- Labor costs include specific resources and expertise (described in Table 5-3) to address the example efforts.
- Estimated costs were cross-checked in three ways: 1) estimated hours and direct costs of specific tasks, 2) estimated resources for the specific time period (annual), and 3) comparison of costs to the scope of the implementation scenario to which the costs apply.
- The Tribe assumes that the costs would be incurred annually.
- Estimated costs are based on 2009 dollars and will need to be escalated for the actual year in which they are incurred.
- A contingency of 30% has been applied.
- Assumed escalation for this category is 3% annually (see Section 7.3.3).

Table 7-7 shows a breakdown of cost estimates by area for the moderately treated Braided Reach 1 example. Appendix F-5 presents more detailed cost information for the Braided Reach 1 example.

Table 7-7. Braided Reach 1, estimated biological monitoring costs, moderate implementation scenario.

Description	Total Estimated Cost (2009 Dollars)
Staff (payroll, fringe, indirect) and subcontractors	$285,000
Vehicles (fuel, insurance, lease, maintenance)	$4,000
Equipment, boats (fuel, maintenance, repair)	$2,000
Equipment, rent, lease	$10,000
Supplies (office, field, lab, other)	$4,000
Telephone, utilities	$3,000
Travel (mileage, lodging, per diem, auto rental, airfare)	$3,000
Insurance, other dues	$1,000
Subtotal	$311,000
Contingency (30%)	$93,000
Total	**$404,000**

7.2.2.6 Post-Construction Project Maintenance

Post-construction project maintenance involves a variety of activities including watering and maintenance of newly planted areas, replanting areas in subsequent years where the initial planting has not thrived, adjusting river training structures, and controlling weeds in planted areas. Costs for activities in this category were based on a percentage of the estimated cost and the general scope of construction for each implementation scenario. The duration and intervals of the costs will be consistent with chapters 4 and 5.

Post-construction Maintenance Estimated Cost Assumptions

- Costs are estimated based on varying percentages of construction costs for each implementation scenario. The percentage applied is based on the scope of the scenario and the activities described in Section 5.3.3.2, and generally ranges from 3% to 5% depending on the implementation scenario.
- Frequency will be based on the schedule provided in Table 5-3.
- The lump sum estimated cost presented is a one-time cost that may be allocated over several years according to the frequencies shown in Table 5-3.
- Estimated costs are based on 2009 dollars and will need to be escalated for the actual year in which they are incurred.
- Assumed escalation for this area is 4% annually (see Section 7.3.3).

Table 7-8 presents the costs associated with post-construction maintenance for the moderately treated Braided Reach 1 example. Additional, more detailed information for the Braided Reach 1 example is presented in Appendix F-6.

Table 7-8. Braided Reach 1, estimated post-construction maintenance costs, moderate implementation scenario.

Estimated Total Construction Cost	Estimated Percentage of Total Construction Cost	Estimated Post-Construction Maintenance Cost (2009 Dollars)	Comments
$22,508,000	3%	$675,000	Total estimated cost allocated between multiple years

7.2.2.7 Permitting and Environmental Compliance

Chapter 6 discusses environmental compliance and permits requirements for the Kootenai River Habitat Restoration Project and provides a list of potential permits and authorizations in Table 6-1. Of these, the most significant review process will occur under the National Environmental Policy Act (NEPA). The environmental effects of the restoration project will be assessed in an environmental impact statement (Section 6.1) prepared under NEPA guidelines. Because the Tribe expects to implement the project in distinct phases, more than one EIS will likely be

required.[2] Similarly, environmental and construction permits will be sought in phases that parallel the NEPA evaluations. Permitting costs identified in Table 7-9 reflect the potential level of effort associated with implementing the "moderate" array of treatments in Braided Reach 1. NEPA costs presented in Table 7-10 identify the possible level of effort to prepare an EIS for measures proposed in Braided Reach 1.

Environmental compliance costs primarily involve labor, site visits, meetings with agencies and the project sponsors, and document production. For the purposes of this Master Plan, costs are estimated by permit requirement for a moderate implementation scenario for Braided Reach 1 and then are increased or decreased based on the scope of the implementation scenarios to which they are applied (see Tables 7-13, 7-15,7-17, 7-19 and 7-21).

Cost Estimate Assumptions Associated with Environmental Compliance (Permits)

- For this category, costs are estimated based on each specific permit requirement identified in Table 6-1 for the Braided Reach 1 moderate implementation scenario. The costs are then reduced or increased and applied to the other reaches according to the scope of the implementation scenarios.
- Estimated costs are based on labor and direct costs associated with each permit requirement.
- Permitting for an implementation scenario is treated as a one-time cost.
- Estimated costs are based on 2009 dollars and will need to be escalated to the actual year in which they are incurred.
- A contingency of 30% is applied.
- Assumed escalation for this category is 3% annually.

Table 7-9. Braided Reach 1, estimated environmental compliance (permits) costs, moderate implementation scenario.

Project Area/ Permit	Total Estimated Cost (2009 dollars)
Water Supply	
NPDES General Construction Stormwater (EPA)	$10,000
Storm Water Pollution Prevention Plan (SWPPP)	$30,000
Water Quality Certification for Channel Modifications (DEQ)	$8,000
Instream Work	
USACE Section 404/10	$30,000
Instream Alteration Permit (Idaho Dept. of Water Resources)	$5,000
Navigational Encroachment Permit (Idaho Dept. of Lands)	$6,000
Planning Approvals	
Fugitive Dust Control (Idaho Dept. of Environmental Quality)	$6,000
Boundary County Dept of Land Conservation and Development – Floodway Development Permit	$5,000

[2] Depending scope and impact of specific habitat actions implemented in different phases, it may be appropriate in some cases to prepare a less complex Environmental Assessment to document the effects under NEPA.

Table 7-9. Braided Reach 1, estimated environmental compliance (permits) costs, moderate implementation scenario.	
Project Area/ Permit	**Total Estimated Cost (2009 dollars)**
Boundary County Site Development Permit	$8,000
NEPA Record of Decision	Cost included in Table 7-10
USFWS Concurrence or Biological Opinion	Cost included in Table 7-10
Section 106 Clearance	Cost included in Table 7-10
Construction	
Boundary County Road and Bridge Permits	$9,000
Subtotal	$117,000
Contingency (30%)	$35,000
Total	**$151,000**

Table 7-10 provides an estimate for a one-time cost range for NEPA documentation. More detailed cost information for the Braided Reach 1 example is found in Appendix F-7.

Environmental Impact Statement (NEPA) Cost Estimate Assumptions

- Costs for an EIS (NEPA) were estimated based on coordination, management, and resource areas required to accomplish the general scope of work for a project of this magnitude.
- Estimated costs for NEPA requirements are presented as an estimate for one EIS (note that an EIS likely will be required for each phase of implementation).
- Labor costs included specific resources and expertise for all resource areas needed for NEPA on a project of this scope.
- Estimated costs were cross-checked in three ways: 1) estimated hours and direct costs of specific tasks, 2) estimated resources for the specific time period (annual), and 3) comparison of costs to the overall scope of the project.
- Estimated costs are based on 2009 dollars and will need to be escalated for the actual year in which they are incurred.
- Cost estimates should be viewed as mid-range estimates; actual costs could be higher.
- A contingency of 30% is applied.
- Assumed escalation for this item is 3% annually (see Section 7.3.3).

Table 7-10. Braided Reach 1, estimated environmental compliance costs for (NEPA EIS), moderate implementation scenario.			
Task	**Total Estimated Labor Costs**	**Total Estimated Direct Expenses**	**Total Estimated Costs (2009 Dollars)**
Project management, coordination	$41,000	$2,000	$43,000
Public scoping and comments, coordination, preparation of DEIS and FEIS	$124,000	$4,000	$128,000
Geology and soils	$29,000	$600	$29,600
Water resources (quality, hydrology, water rights, climate)	$35,000	$0	$35,000

Table 7-10. Braided Reach 1, estimated environmental compliance costs for (NEPA EIS), moderate implementation scenario.			
Task	**Total Estimated Labor Costs**	**Total Estimated Direct Expenses**	**Total Estimated Costs (2009 Dollars)**
Biological resources (fish, plants, wildlife, threatened and endangered species)	$91,000	$7,000	$98,000
Cultural	$34,000	$200	$34,200
Air, noise, health and public safety	$20,000	$0	$20,000
Visuals	$26,000	$900	$26,900
Land use, transportation and recreation	$31,000	$800	$31,800
Socioeconomics	$16,000	$100	$16,100
Cumulative effects	$43,000	$0	$43,000
		Subtotal	$505,600
		Contingency (30%)	$152,000
		Total	**$657,600**

7.2.2.8 Land Use Management

Restoration activities will affect and will be affected by land use practices adjacent to the Kootenai River. The Tribe anticipates that funds will be needed for coordination with landowners and for community outreach. Labor and expenses are the costs associated with this category are expected to include one full-time staff member and part-time assistant to facilitate on-the-ground communications with area landowners to support project design and implementation. Meeting coordination and facilitation associated with formal community outreach will also require services of part-time administrator and part-time assistant to help the Kootenai Tribe's Fish and Wildlife Department Director.

It is possible that the proposed project may need to acquire structures and/or pay reparation to land owners for impacts to their structures (Section 7.2.2.9). There may also be costs associated with mitigation for infrastructure (e.g., relocation). These cost estimates are captured in the construction costs (Section 7.2.2.2).

Land Use Management Cost Estimate Assumptions

- Estimates are based on labor and direct costs specific to the scope of each implementation scenario.
- For this category, costs were estimated for a moderate scenario for a representative reach, then escalated or reduced based on the scope of each implementation scenario.
- Estimated costs were cross-checked in three ways: 1) estimated hours and direct costs of specific tasks, 2) estimated resources for the specific time period (annual), and 3) comparison of costs to the scope of the implementation scenario to which the costs apply.
- Costs in this category will not increase or decrease as dramatically as other cost categories solely based on the scope of implementation scenarios i.e., the costs are expected to remain approximately the same whether a minimum, moderate, or maximum scenario is implemented.

- It is assumed that costs in this category would be ongoing annual expenses.
- Costs are based on 2009 dollars and will need to be escalated for the actual year in which they are incurred.
- A contingency of 30% has been applied.
- The assumed escalation for this category is 3% annually (see Section 7.3.3).

Table 7-11 shows a breakdown of cost estimates by area for management of land use practices. More information about costs associated with the Braided Reach 1 moderate example may be found in Appendix F-8.

Table 7-11. Braided Reach 1, estimated management of land use practices costs, moderate implementation scenario.

Description	Total Estimated Cost (2009 Dollars)
Staff (payroll, fringe, indirect) and subcontractors	$206,000
Vehicles (fuel, insurance, lease, maintenance)	$6,000
Equipment, boats (fuel, maintenance, repair)	$0
Equipment, rent, lease	$10,000
Supplies (office, field, lab, other)	$2,000
Telephone, utilities	$4,000
Travel (mileage, lodging, per diem, auto rental, airfare)	$3,000
Insurance, other dues	$1,000
Subtotal	$232,000
Contingency (30%)	$69,000
Total	**$301,000**

7.2.2.9 Land Acquisition, Leases, and Agreements

It is possible that certain parcels of land may need to be managed and/or acquired through use agreements, leases, or acquisition during the course of the proposed project. At this point, the need for and extent of land acquisition, leases, and other agreements is unknown. Costs for acquisition, if needed, will be estimated during the next project design phase(s). The Tribe expects that during the preliminary design phase, specific implementation scenarios and associated restoration actions will be defined and prioritized. This will allow parcels of land likely to be affected by the future proposed projects to be identified.

A placeholder for costs would be difficult to define at this time. At the conceptual level, it is sufficient to recognize that costs associated with land acquisition, leases, and/or agreements will be included as implementation costs and refined during preliminary design. This is currently identified as a cost category with no cost estimates applied.

7.2.2.10 Costs Applied to All

Costs that would potentially be applied to all of the project reaches include those associated with management of Libby Dam flow and management of backwater from Kootenay Lake.

Libby Dam Flow

As noted in Chapter 2 operation of Libby Dam affects all reaches of the Kootenai River Habitat Restoration Project. Libby Dam operations are dictated by a combination of power production, flood control, fish and recreation objectives. Operations of Libby Dam are also impacted by requirements identified in the Biological Opinion Regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat (USFWS 2006, clarified in 2008) and the Biological Opinion on Federal Columbia River Power System Operations.

Changes to Libby Dam flow (e.g., installation of a new turbine) would involve a number of significant management issues and potential associated costs. No estimated costs have been included in this Master Plan for modifications to Libby Dam flows since: 1) potential actions related to Libby Dam flows would be identified in the preliminary design phase in relation to other implementation scenarios, and 2) the USACE will be responsible for identifying costs and funding associated with Libby Dam.

Kootenay Lake Backwater

It is not possible to estimate costs associated with potential changes to management of Kootenay Lake at this stage of planning. Potential operational actions to modify Kootenay Lake backwater effects will be explored during preliminary design phase. Pending the outcome of that effort, cost estimates based on specific management actions may be developed as part of the preliminary and final design phases.

7.3 Other Cost Considerations

Project sequencing, economy of scale, and cost escalation/inflation are considerations that affect costs in a broad manner across all cost categories. These considerations have been included in the cost estimates presented in Section 7.4 and are summarized in this section.

7.3.1 Project Sequencing

The Kootenai River Habitat Restoration Project will likely be implemented over a number of construction seasons (Section 4.3). Sequencing will be extremely important in managing costs. In some cases, significant savings can be realized by conducting a project in phases. In other cases, cost savings may be realized by minimizing numerous mobilizations of equipment, materials, and manpower (Section 7.3.2). As design and implementation strategies are refined it will be possible to determine which approach is likely be most cost efficient in accomplishing the varying scopes of work.

Implementation sequencing will also be affected by ecological factors. For example, in-stream work may not be possible at certain times of the year due to water conditions or presence of sensitive life stages of ESA listed fish species. In these cases, sequencing the project on a strict cost basis alone will not be possible. Accommodating ecological concerns could lead to higher costs in some circumstances because mobilization or construction may not be able to be accomplished in the most cost-efficient way. In the early stages of planning, numerous sequencing options that consider all potential treatments for each reach will be explored. Significant efficiencies could be realized for a project of this size with well-thought out, creative planning and implementation.

7.3.2 Economy of Scale

Economy of scale is an important aspect to consider when determining potential efficiencies and costs for a particular project. The considerations are similar in some aspects to those mentioned above for project sequencing. The main issue is whether cost savings will be realized if a larger scope of work is accomplished during one mobilization. This usually relates to fixed costs that would occur even if the amount or duration of work is increased.

For example, grading and placement of 50,000 yards of stabilization materials will require mobilization of equipment and manpower and use of fuels and other expendable supplies. Costs associated with mobilization would include labor, equipment rental, supplies, transportation, etc. The fixed cost of this mobilization would likely be the same if 75,000 yards of material were graded and placed with one mobilization. The fixed costs would be incurred each time the activity is mobilized. Therefore, it would be most economical to mobilize once and complete a larger scope of work than to start, stop, and start again.

7.3.3 Inflation and Cost Escalation

Cost escalation, in cost engineering, is defined as "changes in the cost or price of specific goods or services in a given economy over a period of time" (Hollman and Dysert 2007). Escalation is specific to an item or class of items, is not always driven by changes in the money supply, and tends to be less sustained than inflation. It is also driven by changes in technology, practices, and particularly by supply-demand imbalances specific to goods or services (NPPC 2007). For example, while general inflation in the United States was less than 5% during the 2003-2007 time period, steel prices increased (escalated) by over 50% because of supply-demand imbalance.

Inflation and cost escalation will affect costs in all categories over the life of the proposed project. However, escalation mostly applies to construction costs. In development of cost estimates, inflation and price indices are considered to reflect "real time" costs when work might actually occur. Application of these indices can result in more accurate cost estimates.

Currently, the construction industry is experiencing a downturn, However, it is uncertain how various government programs and other market forces may affect costs over the life of the proposed project. Construction costs can fluctuate significantly from year to year as shown on the ENR Construction Cost Index (http://enr.com), which has recorded construction costs since 1913. Since 1978, changes in annual national averages for construction costs have ranged from +11.6% in 1978 to -0.5% in 2001. The fluctuation range of average construction costs from 1997 through 2008 has been between -0.5% and +9.1%.

Though various portions of construction expenses might be escalated at different rates e.g., labor at 4%, materials at 3%, etc., for purposes of this Master Plan, construction cost estimates and post-construction maintenance cost categories have been escalated at 4.0%. Cost estimates for other cost categories were escalated at 3% annually. These estimates may be high or low in any given year depending on the state of the economy, but at this time, they are considered to be reasonable estimates. Escalation will need to be considered as planning proceeds to the preliminary and final design phases and costs are being projected into future years. For example, delaying implementation of a $10,000,000 project for one year could potentially add $400,000 to the cost of the project due to an escalation of 4%.

7.4 Estimated Costs and Cost Considerations for Implementation Scenarios

Section 7.4 presents the conceptual costs for the Braided Reaches 1 and 2, Straight Reach, and Meander Reaches 1 and 2, for the implementation scenarios presented in Chapter 4. Minimum, moderate, and maximum costs, based on level of treatment, are shown for each scenario.

7.4.1 Costs Associated with Implementation Scenarios in the Braided Reaches

Estimated construction costs including unit costs and total cost by treatment, as well as a summary of potential costs for all categories for each implementation scenario described in Chapter 4, for each reach, are presented. It should be noted that the unit costs for construction are "loaded costs" i.e., they include all standard mark-ups, insurance, bonding and other related costs that a construction contractor would incur on a project such as this. It should be noted that for all reaches, as the scope of construction increases, fixed costs (described in Section 7.3.2) may remain the same so a cost of a specific line item can actually drop (i.e., costs associated with infrastructure) from a minimum to a maximum implementation scenario. Assumptions outlined in Section 7.2.2.2 apply to these cost estimates. Cost estimation details for all cost categories are provided in Appendix F.

7.4.1.1 Braided Reach 1

Within Braided Reach 1, construction costs are different among the minimum, moderate and maximum implementation scenarios; these differences correspond to the extent of channel reconstruction and the length of bank that would be treated. In areas where the channel is being reconstructed, a new floodplain surface would also be constructed and instream structures would be installed, so costs increase proportionately for each implementation scenario for each of these restoration treatments. Bank treatments are tied to BEHI ratings, so they are independent of the channel work, but the extent of bank treatments and associated costs also increase from minimum to moderate and maximum implementation scenarios.

Braided Reach 1 implementation scenario criteria that form the basis for costs are explained in Chapter 4. Table 7-12 shows estimated construction costs for Braided Reach 1 for examples of the minimum, moderate and maximum implementation scenarios. Table 7-13 provides other cost categories for each implementation scenario in Braided Reach 1.

Table 7-12. Braided Reach 1, summary of estimated construction costs for all implementation scenarios.								
Treatment	**Treatment Name**	**Unit Description**	**Minimum**		**Moderate**		**Maximum**	
			No. Units	**Total Estimated Cost**	**No. Units**	**Total Estimated Cost**	**No. Units**	**Total Estimated Cost**
BR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	0	N/A	5,280	N/A	20,630	N/A
		Cu yds (cut)	0	$0	527,063	$6,615,000	1,723,682	$16, 530,000
BR-B	Construct floodplain surfaces	Acres	0	N/A	71	N/A	115	N/A
		Cu yds (fill)	0	$0	527,063	$5,223,000	1,723,682	$16,582,000
BR-C	Construct and/or enhance wetlands	Acres	0	$0	36	$1,438,000	55	$2,160,000
BR-D	Construct and/or enhance secondary channels	Ft	0	$0	10,072	$638,000	13,135	$817,000
BR-E	Revegetate the floodplain	Acres	0	$0	71	$2,837,000	115	$4,517,000
BR-F	Install bank structures (bank stabilization, bioengineering)	Ft	7,138	$2,014,000	16,313	$4,350,000	41,835	$10,967,000
BR-G	Install in-stream structures (habitat, river training, grade control)	Units	0	$0	10	$1,194,000	35	$4,109,000
KR-D	Mitigate for impacts from or to infrastructure	Lump Sum	1	$226,000	1	$214,000	1	$210,000

* N/A indicates estimate not provided in this unit, see alternate unit estimate for this treatment.

Table 7-13. Braided Reach 1, estimated costs for all Implementation scenarios (all cost categories).				
Cost Estimation Category	**Minimum Estimated Costs**	**Moderate Estimated Costs**	**Maximum Estimated Costs**	**Associated Detailed Costs**
Planning, coordination, data collection, preliminary and final design	$524,000	$4,368,000	$4,368,000	Cost from Table 7-3 and Appendix F-1
Construction	$2,240,000	$22,508,000	$55,892,000	Cost from Table 7-4 and Appendix F-2
As-built documentation and establishment of monitoring baselines	$56,000	$222,000	$444,000	Cost from Table 7-5 and Appendix F-3
Post-construction (effectiveness) monitoring	$136,000	$136,000	$341,000	Cost from Table 7-6 and Appendix F-4
Biological monitoring	$202,000	$404,000	$404,000	Cost from Table 7-7 and Appendix F-5
Post-construction maintenance	$112,000	$675,000	$1,677,000	Cost from Table 7-8 and Appendix F-6
NEPA (Environmental Impact Statement)		$657,600		Cost from Table 7-10 and Appendix F-7
Environmental compliance (permits)	$26,000	$151,000	$303,000	Cost from Table 7-9 and Appendix F-7
Management of land use practices	$151,000	$301,000	$301,000	Cost from Table 7-11 and Appendix F-8

Notes and Assumptions:

- Because the project is expected to be implemented in distinct phases, more than one EIS may be required. An estimated cost for an EIS for a moderate implementation scenario is shown. This cost could be more or less depending on the complexity and scope of the proposed project.

7.4.1.2 Braided Reach 2

Within Braided Reach 2, construction costs are nearly identical among the minimum, moderate and maximum implementation scenarios because the quantities are similar for all restoration scenarios. Construction costs decrease slightly going from the minimum to moderate to maximum scenarios due to assumed fixed costs mostly related to mobilization and other general costs such as insurance and bonding.

Implementation scenario criteria for Braided Reach 2 that form the basis for costs are explained in Chapter 4. Braided Reach 2 estimated construction costs for examples of minimum, moderate and maximum implementation scenarios are summarized in Table 7-14. Other cost categories for Braided Reach 2 are summarized in Table 7-15.

Table 7-14. Braided Reach 2, summary of estimated construction costs for all implementation scenarios.								
Treatment	Treatment Name	Unit Description	Minimum		Moderate		Maximum	
			No. Units	Total Estimated Cost	No. Units	Total Estimated Cost	No. Units	Total Estimated Cost
BR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	16,669	N/A	16,669	N/A	16,669	N/A
		Cu yds (cut)	1,527,334	$14,311,000	1,527,334	$13,532,000	1,527,334	$13,303,000
BR-B	Construct floodplain surfaces	Acre	253	N/A	253	N/A	253	N/A
		Cu yds (fill)	1,527,334	$8,599,000	1,527,334	$15,625,000	1,527,334	$7,988,000
BR-C	Construct and/or enhance wetlands	Acre	133	$5,621,000	133	$5,314,000	133	$5,224,000
BR-D	Construct and/or enhance secondary channels	Ft	13,688	$917,000	13,688	$866,000	13,688	$852,000
BR-E	Revegetate the floodplain	Acre	253	$10,693,000	253	$10,108,000	253	$9,937,000
BR-F	Install bank structures (bank stabilization, bioengineering)	Ft	12,050	$3,399,000	19,083	$5,089,000	29,059	$7,618,000
BR-G	Install in-stream structures (habitat, river training, grade control)	Units	47	$5,937,000	47	$5,612,000	47	$5,517,000
KR-D	Mitigate for impacts from or to infrastructure	Lump Sum	1	$226,000	1	$214,000	1	$210,000

* N/A indicates estimate not provided in this unit, see alternate unit estimate for this treatment.

Table 7-15. Braided Reach 2, estimated costs for all implementation scenarios (all cost categories).				
Cost Estimation Category	**Minimum Estimate Costs**	**Moderate Estimated Costs**	**Maximum Estimate Costs**	**Associated Detailed Costs**
Planning, coordination, data collection, preliminary and final design	$6,552,000	$6,522,000	$6,522,000	Costs from Appendix F-1
Construction	$49,704,000	$56,360,000	$50,648,000	Costs from Appendix F-2
As-built documentation and establishment of monitoring baselines	$666,000	$666,000	$666,000	Costs from Appendix F-3
Post-construction (effectiveness) monitoring	$409,000	$409,000	$409,000	Costs from Appendix F-4
Biological monitoring	$485,000	$485,000	$485,000	Costs from Appendix F-5
Post-construction maintenance	$1,491,126	$1,691,000	$1,519,000	Costs from Appendix F-6
NEPA (Environmental Impact Statement)		$657,600		Costs from Appendix F-7
Environmental compliance (permits)	$454,000	$454,000	$454,000	Costs from Appendix F-7
Management of land use practices	$361,000	$361,000	$361,000	Costs from Appendix F-8

Notes and Assumptions:

- Because the project is expected to be implemented in distinct phases, more than one EIS may be required. An estimated cost for an EIS for a moderate implementation scenario is shown. This cost could be more or less depending on the complexity and scope of the proposed project.

7.4.2 Costs Associated with Straight Reach Implementation Scenario

Within the Straight Reach, construction costs are different among the minimum, moderate and maximum implementation scenarios. These differences are driven by the extent of channel reconstruction, the length of bank that would be treated, and the amount of riparian revegetation.

Instream structures would be installed throughout the entire Straight Reach as part of all three implementation scenarios. Bank treatments are tied to BEHI ratings and the extent of bank treatments and associated costs increase from minimum to moderate and maximum implementation scenarios. Similarly, riparian revegetation is tied to the amount of vegetation currently present and the level of revegetation increases moving from the minimum to moderate and maximum implementation scenarios.

Straight Reach implementation scenario criteria that form the basis for costs are explained in Chapter 4. Table 7-16 shows estimated construction costs for the Straight Reach for examples of the minimum, moderate and maximum implementation scenarios. Table 7-17 shows other cost categories for each implementation scenario in the Straight Reach.

Table 7-16. Straight Reach, summary of estimated construction costs for all implementation scenarios.								
Treatment	**Treatment Name**	**Unit Description**	**Minimum**		**Moderate**		**Maximum**	
			No. Units	**Total Estimated Cost**	**No. Units**	**Total Estimated Cost**	**No. Units**	**Total Estimated Cost**
SR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	5,821	N/A	5,821	N/A	5,821	N/A
		Cu yds (cut)	0	$0	218,356	$2,646,000	436,713	$4,778,000
SR-B	Revegetate the riparian corridor and establish a riparian buffer	Ft	0	$0	3,151	$2,285,000	11,340	$3,967,000
SR-C	Install bank structures (bank stabilization, bioengineering)	Ft	398	$112,000	3,480	$927,000	9,944	$2,603,000
SR-D	Install in-stream structures (habitat, river training, grade control)	Units	10	$1,445,000	10	$1,366,000	10	$1,342,000
KR-D	Mitigate for impacts from or to infrastructure	Lump Sum	1	$540,000	1	$511,000	1	$502,000

* N/A indicates estimate not provided in this unit, see alternate unit estimate for this treatment.

Table 7-17. Straight Reach, estimated costs for all implementation scenarios (all cost categories).

Cost Estimation Category	Minimum Estimated Costs	Moderate Estimated Costs	Maximum Estimated Costs	Associated Detailed Costs
Planning, coordination, data collection, preliminary and final design	$393,000	$1,747,000	$3,058,000	Costs from Appendix F-1
Construction	$2,097,000	$7,734,000	$13,193,000	Costs from Appendix F-2
As-built documentation and establishment of monitoring baselines	$133,000	$222,000	$222,000	Costs from Appendix F-3
Post-construction (effectiveness) monitoring	$136,000	$136,000	$136,000	Costs from Appendix F-4
Biological monitoring	$202,000	$404,000	$404,000	Costs from Appendix F-5
Post-construction maintenance	$105,000	$232,000	$396,000	Costs from Appendix F-6
NEPA (Environmental Impact Statement)		$657,600		Costs from Appendix F-7
Environmental compliance (permits)	$114,000	$114,000	$125,000	Costs from Appendix F-7
Management of land use practices	$301,000	$301,000	$301,000	Costs from Appendix F-8

Notes and Assumptions:

- Because the project is expected to be implemented in distinct phases, more than one EIS may be required. An estimated cost for an EIS for a moderate implementation scenario is shown. This cost could be more or less depending on the complexity and scope of the proposed project.

7.4.3 Costs Associated with Implementation Scenarios in the Meander Reaches

7.4.3.1 Meander Reach 1

Within Meander Reach 1, construction costs are different among the minimum, moderate and maximum implementation scenarios. These differences result primarily from the length of bank structures and acres of wetland restoration in the floodplain outside the levees. Other restoration treatment costs that vary among the scenarios include secondary channel construction, floodplain re-vegetation adjacent to the river, instream structure installation and tributary restoration.

It is important to note that costs for the most expensive restoration treatments (bank structures and wetland restoration outside the levees) are based on all identified lengths and areas that have potential for restoration, based on criteria for each implementation scenario. Actual lengths and areas would be determined based on coordination in later project phases with landowners and owners of infrastructure that would be affected by restoration work. This is also true for some of the other restoration treatments including secondary channel restoration, floodplain re-vegetation adjacent to the river and tributary restoration.

Meander Reach 1 implementation scenario criteria that form the basis for costs are explained in Chapter 4. Table 7-18 shows estimated construction costs for the Meander Reach 1 for examples of the minimum, moderate and maximum implementation scenarios. Table 7-19 shows other cost categories for each implementation scenario in Meander Reach 1.

Table 7-18. Meander Reach 1, summary of estimated construction costs for all implementation scenarios.								
Treatment	**Treatment Name**	**Unit Description**	**Minimum**		**Moderate**		**Maximum**	
			No. Units	**Total Estimated Cost**	**No. Units**	**Total Estimated Cost**	**No. Units**	**Total Estimated Cost**
MR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	0	$0	0	$0	0	$0
MR-B	Excavate floodplain adjacent to the river	Acres	0	$0	0	$0	0	$0
		Cu yds (cut)	0	$0	0	$0	0	$0
MR-C	Construct and/or enhance wetlands adjacent to the river	Acres	0	$0	0	$0	0	$0
MR-D	Construct and/or enhance wetlands behind levees and connect to the river	Ft	0	$0	2,242	$14,503,000	7,844	$49,881,000
MR-E	Construct or enhance secondary channels adjacent to the river	Ft	0	$0	0	$0	0	$0
MR-F	Construct or enhance secondary channels behind levees and connect to the river	Ft	0	$0	30,350	$1,011,000	39,172	$1,445,000
		Cu yds	0	$0	76,445	N/A	117,893	N/A
MR-G	Revegetate the floodplain adjacent to the river	Ft	0	$0	25,039	$743,000	70,794	$2,066,000
		Acres	0	$0	0	N/A	0	N/A
MR-H	Install bank structures	Ft	10,456	$2,950,000	31,085	$8,289,000	84,504	$22,153,000
MR-I	Install in-stream structures	Units	0	$0	15	$1,791,000	35	$4,109,000
MR-J	Tributary restoration	Barriers	0	$0	3	$356,000	3	$4,133,000
		Ft	0	$0	0	N/A	34,102	N/A
KR-D	Mitigate for impacts from or to infrastructure	Lump Sum	1	$226,000	1	$214,000	1	$210,000

* N/A indicates estimate not provided in this unit, see alternate unit estimate for this treatment.

Table 7-19. Meander Reach 1, estimated costs for all implementation scenarios (all cost categories).				
Cost Estimation Category	**Minimum Estimated Costs**	**Moderate Estimated Costs**	**Maximum Estimated Costs**	**Associated Detailed Costs**
Planning, coordination, data collection, preliminary and final design	$612,000	$4,412,000	$9,609,000	Costs from Appendix F-1
Construction	$3,176,000	$26,908,000	$83,996,000	Costs from Appendix F-2
As-built documentation and establishment of monitoring baselines	$97,000	$278,000	$555,000	Costs from Appendix F-3
Post-construction (effectiveness) monitoring	$65,000	$163,00	$409,000	Costs from Appendix F-4
Biological monitoring	$202,000	$404,000	$525,000	Costs from Appendix F-5
Post-construction maintenance	$95,000	$807,000	$2,520,000	Costs from Appendix F-6
NEPA (Environmental Impact Statement)		$657,600		Costs from Appendix F-7
Environmental compliance (permits)	$21,000	$106,000	$176,000	Costs from Appendix F-7
Management of land use practices	$181,000	$301,000	$391,000	Costs from Appendix F-8

Notes and Assumptions:

- Because the project is expected to be implemented in distinct phases, more than one EIS may be required. An estimated cost for an EIS for a moderate implementation scenario is shown. This cost could be more or less depending on the complexity and scope of the proposed project.

7.4.3.2 Meander Reach 2

Within Meander Reach 2, construction costs are different among the minimum, moderate and maximum implementation scenarios. These differences are driven mainly by the length of bank structures, area of floodplain excavation inside the levees, and acres of wetland restoration in the floodplain outside the levees. Other restoration treatment costs that vary among the scenarios include secondary channel construction, floodplain revegetation adjacent to the river, instream structure installation and tributary restoration.

As with Meander Reach 1, it is important to note that costs for the most expensive restoration treatments (bank structures, area of floodplain excavation inside the levees and wetland restoration outside the levees) are based on all identified lengths and areas that have potential for restoration, based on criteria for each implementation scenario. Actual lengths and areas would be determined based on coordination with landowners and owners of infrastructure who would be affected by restoration work. This is also true for some of the other restoration treatments including secondary channel restoration, floodplain revegetation adjacent to the river and tributary restoration.

Meander Reach 2 implementation scenario criteria that form the basis for costs are explained in Chapter 4. Table 7-20 shows estimated construction costs for Meander Reach 2 for examples of the minimum, moderate and maximum implementation scenarios. Table 7-21 shows other cost categories for each implementation scenario in Meander Reach 2.

Table 7-20. Meander Reach 2, summary of estimated construction costs for all implementation scenarios.								
Treatment	**Treatment Name**	**Unit Description**	**Minimum**		**Moderate**		**Maximum**	
			No. Units	**Total Estimated Cost**	**No. Units**	**Total Estimated Cost**	**No. Units**	**Total Estimated Cost**
MR-A	Excavate and/or dredge the river to modify the channel geometry	Ft	0	$0	0	$0	0	$0
MR-B	Excavate floodplain adjacent to the river	Acres	0	$0	767	N/A	1,396	N/A
		Cu yds (cut)	0	$0	7,930,550	$71,058,000	17,259,190	$151,881,000
MR-C	Construct and/or enhance wetlands adjacent to the river	Acres	0	$0	0	$0	0	$0
MR-D	Construct and/or enhance wetlands behind levees and connect to the river	Ft	0	$0	3,690	$14,503,000	10,456	$40,399,000
MR-E	Construct or enhance secondary channels adjacent to the river	Ft	0	$0	0	$0	0	$0
MR-F	Construct or enhance secondary channels behind levees and connect to the river	Ft	0	$0	57,137	$3,490,000	161,490	$14,482,000
		Cu yds	0	$0	170,340	N/A	1,051,925	N/A
MR-G	Revegetate the floodplain adjacent to the river	Ft	0	$0	204,134	$6,061,000	314,599	$5,959,000
		Acres	0	$0	767	N/A	1,396	N/A
MR-H	Install bank structures	Ft	78,071	$22,025,000	232,116	$61,898,000	330,433	$86,623,000
MR-I	Install in-stream structures	Units	0	$0	0	$0	126	$14,791,000
MR-J	Tributary restoration	Barriers	0	$0	13	$1,544,000	13	$8,045,000
		Ft	0	$0	0	N/A	58,839	N/A
KR-D	Mitigate for impacts from or to infrastructure	Lump Sum	1	$352,000	1	$333,000	1	$327,000

* N/A indicates estimate not provided in this unit, see alternate unit estimate for this treatment.

Table 7-21. Meander Reach 2, estimated costs for all implementation scenarios (all cost categories).				
Cost Estimation Category	**Minimum Estimated Costs**	**Moderate Estimated Costs**	**Maximum Estimated Costs**	**Associated Detailed Costs**
Planning, coordination, data collection, preliminary and final design	$4,412,000	$10,046,000	$19,655,000	Costs from Appendix F-1
Construction	$22,376,000	$158,886,000	$322,506,000	Costs from Appendix F-2
As-built documentation and establishment of monitoring baselines	$275,000	$888,000	$1,332,000	Costs from Appendix F-3
Post-construction (effectiveness) monitoring	$142,000	$545,000	$953,000	Costs from Appendix F-4
Biological monitoring	$404,000	$969,000	$1,212,000	Costs from Appendix F-5
Post-construction maintenance	$671,000	$4,767,000	$9,675,000	Costs from Appendix F-6
NEPA (Environmental Impact Statement)		$657,600		Costs from Appendix F-7
Environmental compliance (permits)	$65,000	$1,212,000	$3,029,000	Costs from Appendix F-7
Management of land use practices	$301,000	$602,000	$602,000	Costs from Appendix F-8

Notes and Assumptions:

- Because the project is expected to be implemented in distinct phases, more than one EIS may be required. An estimated cost for an EIS for a moderate implementation scenario is shown. This cost could be more or less depending on the complexity and scope of the proposed project.

7.5 Summary Discussion

As explained at the outset of this chapter, estimated costs presented in this Master Plan have been developed to the conceptual level. The estimated costs presented in this chapter are based on illustrative examples of potential restoration scenarios. In subsequent projects phases (see Chapter 9 for discussion of next steps), specific habitat actions and implementation sequences will be identified and at that time it will be possible to develop more specific and refined cost estimates.

These conceptual cost estimates are designed to help inform the planning process by:

- Helping guide the Kootenai Tribe, their agency partners, co-managers and stakeholders in weighing the pros and cons of various scales of implementation (e.g., by pointing to potential economy of scale);
- Allowing potential funders, agency partners, and stakeholders to better understand the costs associated with various scales of implementation, and specific habitat actions, and thus to be better prepared to weigh the potential cost trade-offs relative to ecological benefit; and
- Providing a cost framework for use in development, refinement and implementation of a Kootenai River Habitat Restoration Project funding strategy.

Since the cost estimates presented in this Master Plan are based on unit costs, it should be relatively simple to revise cost estimates to describe costs associated with implementation scenarios that are different from those presented in this Master Plan, and to adjust costs of specific units as necessary.

In the following chapters, addition information is provided that will be relevant to future refinement of costs and funding mechanisms.

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8 Funding

This chapter presents a conceptual funding strategy and a preliminary analysis of potential funding sources for implementation of the Kootenai River Habitat Restoration Project.

8.1 Overview

As explained at the beginning of this document, this Master Plan provides a framework for an ecosystem-based habitat restoration project. Because the Kootenai River Habitat Restoration Project covers such a large area and is designed to address such a complex combination of interrelated limiting factors, it will likely take a number of years to complete the habitat restoration work. This will likely result in various restoration phases being implemented in different reaches at different times. Funding availability, environmental compliance, and permitting schedules may also influence, and be influenced by, the selected approach to implementation sequencing. Later design phases of this project will consider funding and sequencing in greater detail with the recognition that the Kootenai River Habitat Restoration Project is a single endeavor with component parts that are all inter-linked and inter-dependent.

The purpose of this chapter is to outline a conceptual funding strategy and investigate potential funding sources that could be used to implement the specific on-the-ground habitat restoration activities that will be identified and refined in the next phases of this project.

Shortly after completion of this Master Plan, the Tribe in coordination with their agency partners, and with input from regional co-managers and other stakeholders, will identify immediate implementation priorities and associated habitat actions, as well as a process for prioritizing and sequencing subsequent project actions (see discussion of next steps in Chapter 9). The Kootenai Tribe expects that once specific preliminary project actions are identified, and a process has been confirmed to prioritize and sequence longer-term project actions, the Tribe with assistance from their agency partners and other interested stakeholders, will refine and implement an appropriate targeted funding strategy for the implementation of the entire Kootenai River Habitat Restoration Project.

This Master Plan presents conceptual costs for a range of potential implementation scenarios (Chapter 7). As previously explained, more precise cost estimates will be developed in subsequent project phases once specific project actions and associated implementation sequencing are identified and preliminary and final design work is initiated. These refined cost estimates will also be critical in developing and securing funding sources for this project. However, for the time being the potential implementation scenarios and associated conceptual cost ranges helped the Tribe in thinking about how to frame this conceptual funding strategy.

The Kootenai Tribe received funding for the development of this Master Plan from the Bonneville Power Administration (BPA) through the Northwest Power and Conservation Council's (NPCC) Fish and Wildlife Program (Project 200200200). The Tribe anticipates that funding for planning and design activities, environmental compliance, and additional targeted data collection and analysis associated with the next phases of this project will also be provided at least in part by BPA through the NPCC's Fish and Wildlife Program (see Chapter 9 discussion of next steps).

The conceptual funding strategy presented in this chapter is based on the following assumptions:

- Funding will be needed primarily for implementation of habitat restoration actions;
- It is possible that some funding might be needed for habitat acquisition and/or leases;
- The Kootenai River Habitat Restoration project will likely be implemented at multiple sites and in different reaches of the river in sequenced phases, with some of the component projects being relatively small and simple and others being comparatively large and complex;
- The project phases will be implemented within an adaptive management framework, such that design and implementation of later phases of the project are informed by data and information gathered through actions implemented in earlier phases;
- Although sequencing of the project implementation will in all likelihood be necessary for a variety of reasons, the Tribe also recognizes that there are benefits to completing major project components as quickly as possible (e.g., urgent ecological need for habitat improvements, opportunity to maximize ecological value and minimize construction impacts, and the potential for reducing costs); and
- Construction related to the first phase of habitat restoration actions is targeted to begin in 2012.

8.2 Conceptual Fundraising Strategy

Although it is difficult to identify details of a fundraising strategy before specific restoration actions have been selected, the Tribe recognizes the importance of anticipating the scale of potential restoration efforts since this will be a critical variable in developing and implementing a fundraising strategy. This is one of the reasons the Tribe has provided illustrative examples of potential minimum, moderate and maximum implementation scenarios and developed conceptual cost estimates associated with each of these scenarios. However, it is important to understand that the final project implementation scenario may be different than any of the illustrative examples provided in this Master Plan.

In developing this Master Plan and discussing the approach to funding, the Tribe and their agency partners agreed that a desirable approach to funding would be a strategy that relies on multiple funding streams, with each source tapped to provide funding for specific elements of the larger ecosystem restoration project.

Such a strategy would ordinarily be executed primarily by securing funds from a variety of competitive grant and loan sources offered by federal and state agencies, with the potential for some additional funding from private sources. The challenges associated with this approach are that it is time-consuming to execute and is subject to the award limits of each of the competitive grant programs. Given these constraints, the Tribe believes it would be very difficult to raise more than $8 to $10 million per year using this approach, and even raising that amount would probably require a significant commitment of time and resources to fundraising activities.

Depending on the scope and scale of the selected habitat restoration scenario, and on the approach to implementation sequencing, it is likely that a dedicated revenue source of considerable size will be needed. While the specific restoration activities and implementation

sequencing will not be identified until the next phases of the project, for the purposes of this chapter the Tribe is assuming that the selected restoration actions will be substantial enough to warrant securing a dedicated revenue source.

The Tribe is recommending the following interim funding strategy, which will be updated, refined and expanded once the initial restoration activities have been prioritized and the approach to project implementation and sequencing has been confirmed:

- The Kootenai Tribe and their agency partners will pursue one or more dedicated revenue sources to serve as cornerstones of the funding strategy and the largest contributors to funding needs;
- Conventional funding sources, including competitive grants and landowner incentives, will be sought to address specific restoration needs;
- All funding sources will be focused on addressing the goals, objectives, and restoration strategies identified in this Master Plan through specific project actions that will be identified and prioritized in the next phases of the project; and
- The Kootenai Tribe in coordination with their agency partners will ensure that capacity is in place to efficiently design, construct, and maintain projects so that initial funding is used effectively.

It is important to note that the federal agencies, while supportive of the project, are prohibited from lobbying Congress. Towards this end the Tribe, co-managers, stakeholders, and other project supporters will play a central role in educating and informing key constituents and potential funders about the project.

The next sections identify potential funding sources and provide a preliminary analysis of the appropriateness of the funding source to the project, as well as identifying specific challenges or opportunities associated with each potential funding source.

8.3 Large-Scale Dedicated Funding Sources

The cornerstone of the recommended funding strategy is securing at least one very substantial funding source that is adequate to fund a major portion of the restoration program. The following sections describe potential large-scale dedicated funding sources.

8.3.1 Water Resources Development Act

The Water Resources Development Act (WRDA) is a bill that is periodically approved by the U.S. Congress that authorizes a wide variety of flood control, water supply, and restoration projects throughout the country. It is the principal mechanism for authorizing large-scale restoration projects under the U.S. Army Corps of Engineers (USACE) restoration authorities.

Typically, WRDA authorizations follow the template of standard USACE projects, with major reconnaissance and feasibility studies that precede construction funding and substantial cost-sharing requirements; however, it is also possible to customize the authorization to secure more flexible terms.

WRDA bills have been infrequent in recent years and it can be difficult to garner the administrative and Congressional support needed to enact a new project-specific authority. In addition, the authorization must be followed by appropriations to the project and there is currently a significant backlog of authorized but under-funded projects nationwide. WRDA 2007 was five years overdue and authorized over 900 water resources projects at a cost of about $23 billion.

WRDA is one of the few options for a targeted source of funding that is large enough to fund most or all of the Kootenai River Habitat Restoration Project. Pursuing WRDA would be contingent on strong support from the Idaho and Montana Congressional delegations.

Timeline: WRDA bills are theoretically compiled and passed every two years.

8.3.2 Northwest Power and Conservation Council's Fish and Wildlife Program

The NPCC's Fish and Wildlife Program is intended to mitigate the impact of Columbia Basin hydropower dams on all fish and wildlife species of the basin. The Council makes recommendations on the investment of BPA hydropower revenues to a wide variety of fish and wildlife projects, including habitat acquisition and restoration, studies, monitoring, and public education. Projects are solicited in annual grant rounds, reviewed by a panel of independent scientists, and proposed to BPA for funding.

The Fish and Wildlife program is funded at approximately $130 million per year, with roughly 30 percent or $35 to $40 million per year spent on habitat projects. The Kootenai Tribe of Idaho has been successful at securing $3 to $5 million per year for fish and wildlife mitigation projects from the program. Collectively, all project sponsors in the Kootenai subbasin have secured $46.3 million (an average of $6.6 million annually) between FY 2001 and 2008 for fish and wildlife projects.

The continuation of annual Fish and Wildlife Program grants to the Kootenai River Habitat Restoration Project is addressed later in this paper. There may be potential to increase the BPA funding commitment beyond the annual grant process. There are strong arguments for a larger-than-average federal role in the recovery process, including the strong correlation between Libby Dam operations and sturgeon declines and the recent settlement of a third-party lawsuit that commits the USACE and BPA to support the restoration effort. If there is willingness to consider a larger BPA commitment, a memorandum of agreement may be the appropriate avenue.

Recently, BPA, USACE, and the Bureau of Reclamation have entered into five separate memoranda of agreement (MOA) in 2008 as a result of court-ordered collaborative processes referred to as the Fish Accords. These agreements address fish affected by federal dams of the Federal Columbia River Power System and will result in numerous new projects and dedicated funding for certain on-going projects (such as watershed restoration programs) throughout the Columbia River Basin for the next 10 years. Annual funding commitments for tribal MOA participants are between $15 and $19 million (not including hatchery capital commitments or inflation adjustments). BPA and the Kootenai Tribe discussed the Tribe's participation in Accords as they were being negotiated, at that time the Tribe elected to not enter into an Accord. Development of a new Accord or similar agreement may still be a possibility.

With or without development of a Fish Accord, BPA funding at an enhanced level may require an adjustment to rates through BPA's normal rate-setting process. A rate case is a biennial process

to adjust power and transmission rates for BPA customers. Through the rate case, BPA develops a proposal for rates that is reviewed by customers and other parties through a formal hearing process, which concludes with the BPA Administrator issuing a Record of Decision and filing the new rates with the Federal Energy Regulatory Commission for final approval. In addition to the standard process, there is an opportunity to revisit rates between formal rate cases in special circumstances.

Timeline: A MOA between BPA and the Kootenai Tribe could be negotiated at any time, pending willingness of both parties to enter into such and agreement. If an adjustment of rates is needed, BPA will issue a federal register notice in the summer of 2010 to allow interested stakeholder groups the option to participate in the FY 2012-2013 rate case.

8.3.3 Economic Stimulus Funding

In 2009, the incoming Obama administration and Congress pursued and passed a major economic stimulus package to address the U.S. economic recession. The resulting American Recovery and Reinvestment Act of 2009 was passed by Congress on Feb. 13, 2009 and signed into law by President Obama on February 17, 2009. The final version is estimated by the Congressional Budget Office to cost $787 billion over the 2009-2019 time frame.

The American Recovery and Reinvestment Act of 2009 was designed to provide additional funding for job preservation and creation, infrastructure investment, energy efficiency and science, assistance to the unemployed, and State and local fiscal stabilization, for the fiscal year ending September 30, 2009, and for other purposes.

Part of that stimulus package included an emphasis on green investments, projects and programs to restore the environment, promote alternative energy sources, and reduce reliance on foreign oil. Substantial stimulus funds have been identified for environmental restoration actions including watershed restoration as part of the American Recovery and Reinvestment Act of 2009.

Environmental restoration stands out as a stimulus option even among green investments. Efforts like the Kootenai River Restoration Project have been shown to be unusually effective at creating jobs, supporting local producers and suppliers of goods and services, and pumping money into local economies quickly and efficiently. Moreover, they are effective at stimulating economies in rural areas that have lagged in employment and wages and are likely to be hardest hit in a downturn.

The 2009 stimulus package specifically sought out "shovel ready" projects; unfortunately, the Kootenai River Habitat Restoration Project was still in the conceptual planning stage in 2008-2009. The Obama administration has discussed the possibility of additional stimulus funding in 2010 depending on the scale and speed of U.S. economic recovery. Congressional support for additional stimulus funding would also be required and at the time this Master Plan was being completed, it is not clear whether there will be adequate support to pass an additional stimulus package. The Kootenai Tribe will continue to track availability of future funding opportunities associated with economic recovery.

Timeline: Although the Kootenai River Habitat Restoration Project did not have any "shovel-ready" components identified in time to secure funding from the American Recovery and

Reinvestment Act of 2009, depending on the scale and speed of economic recovery, there may be opportunities to secure additional stimulus funding in 2010 or beyond.

8.3.4 Appropriations Request

Significant amounts of appropriations are annually provided by Congress on a discretionary basis throughout the United States for various purposes. The Kootenai Tribe has discussed the possibility of receiving such an appropriation with the Idaho and Montana Congressional Delegation recognizing the project helps satisfy ESA, Treaty and Tribal Trust and other federal requirements, as well as the numerous benefits the project offers to Idaho and Montana constituents. Strong Idaho, Montana and Northwest Congressional support for an appropriation will be essential. The Kootenai Tribe and co-managers and stakeholders will continue to work with Congress to identify options.

Timeline: An appropriations request must be completed no later than January 2010 for FY 2011.

8.4 Competitive Grants

Recognizing that securing a single large source to fund the restoration program is likely to be challenging, an annual fundraising program focused on promising grant, loan, and incentive programs may offer more promise in the short run. In a preliminary analysis, the following sources seemed to provide the most promising opportunities.

8.4.1 Potential Sources of Larger Awards

The following sections present potential sources of larger competitive grant awards (i.e., $1 million or more).

8.4.1.1 Northwest Power and Conservation Council Fish and Wildlife Program

As previously indicated, the NPCC's Fish and Wildlife Program is an excellent source of annual funding for fish and wildlife mitigation projects and has been used to great effect by the Kootenai Tribe of Idaho to date. This is an obvious choice for continued annual fundraising efforts.

Timeline: At the time this document was being finalized, the NPCC had not identified a specific timeframe or specific process for the next Fish and Wildlife Program project solicitation. The Tribe anticipates that new projects in the Kootenai region will likely be reviewed in early 2010 for funding in FY 2010 and future years.

8.4.1.2 U.S. Fish and Wildlife Service Cooperative Endangered Species Fund

This funding source is authorized by Section 6 of the Endangered Species Act (ESA) and provides funding for habitat conservation planning and land acquisition to benefit federally listed species. Section 6 of the Endangered Species Act provides grants to states and territories to support participation in a wide array of conservation projects for threatened and endangered species, as well as for species that are either candidates or have been proposed for listing.

This program provides three types of grants:

- Recovery Land Acquisition Grants – These grants provide funds to states and territories for acquisition of threatened and endangered species habitat in support of approved and draft species recovery plans. Acquiring habitat in order to secure long-term protection is often the critical element in a comprehensive recovery effort for a listed species.

- Habitat Conservation Planning Assistance Grants – This category provides funds to states and territories to support the development of Habitat Conservation Plans (HCPs).

- HCP Land Acquisition Grants – These grants provide funds to states and territories to acquire land associated with approved HCPs. They do not fund mitigation required of an HCP permittee, but rather, support acquisitions by the state or local governments of habitat that complement actions associated with the HCP.

For the first time, for fiscal year 2010, the USFWS will also be incorporating aspects of climate change when evaluating the proposals submitted through the Cooperative Endangered Species Conservation Fund.

Awards of several million dollars are possible, although the majority of awards are in the $100,000 to $700,000 range. A grant of $1.5 million was provided to The Nature Conservancy in 2008 for conservation easement acquisition in the Kootenai Valley. The majority of program funding is provided through a national competition and the program is moderately competitive.

Timeline: Proposals for 2010 are due by August 19, 2009. The Proposal deadline for 2011 has not been identified at this time.

8.4.1.3 Environmental Protection Agency Targeted Watersheds Grants Program

This is a fairly new program and has just completed its fourth annual grant round, in which it allocated $16 million to watershed-specific restoration programs across the United States.

Established in 2003, the Targeted Watersheds Grant program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's watersheds.

Individual grants for the latest round are for a maximum of $900,000 and require a 25% match. The program is unusually flexible in eligible activities and has been widely used for watershed restoration strategies. Funding for continuation of the program is contingent on annual appropriations. Projects are reviewed and ranked at the regional and national level, and the program as a whole is moderately competitive.

Timeline: Submissions are typically due in September. At the time this document was being completed, eligible geographic areas had not been selected for 2009 submissions.

8.4.1.4 USFWS North American Wetlands Conservation Act Grants

This program provides grants to organizations and individuals to preserve and restore wetlands and associated upland areas. The North American Wetlands Conservation Act (Act, or NAWCA) of 1989 provides matching grants to organizations and individuals who have developed

partnerships to carry out wetlands conservation projects in the United States, Canada, and Mexico for the benefit of wetlands-associated migratory birds and other wildlife.

There is a Standard and a Small Grants Program:

- The Standard Grants Program – Supports projects in Canada, the United States, and Mexico that involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats.
- The Small Grants Program – Operates only in the United States; it supports the same type of projects and adheres to the same selection criteria and administrative guidelines as the U.S. Standard Grants Program.

Grants in the standard program often exceed $1 million, while the small grants program is capped at $75,000. A dollar-for-dollar match is required. Funds from U.S. Federal sources may contribute towards a project, but are not eligible as match. Projects are subject to a complex review process, including reviews by a "joint venture" board and a national review. The program is moderately competitive.

Timeline: There are two standard grant deadlines typically in early March and August.

8.4.1.5 U.S. Army Corps of Engineers Section 1135 Program

This program permits the USACE to cost-share restoration projects in areas degraded by the construction or operations of USACE projects. Specifically, under the authority provided by Section 1135 of the Water Resources Development Act of 1986, the USACE may plan, design and build modifications to existing USACE projects, or areas degraded by USACE projects, to restore aquatic habitats for fish and wildlife.

Individual projects may cost up to $5 million in federal share and a non-federal cost share of 25% of construction costs is required. The Kootenai River Habitat Restoration Project would be eligible for funding under this program by virtue of the impacts of the operations of Libby Dam, a USACE facility. Two Kootenai River projects were recently awarded funding under this program. The program is highly competitive.

Timeline: No specific timeline for the application. Initiation of projects will typically require an earmark of funding in the federal Energy and Water budget bill that is considered annually by Congress between January and April.

8.4.2 Potential Sources of Smaller Awards

The following sections describe potential funding sources for smaller awards (i.e., less than $1 million).

8.4.2.1 U.S. Fish and Wildlife Service National Fish Passage Program

This program provides financial and technical assistance to remove or bypass artificial barriers that are impeding the movement of fish and contributing to their decline. The range of projects funded has included large-scale dam removals to simple culvert repair. This program could be an annual source of small funding streams (generally less than $100,000). Projects are reviewed and

prioritized on a Regional basis and typically require a 50% match, although there is some flexibility. The program is moderately competitive.

Timeline: Proposals must be submitted to the local Fish and Wildlife Management Office by August of each year.

8.4.2.2 U.S. Fish and Wildlife Service Tribal Wildlife Grant Program

Tribal Wildlife Grants are used to provide technical and financial assistance to Tribes for the development and implementation of programs that benefit fish and wildlife resources and their habitat. This is an annual funding source and the maximum award for any one project under this program is $200,000. Recipients are selected through a nationally competitive process. Proposals are evaluated according to resource benefit, performance measures, work plan, budget, capacity building and their partnerships and contributions.

Timeline: Proposals are typically due by the beginning of September.

8.4.2.3 State Revolving Fund

State Clean Water Revolving Funds, authorized under the Clean Water Act, provide financial assistance for water quality projects including wastewater treatment, non-point source water quality management, watershed protection or restoration, and estuary management projects. Assistance can include instruments such as loans, refinancing, and debt guarantees.

In the past several years, the EPA has encouraged states to increase funding for non-point source pollution, habitat restoration and estuary projects. Fundable projects in 2006 ranged from $150,000 for planning to $15,000,000 for constructing infrastructure.

8.5 Other Potential Funding Sources

The following sections identify a number of other potential funding sources. As the planning for the project progresses into the preliminary design phase, the Tribe will continue to investigate other potential funding sources as well as cost-sharing opportunities.

8.5.1 Natural Resource Conservation Service Farm Bill Conservation Incentive Programs

Large segments of the Kootenai River are bordered by private land in farm and residential uses. Landowner incentives will rarely be sufficient to support major restoration projects, but they can encourage voluntary conservation action on private land that can complement the larger projects.

The Farm Bill suite of programs is provided through the Natural Resource Conservation Service (NRCS) to private farmers to promote conservation projects on their property. The programs include the Environmental Quality Incentives Program (EQIP), the Conservation Reserve Program (CRP), the Wildlife Habitat Incentives Program (WHIP), and several others. Many provide land rental and cost sharing for conservation practices under multi-year contracts with the landowner. In addition, the Conservation Innovation Grants (CIG) awards grants to landowners for innovative conservation projects.

The farm bill programs vary in competitiveness, with grant programs far more competitive than rental and cost-sharing programs. NRCS Farm Bill programs include:

- Wetlands Reserve Program (WRP) – Seeks to protect, restore, and enhance wetlands on private land. Agreements can be 10-year restoration cost share, 30-year conservation easements, or permanent conservation easements.
- Environmental Quality Incentives Program (EQIP) – Emphasizes that agricultural production and environmental quality are compatible. EQIP provides incentives to landowners that implement conservation practices on their land, including wildlife habitat management.
- Wildlife Habitat Incentives Program – Provides landowners with technical and financial assistance to protect and enhance wildlife habitat.
- Conservation Security Program (CSP) – Rewards good stewardship on private land. In 2006, CSP in Idaho focused on the Clearwater and Lower Bear River-Malad watersheds.
- Conservation Innovative Grants – Development and adoption of innovative conservation technologies.
- Grassland Reserve Program (GRP) – Protects, enhances, and restores grassland, rangeland, pastureland, and shrubland on private lands.
- Conservation Reserve Program (CRP) – CRP provides annual rental payments to landowners that practice soil conservation, primarily through conversion of highly erodible lands to resource-conserving vegetative covers, such as native vegetation.

Timeline: Applications for rental and cost-sharing programs can be submitted on an on-going basis. Conservation Innovation Grant applications are typically due in mid-February.

8.5.2 Mitigation/Conservation Banking

Public works agencies and private developers are increasingly looking at off-site restoration options to mitigate for environmental impacts of their construction projects, and a variety of mitigation banking programs and other mitigation alternatives have been created across the United States to meet these needs. The Idaho Statewide Transportation Improvement Program (STIP) identifies several state highway projects in the vicinity and there may be other development activity that could contribute funding to a restoration project in the Kootenai corridor. This would be pursued through consultation with the project managers of the relevant projects.

Timeline: Varies by project. Mitigation requirements are generally established one to two years after project initiation on larger highway projects.

8.6 Summary

The Kootenai Tribe believes securing funding for the Kootenai River Habitat Restoration Project will require a concerted effort focused jointly on the large dedicated source or sources and on maintaining and broadening the annual fundraising effort focused on competitive grant sources.

An annual grant-seeking effort focused on $8 to 10 million in revenue, the maximum that could be expected from this approach, is a considerable undertaking and is likely to require the services of dedicated staff. Experienced fundraisers suggest that a dedicated fundraising staff is likely to be far more successful than distribution of fundraising responsibilities among stakeholders.

One of the immediate priorities of the next phase of the Kootenai River Habitat Restoration Project will be to secure the necessary resources and cooperation to further develop, refine, and implement a suitable funding strategy for this important project.

The Tribe looks forward to working with agency partners, co-managers, and interested stakeholders to identify and secure the funding and cost-share opportunities necessary to successfully implement ecosystem-based habitat restoration actions in the Kootenai River.

9 Next Steps

Chapter 9 provides an overview of the planned next steps for the Kootenai River Habitat Restoration Project. This chapter presents a summary of the general tasks scheduled for the upcoming phases of this project including: interim planning actions, environmental compliance, work associated with the preliminary and final design phases, funding, and project implementation. The Kootenai Tribe will be identifying specific timelines and milestones for the next phases of this project (i.e., implementation of the conceptual framework identified in this Master Plan) within 90 days of release of this document.

9.1 Overview

The development of this Master Plan has provided a valuable learning opportunity for the Kootenai Tribe, the Tribe's consultants, and the agency and technical experts who have participated in various aspects of the project. Among many lessons learned through the planning process, participants have gained an enhanced appreciation for the complexity of ecosystems, the degree of interrelatedness and cumulative nature of limiting factors and their effects on habitats and species and a recognition of the pitfalls of attempting to identify single, one-stop "solutions" to "fix" such an intricately interconnected system.

While developing this Master Plan the Tribe with the help of their consultants collected, analyzed, and incorporated significant quantities of existing and new data; encouraged dialog with, and sought technical input from, regional co-managers (IDFG, MFWP, BCMoE), federal agency representatives (USFWS, USACE, BPA, USGS), and other technical experts representing a range of relevant disciplines. As mentioned in Chapter 1, the Tribe also conducted two separate internal technical reviews of iterative drafts of the Master Plan.[1] As a result of input gleaned through this iterative collaborative process, the overall approach to this project has evolved significantly since work on this Master Plan began. In particular, input gathered through the internal technical reviews of the two draft Master Plans influenced the content, organization, and overall approach to presenting the conceptual framework identified in this document.

As explained in Chapter 1 and articulated throughout this document, the Kootenai Tribe is committed to an ecosystem restoration approach to this project. This approach acknowledges that ecosystems are dynamic and therefore restoration planning must accommodate a range of possible and equally valid outcomes. Towards this end, this Master Plan presents a relatively flexible conceptual framework for designing and implementing the Kootenai River Habitat Restoration Project that is supported by a robust adaptive management and monitoring program during the project's design and implementation phases.

[1] Internal reviewers were selected by the Kootenai Tribe and represented a range of disciplines and entities including co-managers and agencies, independent experts in river restoration, hydraulics, engineering, geomorphology, fish biology, and sediment-transport.

Likewise, the next steps identified in this chapter are intended to support a necessary degree of flexibility and adaptation in the subsequent phases of project design and implementation, while also laying the groundwork for timely on-the-ground implementation of habitat restoration activities.

The next steps outlined in this chapter are presented in the context of the following categories:

- Project management, coordination and outreach;
- Data collection and analysis;
- Environmental compliance and permitting;
- Preliminary and final design;
- Funding analysis and strategy; and
- Implementation.

Figure 9-1 provides a visual summary of the upcoming phases of the Kootenai River Habitat Restoration Project and major tasks associated with each project phase. The following sections of this chapter provide additional examples of specific next steps for each of the categories identified above.

To simplify communication, Figure 9-1 on the following page presents a very linear approach to planning and design development with a clear progression from conceptual to preliminary to final design. While this is consistent with the Tribe's overall approach to project planning and implementation for the Kootenai River Habitat Restoration Project, it is important to note that in some instances design and possibly implementation (pending completion of necessary environmental compliance and permitting) of specific restoration project components may proceed ahead of other project components.

Conceptual Design Phase (Master Plan)	Interim Planning Phase	Preliminary Design Phase (~60% Design)	Final Design Phase (~100% Design)	Implementation Phase
Conduct initial data collection and analysis. Develop Master Plan that presents conceptual design framework including a toolbox of restoration treatments, habitat actions, and implementation scenarios; an adaptive management framework; conceptual cost estimates; and a funding analysis.	Identify critical milestones and target dates for preliminary design, final design, and implementation phases of the project within 90 days of release of Master Plan. In coordination with agency partners, co-managers and regional stakeholders, identify specific restoration actions and that will be prioritized for immediate "phase 1" design and implementation. Identify process and timeline for identifying and prioritizing subsequent phased actions (e.g., "phase 2" and "phase 3" actions). Identify and convene expanded design team and adaptive management team. Finalize work plan for additional targeted data collection and analysis and begin collecting time-sensitive (or seasonal) data. Conduct outreach briefings on Master Plan content.	Continue targeted data collection and analysis. Initiate NEPA process and prepare Draft EIS on initial phase 1 restoration actions. Initiate discussions infrastructure owners. Identify and prioritize next phases of restoration actions. Refine individual restoration treatments, implementation scenarios, and identify sequencing approach. Produce preliminary design document(s), 60 % design drawings, preliminary implementation schedule and refine cost estimates. May also include 100% design of some discrete project components. Technical peer review of preliminary designs; co-manager and agency review of preliminary designs; and value engineering of preliminary designs. Develop permit support document(s) based on preliminary design (s). Refine project measurable objectives, monitoring metrics and success criteria. Refine adaptive management and monitoring program. Conduct targeted community and one-on-one landowner outreach.	Conduct additional targeted data collection and analysis necessary to finalize designs. Collect baseline-monitoring data. Refine objectives, monitoring metrics and success criteria. Prepare landowner and infrastructure agreements. Complete design documents and 100% design drawings for areas or reaches selected for restoration work. Refine implementation schedule. Refine detailed costs for selected restoration designs. Complete the Final EIS. Conduct permitting processes for initial implementation package. Continue targeted community and landowner outreach.	Beginning in 2012 initiate sequenced implementation (construction) of restoration design. Implement adaptive management and monitoring program. As appropriate, refine and modify specific restoration designs that are sequenced for later implementation based on input from adaptive management program. Complete any required additional environmental compliance and permitting. Continue targeted community and landowner outreach.

Figure 9-1. Kootenai River Habitat Restoration Project phases and major associated tasks.

9.2 Project Management, Coordination and Outreach

All phases of the project's next steps will include project management, coordination and outreach tasks. The following sections provide additional detail about specific activities.

9.2.1 Project Management and Planning

Project management and planning activities will include ongoing project planning and oversight; development of a project plan that addresses schedule, scope, cost, and risk; development and implementation of procurement strategies; and related planning activities. Examples of specific tasks include the following.

Interim, Preliminary and Final Design Phases

- Develop project plan (e.g., scope, schedule, budget) for preliminary, final and implementation phases. Develop procurement strategies for design and implementation based on the Master Plan.
- Identify expertise needed for expanded design team (i.e., broader expertise than was required for completion of the Master Plan). Identify and develop project design team for the preliminary and final design phases.
- Identify and confirm project various technical and policy committee roles and membership (e.g., Kootenai Habitat Policy Team, interdisciplinary adaptive management and monitoring team, co-manager/agency technical committee, funding committee).
- Coordinate with federal agencies to identify and confirm NEPA approach, identify cooperating agencies, confirm timeline, and initiate appropriate activities.
- Within 90 days of release of this Master Plan the Kootenai Tribe will identify specific targets and milestones for next phases of the project.
- Develop prioritization process to identify and build agreement around immediate and longer-term restoration actions.
- In preliminary and final design phases, implement project plan developed in interim planning phase (i.e., critical milestones, budget, scope, and risk management). Update and implement procurement strategies.

9.2.2 Coordination and Outreach

During the interim, preliminary and final design phases the Tribe will continue to actively coordinate with project technical and policy committees, regional co-managers, agencies, individual landowners and the local community at large. Examples of specific activities include the following.

Interim Planning Phase

- Convene meeting(s) with federal agency partners, co-managers and stakeholders to discuss, identify, and prioritize immediate short-term restoration priorities and associated habitat restoration actions.

- Convene meeting with Kootenai Habitat Policy Team to discuss and gain additional input on selection of immediate short-term restoration priorities and associated action and next steps.
- Coordinate a meeting or workshop to identify restoration priorities beyond the immediate short-term restoration priorities. Potential approaches include convening a formal expert elicitation process or less formal model designed to address risk and uncertainty. Participants would likely include a combination of local and outside expertise.

Preliminary and Final Design Phases

- Convene meetings with the Kootenai Habitat Policy Team to provide project updates; support timely implementation of project; and identify and resolve critical issues related to funding, policy questions, agency coordination, implementation, etc.
- Convene meetings with co-managers, agency technical representatives, and independent technical advisors at specific design milestones, in order to incorporate new and evolving scientific data and research into the project design, seek input and buy-in on the preliminary design of restoration treatments, implementation scenarios, project sequencing and other technical project components.
- Coordinate technical peer review(s) and value engineering review(s) of the preliminary designs.
- Convene the interdisciplinary adaptive management and monitoring team to refine (preliminary design phase) and finalize (final design phase) the project Adaptive Management and Monitoring program, refine some of the measurable objectives, and identify and confirm success criteria. This group will also have a continued role before, during, and after implementation.
- Conduct targeted outreach and coordination with individual landowners, infrastructure owners, and other stakeholders regarding specific components of proposed restoration scenarios.
- Conduct ongoing community outreach to keep local community apprised of project progress.
- Conduct ongoing coordination with NPCC and BPA regarding project deliverables and progress.

9.3 Data Collection and Analysis

Although a great deal of data has been collected, compiled and analyzed prior to and during the conceptual design phase, some additional targeted data collection and analysis will be required during the preliminary and final design phases in order to address data gaps, confirm technical feasibility of some proposed actions, provide baseline information for the NEPA analysis, and refine the restoration treatments and implementation scenarios.

Examples of data collection, analysis and validation activities that will occur during the interim, preliminary and final design phases include the following.

Interim and Preliminary Design Phases

- Produce data and information management plan to ensure timely collection of critical data.
- Collect and process suspended-sediment and bedload samples in select project reaches in order to improve estimates of sediment supply within the project area and support the design of sediment storage areas on the floodplain. Update sediment rating curve for the Kootenai River using 2009 sediment data and update particle size data.
- Install and retrieve scour chains in the Braided Reaches in order to quantify and understand the magnitude of seasonal scour and fill processes and the sizes of particles entrained and deposited.
- Ongoing data collection and data processing necessary to monitor changes in the channel geometry will include:
    - Establish three new riverbank erosion stations in braided reach, monitor bank erosion at all 24 stations during low flow after the winter Libby Dam load shaping and late summer-early fall after the spring-early summer high flow
    - Monitor erosion and deposition during the December load shaping on the descending limb of the spring freshet and on the descending limb of the sturgeon pulse
    - Collect multibeam bathymetry over entire braided reach channel
    - Survey the elevation of the river banks in the lower canyon reach
    - Measure velocity in the braided reach at approximately six cross-sections to validate the surface-water model.
- Continue to monitor river stage on 15 minute intervals at six stations established in 2006, 2007, and 2008 to support calibration of hydraulic and sediment models.
- Complete construction and validation of multidimensional hydraulic model of existing conditions including multichannel bathymetry of select project reaches.
- Field validate LiDAR data using survey-grade GPS.
- Obtain resource-grade true color aerial photography flown during early July 2009.
- Conduct riparian boundary research and land surveys to determine implications of channel relocation projects on landowners.
- Field survey bankfull indicators for use in developing elevation criteria for floodplain construction.
- Complete preliminary field reconnaissance of tributary habitat and fish passage barriers.
- Compile comprehensive inventory of utilities and infrastructure in the project area
- Initiate discussions with infrastructure owners including bridges.

- Review other completed or ongoing restoration projects that are addressing similar limiting factors or are being implemented in river systems with similar scale and geomorphology.
- Ensure that most current spatial data is obtained for use in suitability analyses as analyses are refined.
- Collect data on channel morphology, vegetation and aquatic habitat from appropriate reference reaches in order to support development of channel dimensions, habitat structures and revegetation designs.
- Analyze Kootenay Lake backwater with regard to specific time periods in order to evaluate effects of controls such as Grohman Narrows, Corra Linn Dam and Libby Dam.
- Collect and analyze information about water management in diking districts, wildlife refuges and other conservation lands within the project area
- Install groundwater monitoring wells and develop a groundwater map within the Meander Reach to refine floodplain restoration suitability analysis and provide additional information about feasibility related to floodplain restoration.
- Integrate with Kootenai Tribe's Operational Loss Assessment project in to utilize and contribute to that project's planning and assessment tools to further refine limiting factors analysis in the Master Plan.
- Complete weed mapping throughout the project area, including aquatic invasive plant species.
- Incorporate additional data from B.C. portion of the Kootenai subbasin so the restoration effort is compatible with management and restoration objectives in Meander Reach 3.
- Design and implement a data management system to support the adaptive management and monitoring program that is flexible enough to incorporate data from related monitoring and evaluation programs.
- Collect baseline information on other potentially affected environmental and social resources, including cultural, recreation and wildlife resources.

Final Design Phase

- Continue specific targeted data collection, analysis and modeling as necessary to further refine designs.
- Complete construction and validation of multidimensional hydraulic and sediment model of design conditions to evaluate design performance and flood elevations.
- Conduct flume studies to evaluate performance of channel reconstruction design.
- Establish baseline-monitoring data for project.

Although no new research is proposed as part of this project, there are a number of ongoing research projects related to sturgeon habitat, spawning analog sites, and early life stage behavior that will be partially or fully complete within the preliminary and final design phase time frames. The USGS National Research Program is also developing a model for the downstream dispersal of Kootenai sturgeon early life stages as part of this project. As the design process

progresses, relevant new research findings and modeling results will also be incorporated into the design process when possible.

9.4 Environmental Compliance and Permitting

As noted in Chapter 6, the approach to environmental compliance and permitting will be critical to timely execution of project implementation, maintaining implementation flexibility, and to the ability of the Kootenai Tribe to initiate project construction in 2012. As previously noted, following release of this Master Plan, the Tribe in coordination with agency partners, co-managers and stakeholders will identify immediate implementation priorities and associated actions. This first phase project or combination of projects will proceed to preliminary design and will be analyzed through the NEPA process when design has progressed sufficiently to identify the scope of environmental effects. Following are examples of likely activities associated with environmental compliance and permitting in the interim planning, and preliminary and final design activities.

Interim Planning Phase

- Confirm NEPA approach with BPA, the lead agency.
- Identify NEPA contractor(s).
- Collect remaining environmental baseline information.

Preliminary Design Phase

- Prepare Draft EIS when preliminary design is sufficiently advanced.
- and identify permitting and consultation requirements.

Final Design Phase

- Complete Final EIS.
- Develop permit support document and conduct permitting and consultation activities.

9.5 Preliminary and Final Design

Work accomplished over the course of the preliminary and final design phases will 1) refine details of the proposed restoration treatments; 2) identify the specific reaches and floodplain areas where restoration work will occur; 3) confirm the technical, social, and cost feasibility of specific restoration scenarios; 4) identify specific proposed implementation scenario(s); 5) refine project objectives, monitoring metrics and success criteria; 6) refine cost estimates; and 7) identify the project implementation sequencing schedule; and produce construction drawings.

9.5.1 Preliminary Design

The preliminary design phase will continue to evaluate project feasibility through a series of documents that address data gaps, summarize data collection and analysis efforts, and identify the specific reaches and floodplain areas where restoration work will occur. At a 60% design

level, the preliminary design drawings may include a range of potential implementation scenarios that could be carried forward for further analysis and refinement in the final design phase. Activities associated with preliminary design include:

- Select river reaches and floodplain areas where restoration work will occur.
- Based on reaches and floodplain areas selected for restoration work, identify landowners and entities that will need to be contacted and coordinated with. Develop a schedule for coordination (see also Section 9.2.2).
- Based on additional data and analysis, outreach to landowners and other entities, and any new information regarding focal species habitat use or needs, identify and refine proposed implementation scenario(s) and associated specific restoration treatments.
- Identify preliminary approach to implementation sequencing.
- Produce preliminary design document(s) for potential proposed implementation scenario(s) at approximately 60% design. Note there may be variance in the level of design detail among some of the component pieces (i.e., restoration treatments) of the implementation scenarios based on availability of critical data and analysis at the preliminary design phase. Design/build expertise will be incorporated in development of preliminary designs. Components will include:
    - Design dimensions for channel and floodplain components;
    - Sediment-transport analysis;
    - Preliminary channel and floodplain grading plans;
    - Hydraulic modeling;
    - Identify areas of potential modification to existing bank armoring;
    - Preliminary design of bank and instream structures;
    - Vegetation cover type plan linked to geomorphic features;
    - Soil and substrate salvage, management and placement plan based on geomorphic features and target plant communities within each vegetation cover type;
    - Infrastructure mitigation and management plan;
    - Preliminary materials and equipment requirements to support development of a procurement plan;
    - Wetland construction and enhancement plans for discrete areas in the Meander Reach floodplain;
    - Meander Reach floodplain management analysis including current water management, groundwater, pumping effects, drainage system, land use, land ownership;
    - Aquatic and terrestrial noxious weed and invasive species management plan;
    - Site preparation and salvage plan for vegetation management; and
    - Preliminary adaptive management and monitoring plan.
- Refine cost estimates to higher level of confidence based on approximately 60% design.

- Initiate permitting and consultation activities as possible.
- Begin growing plant materials that will be needed for project implementation (2 to 3 year lead time).
- Identify sources for necessary materials including woody debris, cobble, bioengineering materials, and large rock and potential sites for stockpiling necessary materials.
- Begin site preparation and weed control activities to prepare some areas for revegetation.
- Identify any critical data gaps that will impact development of final design and identify mechanisms to address those data gaps.
- Continue development of data management system for the adaptive management and monitoring program.

In addition to the specific activities identified above, project management, coordination, data collection and analysis, and environmental compliance activities described in previous sections of this chapter will all feed into the development of preliminary design.

9.5.2 Final Design

The project final design will produce 100% design drawings. The final design will also include a supplemental document or series of documents that describe the design elements for each of the river reaches and floodplain areas based on the project sequencing plan.

Activities associated with final design will include:

- Complete final design and construction documents for selected implementation scenario(s).[2] Develop construction drawings including:
  - Channel and floodplain grading plans;
  - Plan, profile and cross-section sheets;
  - Structure details;
  - Survey control and staking notes;
  - Materials quantities and equipment requirements;
  - Construction specifications;
  - Project infrastructure plans; and
  - Planting plan.
- Completion of implementation sequencing schedule.
- Complete permitting and consultation activities.
- Complete detailed costs for selected implementation scenario(s) and associated restoration treatments.

[2] Assumes any environmental compliance required prior to developing final design and construction documents is completed.

- Develop construction management and QA/AC plan.
- Complete the adaptive management and monitoring plan.
- Develop restoration design-specific monitoring plan including monitoring protocols, metrics, sampling plan, and monitoring schedule (in coordination with the project's interdisciplinary adaptive management and monitoring team).
- Complete development of data management system that will store information necessary to support the project's Adaptive Management and Monitoring program.

In addition to the specific final design activities identified above, project planning and coordination activities, procurement, data collection and analysis, and environmental compliance activities described in previous sections of this chapter will all contribute to completion of the final design.

9.6 Funding Analysis and Strategy

The Kootenai Tribe developed a funding analysis as part of this Master Plan. In the preliminary and final design phases the Tribe will coordinate with agency partners to assist them in their efforts to develop and implement a funding strategy. It is important to note that the federal agencies, while supportive of the project and committed to taking action to implement it, are prohibited from lobbying the federal government. Towards this end, the Tribe and other project sponsors and/or supporters will play a central role in educating and informing key constituents and potential funders about the project. Examples of actions that will occur in the interim, preliminary and final phases include the following.

Interim Planning Phase

- The Tribe will continue coordinating with a funding development specialist to identify strategies for long- and short-term funding, and will continue to assist the Federal agencies in identifying and securing funding.[3]

Preliminary Design Phase

- Identify potential short- and long-term funding opportunities associated with the preliminary design.
- Include funding requests for components of project as part of NPCC Fish and Wildlife Program project solicitation for BPA funding.
- Pursue funding opportunities identified in Master Plan funding analysis (see Chapter 8).
- Work with agency partners to help them develop and refine a short- and long-term funding strategy for the project.

Final Design Phase

[3] Federal agencies are prohibited from lobbying Congress.

- Refine and finalize funding strategy based on final design, cost estimates and implementation sequencing schedule.
- Work with agency partners to help them implement funding strategy.
- Secure identified funding sources.

Implementation Phase

- Continue to secure additional funding sources as appropriate.
- Continue efforts to identify long-term funding for late sequenced project components.

9.7 Implementation

The Kootenai Tribe recognizes the urgency of implementing this project and seeks to balance sound, scientifically-based design, with an aggressive approach to address limiting factors. Towards this end, the Tribe will do everything in their power to initiate construction no later than 2012. Following are examples of activities that will be associated with project implementation:

- Initiate sequenced project implementation (construction activities) in 2012.
- Complete as-built monitoring and develop as-built report.
- Set up monitoring in field and collect necessary initial data (e.g., photo points) linked to as-built report.
- Implement monitoring and maintenance plan according to schedule.
- Review monitoring data and make adaptive management decisions based on effectiveness monitoring of an already-implemented project component.
- Review monitoring data and make adaptive management decisions regarding still to be implemented project components.

9.8 Summary

The Kootenai Tribe envisions the Kootenai River and its floodplain as a healthy ecosystem with clean, connected terrestrial and aquatic habitats that fully support traditional Tribal uses and other important societal uses. The Tribe has an ancient commitment to fulfilling and protecting this vision. The Tribe also recognizes that protection of the environment, including recovery of Kootenai River white sturgeon needs to occur within the context of a sustainable local community and economy.

The Kootenai River Habitat Restoration Project is a large and complex project. Successful design and implementation will require the ongoing cooperation and collaboration of a broad community of individuals and entities. Implementation of the conceptual framework presented in this Master Plan, in concert with implementation of the Tribe's aquaculture conservation plan, improvements to the Kootenai Tribe Sturgeon Hatchery, and complementary habitat projects will go a long way towards achieving this vision.

The Kootenai Tribe looks forward to working with the regional co-managers, agency, and community partners to implement this Kootenai River Habitat Restoration Project.

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