U.S. Army Corps
of Engineers
Seattle District

Shorty's Island / Meander Reach Ecosystem Restoration Kootenai River, Idaho

Draft Continuing Authorities Program Section 1135 Detailed Project Report and Integrated Environmental Assessment

June 2012

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Ecosystem Restoration
Kootenai River, Idaho

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EXECUTIVE SUMMARY

BACKGROUND

The United States Army Corps of Engineers (USACE) in partnership with Kootenai Tribe of Idaho (Kootenai Tribe) as the non-federal sponsor are participating in this Continuing Authorities Program Section (CAP) 1135 study to evaluate restoration of ecosystem function and habitat attributes for Kootenai River white sturgeon (KRWS) (*Acipenser transmontanus*).

This feasibility study was initiated to consider environmental-quality improvements related to the operation of Libby Dam. Altered flow regimes associated with-project operations have modified downstream hydrologic, hydraulic and sediment transport conditions which have impacted downstream habitat functions and attributes important to KRWS. Project operations have also altered natural sediment transport process and nutrient availability downstream. Addressing the limiting factors of KRWS early life stage survival through this authority is also an important component of meeting USACE's obligations under the Endangered Species Act (ESA) associated with the continued operation of Libby Dam.

In July 2009, the Kootenai Tribe published the *Kootenai River Habitat Restoration Project Master Plan* (Master Plan; Kootenai Tribe 2009) which provides a watershed-scale restoration framework for the Kootenai River and provides the context for this feasibility study to be consistent with broader ecosystem-level plans. The Master Plan has three identified purposes:

1. 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.

2. Restore and maintain Kootenai River habitat conditions that support all life stages (i.e., migration, occupancy, spawning, incubation, recruitment and early rearing) of endangered KRWS and other aquatic focal species.

3. 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.

The purpose of this Detailed Project Report/Integrated Environmental Assessment (DPR/EA) is to present the findings of the feasibility study for restoration of ecosystem functions and attributes in the Kootenai River downstream of Libby Dam for KRWS survival. Based on results of the feasibility study a tentatively recommended restoration plan (recommended plan) has been identified and is recommended for implementation to support KRWS recovery efforts. This report describes the recommended plan and documents the plan formulation process, engineering, economic and environmental analyses, cost estimate, and environmental compliance requirements related to the proposed restoration action.

The Kootenai River watershed and study reach for this feasibility study is shown in Figure ES-1. The study reach was selected based on known use of Meander Reach 1 by KRWS for spawning.

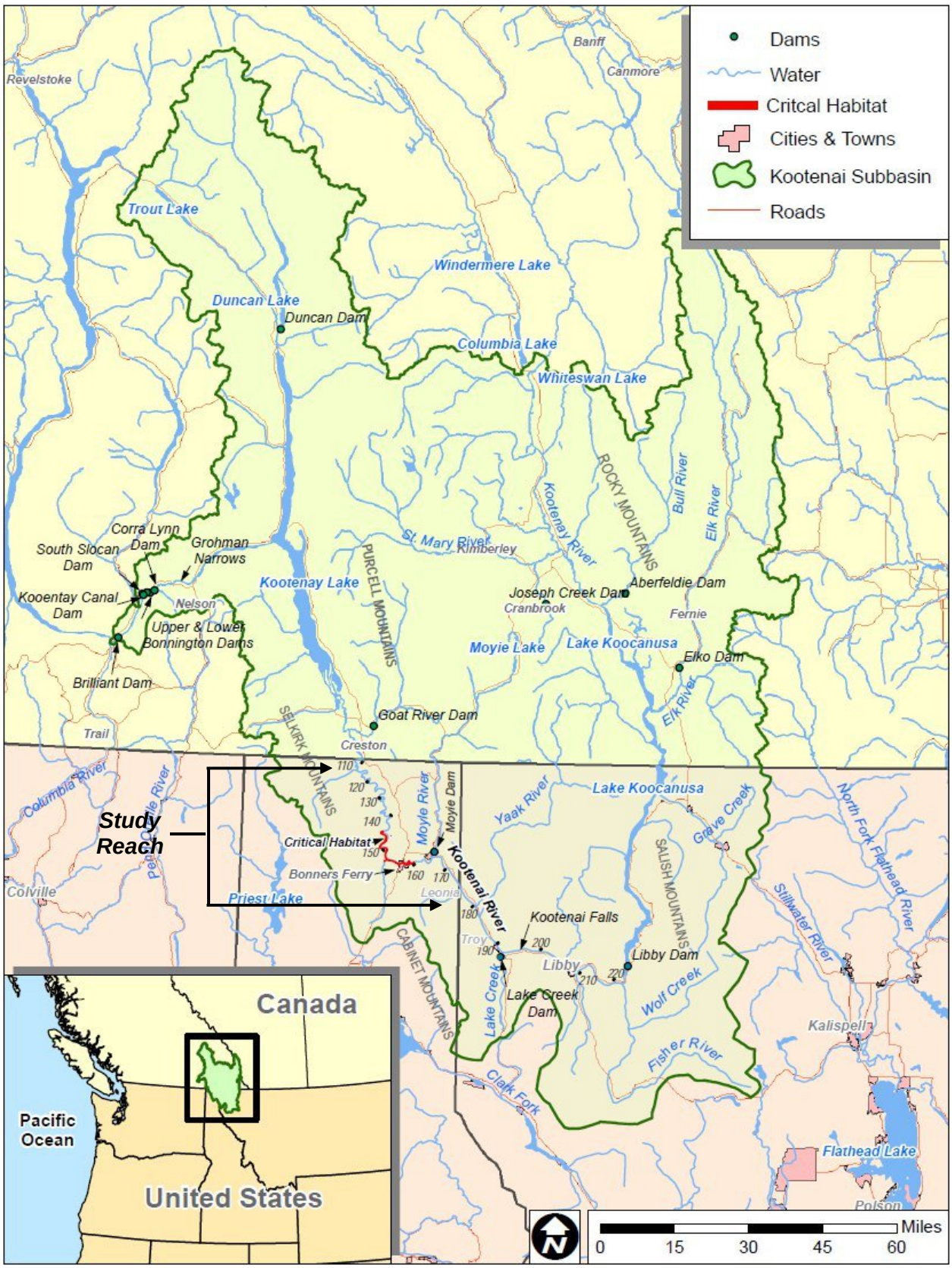

Figure ES-1. Kootenai River Watershed

PURPOSE AND NEED

The purpose of the Shorty's Island/Meander Reach Ecosystem Restoration Project is to identify and implement cost-effective, self-sustaining ecosystem restoration actions to improve ecosystem function and habitat attributes for the early life stage survival of the ESA-listed KRWS.

The first known bottleneck related to reproduction and survival of KRWS is the lack of suitable substrate for egg attachment, incubation, and embryo cover. Fish currently cue to spawn in an area where suitable habitat for egg attachment and early life state development is currently nonexistent or extremely limited. Improvement in suitable habitat of the Kootenai River for early life stage survival is critical to support recovery efforts for the continued survival of wild KRWS.

The need for this project is to provide suitable habitat for survival of the early life history stages for KRWS. Restoration of ecosystem function and habitat attributes is a critical component of KRWS conservation and recovery. The project will address the lack of suitable habitat for survival of the early life stages, which will contribute towards the recovery of a sustainable natural population of the species.

PLAN FORMULATION AND EVALUATION

Plan formulation, evaluation, and comparison in accordance with the established six-step planning process were completed for the study area under consideration. Restoration measures and alternatives were developed and evaluated in order to select a preferred plan that is complete, acceptable, efficient, and effective in accomplishing the project's purpose and objectives. Plan formulation and evaluation focused on measures that would best support early life stage survival in Meander Reach 1 where the vast majority of KRWS spawning has been documented. The measures centered on creating suitable substrate to support early life stages. Measures were further analyzed to ensure that they are sustainable and constructible. Sustainability was an important evaluation consideration identified during the planning process. Sustainable measures would help ensure that they would continue to function for their intended purpose over a period of time. Sustainability considerations included factors to help ensure that operation and maintenance requirements of restoration measures are minimized.

Five potential project sites in Meander Reach 1 were identified based on existing channel bed conditions and egg deposition density data. Once potential project sites were identified, an assessment of which measures could be applied to each site was conducted. This assessment included identification of potential lengths and widths of suitable substrate placement or improvement in order to incrementally develop and evaluate potential measures and alternatives. Scale-specific preliminary designs and costs were developed for each measure.

To quantify habitat benefits, a Habitat Evaluation Procedure (HEP) was applied and a KRWS Habitat Suitability Index (HSI) was developed. The HSI model used in the HEP included habitat variables that would provide the attributes necessary to continue to support successful KRWS spawning and improve survival of early life stages. These variables included substrate suitable to support both egg attachment and free-embryo development and suitable velocities and depths for spawning. For each measure, the effective area of created habitat was multiplied by the HSI score to arrive at habitat units for each measure and scale.

Based on the costs and outputs, a cost effectiveness and incremental cost analysis (CE/ICA) was conducted. The habitat units derived from the HEP were used in the CE/ICA to produce a comparison of the costs and habitat benefits. The initial analysis evaluated several scales of substrate placement at each site. This resulted in an array of site-based plans that were cost-effective and incrementally justified (referred to as "best buy" plans). Then, the site-based "best buys" were compared across all sites. The suite of possible combinations was then assessed for their acceptability, completeness, efficiency and

effectiveness. Based on this evaluation, and considering the importance of a contiguous minimum length of substrate placement, a tentatively recommended plan was identified. This plan includes placement of suitable substrate at two locations in Meander Reach 1.

Following identification of the recommended plan, feasibility-level design and costs were developed and environmental compliance documentation for the recommended plan was completed.

ADAPTIVE MANAGEMENT AND MONITORING

Risks and uncertainties related to the project—particularly those related to sustainability of substrate function for its intended purpose—have been considered throughout the plan formulation and project development process.

The Kootenai Tribe and BPA have emphasized their interests in designing and implementing the project to be being as maintenance free as possible. Multiple design considerations have been included in the recommended plan to promote sustainability and minimize anticipated maintenance. These considerations included designing the substrate placement to prevent mobilization, identifying substrate placement locations to minimize exposure to conditions that could result in deposition of sand, specifying a substrate gradation to promote egg attachment and free-embryo hiding, and the geometry of substrate placements to establish and maintain effective areas for early life stage survival on clay shelves and clay beds.

Some uncertainty related to the potential for sand deposition to occur and persist over the placed substrate and within the interstitial spaces of the suitable substrate continues to exist. One approach considered to address outstanding uncertainty, particularly related to interstitial spaces, is to implement a pilot project. Another approach and the approach recommended as part of the recommended plan is to incorporate an adaptive management approach that not only includes monitoring of substrate placement, but also includes specific provisions for identifying and performing various adaptive management actions.

The uncertainty related to the sustainability of the project must be weighed against the consequences of no action or other alternative approaches. The timeline to address the purpose and need for the project is critical. Additionally, restoration action in this reach has the highest certainty to address early life stage survival within the watershed because KRWS are currently spawning in the area.

Using an adaptive management approach allows for timely implementation of the project and the opportunity to make adjustments if warranted based on project monitoring. If sand deposition occurs on the substrate placements (although not anticipated) or the interstitial spaces are not sufficiently maintained to be free of fine sediment accumulation then intervention and additional adaptive management actions may be necessary to maintain a sufficient area of suitable substrate for KRWS spawning and free-embryo cover. Four possible approaches to this scenario have been outlined and could be pursued to maintain or modify the substrate.

RECOMMENDED PLAN

The recommended plan includes substrate placements at the Shorty's Island South and Myrtle Creek sites that will provide the physical attributes necessary to support wild KRWS early life stage survival and contribute to the recovery of a sustainable natural population of the species. Shorty's Island South placements are located in the main channel east of Shorty's Island between RM 143 and RM 143.5. The Myrtle Creek substrate placements are located approximately 1,000 feet downstream of the Myrtle Creek confluence with the Kootenai River at RM 145.5. Substrate placements at these two sites provide significant contiguous sections of suitable substrate, have acceptable total costs, and are cost effective. The project has been designed to be as sustainable as possible and there is a viable approach to address uncertainties. The recommended plan will create 3,351 new linear feet of suitable substrate and provide

288,040 square feet of effective area suitable for egg attachment and support KRWS early life stage survival within Meander Reach 1 of the lower Kootenai River. Using an adaptive management approach provides an opportunity to implement the project in a timely manner to meet the critical need for the project while also addressing uncertainty related to the sustainability of the recommended substrate placement at Shorty's Island South and Myrtle Creek.

The recommended plan is consistent with the more broadly based *Kootenai River Habitat Restoration Project Master Plan*, but is a stand-alone project which will contribute to KRWS recovery.

ENVIRONMENTAL COMPLIANCE

This DPR/EA serves as documentation for the National Environmental Policy Act (NEPA). This document describes existing environmental conditions in the study area; the proposed action and alternatives; potential environmental impacts of the proposed project; and measures to minimize environmental impacts. No significant adverse effects have been identified. A draft biological assessment (BA) has been prepared for the tentatively recommended plan and will be submitted to the resource agencies for review upon concurrence with the non-federal sponsor. The BA includes a preliminary finding that the plan may affect, and is likely to adversely affect, KRWS and bull trout during construction activities, but would have long-term benefits by providing coarse substrate to the system and would have no effects on the other listed species. KRWS and bull trout critical habitat may also be affected but is not likely to be adversely affected as a result of construction activities.

IMPLEMENTATION

Construction of the recommended plan is anticipated to take place over a two-year period with all in-water work scheduled to be completed during one season. The construction would require barging of the material to the placement locations. Barges would be delivered via truck and assembled onsite. The construction approach includes placing material using a barge-mounted crane. The shore infrastructure to support placement by barge includes a temporary dock/bulkhead, shoreline excavation for the dock/bulkhead, a conveyor for material, and access roads on the landward and riverside of the levee. Staging and access areas have been identified.

The total implementation costs for the project are estimated at $5,963,000. Total federal costs are $4,088,000 and non-federal costs are estimated at $1,874,000. Implementation costs include $223,351 for post project monitoring and $446,702 for adaptive management.

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List of Acronyms and Abbreviations

AAHU	average annual habitat unit
BA	Biological Assessment
BLM	United States Department of the Interior Bureau of Land Management
BMP	Best Management Practice
B.C.	British Columbia
BiOp	Biological Opinion
BPA	Bonneville Power Administration
BCMoE	British Columbia Ministry of Environment
CAP	Continuing Authorities Program
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CEQ	Council on Environmental Quality
cfs	cubic feet per second
CMP	corrugated metal pipe
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSKT	Confederated Salish and Kootenai Tribe of Idaho
dB	decibel(s)
dBA	decibel(s) measured on the A-scale of a sound meter
D_{50}	median substrate particle size
D_{90}	The size of material in a distribution of which 90 percent of the material by weight is finer than. Only 10 percent of the material in a distribution is larger than the $D_{90.}$
DPR	Detailed Project Report
DPS	Distinct Population Segment
EA	Environmental Assessment
ECPUE	egg catch per unit effort
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
FaSTMECH	Flow and Sediment Transport with Morphologic Evolution of Channels. A two-dimensional hydraulic and sediment transport model developed by the USGS, Nelson et al. (2003).
ft/s	feet per second
FCRPS	Federal Columbia River Power System
FFSBC	Freshwater Fish Society of British Columbia
FY	fiscal year
GPS	Geographical Positioning System

HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability Index
HTRW	Hazardous, Toxic, and Radioactive Waste
Hz	Hertz
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDL	Idaho Department of Labor
KRWS	Kootenai River white sturgeon
Kootenai Tribe	Kootenai Tribe of Idaho
LERRD	land, easements, relocation, rights-of-way, and disposal areas
LWD	large woody debris
MFWP	Montana Fish, Wildlife, and Parks
m/s	meters per second
mm	millimeter(s)
NAAQS	National Ambient Air Quality Standards
NAGPRA	Native American Graves Protection and Repatriation Act
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NRA	Natural Research Area
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
ODEQ	Oregon Department of Environmental Quality
OHW	ordinary high water
PCB	polychlorinated biphenyls
PCE	primary constituent element
PDT	Project Delivery Team
RK	river kilometer
RM	river mile
RPA	reasonable and prudent alternative
SARA	Canadian Species at Risk Act
SEL	sound exposure level
SI	Suitability Index

SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
U.S.	United States of America
USDA	United States Department of Agriculture
USFS	United States Department of Agriculture Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WRDA	Water Resources Development Act
WY	Water Year
USACE	United States Army Corps of Engineers
VARQ-FC	Variable Discharge Flood Control
YOY	young-of-the-year

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1 STUDY INFORMATION

The United States Army Corps of Engineers (USACE) in partnership with the Kootenai Tribe of Idaho (Kootenai Tribe) as the non-federal sponsor are participating in this Continuing Authorities Program Section (CAP) 1135 study to evaluate restoration of habitat and ecosystem function for Kootenai River white sturgeon (KRWS) (*Acipenser transmontanus*). This feasibility study was initiated in April 2010.

Restoration measures are proposed to support and improve egg attachment and early life stage (typically up to 21 days post-hatch) survival of KRWS. These measures have been designed to specifically address environmental requirements of early life stages and help avert the possibility of near-term extinction of KRWS. Environmental and habitat requirements to support early life stages have been identified as the primary bottleneck (i.e., limiting factor) for the natural reproduction and survival of the species.

1.1 STUDY AUTHORITY

This study is authorized under Section 1135 of the Water Resources Development Act (WRDA) of 1986 (P.L. 99-662). Section 1135 projects are part of a larger CAP under which the Secretary of the Army, acting through the Chief of Engineers, is authorized to plan, design, and implement certain types of water resources projects without additional project-specific authorization. The Section 1135 authority allows USACE to carry out projects for improving the quality of the environment when it is determined that such modifications are feasible and consistent with the authorized project purpose and will improve the quality of the environment in the public interest. Section 1135 authority is designed to address environmental degradation associated with an existing USACE project using an ecosystem restoration approach to the extent possible. Work under this authority can include modifications to the structures and operations of water resources projects constructed by USACE or undertake restoration projects at locations where a USACE project has contributed to environmental degradation. The federal share of the costs for any 1 project may not exceed five million dollars.

The Section 1135 program is conducted in partnership with a non-federal sponsor. USACE and non-federal sponsor (or partner) share the study and implementation costs. The sponsor is obligated to provide 50 percent of the study costs and 25 percent of the design and implementation costs.

The Section 1135 provides for two main phases. The feasibility and environmental compliance phase includes problem identification, formulation and evaluation of alternatives to address the problem, and if appropriate a recommendation for a restoration plan. The product of the feasibility and environmental compliance phase is a detailed project report (DPR) and integrated environmental assessment (EA) that is submitted for review and approval through the established USACE review and approval process. A recommended and approved plan must be competitive for federal funding at the national level. The second phase is the design and implementation of the recommended plan.

1.2 STUDY PURPOSE AND SCOPE

This Section 1135feasibility study was initiated to consider environmental-quality improvements related to the operation of Libby Dam. Altered flow regimes associated with-project operations have modified downstream hydrologic, hydraulic and sediment transport conditions and thus impacted downstream habitat functions and attributes important to KRWS. Operations have also altered natural sediment transport process and nutrient availability downstream.

The purpose of this DPR and Integrated EA is to present the findings of the feasibility study for restoration of ecosystem functions and attributes in the Kootenai River downstream of Libby Dam for KRWS survival. Based on results of the feasibility study, a tentatively recommended restoration plan

(recommended plan) has been identified. Implementation of the recommended plan will support recovery efforts for KRWS.

This document describes and analyzes the problems and opportunities identified within the study area within the context of the greater Kootenai River watershed and specifies desired outcomes and planning objectives. An overview of broader restoration actions in the watershed as well as the history of plan formulation and alternatives analyses is included to provide a clear understanding of the focused scope of the current feasibility investigation. Restoration and recovery measures are compared and evaluated based on the identified planning objectives. The results of this comparison and evaluation inform the recommended plan which is of composed of the restoration measures determined to be the most targeted and beneficial measures for improving KRWS early life stage survival. This document also addresses environmental compliance requirements for the proposed action and fulfills the requirements of the feasibility phase of a Section 1135-authorized project. Following the completion of review and environmental compliance processes, the recommended plan will be presented for USACE approval and funding.

1.3 LOCATION OF THE STUDY AREA

The study area for the Shorty's Island/Meander Reach Ecosystem Restoration Project is defined as Meander Reach 1 (river mile [RM] 151.7 to RM 141.8) of the Kootenai River extending from below Ambush Rock to just below Shorty's Island in northern Idaho. The following overview begins at the watershed level and provides context for definition of the study area.

1.3.1 KOOTENAI WATERSHED OVERVIEW

The Kootenai River watershed encompasses over 19,000 square miles within British Columbia (B.C.), Canada, Montana, and Idaho, and is part of the Columbia River Basin. The headwaters of the Kootenai are located in the mountains just north of Kootenay National Park, B.C., approximately 150 miles north of the U.S.-Canada border. The river flows south through Kootenay National Park and down the Rocky Mountain Trench where it enters a reservoir (Lake Koocanusa) formed by Libby Dam in Montana. Below Libby Dam, the river turns west, passes through a gap between the Purcell and Cabinet Mountains, enters Idaho, and then loops north where it flows into Kootenay Lake, B.C. which is impounded by Corra Linn Dam. The water flows through the west arm of Kootenay Lake and then south to join the Columbia River at Castlegar, B.C. (Figure 1-1).

Nearly two-thirds of the Kootenai's 485-mile-long channel and almost three-quarters of its watershed area are located within the province of B.C. Roughly 23 percent of the watershed lies within the state of Montana and six percent is in Idaho. The Continental Divide forms much of the eastern watershed boundary, the Selkirk Mountains provide the western boundary, and the Cabinet Range bounds the watershed to the south. The Purcell Mountains fill the center of the J-shaped course the river takes on its way to Kootenay Lake. The Kootenai River is the second largest tributary of the Columbia River in terms of runoff volume and the third largest tributary in terms of watershed area.

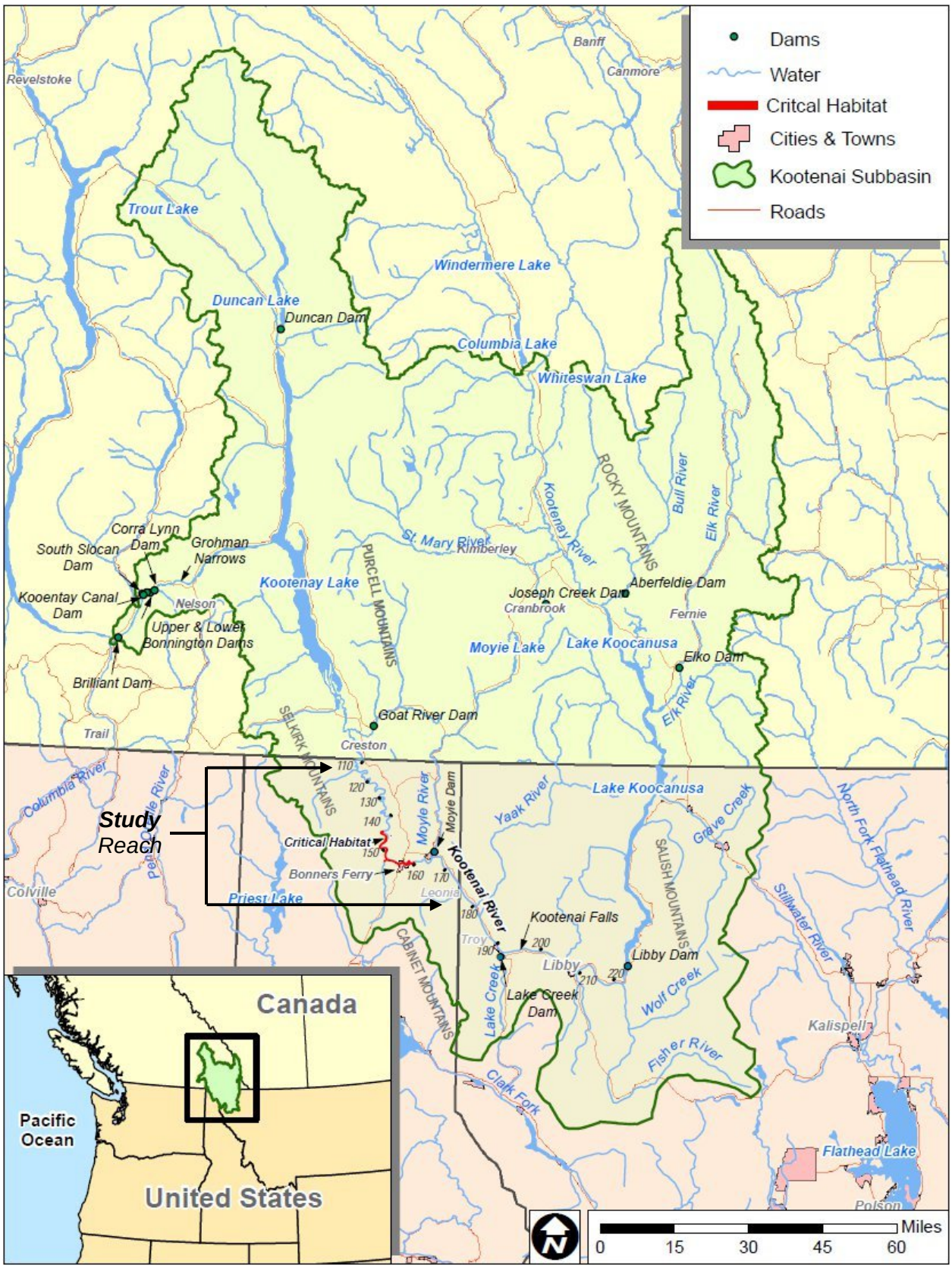

Figure 1-1. Kootenai River Watershed

Hydroelectric power production is an important industry within the watershed. The Libby Dam/Libby Reservoir complex is by far the largest hydroelectric project in operation, although a number of smaller dams with power generation are located throughout the watershed on the mainstem Kootenai River and its tributaries. In B.C., small dams are located in the upper watershed on the Elk River (Elko Dam), Bull River (Aberfeldie Dam), and Goat River (Goat River Dam). Dams on the lower Kootenay River in B.C. include the Corra Linn Dam, Upper and Lower Bonnington Dams at the former location of Bonnington Falls, Kootenai Canal Dam, and South Slocan Dam. Other notable B.C. dams in the lower watershed include Brilliant Dam, Duncan Dam, and Joseph Creek Dam north of Moyie Lake. In the U.S., smaller dams are located on the Moyie River and Lake Creek (Figure 1-1).

Libby Reservoir is a 90-mile-long storage reservoir with a surface area of 46,500 acres at full pool and was formed by impoundment of the Kootenai River in 1972. Libby Dam is operated by USACE and is located in Lincoln County in northwest Montana, approximately 17 miles upstream of the town of Libby. Libby Dam is a multi-purpose water resource project managed for flood-risk management, hydropower, and recreation.

The Kootenai River watershed is the homeland of the Kootenai, or Ktunaxa, Nation which consists of seven modern bands, including the Kootenai Tribe of Idaho.

1.3.2 KOOTENAI RIVER DOWNSTREAM OF LIBBY DAM

The Kootenai River flows for approximately 117 miles from Libby Dam to the U.S.-Canada border. This length is divided into four main reaches and two sub-reaches based on unique geomorphic properties. Starting upstream and moving downstream, the reaches include Canyon Reach, Braided Reaches 1 and 2, Straight Reach, and Meander Reaches 1 and 2 (know together as the Meander Reach). Characteristics of each reach and respective sub-reaches are described in the following sections in reference to river miles. These locations have remained fixed over time for reference purposes 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 1-2 shows the Kootenai River below Libby Dam reach locations and extents.

In 2001, the United States Fish and Wildlife Service (USFWS) designated a portion of the Kootenai River as critical habitat for KRWS (USFWS 2008). The Critical Habitat Reach was originally designated as RM 152.7 to RM 141.8 (USFWS 2008). In 2006, the Critical Habitat Reach was expanded to include all areas from below Shorty's Island upstream to just below the Moyie River confluence (USFWS 2008) from RM 159.7 to RM 141.44. This expanded designation of the Critical Habitat Reach includes a small portion of Meander Reach 2, all of Meander Reach 1, the Straight Reach, Braided Reach 2, and most of Braided Reach 1 (Figure 1-3). The Critical Habitat Reach was identified because it is the only known current location for KRWS spawning habitat. The critical habitat designation extends laterally to the ordinary high-water (OHW) lines of each bank. KRWS spawning areas prior to construction of Libby Dam are not specifically known.

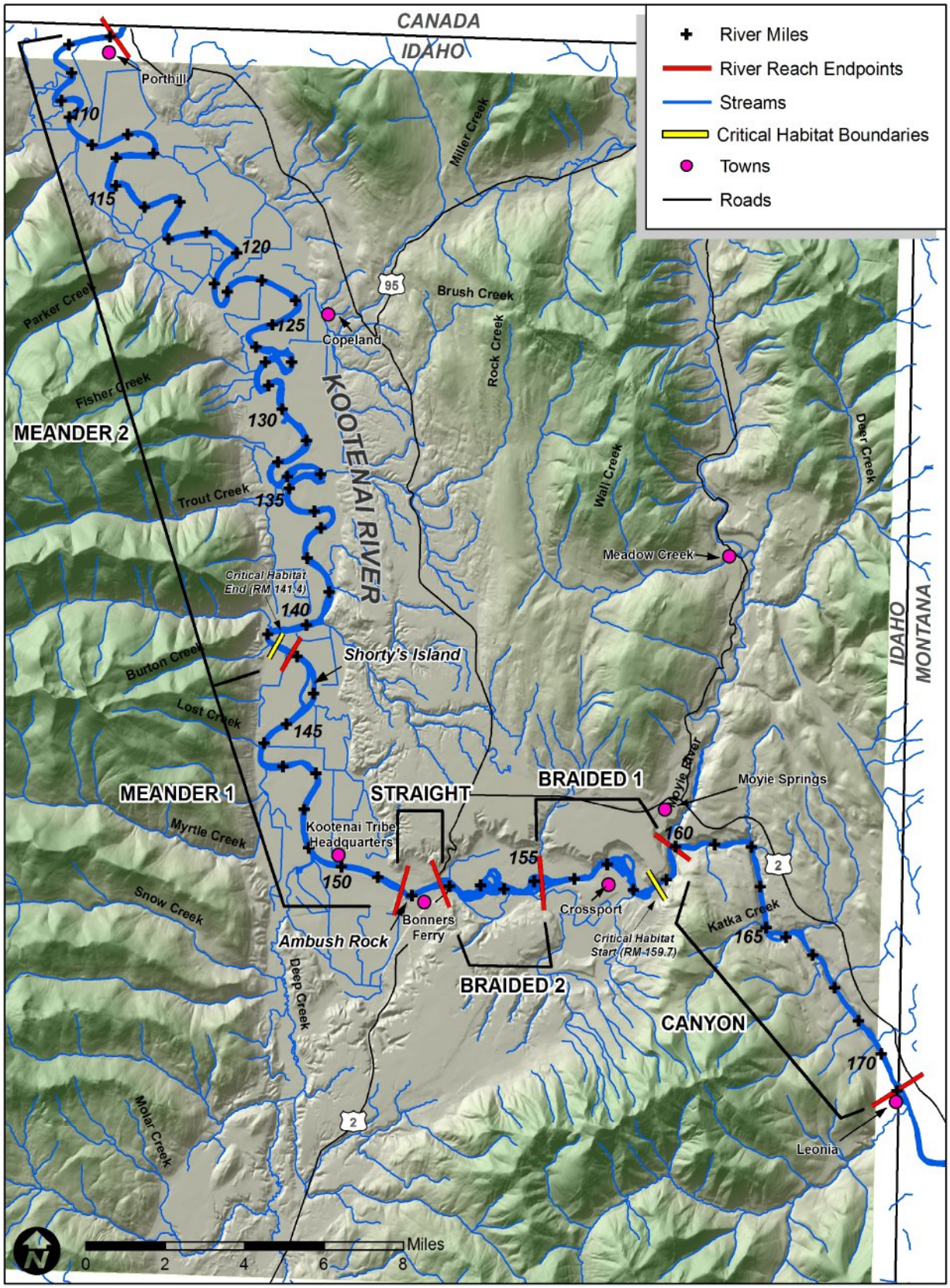

Figure 1-2. Kootenai River Study Reaches

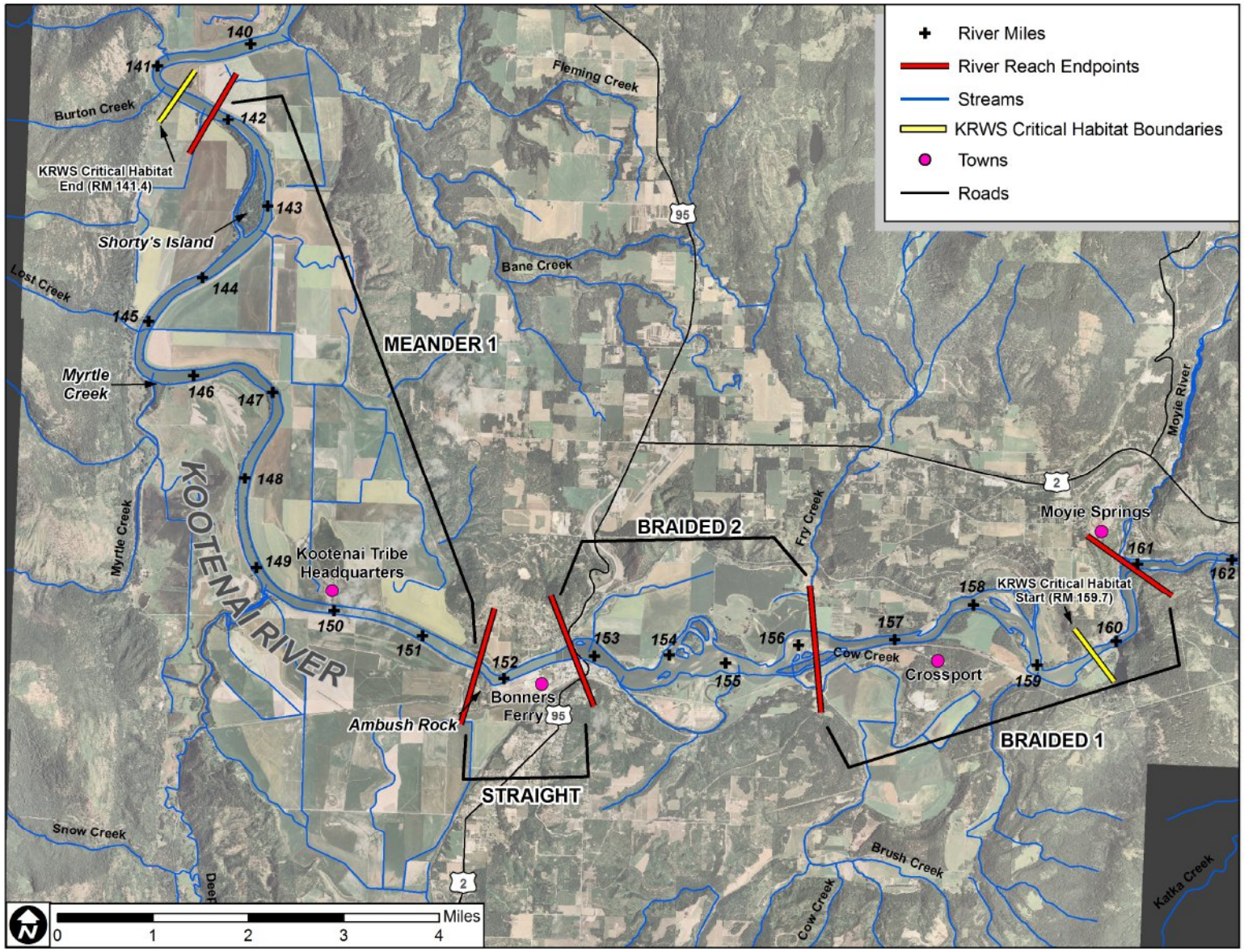

Figure 1-3. Extent of the Designated Critical Habitat Reach within the Braided, Straight, and Meander Reaches

1.3.2.1 CANYON REACH (RM 223.2 TO RM 160.9)

The Canyon Reach extends from Libby Dam to the confluence with the Moyie River. This reach is characterized by a moderately steep gradient averaging nearly six feet per mile and a narrow bedrock valley. The river is laterally confined by bedrock or narrow glacio-fluvial terraces; as a result the floodplain is extremely limited or non-existent in most locations. Kootenai Falls is a natural barrier to fish migration located at RM 194. Curving valley walls formed by historic glacial retreat impart a moderate degree of sinuosity to the channel. Substrate in this reach consists primarily of gravels, cobbles, boulders, and some bedrock outcrops.

1.3.2.2 BRAIDED REACH (BRAIDED REACHES 1 AND 2) (RM 160.9 TO RM 152.7)

The Braided Reach is characterized by multiple channels separated by bars and vegetated islands. The average gradient throughout the reach is about three feet per mile and the streambed is dominated by gravels and cobbles with material becoming finer and characterized by more sand in the downstream direction. The upstream half of the Braided Reach, designated as Braided Reach 1 (RM 160.4 to RM 156.2), has a somewhat narrower floodplain than the lower half. In places the river abuts the valley walls, rock outcrops, or the glacial terrace just north of the railroad grade. In the downstream half of the Braided Reach, designated as Braided Reach 2 (RM 156.2 to RM 152.7), the river has a mile-wide valley but is moderately confined by setback levees on the north side and a railroad embankment on the south side. The floodplain exhibits numerous scars that are traces of braided channels.

1.3.2.3 STRAIGHT REACH (RM 152.7 TO RM 151.7)

The Straight Reach forms a transition zone between the gravel-bedded Braided Reach and the sand-bedded Meander Reach. This reach includes portions of the City of Bonners Ferry and the Highway 95 and railroad bridges. The gradient in this reach varies dependent on runoff and Libby Dam releases and Kootenay Lake backwater effects but is typically less than 0.3 feet per mile. The bed material in this reach transitions from predominantly gravel to predominantly sand at the downstream end of the reach near Ambush Rock. The river has broad natural levees formed by thousands of years of fine sediment deposition from flows that overtopped the banks. The presence of these natural levees suggests that little or no channel migration occurred in this reach prior to management. The heights of the natural levees have been increased by adjacent landowners to provide additional flood protection. At the upstream end of the Straight Reach the channel is narrow and confined between highlands formed by glacial deposits underlain in places by bedrock. The downstream end of the reach opens into a broad floodplain that was once a glacial lake bed. The elevation in this portion of the floodplain is up to 10 feet lower than that of the natural levees found in the upstream portion of the reach. Physical evidence suggests that at times this glacial lake bed extended throughout the Straight and into the Braided Reach.

1.3.2.4 MEANDER REACH (MEANDER REACHES 1 AND 2 INCLUDING SHORTY'S ISLAND) (RM 151.7 TO RM 105.9)

The Meander Reach extends from below Ambush Rock downstream to the U.S.-Canada border near Porthill, Idaho. The gradient in this reach is extremely low with an average of less than 0.1 feet per mile. The river meanders across the nearly-flat Purcell Trench, a former glacial lake bed. The floodplain is two to three miles wide and expands between terraces of lacustrine silt deposits. The river is very sinuous and has high-amplitude meander bends that historically have migrated laterally. Historical meandering and cutoff channels have left behind scrollbar topography and oxbow lakes in the floodplain. Levee construction and flood risk management efforts have significantly slowed the rate of channel migration, confined the river to a narrow corridor, and cut off the connection between the floodplain and the main channel.

The Meander Reach is divided into two sub-reaches: Meander Reach 1 (RM 151.7 to RM 141.8) extending from below Ambush Rock to just below Shorty's Island, and Meander Reach 2 (RM 141.8 to RM 105.9) extending from below Shorty's Island to the U.S.-Canadian border. There are several reasons for the division of the Meander Reach; however, the primary reason is evidence that KRWS spawning has occurred in the portion of the Kootenai River identified as Meander Reach 1 more than any other reach. The Shorty's Island area exhibits the most evidence of KRWS spawning. Meander Reach 1 occupies over half of the area designated as KRWS critical habitat and encompasses the area identified as the most essential KRWS spawning habitat in the Kootenai River. ***Meander Reach 1 was selected for detailed evaluation in this Section 1135 feasibility study for this reason.*** Based on this reach designation, a USACE preliminary determination of federal interest by was identified during the reconnaissance study and was the basis for initiating the current study to investigate restoration opportunities. The Critical Habitat Reach and Meander Reach 1 location are shown on Figure 1-3. Figure 1-4 shows the Meander Reach 1 and adjacent features.

There are differences in planform between Meander Reach 1 and Meander Reach 2. Meander Reach 2 has a higher sinuosity at 2.0 compared to Meander Reach 1 with a sinuosity of 1.5. In addition, the meander bends in Meander Reach 2 are tighter with an average radius of curvature of 1,550 feet compared to Meander Reach 1 at 3,550 feet. Though the beds of both Meander Reach 1 and Meander Reach 2 are dominated by sand, several isolated areas of gravel have been identified in Meander Reach 1 by the United States Geological Survey (USGS). The most significant area of gravel in this reach is located in the area just below the Myrtle Creek confluence though there are several other small areas of gravel in Meander Reach 1 (Barton et al. 2005).

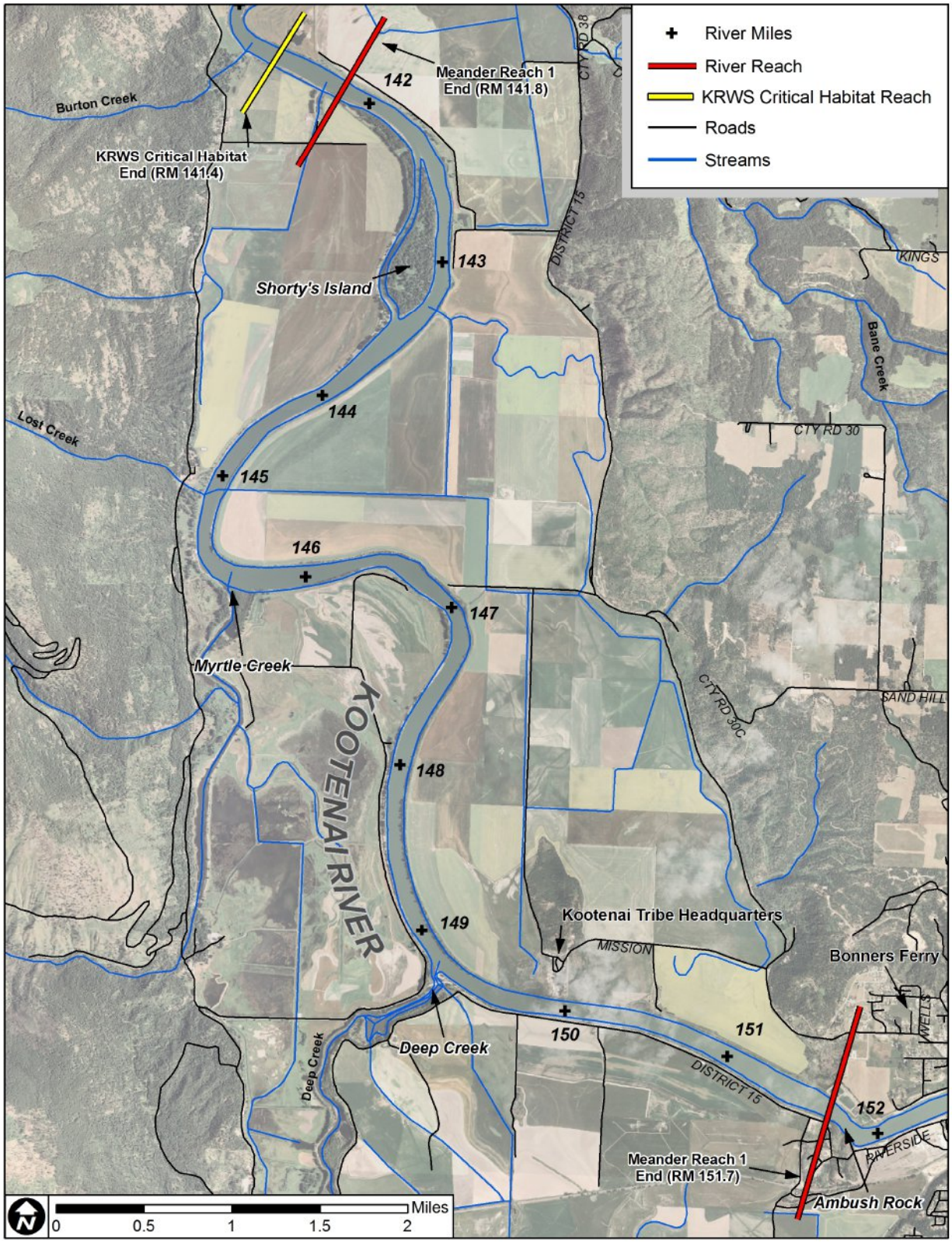

Figure 1-4. Kootenai River Meander Reach 1

1.4 PRIOR REPORTS, STUDIES, AND ONGOING PROJECTS

The following sections provide short summaries of past and ongoing efforts related to KRWS recovery and habitat restoration both by federal and non-federal entities and agencies. A full list of related literature and an annotated bibliography is provided in Appendix D.

1.4.1 FEDERAL REPORTS AND PROJECTS

1.4.1.1 LIBBY DAM, LIBBY, MONTANA, 1972

Libby Dam was authorized by Congress in 1951 (P.L. 516). The construction of Libby Dam began in 1966 and was completed in 1972; the project became fully operational in 1974. Libby Dam is authorized for the purposes of hydropower, flood control (now referred to as flood risk management or FRM), recreation, fish and wildlife, navigation, and other benefits. The dam is 422 feet tall and the dam crest is 3,055 feet in length. Koocanusa Reservoir is a 90-mile-long reservoir impounded by the dam with a surface area of 46,500 acres at full pool. The typical operation schedule for Libby Dam begins in July when the reservoir fills to full pool. Draw-down begins in September and reaches minimum pool elevation in April for flood risk management during spring runoff. Since 1991, USACE, in cooperation with the Bonneville Power Administration (BPA), USFWS, state and Canadian provincial entities, B.C. Hydro, and tribal entities, has provided higher experimental flows in the spring to improve opportunities for spawning (USFWS 2000a). A new flood operation procedure, Variable Discharge Flood Control (VARQ-FC), was initiated in water year 2003. VARQ-FC, on the average, increases reliability of providing flow augmentation to benefit Columbia River salmon. Presently, Libby Dam operations are dictated by a combination of requirements for power production, flood risk management, recreation, and special operations for the recovery of species listed under the federal Endangered Species Act (ESA), including KRWS, bull trout, and Snake and Columbia River salmon stocks in the lower Columbia River (Kootenai River Network 2010).

1.4.1.2 USFWS BIOLOGICAL OPINION, 1995

USFWS issued a Biological Opinion (BiOp) on the effects of five operating scenarios of the Federal Columbia River Power System (FCRPS) on five endangered or threatened species, including four Snake River snails and KRWS. The BiOp concluded that the proposed operating scenarios are likely to jeopardize the continued existence of KRWS (USFWS 1995).

Two Reasonable and Prudent Alternatives (RPAs) were identified in the BiOp, including 1 for water year 1995 and the other for water years 1996 through 1998. These RPAs were developed to encourage significant recruitment of three new age classes to the sturgeon population to avoid jeopardizing the species. Once this has been achieved, significant recruitment to the population must be attained in 1 new age class every three years to avoid jeopardy, which is to be addressed in recovery objectives set by the recovery team in 1995.

1.4.1.3 USFWS RECOVERY PLAN FOR THE KOOTENAI RIVER POPULATION OF THE WHITE STURGEON, 1999

USFWS published a recovery plan for KRWS in September 1999 with the short-term goal of restoring successful natural recruitment and preventing extinction by using conservation aquaculture. The plan also had a long-term goal of down-listing and delisting the species. Actions identified in the plan were identification of key spawning and rearing areas in need of restoration and development of a conservation aquaculture program for KRWS. Other actions included continued research and monitoring, threat identification, and continued efforts to protect KRWS through regulatory mechanisms, dam operation and flow regulation, outreach, and securing of funds (USFWS 1999a).

1.4.1.4 USFWS BIOLOGICAL OPINION, 2000

USFWS completed a BiOp, *Effects on Listed Species from Operations of the FCRPS*, in 2000. Like the 1995 BiOp, this document also concluded that the continued existence of KRWS was jeopardized. The BiOp included four additional RPAs to be addressed to remove the species from jeopardy, including modifications to flow releases from Libby Dam to provide more natural flow timing and duration (USFWS 2000a).

The Center for Biological Diversity filed suit against USACE in 2003 for failure to implement the RPAs in this document and for failure to reinitiate consultation regarding the potential effects of Libby Dam on the recently designated critical habitat for KRWS. USACE and BPA reinitiated consultation with USFWS in 2003 which led to preparation of the 2006 BiOp (see Section 1.4.1.9).

1.4.1.5 KOOTENAI RIVER GEOMORPHIC ASSESSMENT 2004

USACE completed an assessment of geomorphic conditions in the Kootenai River to begin to better understand the role of substrate in KRWS recovery efforts, as well as to help address RPA 3 from the 2000 USFWS BiOp. The assessment provided a historical perspective, a description of physical processes and river conditions, identification of human influences and probable future river trends, and a preliminary assessment of hydrogeomorphic measures to aid in KRWS recovery (Tetra Tech 2004a).

1.4.1.6 HABITAT AND ECOSYSTEM RESTORATION STRATEGY WORKSHOPS, 2003 AND 2004

Habitat and ecosystem restoration strategy workshops were held by USACE which convened experts from Federal, state, local, tribal, and other stakeholder agencies to discuss and document broad issues concerning the recovery of KRWS. The workshops helped define the factors affecting early life stage survival more clearly than had been previously attempted. A study area and reaches were defined and a preliminary suite of possible projects was discussed (Tetra Tech 2004b).

1.4.1.7 SUBSTRATE ENHANCEMENT PILOT PROJECT FOR IMPROVING WHITE STURGEON SPAWNING IN THE KOOTENAI RIVER: PHYSICAL MODELING DATA REPORT, OCTOBER 2005

This report documents the results of physical model tests to quantify the performance of four recommended artificial substrate types, including test configurations for A-Jacks, riprap blanket, conical riprap mounds, and pilings. The results of the pilot project indicated that the pilings did not collect sediment while the A-Jacks collected the largest volume of sediment. This was the first phase of a three-phase effort involving physical modeling to assist in development of substrate restoration measures for KRWS (Thornton et al. 2005).

1.4.1.8 IMPLEMENTATION OF A PILOT PROJECT TO PLACE BANK STONE ON THE KOOTENAI RIVER ADJACENT TO SHORTY'S ISLAND, 2005

This pilot project was constructed on the right bank of the Kootenai River adjacent to Shorty's Island and involved the placement of boulders on the bank. The objectives of the pilot project were to test the bearing capacity of the river bottom in the general area of possible future substrate improvement projects and to get a 'reading' of the possible subsidence that might be expected. There were no direct biological or fishery objectives (Anders et al. 2007).

1.4.1.9 USFWS BIOLOGICAL OPINION, 2006

Under Section 7 of the ESA, federal agencies have an affirmative obligation to "ensure that federal actions are not likely to jeopardize the continued existence of any ESA listed species, or adversely modify their designated critical habitat." In 2006, USFWS completed a BiOp on USACE's proposed operations of Libby Dam and its effects on KRWS. The BiOp concluded that the proposed operations would

jeopardize KRWS and its critical habitat. The BiOp proposed a performance-based RPA that allowed agencies to select from a suite of actions to achieve the habitat attributes necessary for successful KRWS spawning. Actions that are required included a number of flow management actions and habitat management actions (USFWS 2006).

1.4.1.10 SUBSTRATE ENHANCEMENT PILOT PROJECT FOR IMPROVING WHITE STURGEON SPAWNING IN THE KOOTENAI RIVER: PHASE 2 PHYSICAL MODELING DATA REPORT, AUGUST 2006

This study focused on investigating flow velocities and turbulent fields that develop over the surface of artificial substrate restoration measure, as well as evaluating the potential of the individual substrate configurations to capture simulated sturgeon eggs. A secondary area of interest included in the study was the velocities and turbulence along the upstream and downstream edge of the structures. The limited test runs indicated that a rectangular substrate was more efficient in collecting the material used to simulate eggs than a wedge shaped structure (Thornton et al. 2006).

1.4.1.11 SUBSTRATE ENHANCEMENT PILOT PROJECT FOR IMPROVING WHITE STURGEON SPAWNING IN THE KOOTENAI RIVER: PHASE 3 PHYSICAL MODELING DATA REPORT, JULY 2007

This report documents the third phase of physical modeling tests on substrate. This phase included moveable-bed modeling to investigate the long-term interaction of rock substrate structures with the riverbed. Goals Objectives of this effort included determining the impact of substrate additions on the adjacent riverbed, investigating whether sand would fill the substrate and negate its effectiveness, and investigating velocity/turbulence along the edges of and between substrate structures. Based on the study, a variety of observations and conclusions were made concerning designing substrate structures that will perform well within the dune environment of the Kootenai River being considered for substrate augmentation (Thornton et al. 2007).

1.4.1.12 SETTLEMENT AGREEMENT, 2008

The Center for Biological Diversity (CBD), a non-profit endangered species advocacy group, challenged the adequacy and implementation of the 2006 USFWS BiOp in the federal District Court of Montana on May 2, 2006 (U.S. District Court 2008a). The State of Montana and the Kootenai Tribe intervened on the sides of plaintiff and defendant, respectively. The federal judge encouraged all to enter into negotiations overseen by a court appointed mediator. Negotiations were successful and a settlement agreement was entered into on September 2, 2008, resulting in a court order dismissing the case on September 11, 2008.

The settlement agreement requires the following terms and conditions: (1) a clarification of the 2006 BiOp from USFWS, (2) determination of the success of Libby Dam interim operations for sturgeon reproduction needs, (3) defined criteria for the evaluation of success, (4) conditions under which changes are to be made if interim operations are not deemed successful, (5) initiation of the processes for structural modification to the Libby Dam Selective Withdrawal System, (6) support and cooperation with the Kootenai Tribe's implementation of the Kootenai River Restoration Project Master Plan, and (7) document sharing and reporting (U.S. District Court 2008b).

1.4.1.13 USFWS CLARIFICATION OF THE RPA, 2008

Following the Settlement Agreement, USFWS clarified the RPA that USACE should implement to achieve the habitat attributes necessary for KRWS reproduction and survival (U.S. District Court 2008b).

1.4.2 NON-FEDERAL REPORTS AND PROJECTS

A number of the major non-federal reports and projects relevant to the current feasibility study are described below. There are many additional papers and reports associated with KRWS that informed this

study but are not summarized here, including annual monitoring reports, hatchery reports, and annual project reports. The Kootenai Tribe is currently developing a public library of KRWS-related reports that may be referenced in future documentation.

1.4.2.1 KOOTENAI RIVER WHITE STURGEON STUDY AND CONSERVATION AQUACULTURE PROJECT, 1989

The Kootenai Tribe initiated the Kootenai River White Sturgeon Study and Conservation Aquaculture Project in 1990 to preserve the genetic variability of the population, begin rebuilding natural age class structure with hatchery-reared fish, and prevent extinction while measures are implemented to restore the natural production of fish. Consistent with the project's breeding plan and the USFWS Recovery Plan (USFWS 1999a), the Kootenai Tribe has been successfully incubating, hatching, raising, and releasing sturgeon using the eggs and sperm of adult fish taken from the river and later returned. The goal of the aquaculture project is to protect the sturgeon from extinction until suitable habitat conditions are re-established in the Kootenai River ecosystem such that sturgeon survival can improve beyond the egg stage and natural recruitment of juvenile fish into the population can be restored. The work is being coordinated with Federal and state fish and wildlife agencies and with counterpart agencies in B.C. The Kootenai Tribe is currently planning critically needed improvements to the existing sturgeon hatchery and developing a new facility that will allow sturgeon to imprint on waters farther upstream. The new hatchery will also allow the Kootenai Tribe to implement a native burbot conservation aquaculture program (Kootenai Tribe 2008). The Kootenai Tribe completed a master plan to direct the management this program in 2010 (Kootenai Tribe 2010b).

1.4.2.2 KOOTENAI RIVER WHITE STURGEON RECOVERY INITIATIVE, 1998

The Freshwater Fish Society of British Columbia (FFSBC) first gained experience in sturgeon conservation aquaculture through its involvement with the Kootenai Tribe. Specifically, a partnership was established with the Kootenai Tribe for the culture of this trans-boundary sturgeon population in B.C. In 1998, construction of the Kootenay White Sturgeon Conservation Hatchery was completed at the Kootenay Trout Hatchery complex near Fort Steele, B.C. For the Kootenay white sturgeon program, FFSBC receives fertilized sturgeon eggs from the Kootenai Tribe. Young fish are cultured for about a year and are marked and then released into the Kootenai River in Idaho, as well as in Kootenay Lake (FFSBC 2007). The Kootenay White Sturgeon Conservation Hatchery provides an important fail safe hatchery facility for the Kootenai Tribal Hatchery program (Kootenai Tribe 2007).

1.4.2.3 LOWER KOOTENAI RIVER MODEL WATERSHED PROJECT, 2001

The Kootenai Tribe and the Bonneville Environmental Foundation have partnered to restore habitat in selected Kootenai River tributaries in the lower Kootenai watershed. The purpose of the project is to reestablish native riparian vegetation, aquatic insects, and native trout and kokanee salmon habitats and populations. Project actions include grazing management, riparian revegetation using native plants, incorporation of woody debris, and bank stabilization (Kootenai Tribe 2011).

1.4.2.4 LIBBY DAM OPERATIONAL LOSS ASSESSMENT PROJECT, 2002

This Kootenai Tribe project is designed to measure and better understand the impacts of various changes to the ecosystem that have occurred as a result of the construction and operation of Libby Dam. For example, changes in the timing, amount, and force of water traveling down the river and how that water interacts with the floodplain have contributed to changes in fish and wildlife communities living in the Kootenai River and floodplain. The assessment will help the Kootenai Tribe better target activities to restore abundant fish and wildlife communities. In addition, the assessment methodology developed by this project will help others throughout the Columbia Basin better understand and manage the impacts of hydroelectric projects (Anders et al. 2002; CBFWP 2011).

1.4.2.5 RECONNECTING THE KOOTENAI RIVER WITH THE HISTORICAL FLOODPLAIN, 2002

The Kootenai Tribe is leading this BPA-funded project which focuses specifically on targeted tributaries that will be restored by returning them to their original channel and reconnecting them with the Kootenai River, thus restoring critical floodplain habitat (Kootenai Tribe 2011).

1.4.2.6 KOOTENAI RIVER SUBBASIN ASSESSMENT, 2004

The Kootenai Tribe and Montana Fish, Wildlife, and Parks (MFWP) prepared the Kootenai River Subbasin Assessment in 2004 concurrent with the preparation of subbasin plans for the Northwest Power Planning Council for all of the subbasins of the Columbia River system. The subbasin assessment included a detailed evaluation of fish and wildlife habitats and focal species in the watershed, an assessment of limiting factors, and the development of a management plan to maintain and restore a healthy ecosystem for submission to the Northwest Power Planning Council (Kootenai Tribe 2004a).

1.4.2.7 KOOTENAI RIVER VALLEY WETLANDS AND RIPARIAN CONSERVATION STRATEGY, 2004

This Kootenai Tribe project provides a mechanism to link information about wetland and riparian areas to community values and issues of concern. The purpose of the strategy is to encourage and support integration of community needs, economic benefits, and local values in the identification and development of wetlands and riparian conservation opportunities and programs (Kootenai Tribe 2004b).

1.4.2.8 KOOTENAI RIVER ECOSYSTEM IMPROVEMENT PROJECT, 2005

Since Libby Dam began operating, the primary productivity in the Idaho portion of the Kootenai River has been significantly reduced. Approximately 63 percent of nitrates and 25 percent of phosphorus are lost through binding to sediments in Lake Koocanusa. This loss of nutrients impacts algal growth and in turn affects organisms higher on the food chain, including insect and fish communities. To help make up for this loss of productivity and restore fisheries, a large-scale nutrient addition program was initiated on the Kootenai River in 2005. Phosphorus has been added to the river for five years from approximately June to September (the main growing season) at a nutrient release station located in Leonia, Idaho on the Montana-Idaho border. The program is a partnership between the Kootenai Tribe and Idaho Fish and Game (IDFG), funded by BPA. Actions include monitoring of water quality, algal, invertebrate, and fish community conditions; biomonitoring; fertilization on the south arm of Kootenay Lake; and a large-scale nutrient restoration experiment (Holderman et al. 2005).

1.4.2.9 KOOTENAI RIVER HABITAT RESTORATION PROJECT MASTER PLAN, 2009

The Kootenai Tribe published the *Kootenai River Habitat Restoration Project Master Plan* in July 2009 (Master Plan; Kootenai Tribe 2009). The Master Plan provides a watershed-scale restoration framework for the Kootenai River Habitat Restoration Program. Documentation developed for the Master Plan has provided an invaluable foundation for the plan formulation effort of this feasibility study. The goal of the Master Plan is to restore river habitat conditions that will support all life stages of KRWS.

The Kootenai River Habitat Restoration Program is executing a phased approach to ecosystem restoration on the Kootenai River. Phase 1 of the program included projects to address bank erosion in the Braided Reach in order to reduce sediment loading and degradation of habitat downstream. The projects will also restore bank cover/shade and channel margin complexity. Phase 1 of this plan was completed in the fall of 2011. 1,600 linear feet of mainstem bank was restored, 2,800 linear feet of side channel was regraded and improved, and 8.5 acres of floodplain and wetlands were restored (Kootenai Tribe 2012).

The program also includes a Phase 2 and Phase 3. Phase 2, currently in preliminary design, focuses on the Braided and Straight reaches. Activities in the Braided Reach will focus on restoring natural river hydraulic and morphologic conditions (channel depth, velocity, and dimension) and restoration of the floodplain. In the Straight Reach, activities will focus on aquatic habitat through cover, hydraulic complexity, and riparian buffers.

Phase 3, scheduled to enter preliminary design in 2013, will focus on the Meander Reach. Specifically, Phase 3 will focus on improving interaction between the river and the floodplain though action such as reduction of bank erosion through instream structures and bank restoration, wetland and riparian restoration, off-channel habitat creation, and removal of barriers to fish passage.

1.4.2.10 OTHER ONGOING KOOTENAI TRIBE FISH AND WILDLIFE PROGRAMS

The Kootenai Tribe has a number of other ongoing fish and wildlife programs that focus on habitat restoration and restoring populations in the Kootenai River ecosystem (Kootenai Tribe 2011). These programs include:

- *Sturgeon and Burbot Conservation Aquaculture:* Started in 1989, the KRWS aquaculture program includes a hatchery near Bonners Ferry. Program goals include prevention of KRWS extinction and reestablishment of a sturgeon population capable of future Tribal Treaty subsistence and cultural harvest. An expanded KRWS aquaculture program, as well as the burbot program, is currently in the design phase.
- *Reconnecting the Kootenai River with the Historical Floodplain:* This program focuses on targeted tributaries that will be restored by reconnecting them with their original channel and the Kootenai River, thus restoring critical floodplain habitat.
- *Nutrient Restoration and Biomonitoring:* This program is co-managed with IDFG and includes extensive monitoring of baseline nutrient conditions. Actions include monitoring of water quality, algal, invertebrate, and fish community conditions, and large-scale nutrient restoration experiments. The program emphasizes restoration of important fish stocks, including sturgeon, burbot, bull trout, kokanee and other salmonids.
- *Restoration of Kootenai River Tributaries:* The Lower Kootenai River Model Watershed Project is designed to restore habitat in selected tributaries in the lower Kootenai watershed. The project is designed to reestablish native riparian vegetation, aquatic insects, and native trout and kokanee salmon habitats and populations.
- *Impacts from Libby Dam:* The overarching goal of this project is to create an operational loss assessment tool to assess ecological losses caused by the operations of Libby Dam. Goals of the program include development of a tool to help protect, restore and/or improve the floodplain ecosystem (e.g. riparian, wetland, and related uplands and tributary areas) in order to promote healthy self-sustaining fish and wildlife populations.

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2 NEED FOR AND OBJECTIVES OF ACTION

The Shorty's Island/Meander Reach Section 1135 study is just 1 component of broader restoration efforts in the Kootenai River Basin being implemented as part of the Kootenai River Habitat Restoration Program Master Plan. The Section 1135 study is consistent with goals of the Master Plan, but focuses on specific and measureable benefits as a standalone increment to support recovery efforts.

The measureable decline in the KRWS population is the central problem addressed by this feasibility study. Detailed population and habitat conditions and dynamics frame more specific problems and opportunities that can be addressed at the project site, reach, and broader basin-wide level. This chapter summarizes the reasons why urgent action is required to implement protection and recovery actions for KRWS. These summaries are followed by an overview of the broader basin-wide recovery approach to KRWS recovery which provides context for defining the scope, purpose, and need for the feasibility study and implementation of the project. Specific goals and objectives for the Shorty's Island/Meander Reach Ecosystem Restoration Project are identified. These project-specific goals and objectives are informed by the USACE National Ecosystem Restoration objective, outlined in Section 2.1.

2.1 NATIONAL OBJECTIVES

Ecosystem Restoration is one of the primary missions of the USACE Civil Works program. Guidance document ER 1165-2-501, Civil Works Ecosystem Restoration Policy, dated September 30, 1999, states:

> *"The purpose of the Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded…The intent of restoration is to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system."*

The Section 1135 authority is one of several ecosystem restoration related programs. The specific objective of the 1135 authority is to improve the quality of the environment where an authorized project has contributed to environmental degradation. The Federal objectives for the ecosystem restoration mission differ slightly from other missions. Evaluation and comparison of ecosystem restoration alternatives necessitates both monetary and non-monetary metrics. As such, the guidance ER 1165-2-501, Civil Works Ecosystem Restoration Policy, dated September 30, 1999, states:

> *"Consistent with the analytical framework established by the P&G, plans to address ecosystem restoration should be formulated and recommended, based on their monetary and non-monetary benefits. These measures do not need to exhibit net national economic development (NED) benefits and should be viewed on the basis of non-monetary outputs compatible with the P&G selection criteria."*

Restoration of ecosystem function for KRWS habitat is consistent with the USACE ecosystem restoration mission as well as the ecosystem restoration federal objective.

Much of the background information provided in this DPR is drawn from information presented in the Master Plan as well as two feasibility study planning workshops, the first held on May 19 and 20, 2010, and the second held on December 2 and 3, 2010. These workshops helped developed project-specific information and relied on the collaboration of stakeholders and experts from the Kootenai Tribe, USACE, and resource agencies including B.C. Hydro, British Columbia Ministry of Environment (BCMoE), BPA, IDFG, MFWP, USFWS, and USGS. Other citations are provided in the text as needed.

2.2 KOOTENAI RIVER WHITE STURGEON DECLINE & REGIONAL RESTORATION OBJECTIVES

The physical changes and regulatory environment related to KRWS decline provide the context for this DPR. A significant amount of work has been conducted to date by multiple entities in the watershed and this DPR builds upon previous work to move toward the implementation of critical restoration measures. Various studies and programs to identify and restore KRWS habitats have been in operation since the listing of the species under the federal ESA in 1994. Federal, state, and tribal agencies have conducted a number of studies on KRWS and other species to identify spawning locations, population size, preferred habitats, limiting factors and a variety of other issues relative to recovery of the watershed and its species (see Section 1.4 of this DPR for an abbreviated summary of relevant studies and regulatory documents).

2.2.1 ENDANGERED SPECIES LISTING AND CRITICAL HABITAT DESIGNATION

KRWS was listed as an endangered under the federal ESA on September 6, 1994 (USFWS 2010a). KRWS is 1 of 18 species of land-locked white sturgeon populations known to occur in western North America. KRWS occur in Idaho, Montana, and B.C., and are restricted to approximately 167.7 miles of the Kootenai River extending from Kootenai Falls (RM 31) downstream through Kootenay Lake to Corra Linn Dam at the outflow from Kootenay Lake. Approximately 45 percent of the species' range is located within B.C. Many KRWS migrate to spawn in the Kootenai River and then spend part of their life in Kootenay Lake. The wild population now consists of an aging cohort of large older age class fish. The population has declined from approximately 6,800 white sturgeon in 1980 to approximately 640 wild fish in 2002 (Paragamian et al. 2005). Using the most recent estimated mortality rate of four percent per year (Beamesderfer et al. 2009), the wild KRWS population could be extinct by 2030. During the last 14 years of intensive monitoring using techniques proven suitable elsewhere, only one wild-hatching KRWS embryo has been found and no free-swimming larvae or young-of-the-year (YOY) have been captured anywhere in the Kootenai River.

A Recovery Plan was developed in 1999 (USFWS 1999a) and critical habitat was designated for the protection of KRWS in October 2001 (USFWS 2001) and expanded in 2006. The Critical Habitat Reach spans 18.3 miles from upstream of Bonners Ferry (RM 159.7) downstream to below Shorty's Island (RM 141.4). Critical habitat includes the reach where KRWS 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.

The status of the listed KRWS population imposes a particularly urgent timeline for implementation of habitat restoration actions: the next 5 to 20 years are critical to the survival of the KRWS population. There may still be an adequate number of reproductively-active 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 have increasingly difficulty finding mates (Kootenai Tribe 2009). Additionally, the inability of KRWS to sustainably self-populate will result in the loss of a critical component of native diversity. Without intervention functional extinction will occur. Currently, the Kootenai Tribe's Sturgeon Hatchery is stalling the extinction of KRWS while this study and other habitat restoration actions are pursued.

2.2.2 2006 BIOLOGICAL OPINION AND 2008 SETTLEMENT AGREEMENT

In the February 2006 BiOp, USFWS concluded that the operation of Libby Dam jeopardizes the continued existence of KRWS and adversely modifies its critical habitat. The BiOp contained an RPA that, in the opinion of USFWS, allowed for the continued operation of Libby Dam but avoids

jeopardizing KRWS or adversely modifying its critical habitat. The RPA habitat attributes that USFWS determined necessary for successful sturgeon spawning and natural in-river production, those attributes include provision of

- More normative flow timing and duration from Libby Dam to mimic natural conditions and promote spawning and successful incubation;
- Suitable velocities for spawning between RMs 152 and 157;
- More natural temperature fluctuations in releases from Libby Dam;
- Suitable depth conditions in the between RM 152 and RM 157; and
- Suitable substrate for spawning and early life history stages.

Under the terms of the Settlement Agreement, USFWS issued a clarification of the 2006 USFWS BiOp RPA on December 29, 2008. Under the clarified RPA, USACE and BPA are to maintain the habitat attributes in the Braided and Meander Reaches of the Kootenai River to facilitate sturgeon recruitment and recovery, as well as cooperating in good faith with, and supporting the Kootenai Tribe's good-faith efforts to implement the Kootenai River Habitat Restoration Project Master Plan (Kootenai Tribe 2009), including developing a funding strategy to implement the Plan to meet ESA obligations for the continued operation of Libby Dam.

Addressing limiting factors to KRWS reproduction and survival through the Section 1135 authority is an important component of meeting USACE obligations under the ESA associated with the continued operation of Libby Dam.

2.2.3 TRUST RESPONSIBILITY

The federal government has a "trust responsibility" to preserve and rebuild fisheries in the Kootenai Tribe's usual and accustomed areas and to do so in consultation and coordination with the Kootenai Tribe. This trust responsibility is derived from the special relationship between the U.S. and Native American Indian Tribes, first defined by U.S. Supreme Court Chief Justice John Marshall in Cherokee Nation v. Georgia, 30 U.S. 1 (5 Pet.) (1831). Later, in Seminole Nation v. United States, 316 U.S. 286 (1942), the Supreme Court noted that the U.S. "has charged itself with moral obligations of the highest responsibility and trust" toward Native American Indian Tribes. The scope of the federal trust responsibility is broad and incumbent upon all federal agencies. The U.S. government has an obligation to protect tribal land, assets, resources and rights, as well as a duty to carry out the mandates of federal law with respect to Indian Tribes.

2.2.4 CUMULATIVE PHYSICAL CHANGES

Since Euro-American settlement began, the Kootenai watershed has been modified by agriculture, logging, mining, flood risk management, hydroelectric power generation, and urbanization. Historic conditions and the results of Euro-American development on resources in the study area and greater watershed are discussed in detail in Chapter 3, Affected Environment. Table 2-1 summarizes critical benchmarks for physical changes and KRWS declines. The cumulative effects of these changes have been a decline in the KRWS population which requires immediate protection and recovery actions in order to avoid species extinction.

Table 2-1. Summary of Critical Benchmarks Related to Kootenai River Physical Changes and Kootenai River White Sturgeon Declines

Date	Benchmarks
1890s	• Early attempts at dike construction in British Columbia.
Early 1900s	• Kootenai valley wetland drainage and conversion to agriculture.
1930s	• Corra Linn Dam completed and Grohman Narrows blasted/dredged.
1939	• Nearly one half of the floodplain was behind dikes.
1940s	• Levees built from Bonners Ferry to the U.S.-Canada border.
1974	• Libby Dam is fully operational,
1980	• Population problems first reported for KRWS (Andrusak 1980).
1983	• Recruitment failure reported in Idaho portion of Kootenai River (Partridge 1983). • Estimated adult population size of 8,000–9,000 fish.
1988	• The Kootenai Tribe initiates Kootenai sturgeon studies and program planning.
1991	• Construction of Kootenai Tribe experimental sturgeon hatchery completed.
1994	• KRWS federally listed as endangered under ESA. • Hatchery production stopped while under federal review. • Population abundance estimated at 1,694 fish. • USFWS Kootenai River White Sturgeon Recovery Team formed.
1999	• Sturgeon Recovery Plan completed and signed by USFWS Regional Director (USFWS 1999a; Duke et al. 1999); hatchery upgrades completed. • Kootenai Tribe provides funding and direction for B.C. Kootenay Hatchery program to be developed as failsafe and additional rearing site. • Sturgeon tiered flows begin.
2001	• Critical Habitat designated by USFWS.
2002	• Adult population abundance estimated at 620 fish.
2003	• VARQ-FC flood operation adopted by USACE.
2006	• BiOp regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon and bull trout released by USFWS in February (clarified in 2008).
2008	• Settlement Agreement and Clarifications to 2006 BiOp.
2009	• Kootenai River Habitat Restoration Master Plan completed. • Kootenai River Native Fish Conservation Aquaculture Programs Master Plan completed.

Source: Modified from Kootenai Tribe 2009.
Notes: BiOp – Biological Opinion, ESA – Endangered Species Act, KRWS – Kootenai River White Sturgeon, USACE – U.S. Army Corps of Engineers, USFWS – U.S. Fish and Wildlife Service, VARQ-FC - Variable Discharge Flood Control

Historically, the Kootenai watershed was dominated by coniferous forestlands on the upland hill slopes with some areas of grassland and wetlands in the valley bottoms (Kootenai Tribe and MFWP 2004). The historical river corridor was a diverse mix of river channels, backwaters, flood channels and meandering tributaries that joined with a vast wetland complex to form the floodplain (Kootenai Tribe 2009). The floodplain within the study area was over three miles in width and frequent overbank flows maintained a strong connection between the floodplain and its vegetative biomass and the riverine ecosystem. Despite this extensive aquatic ecosystem, the Kootenai River has always had fewer fish species than other Columbia River tributaries due to its isolation by Bonnington Falls (Kootenai Tribe 2009). Fish populations were nonetheless historically abundant and provided ample resources for the Kootenai people

living in the watershed. Anadromous species including salmonids and lamprey have not been present since recent glaciation and KRWS and kokanee have been isolated populations since the retreat of the last glaciers of that time (approximately 10,000 years ago).

The historic and current hydrology of the watershed is driven by snowmelt runoff that causes peak flows from April to June. Groundwater driven base flows occur from July to September and low flows typically occur in the winter months (November to March) when precipitation largely occurs as snow and runoff is limited (Kootenai Tribe and MFWP 2004). Occasional rain on snow flood events can occur during the winter and spring months. Kootenay Lake is a natural waterbody in the watershed, though its historical elevation was higher than occurs now.

Since Euro-American settlement began, the Kootenai watershed has been modified by agriculture, logging, mining, flood risk management, hydroelectric power generation, and urbanization. The Kootenai River floodplain was dramatically modified by the draining of floodplain wetlands early in the 20th century to facilitate agricultural uses. It is estimated that over 50,000 acres of floodplain wetland have been drained in the study area, and an equivalent area was likely drained in Canada downstream of the project (Kootenai Tribe 2009). Additionally, manmade levees were constructed on top of natural levees along the riverbanks in many areas, limiting the hydrologic connection between the Kootenai River and its floodplain. Conversion of floodplain and wetlands to agricultural fields has resulted in dramatic losses of riparian and wetland plant and animal species, and related functions that support a healthy riverine ecosystem.

Although levee construction and the regulation of the natural flow regime through operations of Libby Dam benefited agriculture and played an important role in flood risk management, 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 has also reduced the Kootenai Tribe's access to traditional resources historically relied on for subsistence and cultural uses, and for which it has federally reserved rights to access and utilize. Today, this modified ecosystem is no longer able to support the biological complexity it once sustained.

In Canada, Corra Linn Dam was completed in 1931 for hydropower generation. The dam originally raised the elevation of Kootenay Lake. Grohman Narrows, the natural bedrock sill outlet to Kootenay Lake, was removed in the late 1930s, thus allowing Corra Linn Dam to provide control of the lake elevations, which now are typically about six feet lower in the spring/summer runoff months than occurred naturally and about three feet higher from October to May (Kootenai Tribe 2009).

Only limited information is available on KRWS populations and potential declines prior to the construction of Libby Dam, which became fully operational in 1974. However, the construction and operation of Libby Dam likely contributes significantly to the nearly complete recruitment failure of KRWS that is currently seen in Kootenai River (Paragamian et al. 2005). Flow regulation at Libby Dam is thought to be one of the reasons for the continued decline. Historically, the annual Kootenai River hydrograph consisted of minimum flows during the winter, followed by a rise in discharge in the spring, a peak in the late spring or early summer, and a recession for the remainder of the summer, fall and winter. Regulated spring peak flows are less than half the pre-Libby Dam peak flows, while winter flows have increased by 300 percent relative to the pre-dam period (USFWS 1999a; Kootenai Tribe 2009). High spring flows similar to pre-dam conditions have rarely occurred during the May-July spawning season since Libby Dam began operating in 1974.

Flow regulation at Libby Dam has also altered the sediment regime in the Kootenai River by trapping bedload and suspended load from the upper Kootenai sub-basin and reducing the sediment transport capacity of the river. In addition, flow regulation at Libby Dam has led to changes in the thermal regime

that may influence spawning cues and the rate of growth for various life stages of KRWS. Pre-dam conditions also supported higher turbidity due to glacial sediment, which likely provided some protection for eggs and larvae, as well as for migrating adults, from visual predators. Higher river stages associated with pre-dam conditions also supported greater floodplain connectivity; although the diking that occurred prior to construction of Libby Dam had already greatly affected floodplain connectivity. Construction of Libby Dam also significantly reduced the availability of nutrients that were historically delivered from the upper Kootenai sub-basin; those nutrients are now sequestered in Lake Koocanusa, changing the food web in the downstream reaches.

KRWS population estimates in the late 1970s and early 1980s indicated that recruitment was inconsistent and may have failed in many years before Libby Dam was completed (Andrusak 1980 and Partridge 1983 cited in Paragamian et al. 2005). The age structure data analyzed in Paragamian et al. (2005) also indicates few KRWS below age 20 by 1980. Following the completion of Libby Dam, native fish stocks such as KRWS, burbot (*Lota lota*), kokanee (*Oncorhynchus nerka*), redband trout (*O. mykiss gairdneri*), westslope cutthroat trout (*O. clarki lewisii*) and bull trout (*Salvelinus confluentus*), as well as local wildlife populations, have exhibited significant declines. The most comprehensive published study of KRWS populations from 1977 to 2001 indicates that the KRWS population has declined from approximately 6,800 fish in 1980 to approximately 640 fish in 2002 (Paragamian, Beamesderfer, and Ireland 2005). This is a cumulative decrease of approximately 90 percent over that time period and an average annual decline of 9 percent. Fishing was still allowed until 1994, and the rate of decline/mortality has been reduced with the closure of the fishery, and averaged 5.6 percent for the 1997 to 2001 time period from catch curve data (Paragamian, Beamesderfer, and Ireland 2005). Recent empirical data analyses indicate the current population is around 1,000 fish with an annual mortality rate of four percent (Beamesderfer et al. 2009).

The cumulative effects from other actions prior to completion of Libby Dam have undoubtedly played a significant role, but Libby Dam has become an obvious factor for declines in fish and wildlife populations and constrains restoration options due to its on-going operation.

2.2.5 Kootenai River Habitat Restoration Project Master Plan Goals and Objectives

The *Kootenai River Habitat Restoration Project Master Plan* (Kootenai Tribe 2009) provides a watershed-scale 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 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 riverine ecosystem to restore the conditions necessary to create and maintain habitat benefiting a range of species in dynamic environments.

Table 2-2. Goals and Objectives of the Kootenai River Habitat Restoration Project Master Plan

Goal	Objective
Morphology Restore physical habitat by reducing the negative effects to river and floodplain ecological processes caused by river response to the altered landscape.	Mainstem Kootenai River: Improve channel stability to similar levels as reference streams assuming that such levels will support sustainable populations of focal species that function naturally and may be capable of supporting appropriate forms of human use (i.e., harvest).
Riparian Vegetation Restore native vegetation by establishing stream bank and floodplain conditions that sustain plant community development processes.	• Tributary: Restore riparian habitats to similar levels as reference streams. • Riparian: Restore riparian vegetation communities on 10 percent of the riparian acres in specific subunits 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.
Aquatic Habitat Restore aquatic habitat conditions that support all life stages of native fish and promote sustainable populations.	• Improve riparian function and complexity of mainstem riparian habitat to levels that support or contribute to sustainable populations of focal species that function naturally and may be capable of supporting appropriate forms of human use (i.e. harvest). • Improve habitat diversity. • Protect and maintain prime, functioning tributary habitat. • Protect habitat diversity in prime, functioning streams and reaches. • Determine opportunities for altered hydroelectric operations to remove delta blockages from tributary streams. • Restore and provide passage to migratory fish by removing potential barriers, i.e., impassable culverts, hydraulic head-cuts, water diversion blockages, landslides, and impassable deltas. • White Sturgeon, Bull Trout, and 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). • 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).
River Stewardship Create opportunities for river and floodplain stewardship in the community.	• Secure management rights and implement management agreements to conserve, maintain and restore 10 percent of riparian or floodplain acres consistent with current or future management and mitigation plans. • Monitor and treat an average of 10 percent of acres with exotic species infestations consistent with current and future management and mitigation plans. Most grassland/shrub, xeric forest and mesic forest objectives in the Subbasin Plan also support this goal.

Source: Kootenai Tribe 2009.

2.3 MEANDER REACH 1 PROBLEMS AND OPPORTUNITIES

The Master Plan provides a watershed scale restoration framework for the Kootenai River, and provides the context for conducting this Section 1135 study consistent with these broader ecosystem level plans Previous studies on KRWS spawning have indicated that nearly all KRWS attempts to spawn occur in Meander Reach 1. Thus, restoration actions focused on early life stage survival are most likely to be effective within the reach currently used by KRWS for spawning and are the focus of the feasibility study.

The Project Delivery Team (PDT) composed primarily of USACE discipline specialists, federal and state agency technical experts and representatives, and non-federal sponsor experts and representatives convened a workshop in May 2010 to identify problems and opportunities specific to Meander Reach 1 (see Chapter 7 for more information on Public Involvement). Table 2-3 is a compilation of problems and opportunities related to KRWS population decline developed using information in the Master Plan, review of relevant literature, and discussion at the May 2010 workshop.

There has been no significant recruitment of young sturgeon into the KRWS population since the early 1970s and consistent recruitment has not been seen since the 1950s. The existing wild population is currently spawning over compacted and lacustrine clay and sand substrate in Meander Reach 1. Coarse substrates, *defined as consisting of material within the gravel, cobble and boulder size ranges*, are thought to be necessary to early life stage survival. Eggs need to attach to a coarse substrate for approximately 8 to 15 days to develop properly and free-embryos (dependent on yolk sac for energy) are photonegative through about seven days following hatching and seek refuge from predators in the interstitial spaces of coarse substrate. After this stage, the larval fish are free swimming and become photopositive and no longer seek refuge in the substrate (typically 21 days).

The availability of suitable habitat for early life stage survival was identified as the first bottleneck in the survival of KRWS and was therefore selected as the highest priority restoration action for this Section 1135feasibility study. Broader restoration opportunities such as reconnection of the floodplain, restoring floodplain habitat and riparian zone, and increasing food web productivity are all important ecosystem components that would provide benefit to other life stages of KRWS or secondary benefits to early life stages but do not directly address failure of KRWS to survive through the early life stages. Shorty's Island/Meander Reach Ecosystem Restoration Project and other larger-scale projects that address other aspects of the degraded Kootenai River ecosystem are considered in the Master Plan (Kootenai Tribe 2009) and could also be considered under larger-scale USACE authorities. Federal-funding limits under the Section 1135 program (five million dollars) are also intended to support focused projects that address specific and discreet water resource issues.

Table 2-4 summarizes the identified problems and opportunities specific to the early life stage survival in the context of ecosystem structure and function that are the focus of this project.

This study focuses on the restoration of ecosystem function and suitable habitat attributes for KRWS early life stages because it is factor requiring urgent action. Restoration of suitable habitat function, complement the restoration approach of the Master Plan and on-going activities likely to be undertaken by the Kootenai Tribe and other entities to restore ecosystem functions and processes and will aid in the natural reproduction and recovery of KRWS.

Based on the assessment of problems and opportunities the PDT identified the following as the goal of the project:

Improve the early life stage survival of the ESA-listed Kootenai River White Sturgeon.

Table 2-3. Kootenai River White Sturgeon Recovery: Problems and Opportunities in Meander Reach 1

Problems	Opportunities
Significant decline in KRWS populations, since the 1950s, most noticeable since 1970s, leading to possible extinction by 2030.	Restore and maintain Kootenai River habitat conditions in Meander Reach 1 to support all life stages of endangered KRWS.
Lack of natural recruitment since before 1980. Low rate of early life stage survival, contributing to decline in population.	
Wild population is reproductively mature and declining (640 adults in 2002 with 5.6 percent estimated decline [Paragamian et al.2005]), implying that the population's ability to recover is declining.	Restore habitat in Meander Reach 1 to create more resilient ecosystem, capable of sustaining diverse native plant and animal populations, and tolerant of natural disturbances and altered regimes.
Vast majority of documented spawning occurs over sand substrate unsuitable for successful early life stage survival.	Improve spawning and early life stage survival habitat in Meander Reach 1 by addressing physical attributes within the context of river morphology and river management.
Degradation of KRWS natural habitat and population has led to loss of a Tribal cultural, economic, and socio-economic resource. In consultation and coordination with the Kootenai Tribe, preserve and rebuild fisheries in the Kootenai Tribe's usual and accustomed areas in order to meet the federal government's trust responsibilities to the Kootenai Tribe. The Kootenai Tribe harvested KRWS and other fish species and the right to do so was reserved by the Treaty of Hell Gate of 1855. The Kootenai Tribe voluntarily halted harvest of KRWS in the 1980s due to the imperiled status of the species.	Contribute to the recovery of the KRWS population such that it may be reincorporated into the Tribal and local culture and economy.
Natural floodplain disconnected from Kootenai River due to levee construction contributing to loss of ecosystem function.	Reconnect Kootenai River floodplains to Meander Reach 1.
Loss of riparian zone along river due to agriculture encroachment and construction of levees.	Restore riparian zone in Meander Reach 1.
Loss of habitat diversity due to floodplain disconnection, loss of riparian zone, and operation of Libby Dam.	Increase habitat diversity in the Meander Reach 1.
Degradation of food web due to disconnection and elimination of productive floodplain habitats and storage of nutrients behind Libby Dam.	Restore productive habitats and improve nutrients in Meander Reach 1 as necessary to compensate for Libby Dam.

Note: KRWS – Kootenai River White Sturgeon

Table 2-4. Identified Section 1135 Problems and Opportunities for Meander Reach 1

Problems	Opportunities
Lack of natural recruitment: Low rate of early life stage survival is primary bottleneck to KRWS recruitment. Documented spawning occurs over sand substrate unsuitable for successful early life state survival.	Provide suitable early life stage habitat for the reproduction and survival of KRWS.

2.4 PROJECT PURPOSE AND NEED

2.4.1 PURPOSE

The purpose of the Shorty's Island/Meander Reach Ecosystem Restoration Project is to identify and implement cost-effective, self-sustaining ecosystem restoration actions to improve ecosystem function and habitat attributes for the early life stage survival of the ESA-listed KRWS.

2.4.2 NEED

The first known bottleneck related to reproduction and survival of KRWS is the lack of suitable substrate for egg attachment, incubation, and embryo cover. Fish currently cue to spawn in an area where suitable habitat for egg attachment and early life state development is currently nonexistent or extremely limited. Improvement in suitable habitat of the Kootenai River for early life stage survival is critical to support recovery efforts for the continued survival of wild KRWS.

KRWS have been listed as an endangered species since 1994 and since that time minimal successful natural reproduction has occurred (Paragamian et al. 1997). Based on recent population and mortality rate estimates KRWS could be extinct by 2030 if recovery efforts are not successful. 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 experience increasing difficulty finding 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, as the lack of successful reproduction will prohibit the wild population from sustaining itself.

The need for this project is to provide suitable habitat for survival of the early life history stages for KRWS. Restoration of ecosystem function and habitat attributes is a critical component of KRWS conservation and recovery. The project will address the lack of suitable habitat for survival of the early life stages, which will contribute towards the recovery of a sustainable natural population of the species.

2.5 PLANNING OBJECTIVES AND CONSTRAINTS

This section identifies the specific study objective and the conditions that may limit achieving that objective. Per guidance ER 1105-2-100, Planning Guidance Notebook, dated April 22, 2000, an objective is a statement of what an alternative plan should try to achieve, while a constraint is basically a restriction on what alternative plans should be considered or implemented. The objective has been developed based on the assessment of problems and opportunities. The PDT reviewed and revised the objectives and constraints to focus the study on the types of actions that could realistically be accomplished through the Section 1135 authority.

2.5.1 OBJECTIVES

The Master Plan identifies a suite of broad objectives to meet the goal of improving the KRWS population in the Kootenai River. The Master Plan objectives address various life stages of KRWS and known limiting factors. During initial scoping for this study, these broad objectives were considered for inclusion. However, given the critical need to address KRWS early life history stage survival, as well as the funding limits of the Section 1135 program, the objective of this investigation is more focused.

Dramatic improvement in suitable habitat within Meander Reach 1 to support egg attachment and early life stage development is critical to the continued survival of wild KRWS. Implementation of measures to restore and improve aquatic habitat suitable for early life stages is the primary focus of this study.

Considerations of key characteristics of the KRWS species were taken into account during identification of objectives.

White sturgeon are generally known to spawn in fast-flowing water and velocity appears to act as an important cue for spawning (USFWS 2008). Fast-flowing waters also help to maintain the open interstitial space of the exposed coarse substrate essential for successful egg incubation and the free-embryo hiding phase of the KRWS reproduction cycle (USFWS 2008). Water depth is also thought to be an important factor in spawning site selection. White sturgeon have been found to spawn between 0 and 20 meters in depth.

White sturgeon are broadcast spawners and release demersal eggs (eggs that are negatively buoyant and 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 spawning over coarse bed material that supports egg viability and where the free-embryos that emerge from eggs have appropriate habitat for development and protection from predators (USFWS 2008). Coarse rocky substrates provide fixed surfaces for the attachment of the adhesive eggs during incubation and also provide shelter for the free-embryo hiding phase following hatching in which free-embryos seek cover from predators in the inter-gravel spaces (Brannon et al. 1984; Parsley et al. 2002).

The term suitable substrate is used throughout this document to refer to hard substrate that consists of a mixture of gravel, cobble, and small boulders, is relatively free of sand, and that meets the spawning and early life stage needs of KRWS. The existing wild population is currently spawning over sand and compacted lacustrine clay and sand substrate in Meander Reach 1. Coarse substrates, *defined as consisting of material within the gravel, cobble and boulder size ranges*, are believed to be necessary for early life stage survival (see Section 2.4 for additional discussion of early life stage use of coarse substrates).

Based upon the discussion of the critical need to address KRWS early life history stage survival via the project purpose and goal, the following objective for the restoration project was developed cooperatively by the PDT:

Provide suitable aquatic habitat in Meander Reach 1 for early life stage survival of KRWS to support recovery efforts over the next 5 to 20 years.

Implementation of measures to restore and improve aquatic habitat suitable for early life stages is the primary focus of this study. If KRWS cannot survive past the egg and early life history stages, there is little benefit of improving broader ecosystem conditions. Thus, the objective of the project is to improve early life stage survival for KRWS. The limited scope and objective of this project will restore a small component of the Kootenai River ecosystem. Broader ecosystem restoration objectives, such as those identified in the Master Plan may lead to the future development of projects that provide benefit to other life stages of KRWS or secondary benefits to early life stages but do not directly address early life stage survival.

2.5.2 CONSTRAINTS AND CONSIDERATIONS

Constraints are significant barriers or restrictions that limit the planning process. Constraints can be related to resources or physical implementation of a plan. Constraints also reflect federal law, USACE policy, or other regulation that must not be violated. Considerations inform the study scope and planning framework. The following are several constraints and considerations specific to this Section 1135 feasibility study in Meander Reach 1.

2.5.2.1 CONSTRAINTS

The following constraints for the current feasibility study have been identified:

- Libby Dam and Kootenay Lake operations: The design of restoration measures must account for current Libby Dam operations and Kootenay Lake levels.
- Actions taken for KRWS cannot adversely affect other ESA-listed species in the project area.
- The in-water work window has been identified as August 1 to November 30.
- Project operation and maintenance requirements must be minimized.

2.5.2.2 CONSIDERATIONS

The following considerations for the current feasibility study have been identified:

Scope/Planning

- Restoration measures and alternatives will be limited to the study area, Meander Reach 1, the Kootenai River reach where wild KRWS are currently known to spawn.
- Opportunities related to other life stages and other limiting factors identified in the Master Plan, such as restoration of floodplain and the riparian zone are beyond the scope of this study and will not be considered further. Riparian and side channel restoration actions that could support spawning and early life stages are considered under preliminary plan formulation in Section 4.1. It is not possible to contribute significantly to the productivity of the food web unless large scale floodplain and habitat restoration actions are feasible; thus, actions focused solely on food web restoration will not be further considered.

Physical or Existing Limitations

- Land required for restoration features must be in public ownership or owned by willing, participating parties.
- Existing Land Uses
    - Restoration actions must account for existing land uses. Some existing land management uses (e.g., existing livestock grazing of riparian areas) may require inclusion of protective measures as part of the project.
- Hydraulic, Geomorphology and Sediment Transport
    - Bank erosion in the Braided Reach will continue to contribute sand and finer sediment to Meander Reach 1.
    - Project operation and maintenance requirements must be none or very minimal.
    - A significant load of sand and finer sediment will continue to be contributed from the watershed between Libby Dam and the Braided Reach.
    - The Kootenai River will continue to be incapable of transporting gravel and larger sediments suitable for spawning and early life stage survival into the Meander Reach.
- Libby Dam and Kootenay Lake Operations
    - To the extent practical, restoration measures need to account for potential future changes in Libby Dam operations and Kootenay Lake elevations.

3 AFFECTED ENVIRONMENT

Chapter 3 provides an assessment of the existing and future without-project conditions for the affected study area environment. This chapter corresponds to step two in the planning process; to develop an inventory and forecast of critical resources relevant to the problems and opportunities under consideration in the planning area. All aspects of the affected environment are addressed in accordance with NEPA. Particular emphasis is placed on those aspects of the physical environment related to KRWS decline including hydrology, hydraulics, geomorphology, and sediment transport. Evaluating the existing and future without-project condition establishes the baseline against which measures and alternatives will be evaluated. USACE typically uses a 50-year evaluation period, so it is important to consider the existing environment but also anticipated changes in the future without-project condition. Historic conditions are also presented as a point of reference and help document the type of structure and function that previously existed to support KRWS.

The text in Chapter 3 draws information from the *Kootenai River Habitat Restoration Project Master Plan* as well as two planning workshops, the first held May 19 and 20, 2010, and the second held December 2 and 3, 2010. These workshops developed project-specific information, and relied on the collaboration of stakeholders and experts from the Kootenai Tribe, USACE, and resource agencies including the BC Hydro, BCMoE, BPA, IDFG, MFWP, USFWS, and USGS. Other citations are provided in text as needed.

The area of concern for the affected environment description is defined as the Meander Reach 1 of the Kootenai River, as described in Section 1.3.2.4. The description of affected environment may describe a larger geographic area as necessary to fully characterize the Meander Reach and the existing and future without-project condition.

3.1 GEOLOGY AND SOILS

3.1.1 GEOLOGY

The sinuous course of the Kootenai River reflects the influence of structural geology and multiple glaciations. From its origin in B.C., the river flows south-southeast down the Rocky Mountain Trench (Galay et al. 1983) that is overlain with large volumes of glacial and alluvial deposits. A few miles south of the international border, the river diverges from the Trench and flows south down a narrow mountain valley that is now the site of Libby Dam. The abrupt turn to the west just below Libby Dam is a result of the river cutting almost directly across the mountain ridges of the Purcell and Cabinet Mountain Ranges. In the Kootenai Flats area the river turns north and flows through the broad Purcell Trench back into Canada, where it enters Kootenay Lake.

The Kootenai watershed is largely underlain by metamorphic Precambrian sedimentary bedrock, primarily of the Belt supergroup. These ancient rocks were later intruded by Tertiary plutonic rocks in the western portion of the watershed (Aadland and Bennett 1979). Folding, faulting, uplift and erosion created the north-northwest trending mountains and valleys of this northern portion of the Rocky Mountains. The Belt supergroup rocks are characterized as hard, fine-grained and highly resistant to erosion as well as being very low in nutrients. Where rocks are exposed, they form steep cliffs and confined river reaches, and there is little input from erosion of sediments (Kootenai Tribe and MFWP 2004).

During at least two glaciations, the Cordilleran ice sheet covered the Kootenai watershed and only the highest peaks of mountain ranges were exposed above the ice (Alden 1953). The ice broadened and deepened pre-existing structural valleys. Glacial till was deposited by the ice sheet. During glacial

advances and retreats, the glacier blocked the Kootenai River's outlet creating a huge lake that filled the valleys of the Kootenai River and its south-side tributaries. In addition, the glacial Lake Kootenay was occasionally connected to the glacial lakes in the Columbia River system to the south; thus allowing Columbia River basin fish that would otherwise have been blocked by falls to enter the Kootenai River (Kootenai Tribe and MFWP 2004). These vast glacial lakes received sediment from rivers and glaciers and accumulated sediment deposits tens to hundreds of feet thick. This glacial history created a complex sequence of deposition and erosion that formed heterogeneous, interbedded valley-fill sediments along the valley bottom. These sediments are of both glacial and inter-glacial origin. Depositional mechanisms in the study area likely included ice-contact deposition, proglacial outwash and lake deposition, and inter-glacial depositional settings (Barton 2004).

When the ice sheet receded to Canada, the lake level lowered and the soft lacustrine silt beds were rapidly eroded. The steep, rejuvenated rivers and streams widened their valleys, eroding and transporting both coarse and fine glacial sediments. As the river downcut, an inner gorge developed that was flanked by one or more levels of terraces. The high upper terraces are composed primarily of glacial deposits, while the lower terraces are fluvial deposits of gravel (Alden 1953). In some places, the Kootenai River has cut through the glacial sediments into the underlying bedrock. Bedrock is exposed in the riverbed near the Fisher River, in the Kootenai Falls area, and near Troy. It is also exposed in riverbanks and bottomlands near Bonners Ferry.

Post-glacial fluvial erosion of glacial sediments produced a huge volume of sediment that was carried downriver. The bedrock sill at the outlet of the West Arm of Kootenay Lake resisted downcutting. It is likely that post-glacial Kootenay Lake originally extended south along the Purcell Trench nearly to Bonners Ferry, but was gradually filled with hundreds of feet of fine sediment eroded from up-valley, so that the lake was gradually converted into a floodplain (Alden 1953). Infilling of the lake continues today as sediment is deposited in the delta of Kootenay Lake, although the rate has probably slowed appreciably due to sediment trapping by Libby Dam and other anthropogenic reasons. This low gradient, depositional environment is a factor in creating the highly sinuous planform of Meander Reach 1 and 2.

Three major named faults occur in the survey area including the Kootenai Fault, which trends north-south along the present trace of the Kootenai River, the Round Prairie Fault, which trends east-west between the Moyie Range and the Cabinet Mountains, and the Moyie Fault, which extends north-south along the Moyie River (USDA Soil Conservation Service 2005).

3.1.2 SOILS

The soils in the study area formed from residual glacial, lacustrine, alluvial, and eolian parent material. The mountains are mainly residual material derived from Precambrian metasedimentary rocks and metamorphosed igneous rocks of the Kaniksu Batholith (Ross and Forrester, 1958). These rocks are highly fractured and weather into the parent material for most soils of the area, which contain a high percentage of rock fragments. The Baldeagle, Jaypeak, Katka, and McArthur soils are typical of this group. These soils also contain varying amounts of loess and volcanic ash deposited during the late Pleistocene and Holocene Epochs (USDA Soil Conservation Service 1984).

Many soils in the foothills and mountains are formed in glacial till that consists of varying amounts of sand, silt, gravel, cobbles, and stones deposited directly or indirectly by the action of glacial ice and melt water. This material is covered by a surficial deposit of volcanic ash and loess. The Caribouridge, Dufort, Highfalls, Idamont, Pearsoncreek, Pend Oreille, Redraven, Roman, Rubycreek, Treble, and Zee soils formed in glacial till. During the late Pleistocene Epoch, the Dodgecreek, Myrtlecreek, Snowlake, and Stien soils formed in glacial outwash deposited by melt water from receding glaciers. These soils contain a high percentage of sand or rock fragments.

Volcanic ash present in the study area is predominantly silt sized, and originated from many active volcanoes in western Washington and western Oregon, including Mt. St. Helens, Mt. Rainier, and Glacier Peak. The greatest contribution of ash in this area, however, came about 6,700 years ago from the eruption of Mt. Mazama, the cone of which is now Crater Lake, in southwestern Oregon. The Mazama ash fall was the only one of sufficient extent and thickness to have significantly affected the soils in the area. The ash fell over the entire area but was eventually eroded from areas that did not have full tree coverage. Soils, such as those of the Dufort, Idamont, and Pend Oreille series, retain most of the volcanic ash and are strongly influenced by this material.

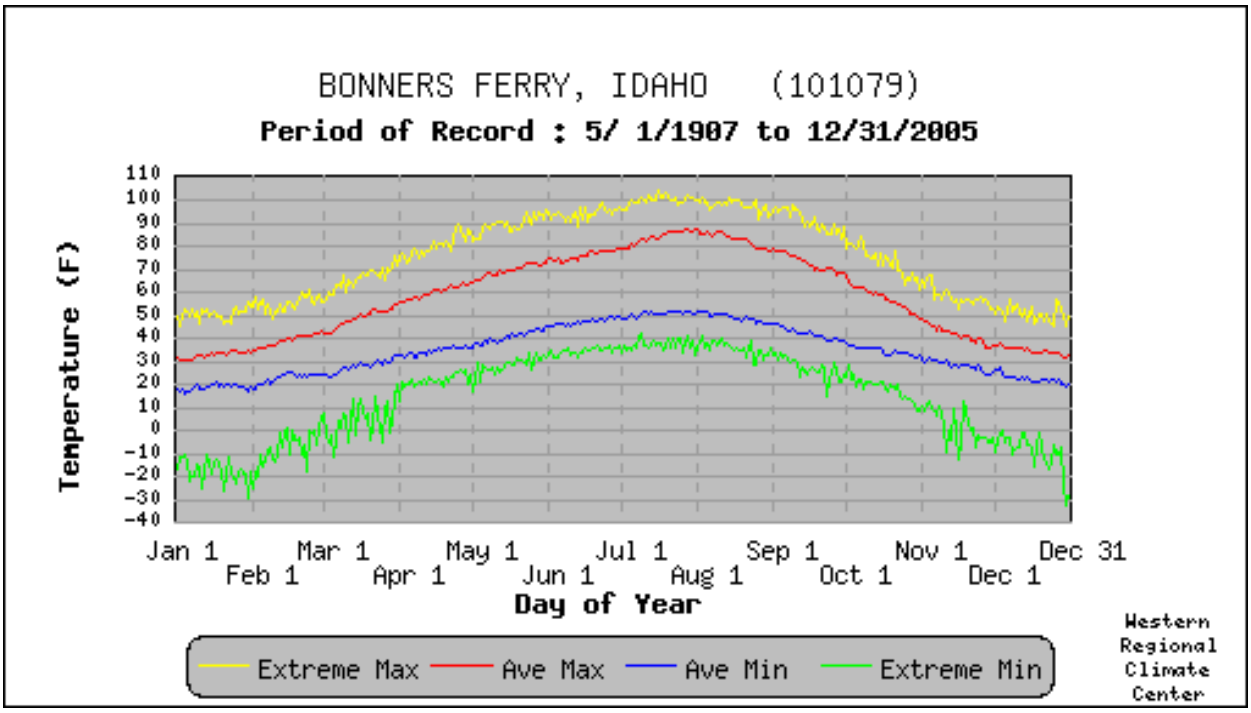
The high terraces or benches adjacent to the broad Kootenai River floodplain are primarily silty, calcareous, glaciolacustrine deposits many hundreds of feet thick. The Frycanyon, Porthill, Rubson, and Zioncreek soils occur on the gently sloping tops of the terraces. The Artnoc, Caboose, Crash, Flemingcreek, and Wishbone soils occur on the steep escarpments and terrace slopes (USDA 2005). Soils in the Kootenai River floodplain formed mainly in relatively recent silty alluvial deposits. As water spread over the floodplain and slowed, silt, clay, and very fine sand sediments were deposited. The Farnhamton, Ritz, and Schnoorson soils formed in these alluvial deposits. The DeVoignes and Pywell soils formed in a combination of organic deposits and alluvium. Large areas of eolian sand associated with wind deposition of the original lake-laid sediments are found near Naples. The Elmira and Selle soils formed in these sandy, dune areas (NRCS 2005).

3.2 CLIMATE

The strongest determinants of weather across the area are the Pacific Ocean and mountains. Warm, moist air masses from the Pacific bring moisture during winter, spring, and fall; mountains then influence where most of the moisture will fall. The mountains also act as a trap for moisture, as well as a barrier to the flow of continental air, especially during winter. 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.

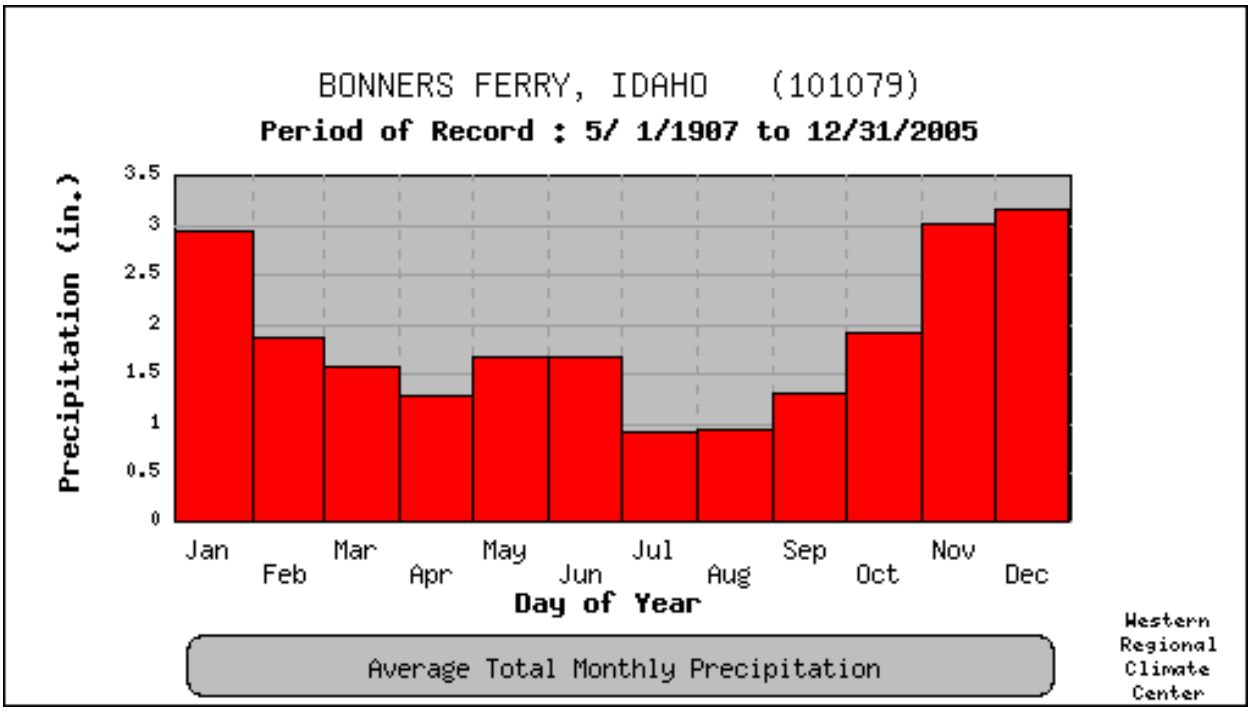
The average annual air temperature at Bonners Ferry, Idaho is 47°F, reaching or exceeding 90°F on half the days in July and August. July is the warmest month with an average maximum of 84°F and minimum of 50°. In contrast, January is the coldest month with an average maximum of 32°F and average minimum of 19°F. Figure 3-1 shows average and extreme temperature at Bonners Ferry throughout the year.

Mean annual precipitation in the Idaho portion of the Kootenai subbasin is 30 inches, approximately 70 percent to 80 percent of which falls as snow between November and March. Bonners Ferry is drier than the average for the subbasin with a mean annual precipitation of 22 inches. The wettest month is December with an average monthly precipitation of 3.1 inches. It is closely followed by November and January which each average 3.0 inches of total precipitation. The driest month is July with 0.9 inches of precipitation on the average. The average annual snowfall in Bonners Ferry is 65 inches, with nearly 80 percent falling in December, January and February. Figure 3-2 provides a plot of the average monthly precipitation at Bonners Ferry.



Source: Western Regional Climate Center 2010

Figure 3-1. Daily Average and Extreme Temperatures for the Period of 5/1/1907 to 12/31/2005 at Bonners Ferry, Idaho



Source: Western Regional Climate Center, 2010

Figure 3-2. Average Total Monthly Precipitation for the Period 5/1/1907 to 12/31/2005 at Bonners Ferry, Idaho

3.3 HYDROLOGY

The Kootenai River drains a basin of 19,300 square miles. Approximately 75 percent of the basin lies within B.C. About two-thirds of its 485 mile length lies in Canada, and the remainder flows through the states of Montana and Idaho (see Figure 1-1). The Continental Divide forms much of the eastern basin boundary. The western and southern boundaries of the Kootenai River basin are formed by the Selkirk Mountains and Cabinet Mountains, respectively, with several peaks in excess of 10,000 feet. The Purcell Mountains fill the center portion of the basin. From its headwaters in B.C. to Kootenay Lake in B.C., the river drops approximately 2,300 feet in elevation and flows southward into northwestern Montana.

Libby Dam impounds the nearly five million acre-feet Lake Koocanusa (useable storage of 4.93 million acre-feet, gross storage of 5.89 million acre-feet) near the midpoint of the Kootenai River's path. Lake Koocanusa and its tributaries receive runoff from approximately 50 percent of the Kootenai River drainage basin. At Wardner, B.C., where the river enters Lake Koocanusa, the mean annual discharge is 7,344 cubic feet per second (cfs), or about 46 percent of the water flowing into Kootenay Lake (Kootenai Tribe and MFWP 2004). Of the 90 miles of Lake Koocanusa, 48 miles lie in the U.S.

Major tributaries to the Kootenai River downstream from Libby Dam include the Fisher, Yaak, and Moyie Rivers; their average combined discharge is 2,306 cfs, about 14.5 percent of the flow that ultimately enters Kootenay Lake. By the time the Kootenai River reaches Bonners Ferry, Idaho, the mean annual flow has increased to 14,981 cfs, about 94 percent of what the Kootenai River delivers to Kootenay Lake.

At Bonners Ferry, approximately 35 miles downstream of Troy, the Kootenai River enters the broad floodplain area known as Kootenai Flats and picks up flow from two major tributaries; Deep Creek (194 square miles) and Boundary Creek (95 square miles). Flowing northward through Kootenai Flats, the river crosses the international boundary approximately 50 miles downstream of Bonners Ferry. About 25 miles north of the international boundary, the river enters Kootenay Lake. The Kootenai River exits 50 mile long Kootenay Lake near Nelson, B.C. through the Grohman Narrows and flows 23 miles downstream to the Columbia River confluence at Castlegar, B.C. Just downstream from where it leaves the lake through the western arm; its average annual discharge is 27,965 cfs (Kootenai Tribe and MFWP 2004). In this lower reach, it is impounded by Corra Linn Dam, about 10 miles downstream of Kootenay Lake. Depending on flow and lake elevations, the outflow from Kootenay Lake is controlled by either the Grohman Narrows or Corra Linn Dam. A natural barrier at Bonnington Falls has historically isolated fish from other populations in the Columbia River basin. The natural barrier isolated sturgeon and other species for approximately 10,000 years (Northcote 1973). The natural barrier has been superseded by the completion of a series of four dams that maintain this separation.

3.3.1 HISTORICAL FLOWS

USGS operates several stream gages on the Kootenai River from Libby Dam downstream to Porthill at the international boundary (Table 3-1). The Bonners Ferry gage, which is closest to the study area, provides data only for stage. Consequently, the Porthill gage was chosen because of its long-term and complete record of discharge. The Porthill gage record available at the time of this report spans the period from water year (WY) 1929 to WY 2009 and includes both mean daily flows and instantaneous annual peak flows. The period prior to Libby Dam construction is referred to as pre-Libby Dam and represents the historical condition. To be consistent with the Master Plan (Kootenai Tribe 2009) the period of the pre-Libby Dam Record from WY 1961 through WY 1971 was used to represent historical condition.

Table 3-1. Summary of USGS Gage Information Available for the Kootenai River between Libby Dam and the U.S.-Canada Border

Gage Name	USGS Gage ID Number	Drainage Area (square miles)	Period of Record
Kootenai River at Worland Bridge near Libby, MT	12301850	8,892	7/1961 to 9/1971
Kootenai River below Libby Dam near Libby, MT	12301933	8,985	10/1971 to 7/2010
Kootenai River at Libby, MT	12303000	10,240	10/1910 to 9/1991
Kootenai River at Leonia, ID	12305000	11,740	3/1928 to 7/2010
Kootenai River at Katka, ID	12306000	11,860	4/1928 to 9/1933
Kootenai River near Copeland, ID	12318500	13,400	5/1929 to 9/1992
Kootenai River at Porthill, ID	12322000	13,700	10/1928 to 01/2010

Utilizing the data from the Porthill gage the representative hydrologic characteristics were calculated for the available pre-Libby Dam period of record spanning WY 1929 through WY 1971 from the daily flow record. The hydrologic characteristics were also calculated for the shorter pre-Libby period of WY 1960 through WY 1971 used to represent pre-Libby Dam conditions in the Master Plan (Kootenai Tribe 2009). For the pre-Libby Dam period the median of the annual peak flows is 81,500 cfs or 87,100 cfs for the shorter period used in the Master Plan. The average annual water yield over this period is 11.7 million acre-feet per year corresponding to an average flow rate of 16,110 cfs or 12.3 million acre-feet and 16,950 cfs for the shorter period used in the Master Plan. The highest instantaneous peak flow recorded in the pre-Libby Dam period is 125,000 cfs, on May 29, 1961 (117,000 cfs on May 29, 1961 for the shorter period used in the Master Plan). The month with the highest average flow over the pre-Libby Dam period is June with an average flow of 51,500 cfs (60,600 cfs for period used in the Master Plan). The month with the lowest average pre-Libby Dam flow is January with 4,670 cfs (4,580 cfs for the shorter period used in the Master Plan).

To develop a typical hydrograph, the flows occurring on each calendar day were ranked and a median flow was determined for each day of the year. To smooth these flows, a seven day moving average was also applied. The resulting flows were referred to as the "daily median flows." Since this was performed for each day of the year, 365 daily median flows were determined. Using this procedure the maximum daily median flow for the pre-Libby Dam period is 56,700 cfs occurring on June 9 (65,500 cfs on June 12 for the shorter period used in the Master Plan).

Table 3-2. Selected Hydrologic Characteristics for the Pre-Libby Dam Period (Historical Condition) for both the Entire Available Period of Record and the Master Plan Pre-Libby Dam Period

Hydrologic Characteristic	Period Pre-Libby Dam	
	WY 1929 through WY 1971	WY 1961 through WY 1971[1]
Average annual water yield for period (acre-feet)	11,670,000	12,276,000
Average annual discharge (cfs)	16,110	16,950
Median annual daily flow[2] (cfs)	7,490	7,590
Highest instantaneous annual peak flow (cfs)	125,000	117,000
Month, day and year of annual peak flow	June 1, 1948	May 29, 1961
Median instantaneous annual peak flow[3] (cfs)	81,500	87,100
Maximum daily median flow[4] (cfs)	56,700	65,500
Month and day of maximum daily median flow	June 9	June 12
Highest average monthly flow (cfs)	51,500	60,600
Month of highest average monthly flow	June	June
Lowest average monthly flow (cfs)	4,670	4,580
Month of lowest average monthly flow	January	January

Notes: cfs – cubic feet per second, WY – water year

[1] Period of WY 1961 through WY 1971 corresponds to period used in the Master Plan (Kootenai Tribe 2009) to represent pre-Libby Dam condition.

[2] This is the median daily flow for the period under consideration.

[3] This is the median of the instantaneous peak flows for the period under consideration.

[4] Separate median flows were calculated for each day of the year and referred to as the "daily median flows;" this value represents the maximum of the daily median flows for the period under consideration.

3.3.2 EXISTING AND FUTURE WITHOUT-PROJECT FLOWS

An analysis of the post-Libby Dam hydrologic record was performed to represent the existing condition and the future without-project condition. The record starting in WY 1992 was considered to represent the period when manipulation of Libby Dam releases were made to consider the spawning needs of KRWS. These flows are referred to as "post-sturgeon flows." The period of record for the post-sturgeon flows is WY 1992 through WY 2009. The post-Libby Dam period prior to the flows is referred to as pre-sturgeon flows and spans the period of WY 1972 through WY 1991.

Table 3-3 provides the hydrologic characteristics for the post-Libby Dam periods. The post-Libby Dam period includes statistics for both the pre-sturgeon flow and post-sturgeon flow periods. The primary comparisons provided in this section are between the entire pre-Libby Dam period (WY 1929 through WY 1971) and the post-sturgeon flow (WY 1992 through WY 2009). The former provides the most complete record for the pre-Libby Dam conditions and the latter is the closest representation of both existing and expected future conditions, which include sturgeon flows and well as other operational changes that have been implemented at Libby Dam over the past two decades. The shorter pre-Libby Dam period of WY 1961 through WY 1971 provides the hydrologic statistics for the period assigned to represent pre-Libby Dam conditions in the Master Plan (Kootenai Tribe 2009). The post-Libby Dam period of WY 1972 to WY 1991 provides post-Libby Dam hydrologic characteristics prior to sturgeon flows and other operational changes that have occurred at Libby Dam since 1992.

Table 3-3. Selected Hydrologic Characteristics for Post-Libby Dam for both Pre-Sturgeon Flow Period and Post-Sturgeon Flow Period (Existing and Future Without-Project Condition)

Hydrologic Characteristic	Period Post-Libby Dam	
	Pre-Sturgeon Flows	Post-Sturgeon Flows
	WY 1972 - WY 1991	WY 1992 - WY 2009
Average annual water yield for period (acre-feet)	10,948,000	11,280,000
Average annual discharge (cfs)	15,110	15,570
Median annual daily flow[1] (cfs)	15,300	12,900
Highest instantaneous annual peak flow (cfs)	60,200	62,700
Month, day and year of annual peak flow	June 1, 1972	June 20, 2006
Median instantaneous annual peak flow[2] (cfs)	36,000	36,700
Maximum daily median flow[3] (cfs)	19,800	30,500
Month and day of maximum daily median flow	Jan 20	June 5
Highest average monthly flow (cfs)	19,300	28,100
Month of highest average monthly flow	May	June
Lowest average monthly flow (cfs)	9,790	9,690
Month of lowest average monthly flow	March	March

Notes: [1] This is the median daily flow for the period under consideration.
[2] This is the median of the instantaneous peak flows for the period under consideration.
[3] Separate median flows were calculated for each day of the year and referred to as the "daily median flows;" this value represents the maximum of the daily median flows for the period under consideration.

The average annual water yield over post-Libby Dam post-sturgeon flow period is 11.3 million acre-feet per year or an average flow rate of 15,570 cfs. These values are within 10 percent of the pre-Libby values. The similarity of the annual water yields a good indicator that the differences seen in the pre- and post-Libby conditions are mainly a result of operations and not due to large fluctuations in the hydrologic cycle. Figure 3-3 provides the time series of daily flows over the period of record with the various sub-periods identified. Though the water yield changes very little, the distribution of flows throughout the year has changed significantly.

For post-sturgeon flow period of the post-Libby Dam record, the maximum daily median flow is 30,500 cfs. This is 54 percent of the pre-Libby Dam value of 56,700 cfs. For the post-sturgeon flow period, the highest instantaneous peak flow recorded is 62,700 cfs, on June 20, 2006, which is a 50 percent reduction from the 125,000 cfs for the pre-Libby period. The month with the highest average flow over the post-sturgeon period is June with an average flow of 28,100 cfs. For the pre-Libby Dam condition, June also has the highest average monthly flow, but the pre-Libby Dam value of 51,500 is almost double that of the post-sturgeon flow period. In contrast, during the pre-sturgeon flow period, the month with the highest average flow was May with only 19,300 cfs. The month with the lowest average flow for the post-sturgeon period is March with 9,690 cfs in contrast to January for the pre-Libby Dam period with 4,670 cfs which is about half the post-sturgeon flow value.

In terms of the various median flow characteristics, there are substantial differences between the pre-Libby Dam and post-sturgeon flow periods. The median annual daily flow, which corresponds to the 50 percent value on an annual flow duration curve, is 12,900 cfs for the post-sturgeon flow period in contrast to 7,490 cfs for the pre-Libby Dam period. The median of the instantaneous peaks for the post-sturgeon flow period is 36,700 cfs which is less than half the 81,500 cfs value for the pre-Libby Dam period. The maximum daily median flow of 30,500 cfs occurs on June 5 for the post-sturgeon flow period while it occurs on June 9 and has a value of 56,700 cfs for the pre-Libby Dam period.

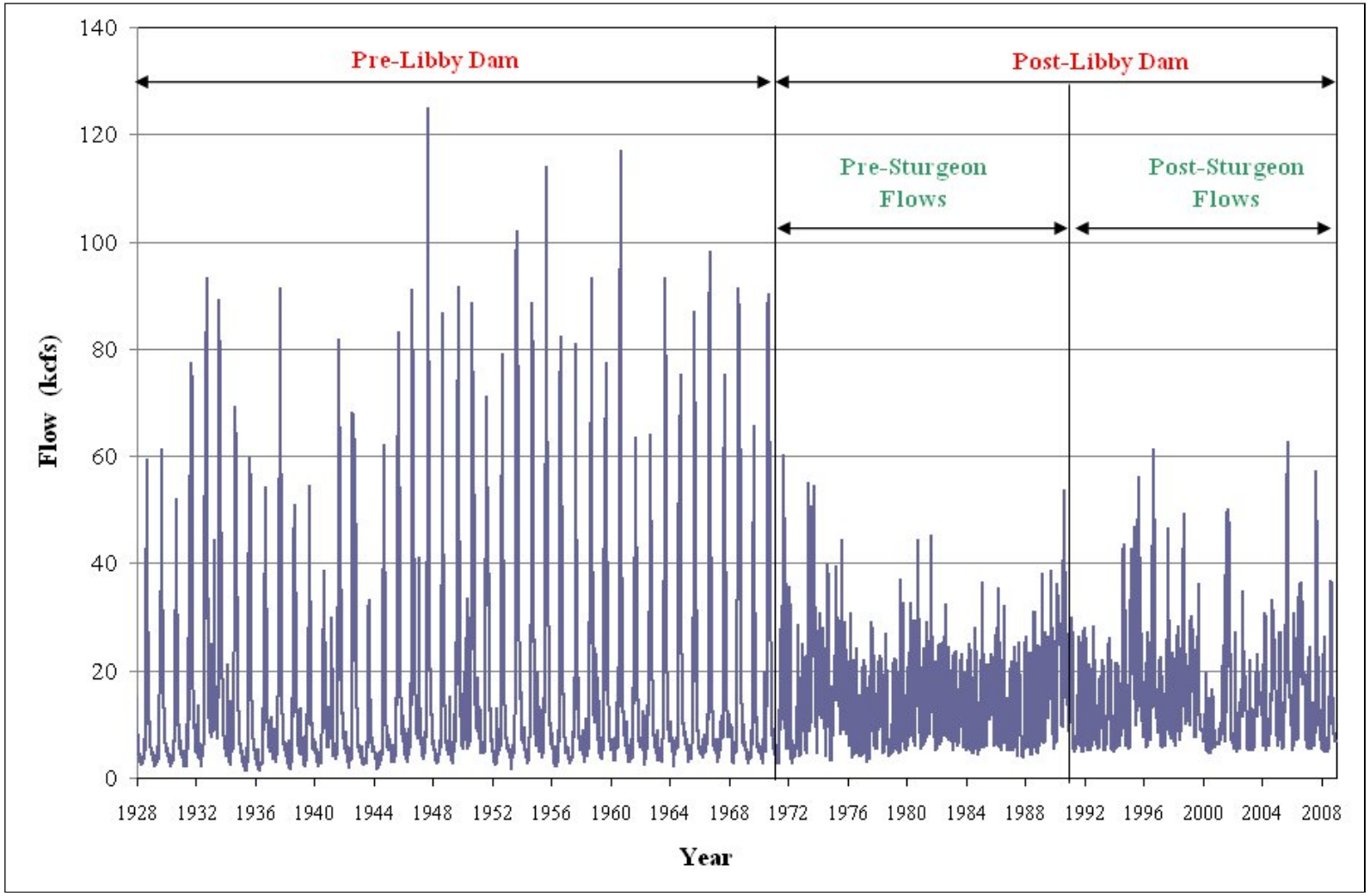


Figure 3-3. Time Series of Daily Flows at Porthill for the Period of Record, WY 1929 through WY 2009

In summary, the existing condition has peak flows that are reduced on the order of 50 percent from those during the pre-Libby Dam period. The peaks still occur in roughly the same period, May and June. The trend for low flows is the opposite. January had been the month with the lowest average flows prior to Libby Dam, but under the operation of Libby Dam during the post-sturgeon flow period, March now has the lowest average monthly flow. The existing low flow is nearly double the historical condition represented by the pre-Libby Dam period.

Figure 3-4 provides the daily median flows as well as the 25 and 75 percent quartile envelope for the Porthill gage. Trends previously discussed are apparent, especially the shifting of the low flow patterns. The operation of Libby Dam has created a second peak in the December and January time frame that is four to five times the historical flows during what was previously the lowest flow period of the year. The same trend is evident in the average monthly flows provided in Figure 3-5.

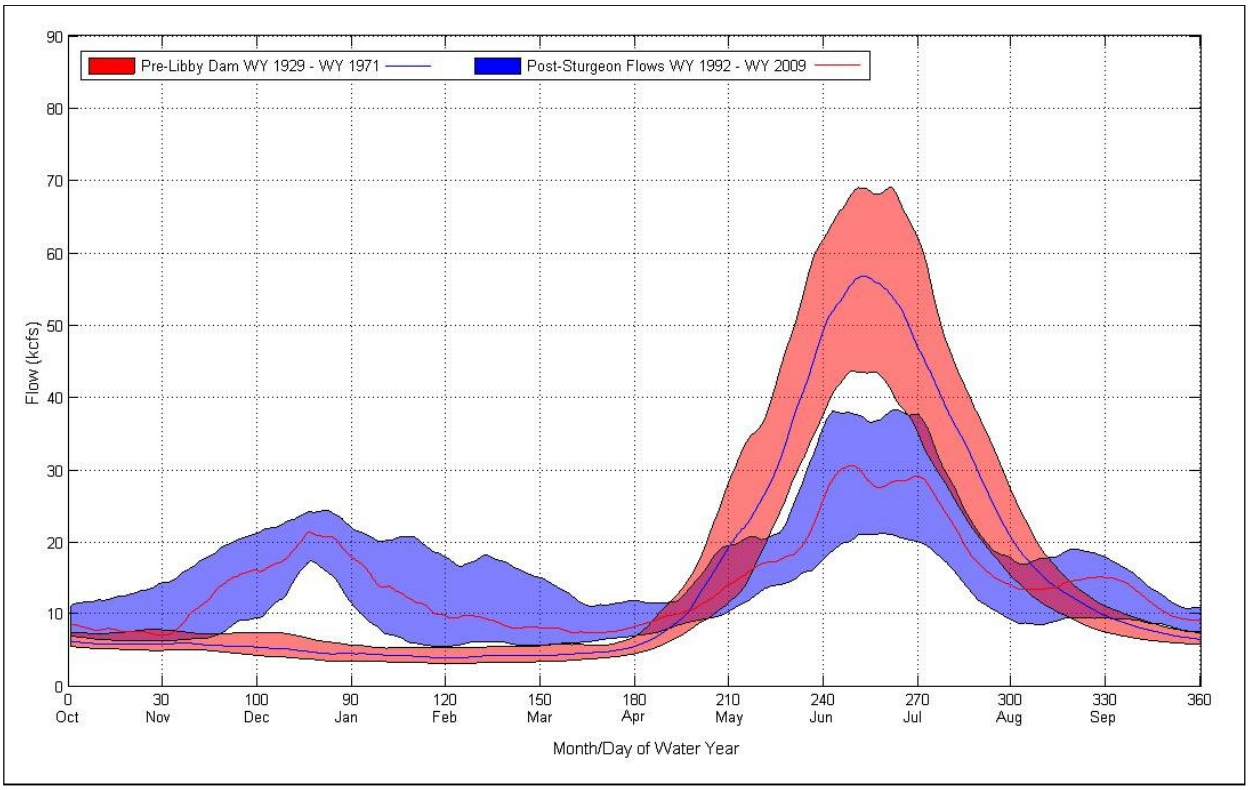


Figure 3-4. Daily Median Discharge at the Porthill gage for Pre-Libby Dam Period (Historical Condition) and Post-Sturgeon Flows Period (Existing and Future Without-Project Conditions) Including the 25 and 75 Percentiles

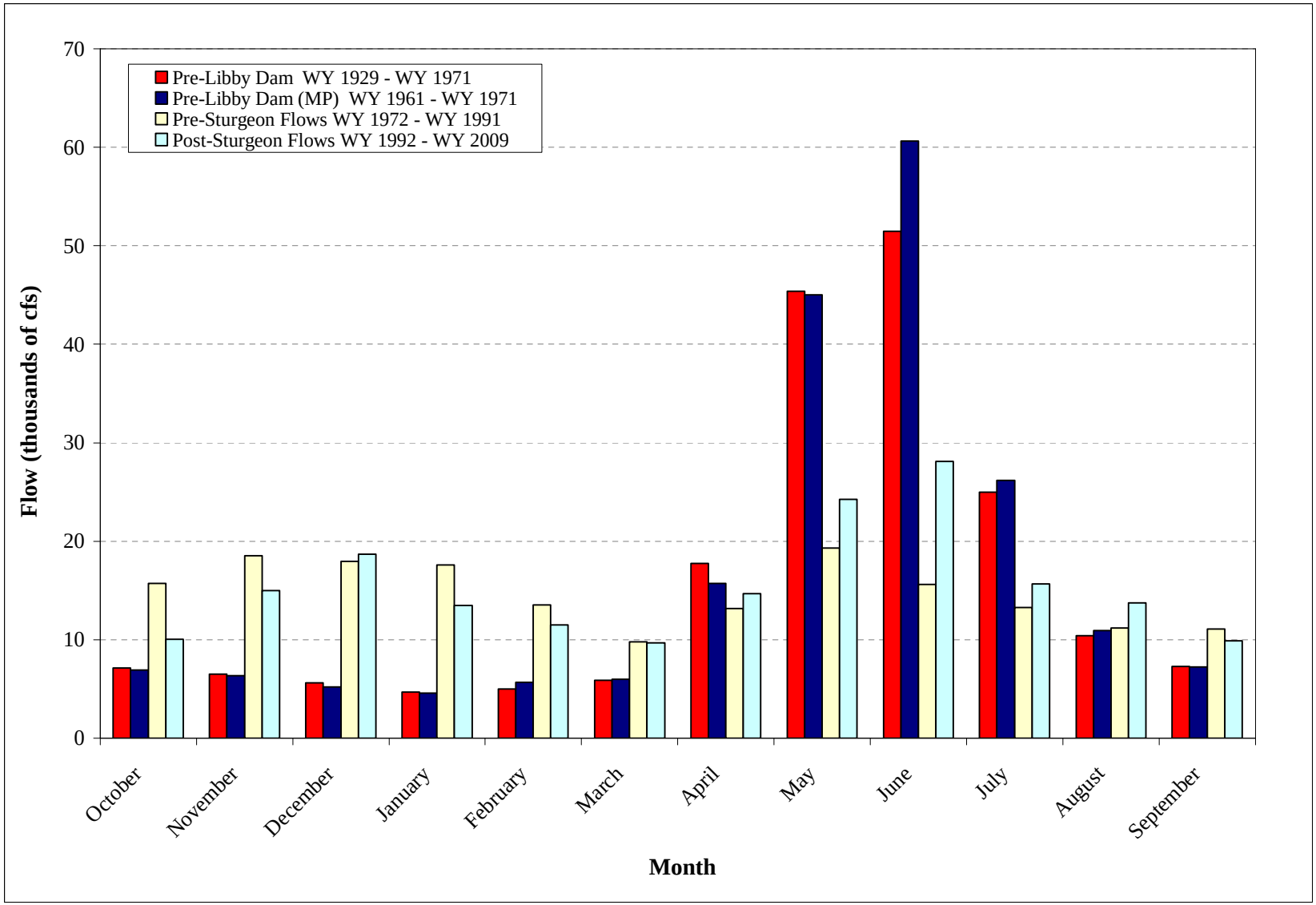


Figure 3-5. Average Monthly Flows at the Porthill Gage for Pre-Libby Dam (Historical Condition), Pre-Sturgeon Flows Period and Post-Sturgeon Flows Period (Existing and Future Without-Project Conditions)

A daily flow duration curve is provided in Figure 3-6 comparing the pre-Libby Dam, pre-sturgeon and post-sturgeon flow periods at the Porthill gage. This curve illustrates the magnitude of change in the duration of various flows. In the post-sturgeon flow condition, the median flow for the year (exceedance of 50 percent) is 12,900 cfs compared to 7,490 cfs for the pre-Libby Dam condition. This is a 72 percent increase for the post-sturgeon period. At 21,000 cfs the two curves cross and have equal exceedances of 23 percent. For a given flow larger than 21,000 cfs, the probability of exceedance is higher for the pre-Libby Dam condition than the post-sturgeon flows. Conversely, for a given flow of less than 21,000 cfs, the probability of exceedance is higher for the post-sturgeon condition. Finally, identification of the 90 percent and 10 percent exceedance flows for both conditions indicates that the range in flows is narrower for the post-sturgeon flows condition. The pre-Libby Dam range is 4,000 cfs to 44,000 cfs, a factor of 10 times, whereas the range for the post-sturgeon flow condition is 6,000 cfs to 28,000 cfs, a factor of about five times. This illustrates the higher variability of the flows during the pre-Libby Dam period with the both the highest and lowest flows in the flow duration analysis occurring for the pre-Libby Dam condition.

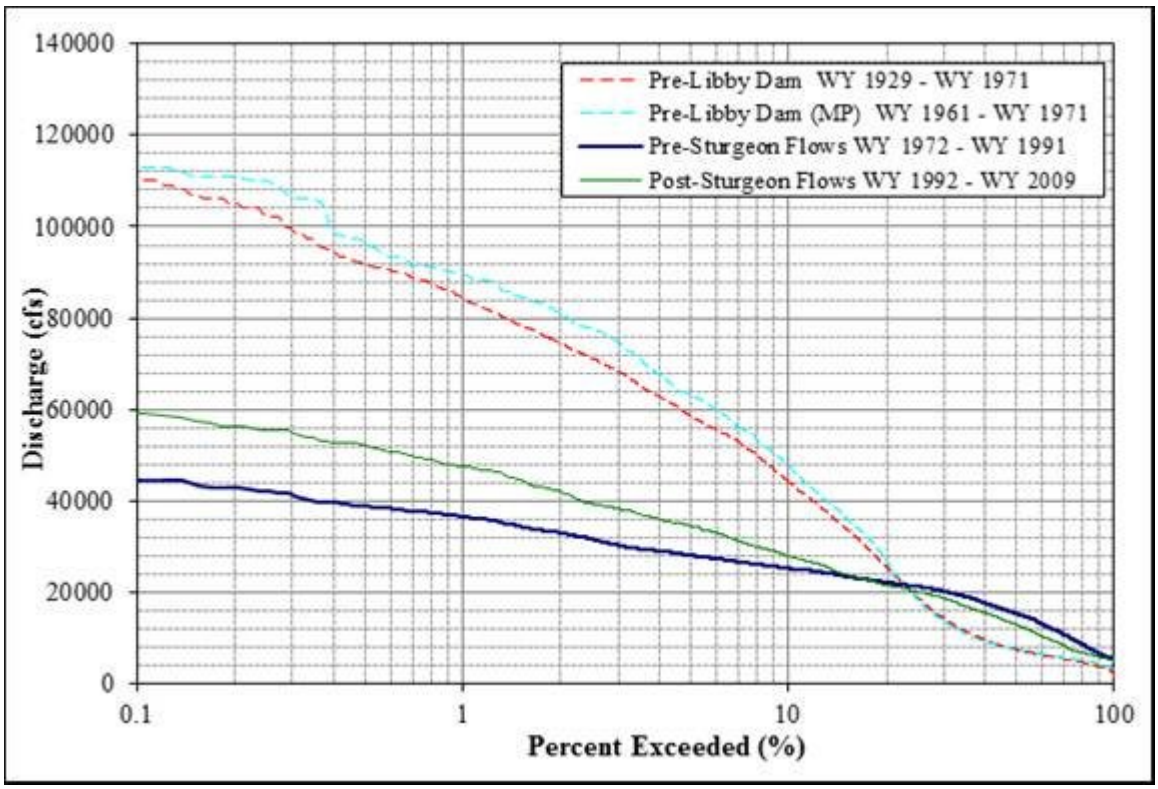


Figure 3-6. Daily Flow Duration Curve at the Porthill Gage for Pre-Libby Dam Period (Historical Condition), Pre-Sturgeon Flows Period and Post-Sturgeon Flows Period (Existing and Future Without-Project Conditions)

Figure 3-7 provides a comparison of two post-Libby Dam periods. The first period is from WY 1972 through WY 1991 and is prior to flow adjustments related to improved conditions for sturgeon, or pre-sturgeon flows. The second post-Libby Dam period is the post-sturgeon flows covering WY 1992 through WY 2009 when flows were altered to improve conditions for sturgeon. The figure shows the peak flows in the spring freshet have increased under the post-sturgeon flow operations. In addition, the period of increased flows during the fall and winter, relative to the pre-Libby Dam period, has been narrowed under post-sturgeon flows. In reviewing Figure 3-7 the effect on the spring outflow is more noticeable for the

pre-sturgeon flow period as water is stored for refill. Additionally, more stored water was released in the winter for the pre-sturgeon period, creating higher winter-time flows.

Though it is not shown by a separate period, there has been some shift in winter flows under VARQ-FC which has reduced winter drafting for flood risk management on average beginning in 2003. Since 2003 there is less draft in winter in order to better assure refill in spring, while maintaining needed levels of flood protection. VARQ-FC has not provided volumes or flows directly for sturgeon, but it has facilitated spring flows for salmon.

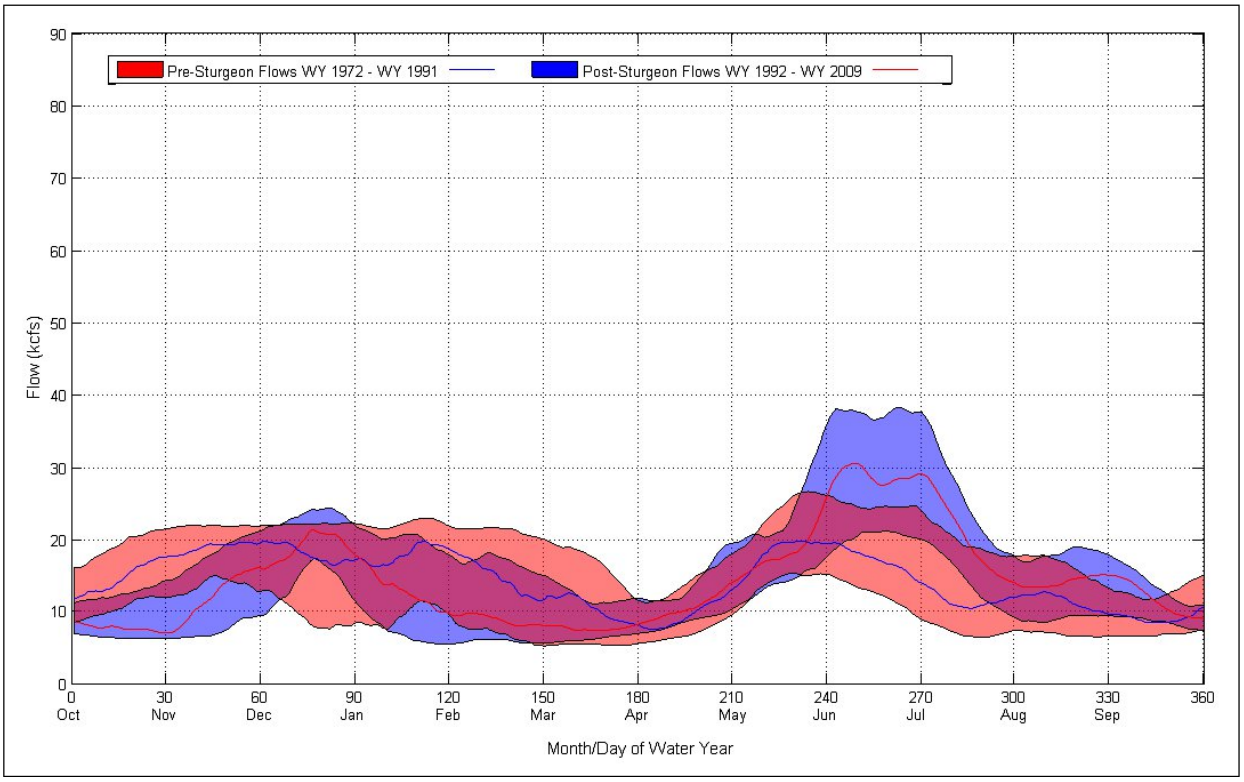


Figure 3-7. Daily Median Discharge at the Porthill Gage for Post-Libby Dam/Pre-Sturgeon Flows and Post-Libby Dam/Post-Sturgeon Flows Including the 25 and 75 Percentiles

3.4 HYDRAULICS

Hydraulic conditions are an important consideration in developing the ecosystem restoration efforts in the riverine environment. Hydraulic conditions such as velocity and depth help characterize aquatic habitat and determine suitability for various species and life stages. They also greatly influence sediment transport conditions that help determine the composition of the river bed material (substrate), another important component of the habitat, particularly for spawning and early life stages. Hydraulic and sediment transport conditions also play a key role in determining the long-term morphology of the system.

This section provides a characterization of important hydraulic conditions in the study area for the historic, existing, and future without-project conditions. Much of the information in this section was provided by the Master Plan (Kootenai Tribe 2009). The analysis utilized the one-dimensional steady state hydraulic model of the Kootenai River developed by USGS from cross section surveyed in 2002 to 2003 (Berenbrock 2005). USACE HEC-RAS software was used as the model tool (USACE 2002).

The "pre-dam" (pre-Libby) condition from the Master Plan was taken to represent the historical condition. The period used to represent this is from WY 1961 through WY 1971. The post-BiOp period of October 1993 through December 2009 from the Master Plan was taken to represent the existing and future without-project conditions. The Master Plan values were used as extensive work had been performed to develop this analysis for the Master Plan and the scope of work for the 1135 effort did not include replicating this effort. The maximum median daily flows from the Master Plan were utilized to characterize the period's hydraulic conditions. The representation of the hydraulic conditions utilizing the flows is important because it is typically the high flow period when sturgeon are spawning and the peak flows are largely responsible for determining the long-term morphologic and sediment transport conditions. The maximum daily median peak flow for the historic condition is 65,000 cfs. The maximum daily median peak flow for existing and future without-project conditions is 30,000 cfs (Kootenai Tribe 2009). The 56,700 cfs for the entire Porthill pre-Libby Dam record of WY 1929 through WY 1971is 13 percent lower than the 65,000 maximum daily median flow for the Master Plan pre-dam period of WY 1961 through WY 1971. The 30,000 cfs is nearly equal to the 30,500 cfs maximum daily median flow for the post-sturgeon flow period.

3.4.1 HISTORICAL CONDITION

The hydraulic model in the Master Plan spanned six reaches of the Kootenai River that covered the area from the international border (RM 105.9) to the Canyon Reach ending at Leonia, Idaho (RM 172.0). Three important hydraulic parameters were presented for each of the six reaches the model spanned including depth, velocity and shear stress. Shear stress is that 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 resting on a channel bed is affected by the shear stress created by water moving on the bed. The values represent the cross-section averages for each reach and are summarized in Table 3-4.

Table 3-4. Summary of Reach Average Hydraulic Parameters for the Median Peak Flow, Historical Condition

Reach	Parameter at 65,000 cfs*		
	Hydraulic Depth (feet)	Velocity (feet/second)	Shear Stress (lbs/square foot)
Canyon	20.9	7.0	0.63
Braided 1	16.8	6.5	0.55
Braided 2	20.5	2.9	0.13
Straight	31.1	3.4	0.09
Meander 1	31.4	3.1	0.07
Meander 2	35.2	3.0	0.07

Source: Kootenai Tribe 2009
Note: *Assumes water-surface elevation at Porthill (USGS Station No.12322000) of 1,763 feet.

These values illustrate the dramatic decrease in the hydraulic conditions that occur as the Kootenai River flows out of the steep canyon area and enters the Kootenai Flats area. For the historic condition, Braided Reach 1 retains similar hydraulic conditions to the upstream Canyon Reach with reductions of 20, 7 and 13 percent for depth, velocity and shear stress, respectively. This is primarily a result of the reduced confinement and wider channel in Braided Reach 1 compared to the Canyon Reach. In contrast, Braided Reach 2 returns to a depth similar to the Canyon Reach, but the velocity is reduced by over 50 percent and the shear stress by 80 percent compared to the Canyon Reach. The decrease in shear stress is due to the dramatic change in the energy slope as backwater from Kootenay Lake affects the entire Braided Reach 2. The backwater also contributes to the depth increase and the velocity decrease in comparison to Braided Reach 1.

The three hydraulic parameters in the Straight, Meander 1 and Meander 2 reaches are fairly similar. In all three reaches the depths increase to 30 feet or greater, a 50 percent increase in depth from the Canyon Reach. The velocity for the Straight Reach actually increases slightly in comparison to the adjacent upstream Braided Reach 2, but is still less than half the value of the Canyon Reach. The shear stress continues to fall with a 20 percent reduction from Braided Reach 2. In the two Meander reaches, the velocity drops back down to about three feet per second and the shear stress falls to its lowest value of lbs per square foot. This is about one-tenth the shear stress that occurs in the Canyon Reach under the same flow.

3.4.2 EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

Utilizing the hydraulic modeling results from the Master Plan, Table 3-5 was created to present the existing and future without-project reach average condition results and provide a comparison with the historical reach average condition. The median peak flows of 65,000 cfs and 30,000 cfs were used to represent the historical condition and existing and future without-project conditions. It should be noted that differences for specific cross sections can show more variability than indicated by the reach average conditions.

Table 3-5. Comparison of Reach Average Hydraulic Parameters for the Median Peak Flows Representing the Historical Condition (65,000 cfs) and the Existing and Future Without-Project Conditions (30,000 cfs)

Reach	Hydraulic Depth (feet)*			Velocity (feet/second)*			Shear Stress (lbs/square foot)*		
	65,000 cfs	30,000 cfs	Change	65,000 cfs	30,000 cfs	Change	65,000 cfs	30,000 cfs	Change
Canyon	20.9	15.8	-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%

Source: Kootenai Tribe 2009
Note: *Assumes water-surface elevation at Porthill (USGS Station No.12322000) of 1,763 feet for 65,00 cfs and 1,754 for 30,000 cfs.

In the case of depth, all values decreased for the existing and future without-project conditions in comparison to the historical condition. For all reaches, except Braided 2, the decrease was between 22 and 29 percent. In contrast, Braided Reach 2 decreased by 47 percent. This was due to the reduced backwater effect in Braided Reach 2 associated with the lower discharge and the lower Kootenay Lake level of the 30,000 cfs flow condition. Figure 3-8 provides water surface profiles for both conditions. Braided Reach 2 falls between RM 156.2 and RM 152.7. Whereas the majority of Braided Reach 2 was under a substantial backwater effect of Kootenay Lake at 65,000 cfs, the water surface profile drops and steepens appreciably under the 30,000 cfs flow condition.

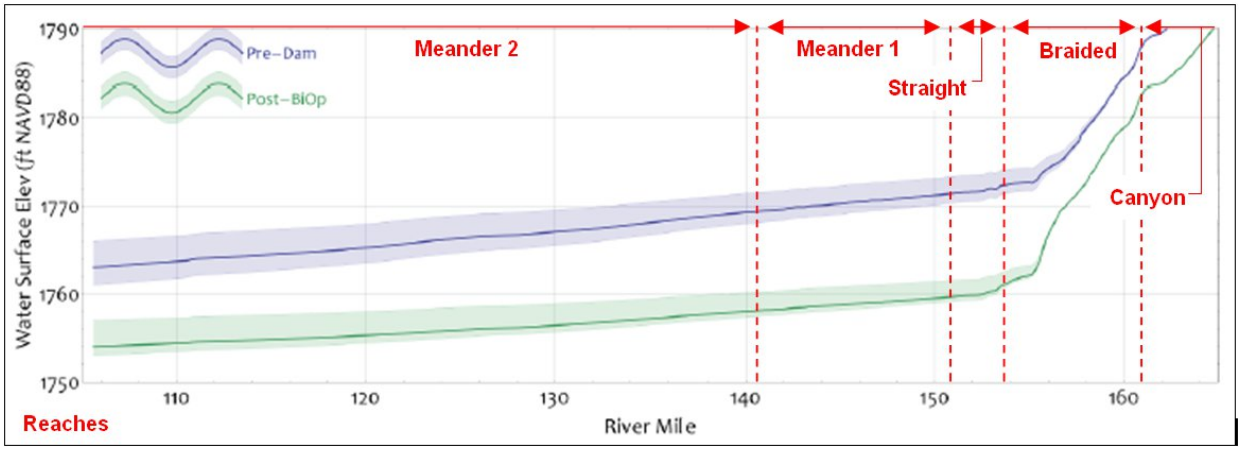


Figure 3-8. Water Surface Profile for Median Peak Flow for Pre-Dam/Historical (65,000 cfs) and Post-BiOp/Existing and Future Without-Project Conditions (30,000 cfs)

Under the greater than 50 percent lower discharges of the existing and future without-project conditions, the typical response of velocity is to experience a significant drop. This was the case for five of the six reaches; the Canyon, Braided 1, Straight, Meander 1 and Meander 2 reaches all experienced a similar reduction in velocity ranging between 29 and 35 percent. However, the velocity for Braided Reach 2 stayed nearly the same, dropping only 1.5 percent. The behavior of the velocity, as was the case for depth, is attributable to the reduced backwater effect in Braided Reach 2 under the lower flow conditions.

Shear stress followed a similar trend with five of the reaches experiencing a potentially significant decrease for the existing and future without-project conditions. The exception was again Braided Reach 2 which experienced a 40 percent increase. In contrast, the reduction in shear stress in the two Meander reaches exceeded 40 percent and in the Canyon, Braided 1 and the Straight reaches were about 30 percent.

3.5 GEOMORPHOLOGY AND SEDIMENT TRANSPORT

The geomorphic and sediment transport characteristics of the Kootenai River are extremely important factors in determining the physical habitat conditions for KRWS. An understanding of these processes is essential in developing restoration measures for improving the early life stage survival of the ESA endangered KRWS. Unlike in the discussion of hydrologic and hydraulic conditions in which the historic condition was limited to the period of WY 1961 through WY 1971 due to availability of information in the Master Plan (Kootenai Tribe 2009), in this section historical conditions encompass a longer time period.

3.5.1 HISTORIC CONDITIONS

Within the study area, from Libby Dam downstream to the international border, the Kootenai River exhibits a wide range of characteristics. Geomorphically, this range of conditions resulted in division of the river into six reaches. The characteristics of these reaches are described in Section 1.3.2.

The most striking aspect of the area of interest is the great difference in gradient and planform that occurs across reaches. For the first 62 miles of the 117 mile river, downstream of Libby Dam (Canyon Reach [RM 223.2 to RM 160.9]), the Kootenai is confined to a narrow canyon and has an average gradient of about three to six feet per mile. The bed comprises gravels and cobbles with some boulders and outcroppings of bedrock. In the lower 46 miles (RM 151.7 to 105.9) the river winds through a two to three mile-wide valley with a gradient on the order of 0.1 feet per mile. This portion of the Kootenai River is divided into Meander Reach 1 (RM 151.7 to RM 141.8) and Meander Reach 2 (RM 141.8 to RM

105.9). In contrast to the Canyon Reach, the Meander Reaches contain a sand bed. Prior to development, the Kootenai would spill into the broad floodplain and distribute part of its suspended load on the valley floor. This process created a system of wetlands, oxbows, large sloughs, low gradient floodplain tributaries, and natural levees.

There is a nine-mile portion of the river, between the Canyon and Meander Reaches, which serves as a transition between the vastly different Meander and Canyon reaches. This area comprises the Braided Reaches (Braided Reach 1, RM 160.9 to RM 156.2 and Braided Reach 2, RM 156.2 to RM 152.7) and the Straight Reach (RM 152.7 to 151.7). The Braided Reach occurs as the Kootenai River leaves its canyon about a mile downstream of the Moyie River confluence. The gradient in the upper portion of Braided Reach 1 (RM 160.9 to RM 156.2) is similar to the Canyon Reach at about three feet per mile. However, the gradient in the lower portion of Braided Reach 2 (RM 156.2 to RM 152.7) is highly dependent on flow and Kootenay Lake level, and can range from less than 1 foot per mile to over two feet per mile. The bed is dominated by gravel and cobble. In the mile-long Straight Reach (RM 152.7 to RM 151.7) the bed changes from gravel and cobble to sand.

The drastic change is the result of the ancient Kootenai River flowing into a glacial lake bed that formed during the Pleistocene Epoch at times when ice blocked the outlet of Kootenay Lake. The ancient lake resulted in the deposition of fine-grained lacustrine sediments consisting of silt and clay. The modern Kootenai River has eroded and incised into the lacustrine silt-clay layer. There are locations in the Meander Reach 1 where scour removes the sand bed and exposes the lacustrine sediments. In general, there are several feet or more of sand covering the lacustrine sediments.

Based on the characteristics of the bed material, there is a large difference in the ability of the various reaches to mobilize and transport sediments. The Master Plan provided graphs of the sizes of sediment moving at various flows during the year, including the median peak flow. For the pre-dam flows (WY 1961 to WY 1971), the median flow of around 65,000 cfs can mobilize up to 25 millimeter (mm) sediments (coarse gravel) in Braided Reach 1, but this falls to about 4 mm sediments (fine/very fine gravel) in the Meander Reaches. Based on this evidence as well as the results of sediment cores, it is not believed that any large gravels and cobbles suitable for sturgeon spawning were conveyed into the Meander Reach, where the vast majority of KRWS spawning activity currently occurs, even under larger spring freshet flows experienced prior to the completion of Libby Dam in 1972.

Based on investigations conducted by USGS for the Kootenai Tribe, some areas of limited gravel and cobble deposits were found in Meander Reach 1 near Myrtle Creek (RM 145.8 to RM 145.5). This coarse substrate is often exposed or covered by a thin layer of sand (Barton et al. 2005). These sediments are remnants of past glacial or local hillslopes and were not transported down the Meander Reach during the past 10,000 years. Based on the lack of flow energy to transport gravels and cobbles into the Meander Reach and the results of sediment borings, only minor amounts of coarse substrate are present in the bed of the Meander Reach.

Prior to Libby Dam completion, the Kootenai River transported a significant suspended sediment load during the spring freshet. Based on data collected at the USGS gage at Copeland (No. 12318500) the average annual suspended sediment load was about 2,000,000 tons/year gage (Barton et al. 2006). Studies conducted during the planning and design of Libby Dam estimated the average annual suspended sediment load at the Libby Dam site was about 1,500,000 tons/year (Tetra Tech 2004a). The drainage areas at Libby Dam and Copeland are 8,985 square miles and 13,400 square miles, respectively. The drainage area at Libby Dam represents about 67 percent of the drainage area at Copeland, and the average annual pre-dam sediment loads at Libby Dam were estimated at 75 percent of the estimate at Copeland. In the estimates prior to Libby Dam, sediment loads were nearly proportional to the drainage areas; about

one-third of the drainage area enters below Libby Dam, and about one-quarter of the suspended sediment load was contributed below Libby Dam.

3.5.2 EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

The reaches in the area of interest still retain similar profile and planform to historic conditions; however, there have been changes in the geomorphic and sediment transport characteristic of the area. The primary influences on the Kootenai River in the past century have been the construction and operation of Libby Dam, the diking-off of the floodplain from Bonners Ferry to Kootenay Lake, the management of Kootenay Lake levels by Corra Linn Dam, and the excavated Grohman Narrows.

The diking, which occurred in the first half of the twentieth century, isolated the channel from its floodplain. This effectively stopped the process of distributing suspended sediment from the river onto the floodplain. Additionally, many of the dikes were constructed near the channel banks and, as a result, required protection by riprap whenever channel migration threatened to erode the dikes. Comparison of mapping and aerial photographs from 1928 through the present show that within the Meander Reach the basic series of bends have remained intact, except for a single cutoff in Meander Reach 2 that occurred between 1968 and 1992 (Tetra Tech 2004a). Over nearly a century, most bends in Meander Reaches 1 and 2 have migrated several hundred feet or less.

Under existing conditions, Libby Dam traps nearly all the sediment from about half the entire Kootenai River watershed, or two-thirds of the watershed above the Meander Reach. The dam has reduced the typical peak discharge associated with the spring freshet by 50 percent, while at the same time, increasing the flows during the historical low flow periods in the fall and winter by a factor of five. Comparison of morphometric parameters of meander length, belt width, radius of curvature, and bankfull width show that between 1934 and 2006 the parameters have changed by 10 percent or less in spite of the twofold reduction in the annual median peak discharge. In fact, the largest changes have been a five and ten percent increase in the bankfull width in Meander Reaches 1 and 2, respectively. Viewed solely as a function of discharge, the bankfull width would be expected to decrease with decreasing discharge.

Analysis of post-Libby Dam suspended sediment samples at the USGS Copeland gage showed an average annual load of 210,000 tons/year (Barton et al. 2006). This is about 10 percent of the estimated 2,000,000 tons/year for pre-Libby Dam conditions. The dam has reduced the suspended sediment load by trapping sediment behind the dam and altering the flow regime, which resulted in changes to the sediment transport capacity. Though suspended sediment transport is greatly reduced during the spring freshet, suspended sediment loss during the fall and winter may have increased by six times (Kootenai Tribe 2009). This increase is similar to the level of increase in flow during this period. The increase in sediment transport during the winter and fall, coupled with the decrease in transport during the spring freshet, could reduce the ability to scour sand from the few areas where coarse sediments are present in the Meander Reach.

Another aspect of sediment transport that has been altered by Libby Dam is the ability to mobilize sediments. Table 3-6 presents results of bed sediment mobilization analysis for pre-Libby and post-Libby median peak flows taken from figures provide in the Master Plan (Kootenai Tribe 2009). For the Braided 1, Straight, and Meander 1 reaches, there is a similar reduction in the bed sediment size mobilized for the pre- and post-Libby Dam median peak flows ranging from 35 to 40 percent. For the Straight Reach, there is actually a 9 percent increase. This is due to the reduction in backwater and associated steepening of the energy gradient in the Straight Reach for the post-Libby Dam condition. Though the size of sediment mobilized in Meander Reach 1 has decreased with the altered flow regime of Libby Dam, neither before or after Libby Dam are coarse sediments suitable for sturgeon spawning and early life stage needs transported into this reach.

Table 3-6. Mobilization of Bed Sediments based on Pre- and Post-Libby Dam Annual Median Peak Flow Conditions

Reach	Mobilized Sediment Size (mm)		Percent Change
	Pre-Libby Dam 65,000 cfs (WY 1961 to 1971)	Post-Libby Dam 30,000 cfs (WY 1994 to 2009)	
Braided 1	26	17	-35
Braided 2	11	12	+9
Straight	5	3	-40
Meander 1	4	2.5	-38

Source: Kootenai Tribe 2009

USGS has mapped the sediment facies (Figure 3–9) for distinct sediment features for the critical habitat reach using underwater videography and numerous core samples (Barton et al. 2011). Results of the mapping are provided in Appendix A. The map shows the location of the strip of gravels below the Myrtle Creek confluence as well as the exposed lacustrine clays at Myrtle Creek, the right channel at Shorty's Island, and the outside of bends at several other locations. Figure 3-10 is a map of the same area showing locations where sturgeon spawning is inferred by collection of sturgeon eggs on mats.[1] The egg collection data were used to determine the egg catch per unit effort (ECPUE). The ECPUE was calculated based on the number of eggs collected, the number of mats, and time period mats were in place for each 0.1 river kilometer (RK) interval.[2] This combination of figures is very important to the development of alternatives for substrate improvement and augmentation. The greatest opportunities for successfully implementing these projects are in the areas that are currently being used for sturgeon spawning and have either gravels that are exposed or at least exposed clay. It is in these exposed areas that sand is being effectively scoured from the bed and where there is the greatest potential for placed substrate to remain relatively free of sand during the spawning and early life stage periods.

It is expected that with Libby Dam in place, future without-project conditions will remain consistent with the existing condition.

[1] Note: Dots in Figure 3-10 represent 0.1 kilometer intervals at which all mats 0.05 kilometers upstream and downstream were aggregated to a single point. They do not represent actual locations of eggs collected.

[2] Note: Data for 1994 to 2001 were collected in this manner. Data from 2008 to 2011 used GPS to identify location of each mat. In the latter data, both mats with eggs collected and ones without eggs collected were recorded. Both types of egg matt data are depicted in Appendix A. The more recent data with GPS locations identifying mats with and without eggs collected was extremely useful in designing the substrate placement.

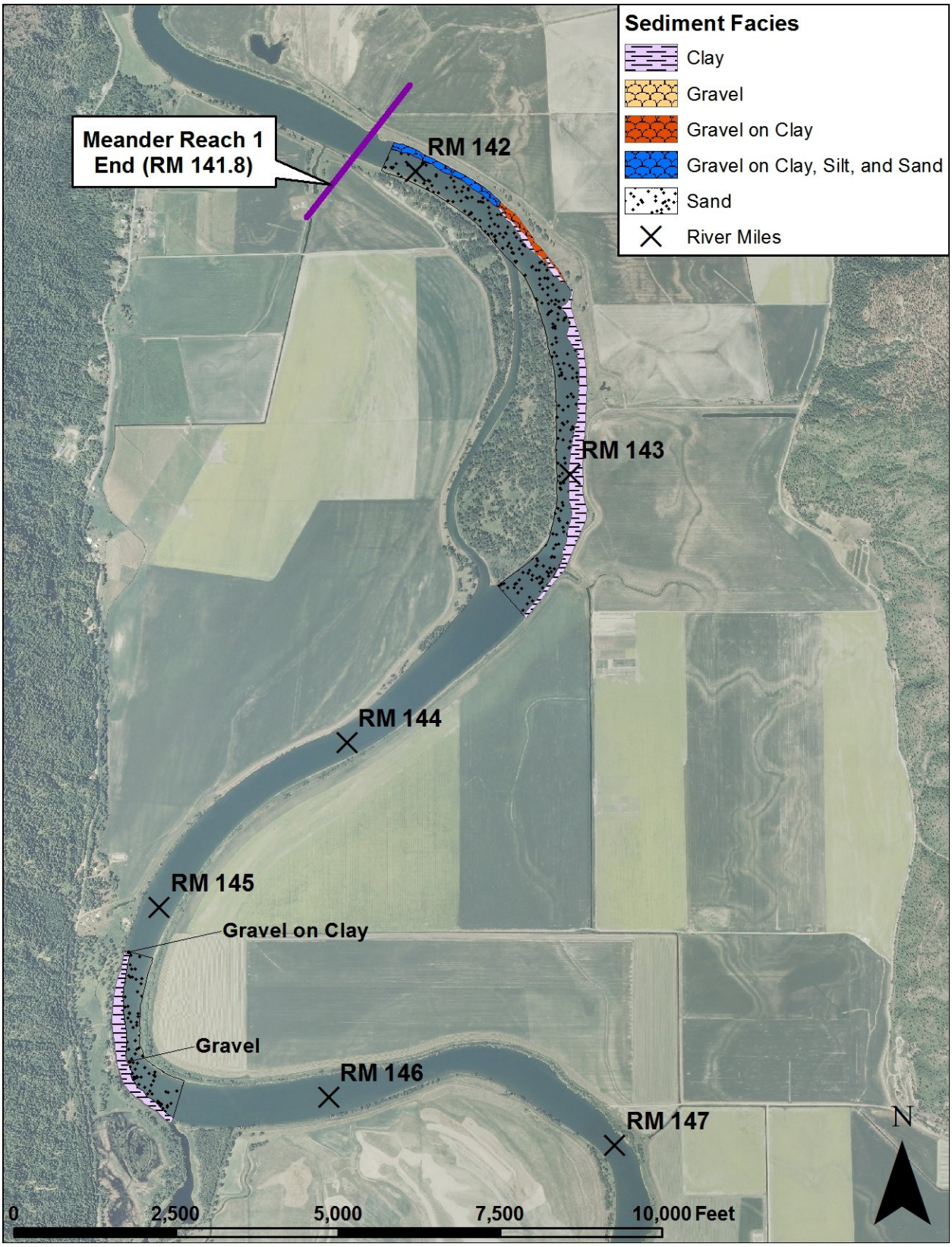


Figure 3-9. Map of Sediment Facies in Areas of Interest in Meander Reach 1, Including Locations of Exposed Gravel, Cobbles and Lacustrine Clays

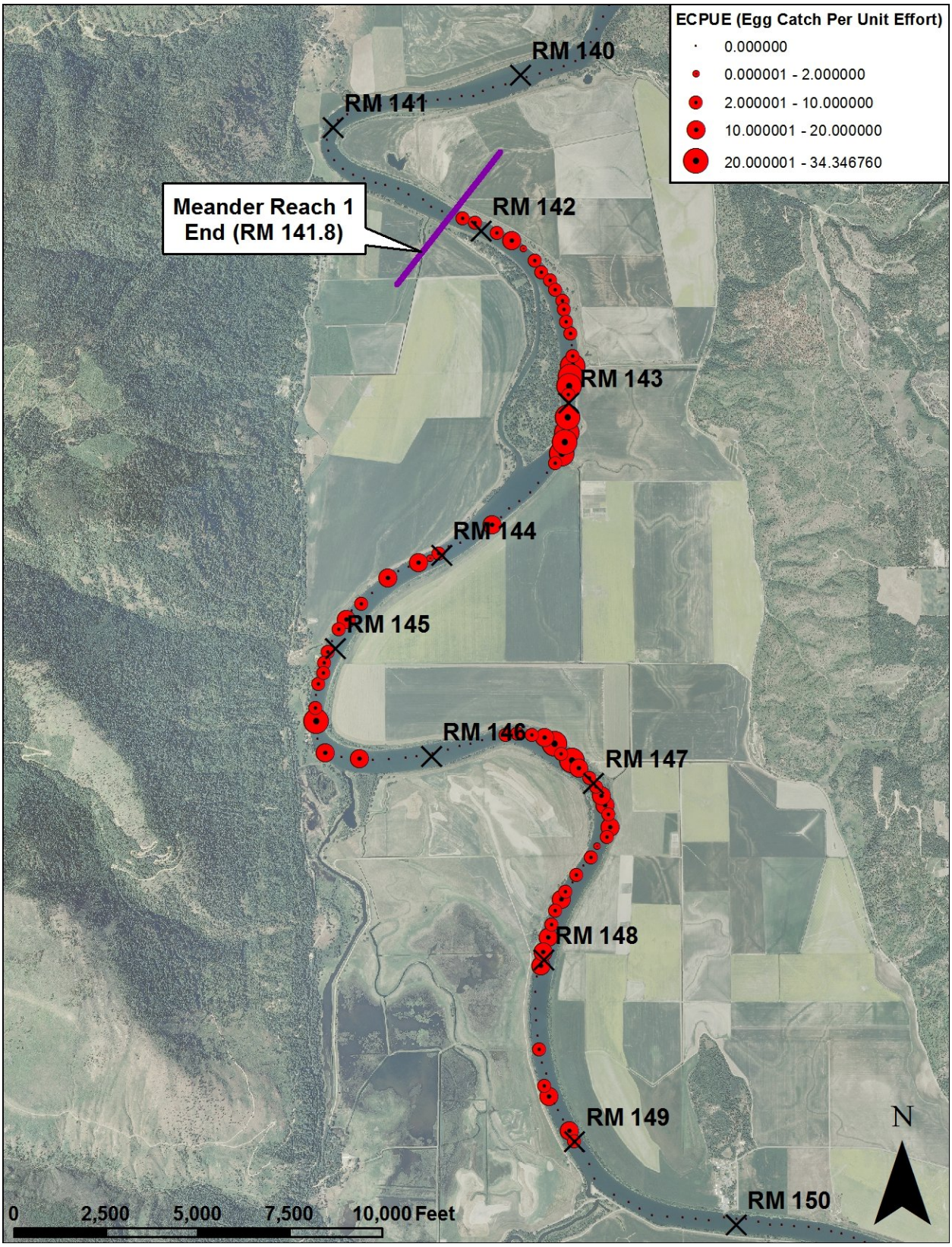


Figure 3-10. Approximate Locations of KRWS Eggs Collected on Mats Shown as Circles (From Data Collected by IDFG; Figure from USGS unpublished)

3.6 WATER QUALITY

The Kootenai River watershed is naturally oligotrophic (low nutrient load) due to the underlying geology (Kootenai Tribe and MFWP 2004). However, in the 1950s and 1960s significant discharges of sewage, mining waste, fertilizer and other materials caused a change from oligotrophic to eutrophic or high nutrient load conditions (Kootenai Tribe and MFWP 2004). Most of these discharges are no longer permitted but legacy mining wastes and tailings have contributed heavy metals to the study area including arsenic, chromium, copper, lead and nickel. Organochlorine pesticides and polychlorinated biphenyls (PCBs) have also been detected in sediment samples taken immediately upstream of the study area (Kruse 2008a). Sampling conducted by the Kootenai Tribe in 1997 to 1998 indicated that while these pollutants are present, they are generally below EPA freshwater criteria for acute or chronic exposure of aquatic organisms (Kootenai Tribe and MFWP 2004). However, this does not mean that aquatic organisms are not exposed to pollutants via sediments, bioaccumulation, or biomagnification.

Kootenai River and most of the tributaries in the study area have not been listed on the 303(d) list of water quality impaired waterbodies in the State of Idaho (Kootenai Tribe et al. 2006). However, some of the tributaries to the Kootenai have been listed including Deep, Boundary, and Cow Creekfor sediment and/or temperature exceedances of water quality criteria. A Total Maximum Daily Load (TMDL) has been developed for both temperature and sediment load for these tributaries in the Lower Kootenai and Moyie Rivers subbasins (Kootenai Tribe et al. 2006) and approved by EPA in 2007.

The City of Bonners Ferry holds the only two permitted point source discharge permits in the study area for their wastewater treatment and water supply treatment discharge. Monitoring of water quality adjacent to these discharges indicated that chlorine concentrations historically often exceed EPA's freshwater life criterion. These chlorine discharges and may be limiting primary productivity and/or invertebrate populations in the Straight Reach of the river (Kruse 2008b). The City of Bonners Ferry has worked with EPA to develop and implement a schedule to address the concerns related to chlorine discharges and is now operating under an approved National Pollutant Discharge Elimination System (NPDES) permit study area.

The without-project conditions are not expected to be affected by this project. The temperature and sediment TMDL developed for the Lower Kootenai and Moyie River subbasins will improve water quality conditions in the subbasins, however these TMDLs are specific to tributaries rather than the mainstem Kootenai River in the project area, so improvements to the Kootenai River may only be minor.

3.7 VEGETATION AND WETLANDS

3.7.1 VEGETATION

The study site is in the mountainous area of the interior Pacific Northwest, generally referred to as the maritime-influenced interior mountain west region. Vegetation is characterized as the Northern Rocky Mountain Forest-Steppe-Coniferous Forest-Alpine Meadow Province (Kootenai Tribe and MFWP 2004). Natural forest communities include Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies bifolia*) and lodgepole pine (*Pinus contorta*) in the higher elevations and Douglas fir (*Pseudotsuga menziesii*), Western larch (*Larix occidentalis*), and Ponderosa pine (*Pinus ponderosa*) in the lower elevations (Kootenai Tribe and MFWP 2004; Kershaw et al. 1998; USFS 1991).

The Kootenai River Valley was historically a vast floodplain lowland area dominated by numerous channels, oxbow lakes, marshes, meadows, willow and cottonwood stands (Jamieson and Braatne 2001). It was a highly productive and diverse riparian ecosystem that spanned over 55,000 acres (70,000 acres including Canada floodplain area). Diking along the river first began in the 1920s and was followed by the construction of Corra Linn Dam and the excavation at Grohman Narrows in the 1930s, which

substantially lowered flood levels in the valley, making agricultural uses more viable in the floodplain, but altering the natural hydrologic regime and thereby the riparian vegetation that it sustained (Jamieson and Braatne 2001). Further draining and diking of the floodplain areas continued into the 1970s when Libby Dam was completed, significantly reducing flooding in the valley. Along with diking activities, the majority of the riparian vegetation was cleared and sedge meadows were converted to agricultural fields.

Currently, the vast majority of the floodplain is in agricultural land uses. Cottonwood riparian forest exists in narrow bands along the dikes, on Shorty's Island, at the Kootenai National Wildlife Refuge, and in the system of sloughs, wetlands, and bottomlands in the Creston Valley Wildlife Management Area (B.C.). Jamieson and Braatne (2001) found generally equal distribution of the black cottonwood (*Populus balsamifera*) and the non-native Great Plains cottonwood (*Populus deltoides*). They found no cottonwood seedlings or saplings during their vegetation surveys, indicating a lack of natural cottonwood recruitment. A vegetation assessment conducted recently for the Master Plan (Kootenai Tribe 2009) indicated that in a few areas of scour along sharp bends or bars in the study area there are bands of cottonwood seedlings or saplings that correspond to recent high flows. The Great Plains cottonwood is most typical, but small numbers of black cottonwood are also found. The invasive reed canary grass (*Phalaris arundinaceae*) is widely established on the river banks above the zone where more frequent inundation or erosion occurs.

Shorty's Island is one of the largest remaining areas of cottonwood forest in the study area. The island has a mature cottonwood forest established with an understory of red-osier dogwood (*Cornus stolonifera*), snowberry (*Symphoricarpos occidentalis*), Douglas' hawthorn (*Crataegus douglasii*), chokecherry (*Prunus virginiana*), and thimbleberry (*Rubus parviflora*) (Kootenai Tribe 2009). However, this site is moderately disturbed as a result of cattle use and the establishment of non-native plants.

For the future without-project condition, further development in the study area is likely to occur that would tend to reduce riparian and floodplain vegetation. Agricultural land uses are expected to continue as well. Because the operation of Libby Dam has changed the natural spring runoff hydrology of the basin, recruitment of cottonwood will continue to be sporadic and sparse in the future. The Kootenai Tribe and other entities are undertaking restoration actions along a 55-mile reach of the Kootenai River; however, due to the large percentage of privately owned lands, the extent to which these actions can comprehensively restore vegetation and wetlands depends on the willingness of private landowners to participate in the restoration projects. The need to protect current land uses from flooding by the combination of Libby dam flood operations and the dike system also limits the potential for floodplain and wetland restoration. In addition, USACE levee vegetation management policy does not allow trees larger than two inches in diameter within the vegetation-free zone, which extends 15 feet outward from the levee toe.

As global climate change occurs in the without-project condition, changes in conditions such as precipitation and hydrology may alter the suitability of the current plant community. A drier, warmer summer may shift habitat conditions to favor more drought tolerant plant species.

3.7.2 WETLANDS

Wetland habitats are rare in the study area. The total acreage and distribution of wetlands in the floodplain has been reduced by approximately 90 percent from the natural conditions (Kootenai Tribe and MFWP 2004).

The only notable area of wetlands in the project vicinity is on the Kootenai National Wildlife Refuge, with over 2,000 acres of lakes, ponds, wetlands, and riparian habitats between Deep Creek and Myrtle Creek on the west bank of the river (USFWS 2010b). These wetlands are maintained behind the dikes along the river and flooded to maintain waterfowl habitat.

The dramatic reduction in riparian and floodplain wetland habitat has reduced the natural functions that wetlands provide including groundwater recharge, sediment storage, erosion control, nutrient production and transport, and foodweb support (Kootenai Tribe and MFWP 2004). The Kootenai Tribe has started a nutrient enhancement and monitoring program to understand its potential benefits to productivity for the aquatic ecosystem.

As part of this study, a wetland delineation was conducted to determine the presence of wetlands at the proposed staging and access area. The staging and access area is located on agricultural land with levees surrounding much of the site. The delineation is described in detail in Appendix K.

Wetlands and wetland types identified in the survey area are summarized in Table 3-7. A total of 0.114 acres of wetland and 1.561 acres of other waters of the U.S. were identified within the survey area. No wetlands were identified above or below the OHW mark adjacent to the Kootenai River. All sample plots taken on agricultural land, levees, and sloped areas in drainage canals were non-wetland. A map of the delineated wetlands is provided in Figure 3-11.

Table 3-7. Acreages of Wetlands and Other Waters of the U.S. Found in the Survey Area

Wetland/Waters Type	Wetland 4	Wetland 5	Entire Survey Area
Wetland Acreages	0.039	0.075	0.114
Other Waters Acreages	0.105	0.139	1.561

The altered state of the survey area makes applying standard wetland classifications somewhat difficult; however, both Wetland 4 and Wetland 5 can be classified as Riverine, Flood Plain, Excavated Canal, herbaceous (NRCS 2008) or as Riverine, Lower Perennial, Emergent, Persistent, saturated (Cowardin et al. 1979). The on-going land use of the survey area for agricultural purposes has caused the wetlands identified by this survey to be of low quality. Artificially controlled hydrology, mechanical and chemical maintenance of vegetation, substantial past topographical manipulations, small size, and lack of free connectivity to the Kootenai River all result in Wetlands 4 and 5 to have limited functions.

Figure 3-11. Wetlands Delineated at the Project Site

3.8 FISH AND WILDLIFE

The Kootenai River basin supports a diverse array of fish and wildlife species. Documented observations at the Kootenai National Wildlife Refuge, which is located adjacent to the left bank of the Kootenai River in Meander Reach 1, include over 300 species of wildlife, including 22 species of fish, seven species of amphibians, six species of reptiles, 45 species of mammals, and over 223 species of birds (USFWS 2010b). Waterfowl and water birds species include mallards, redheads, grebes, rails, and black terns. Forest supported bird species include warblers, thrushes, nuthatches, flycatchers and woodpeckers including the majestic pileated (USFWS 2010b).

The fish community has a relatively low species diversity (Table 3-8) 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 (Kootenai Tribe 2009). The multiple runs of anadromous salmon, steelhead, and lamprey that were historically common in other tributaries to the Columbia River did not develop postglacially in the Kootenai River due to these barrier falls. Many species that have anadromous life form counterparts (e.g., white sturgeon and kokanee) are land-locked in the Kootenai Basin.

Table 3-8. Fish species in the Kootenai subbasin

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

Source: Kootenai Tribe 2009

Natural areas and lands designated to protect wildlife and associated habitats adjacent to the study area include Myrtle Creek Game Preserve managed by the USFS and several Natural Research Areas (NRA's) that are managed by USFS and the Bureau of Land Management (BLM). The Kootenai Tribe owns several properties that are designated for wildlife protection. Other wildlife management areas within the basin include Boundary Creek Wildlife Management Area (IDFG), McArthur Lake Wildlife Management Area (IDFG), and the Creston Valley Wildlife Management Area (B.C.) (Kootenai River Network 2010).

3.9 SPECIAL STATUS SPECIES

Several threatened and endangered species are present in Boundary County, Idaho. The county list was obtained from the U.S. Fish and Wildlife Service website (USFWS 2010c) and provided in Table 3-9. Conditions and life histories of each listed species are provided below.

Table 3-9. Relevant Threatened and Endangered Species

Common Name	Scientific Name	Status	Critical Habitat
Kootenai River white sturgeon (KRWS)	*Acipenser transmontanus*	Endangered	Designated; within study area
Canada lynx	*Lynx canadensis*	Threatened	Designated; not within study area
Grizzly bear	*Ursus arctos horribilis*	Threatened	Proposed; not within study area
Selkirk Mountain caribou	*Rangifer tarandus caribou*	Endangered	Proposed, not in the study area
Bull trout	*Salvelinus confluentus*	Threatened	Designated; within study area

3.9.1 CANADA LYNX

Canada lynx are a North American mammal of the cat family, Felidea. They are medium in size with long legs, large, well-furred paws, long tufts on the ears, and a short, black-tipped tail. Adult males average 10 kilograms (22 pounds) in weight and 85 centimeters (33.5 inches) in length (head to tail), and females average 8.5 kilograms (19 pounds) and 82 centimeters (32 inches) (USFWS 1998a).

3.9.1.1 DISTRIBUTION AND ABUNDANCE

The Canada lynx is currently found throughout Alaska and Canada (except arctic islands), south through the Rocky Mountains, in the northern Great Lakes region, and in northern New England, and the DPS listed as threatened occurs in Alaska, Arizona, Colorado, Idaho, Indiana, Iowa, Maine, Massachusetts, Michigan, Minnesota, Montana, Nevada, New Hampshire, New York, North Dakota, Ohio, Oregon, Pennsylvania, Washington, and Wyoming. The Canada lynx was considered historically resident in 16 states represented by five ecologically distinct regions: Cascade Range (Washington and Oregon); northern Rocky Mountains (northeastern Washington, southeastern Oregon, Idaho, Montana, western Wyoming, northern Utah); southern Rocky Mountains (southeastern Wyoming, Colorado); northern Great Lakes (Minnesota, Wisconsin, Michigan); and northern New England (Maine, New Hampshire, Vermont, New York, Pennsylvania, Massachusetts) (USFWS 1998a).

Within Idaho, populations occur north of the Salmon River in the western part of the state and north of the Caribou Range in eastern Idaho (McKelvey et al. 2000) as cited in (IDFG 2005). The total population size in Idaho is unknown, but it is thought to be less than 100 individuals (C. Harris, IDFG, pers. comm., as cited in IDFG 2005). Periodically, populations may be augmented by dispersal of individuals from Canadian populations (IDFG 2005). Population trends within Idaho are unknown. However, in the contiguous U.S. overall numbers and range have been substantially reduced from historical levels (IDFG 2005). USFWS listed the contiguous U.S. distinct population segment (DPS) of Canada lynx as threatened in March 2000 (USFWS 2000b).

3.9.1.2 HABITAT REQUIREMENTS

The Canada lynx generally inhabits boreal and montane regions dominated by coniferous or mixed forest with thick undergrowth (generally above 4,000 feet in elevation), but they may also enter open forest, rocky areas and tundra to forage. When inactive or birthing, lynx occupy dens typically located in hollow trees, under stumps or in thick brush. Den sites tend to be in mature or old growth stands with a high density of logs (Koehler 1990). They feed primarily on snowshoe hares (*Lepus americanus*), but may supplement their diet with squirrels, small mammals, beaver, deer, moose, muskrat and birds. Lynx will also consume carrion and may cache food for later use. When prey is scarce, lynx home range increases, and individuals may become nomadic (Ward and Krebs 1985; Saunders 1963; Mech 1980). Male lynx's home ranges average 15 to 30 square kilometers and are larger than that of females. Long distance dispersal movements of up to several hundred kilometers have also been recorded. Population density usually is less than 10 individuals per 100 square kilometers but can reach up to 20 individuals per 100 square kilometers, depending on prey availability. Mean densities range between two and nine per 100 square kilometers (McCord and Cardoza 1982). In 2009, USFWS revised the critical habitat designation for Canada lynx to include Unit 3 for the Northern Rocky Mountains includes Northwestern Montana and a small portion of northeastern Idaho, in Boundary County (USFWS 2009a). The designated critical habitat is all above 4000 feet in elevation, thus the Kootenai River Valley is not within the critical habitat area.

3.9.1.3 FACTORS OF DECLINE

Three primary habitat components are reported for lynx in the northwestern U.S.: (1) foraging and cover habitat to support snowshoe hare (15 to 35 year old lodgepole pine dominated forest); (2) den sites, defined by patches of >200-year-old spruce and fir, with adequate amounts of downed wood, generally

less than five acres; and (3) dispersal and travel cover, which varies in vegetation composition and structure (USFS 1993).

A limiting factor for Canada lynx is the abundance of the snowshoe hare, which in turn is limited by availability of winter habitat. Winter habitat for snowshoe hare in the northwest primarily consists of early successional lodgepole pine forest dominated by trees at least six feet tall (USFS 1993).

Lynx numbers were initially reduced as a result of overexploitation through regulated and unregulated harvest that occurred in the 1970s and 1980s. Forest management practices that result in the loss of diversity, fragmentation, increased roads, developments, and unnatural fire frequencies have altered suitable habitat for lynx that remain. As a result, many states may have insufficient habitat quality and/or quantity to sustain lynx or their prey (USFWS 1998a). Although legal take is highly restricted, existing regulatory mechanisms may be inadequate to protect small, remnant populations or to conserve habitat. Competition with bobcats and coyotes may also be a concern in some areas.

Current population size of the Canada lynx in the contiguous U.S. is unknown, but is thought to number less than 2,000 individuals. In Idaho, Biologists suspect that less than 100 individuals inhabit the state. It has been suggested that since lynx occurrence throughout much of the contiguous U.S. is on the southern periphery of the species' range, the presence of lynx is solely a consequence of dispersal from Canada, and that most of the U.S. may never have supported self-sustaining, resident populations over time (USFWS 1998a).

3.9.1.4 PRESENCE OF SPECIES RELATIVE TO ACTION AREA

Canada lynx do not occur near or within the action area and no critical habitat is present within the action area. It is unlikely that Canada lynx would occur in the floodplain area of the Kootenai River, as the project area is low in elevation and has no boreal or montane forests.

3.9.2 GRIZZLY BEAR

The grizzly bear is one of two subspecies of the brown bear (*Ursus arctos*) which occupy North America. Coloration varies from light brown to almost black, with guard hairs often paled at the tips. Grizzly bears are generally larger than black bears (*Ursus americanus*) and can be distinguished from them by humped shoulders, a more concave face, and shorter and rounder ears. Grizzly bears measure from five to eight feet long and adult males can weigh as much as 600 pounds. Females generally are smaller, weighing about 250 to 350 pounds. Females start producing year around six years of age and produce an average of two cubs every three years. The cubs stay with the sow for about two years.

The grizzly bear was listed as threatened under the ESA on July 28, 1975 (USFWS 1975). The Idaho populations of grizzly bears are estimated to include 30 to 40 bears that are found in the Cabinet-Yaak Recovery Zone, the Selkirk Mountain Recovery Zone with approximately 40 to 50 bears and the Yellowstone Recovery Zone with approximately 580 bears (USFWS 2009b). On March 22, 2007, USFWS announced that the Yellowstone DPS of grizzly bears was recovered; however, this decision was remanded on September 21, 2009 and the threatened status was reinstated for this DPS of grizzly bear.

3.9.2.1 DISTRIBUTION AND ABUNDANCE

The historical range of the grizzly bear included a variety of habitats across most of North America. However, grizzly bear populations today occupy only 2 percent of their original range (in the lower 48 states). They are generally found in remote areas of Alaska, Idaho, Montana, Washington, and Wyoming.

3.9.2.2 HABITAT REQUIREMENTS

In the spring, grizzlies leave their dens in search of new green vegetation (i.e., vegetation high in nutrients, digestibility, etc.) and winter-killed big game carrion, leading them to low elevation areas in river valleys and avalanche chutes. As the seasons progress, bears follow green vegetation up into the mid elevations. In the summer, bears concentrate on ripening berries and green vegetation, while seeking out cool riparian areas to reduce heat stress. As huckleberries and other berries ripen in July, grizzlies focus heavily on berry patches. During this time and through the fall, bears enter a hyperphagic stage where they become ravenous foragers, searching out any available food source in a quest to build enough fat reserves to sustain it through the long winter hibernation period of November through April. Adult grizzly bears are individualistic and normally solitary, with the exceptions of females with cubs and during the short breeding season in June. Grizzly bears in Idaho have home ranges between 200 to 300 square miles (USFWS 2009b).

3.9.2.3 FACTORS OF DECLINE

Human-caused mortality has been quantified as a larger factor of decline than natural causes; recent models speculate that reported mortality may be only 50 percent of actual human-caused mortality (McLellan and Shackleton 1988). Between 1800 and 1975, grizzly populations in the lower 48 states declined drastically. Fur trapping, mining, ranching, and farming pushed westward, altering habitat and resulting in the direct killing of grizzly bears. Grizzly bears historically were targeted in predator control programs in the 1930s. Predator control was probably responsible for extirpation in many states that no longer support grizzlies. The last legal grizzly bear hunting season in the contiguous U.S. ended when Montana closed it season in 1991.

More recent human-caused mortality includes management control actions, defense of life, defense of property, mistaken identity by hunters of black bear or other big game, poaching, and malicious killing. Habitat loss and low reproductive rates continue to affect grizzly bear numbers in Idaho. In addition, habitat for grizzly bears has been fragmented due to roads and other human developments causing displacement.

3.9.2.4 PRESENCE OF SPECIES RELATIVE TO ACTION AREA

Grizzly bear may occasionally be present in the study area, especially in spring due to increased range of foraging, but are more likely to be found in the surrounding mountainous areas.

3.9.3 SELKIRK MOUNTAIN CARIBOU

In 1980, USFWS received a petition from a private citizen and another from IDFG requesting the ESA listing of the Selkirk mountain population of woodland caribou. On January 14, 1983, the Selkirk mountain caribou population was listed as endangered under emergency rule due to concerns about poaching, habitat loss, and genetic problems associated with small populations (USFWS 1983). The final rule published February 29, 1984, lists Selkirk mountain caribou population as endangered in northern Idaho, northeast Washington, and southeast B.C. (USFWS 1984). Mountain caribou within B.C. are provincially red-listed, indicating that they are considered to be threatened or endangered. They are listed as threatened under the Canadian Species at Risk Act (SARA). Proposed critical habitat for woodland caribou was published in November 2011. Although the general project vicinity is included, the immediate study area is not.

3.9.3.1 DISTRIBUTION AND ABUNDANCE

Woodland caribou are considered one of the most critically endangered mammals in North America (USFWS 1993). Historically, woodland caribou were widely distributed throughout the northern tier of the coterminous U.S. from Washington to Maine, as well as throughout Canada. In the northwestern U.S., woodland caribou occurred in Washington, Idaho, Montana and perhaps Wyoming (Cringan 1957; Flinn

1956; Evans 1960; Layser 1974). Historical caribou numbers in the northwestern U.S. are difficult to determine with certainty because early records are composed primarily of anecdotal accounts gathered from trappers, early settlers, prospectors, and forest workers, as compiled by Flinn (1956), Layser (1974), and others. Nevertheless, these accounts indicate that caribou were plentiful in the northwestern U.S. in the 1800s (Layser 1974). However, as a result of habitat loss and fragmentation, overhunting, and predation, caribou numbers have decreased. The population, which was estimated at 25 to 30 animals at the time of listing in 1984, is now estimated at 46 animals. Most of the population typically occupies habitat in the B.C. portion of the recovery area, although a small number of caribou occur within the U.S. portion of the recovery area as well. Overall, the range of this species has been reduced by approximately 60 percent.

3.9.3.2 HABITAT REQUIREMENTS

Caribou habitat is typically segregated into two distinct vegetation zones, the cedar/hemlock zone (*Thuja plicata/ Tsuga heterophylla*) at lower elevations and the subalpine fir/Engelmann spruce (*Abies lasiocarpa/Picea engelmanii*) zone at higher elevations. Seasonal habitats consist of early winter, late winter, spring, calving, summer, and late summer habitats. Of primary management concern are the early winter and late winter habitats as they provide accessible forage during a period when available vegetation is limiting to mountain caribou on the landscape (USFWS 1993).

The cedar/hemlock forests and the lower limits of the subalpine fir/Engelmann spruce habitats are important to caribou during the early winter period, which generally extends from November through January. The early winter period is typically identified as the period of rapid snow accumulation. During this timeframe and prior to their elevational migratory movements, caribou typically seek out more closed timber stands which contain a high level of internal diversity. Components such as a high overstory canopy cover, the presence of arboreal lichens and an understory shrub component are very important. Early winter habitat consists of mature to old growth forests with a dominant overstory of western red cedar/western hemlock and subalpine fir/Engelmann spruce cover types. Ideal habitats or suitable habitats are multi-storied and have an overstory canopy cover greater that 70 percent.

The late winter period until approximately late April to May, caribou utilize subalpine fir and Engelmann spruce habitats which are at the upper portion of the ridge systems. Suitable habitat consists of mature to old stands of subalpine fir and Engelmann spruce which are relatively open-canopied. An overstory canopy of 10 to 50 percent is considered optimal. During this timeframe arboreal lichens are extremely important, as the caribou diet is almost entirely comprised of lichen.

Arboreal lichens comprise a critical winter food source. The preferred species of lichens are generally most abundant on trees that are more than 100 years old, but factors such as relative humidity, wetting and drying cycles and amount of light are ultimately the controlling factors. Subalpine fir trees and snags tend to support higher densities of these lichens than other tree species. One reason for this association is that most other conifer species in this region tend to lose their lower branches as they age, providing less substrate for arboreal lichens (Detrick 1984). Forage during spring and summer consists of succulent forbs and graminoids in subalpine meadows, and huckleberry leaves.

3.9.3.3 FACTORS OF DECLINE

The many factors leading to caribou decline include habitat loss when forest land is converted to other uses such as agriculture; habitat degradation as a result of harvesting or other disturbances, and landscape and habitat fragmentation due to harvesting, roads, pipelines, transmission corridors or other developments.

3.9.3.4 PRESENCE OF SPECIES RELATIVE TO ACTION AREA

Since the 1960s, the Selkirk mountain population of woodland caribou population has restricted its range to the Selkirk Mountains of northeastern Washington, northern Idaho and southeastern B.C. They are generally found on moderate slopes above 4,000 feet elevation in the Selkirk Mountains in Englemann spruce/subalpine fir and western red cedar/western hemlock forest types. It is unlikely that Selkirk mountain caribou are found within the study area.

3.9.4 BULL TROUT

The federal government listed the Columbia River DPS of bull trout (*Salvelinus confluentus*) as threatened on June 10, 1998 (USFWS 1998b). In the final ESA listing rule for bull trout, five subpopulations were recognized within the Kootenai River Subbasin (USFWS 1998b). 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 U.S./Canada border. In the draft Recovery Plan (USFWS 2002), USFWS identified 27 recovery units based on large river basins and generally following existing boundaries of conservation units for other fish species described in state plans, where possible. The Kootenai River Recovery Unit forms part of the range of the Columbia River population segment. The Kootenai River Recovery Unit includes four core areas and about 10 currently identified local populations. In B.C., bull trout are listed as an intermediate priority candidate species (COSEWIC 2003). The British Columbia Conservation Data Centre has blue-listed bull trout in B.C., 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 (COSEWIC 2003).

Historically, bull trout were one of six native salmonid species distributed throughout the Kootenai River drainage. The historical importance of Kootenai Falls as a barrier to fish movement is unknown, although radio telemetry information indicates that this series of falls is traversed by adult bull trout at certain flows (Marotz et al. 1988). If this was the case, this bull trout population likely included migratory fish from Kootenay Lake in B.C. as well as Kootenai River fish, which may have moved freely throughout the drainage. Resident bull trout may have been present. 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. 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. 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.

3.9.4.1 DISTRIBUTION AND ABUNDANCE

Bull trout are widely distributed through the lower Kootenai River from Libby Dam downstream to Kootenay Lake in B.C. Spawning and rearing by migratory adults occur in tributaries draining portions of B.C., Idaho, and Montana. These migratory fish spend their adult lives in Kootenay Lake or the Kootenai River. Libby Dam is an impassable barrier to upstream migration.

Spawning and rearing of migratory bull trout have been documented in four tributaries of the Kootenai River between Libby Dam and Kootenai Falls (Quartz, Pipe, and Libby creeks and the Fisher River). Tagging studies had previously confirmed that fish from above the falls sometimes moved downstream over Kootenai Falls (Marotz et al. 1988). Kootenai Falls is not a complete barrier, but rather a substantial barrier to upstream bull trout movement.

Limited information is available regarding abundance and life history attributes of bull trout in the Kootenai River downstream of Kootenai Falls. IDFG is currently conducting research on bull trout distribution and movements. Bull trout have been documented in the Idaho portion of the basin in the Kootenai and Moyie Rivers and Callahan, Curley, Deer, Deep, Fall, Caribou, Snow, Myrtle, Rock, Trout, Parker, Long Canyon, and Boundary creeks (PBTTAT 1998). Additional observations of bull trout were reported in Boulder, Caboose, and Debt creeks in Idaho, just downstream from the Montana border. Typically, sightings of bull trout in Idaho waters have been limited to individual fish. Adult bull trout appear to be well distributed throughout the Kootenai River in Idaho, but at very low densities, based on electrofishing data. Radio telemetry data indicate that some of those fish overwinter in the deep holes of the lower river (Walters 2002). Five of eight adult bull trout radio-tagged in O'Brien Creek in Montana migrated downstream into Idaho following spawning.

3.9.4.2 HABITAT REQUIREMENTS

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). All three life history forms are present in the Kootenai subbasin.

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 1985). 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, Pratt, and Graham 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 1984; 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 1984). Time spent migrating from natal streams to the Kootenai River has not been studied, but Goetz (1991) reported that juvenile outmigrants move downstream quickly in other stream systems (Kootenai Tribe and MFWP 2004).

3.9.4.3 FACTORS OF DECLINE

Bull trout in the Kootenai River have been impacted by habitat degradation, altered hydrology and river hydraulics related to flow changes, habitat fragmentation and degradation, gas supersaturation due to reservoir spill, competition with introduced species, and a diminished prey base related to suppressed kokanee production caused by nutrient depletion (Kootenai Tribe 2009; USFWS 2002). This risk to the bull trout population is elevated due to the small number of available core areas 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 (Kootenai Tribe and MFWP 2004). Introduced species are widespread throughout the watershed. Brook trout is currently thought to present the greatest nonnative species risk to bull trout, because of the threat of hybridization. In addition, ecological interactions and

competition with other non-native species, such as brown trout, are also increasing threats as these populations establish and grow (USFWS 2002).

3.9.4.4 PRESENCE OF SPECIES RELATIVE TO ACTION AREA

Bull trout are currently widely distributed through the lower Kootenai River, from Libby Dam downstream to Kootenay Lake in B.C. (Kootenai Tribe and MFWP 2004). These migratory fish spend their adult lives in Kootenay Lake or the Kootenai River. Bull trout abundance is relatively low in the Kootenai River in Idaho (Kootenai Tribe and MFWP 2004).

3.9.5 KOOTENAI RIVER WHITE STURGEON

Within the U.S., KRWS were listed as endangered on September 6, 1994 (59 FR 45989) and a recovery plan was completed in 1999 (USFWS 1999a). Within Canada, white sturgeon occur only in B.C. 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 in Canada were listed as endangered by Committee on the Status of Endangered Wildlife in Canada (COSEWIC), but only the latter four are legally listed under SARA. Kootenay white sturgeon are included in this group and are listed as endangered under SARA. The SARA Recovery Strategy being developed for white sturgeon is currently in draft.

3.9.5.1 DISTRIBUTION AND ABUNDANCE

KRWS is a naturally landlocked, locally adapted population that has been isolated since the last glacial age that occurred approximately 10,000 years ago (Kootenai Tribe 2009). Most white sturgeon populations in western North America are anadromous. KRWS is the only naturally land-locked population of white sturgeon in western North America; other populations have become land-locked (potamodromous) due to dams and other passage barriers. Kootenai sturgeon have adapted to local conditions, 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 1988; Setter and Brannon 1992; Anders et al. 2000; Anders 2002; Anders et al. 2002; Rodzen et al. 2004).

Relatively little is known about the historical status of Kootenai sturgeon in the Kootenai Subbasin (Kootenai Tribe and MFWP 2004). Within the Kootenai River subbasin, white sturgeon historically occupied an approximately 184 mile reach, from Kootenai Falls (RM 194) downstream to the north end of Kootenay Lake (RM 10), and upstream into what is now Duncan Reservoir, as well all of the lake's West Arm (approx. 31 miles) (Kootenai Tribe and MFWP 2004).

Very little information is available on historic population size of KRWS. A hind-casted recruitment history generated with empirical data indicates that natural recruitment initially plummeted 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 140 mile reach of the Kootenai River from the Bonners Ferry area downstream into and including all of Kootenay Lake.

Current population abundance is estimated to have been approximately 640 adults in 2002, down from a reconstructed abundance estimate of approximately 6,800 adults in 1980 (Paragamian et al. 2005). The next 10 to 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 mature, on average, at around 30 years of age (slower than other populations)

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.

3.9.5.2 HABITAT REQUIREMENTS

Sturgeon spawn repeatedly over their adult lives, but most females do not spawn annually (Bemis and Kynard 1997). In the Kootenai River system, females have been documented to mature as early as age 22 and males at age 16 (Paragamian et al. 1997), but the average age of female maturity is approximately 30 years of age. The longevity of KRWS (up to 100 years), lengthy maturation period, and spawning periodicity (five or more years in females) suggests that KRWS 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 (Beamesderfer and Farr 1997).

KRWS spawn during the period of historical peak flows from May through July (Apperson and Anders 1991; Marcuson 1994). Spawning at peak flows with high water velocities disperses and prevents clumping of eggs. A coarse substrate of hard material is generally required to ensure a stable attachment surface for eggs and limited fine materials to reduce coating and allow sufficient oxygenation of eggs during incubation (Bemis and Kynard 1997). Following fertilization, eggs adhere to the river substrate and hatch after a relatively brief incubation period of 8 to 15 days, depending on water temperature (Brannon et al. 1984). Most free-embryos hide under cover when first hatched (Kynard et al. 2010; Mc Adam 2011; Kynard et al. 2008; Kynard et al. 2009). Dispersal downstream occurs for all once they have developed into larvae (Kynard et al. 2010) and then eventually settle back into interstitial spaces in the substrate. Larval white sturgeon require an additional 20 to 30 days to metamorphose into juveniles with a full complement of fin rays and scutes.

KRWS 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). A particular spawning site is usually used from year to year. Such site fidelity might derive either from the particular characteristics of the site or from homing (Bemis and Kynard 1997).

3.9.5.3 FACTORS OF DECLINE

In addition to demographic and genetic requirements, suitable physical habitat (abiotic) and ecological (biotic) conditions are required for viability and persistence of fish populations (Kootenai Tribe and MFWP 2004; Parsley et al. 2002). In particular, key ecological requirements for KRWS 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 (Kootenai Tribe and MFWP 2004; Parsley et al. 2002).

Self-sustaining natural population of Kootenai sturgeon may be recruitment habitat limited, stock limited or both (Anders, Richards, and Powell 2002). Food limitations in the first year of life may be a potential bottleneck in the system. 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 fingerlings, food limitations, and first over-winter mortality (Duke et al. 1999; USFWS 1999a; Anders, Richards, and Powell 2002).

A number of factors are thought to account for the Kootenai sturgeon's population 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 the first bottleneck to recruitment most likely occurs during the embryo (incubation to early life) stages (Partridge 1983; Duke 1999; USFWS 1999a; Paragamian, Kruse, and Wakkinen 2001; Anders, Richards, and Powell 2002; Paragamian, Beamesderfer, and Ireland. 2005; Kootenai Tribe 2008). Without-project conditions will result in the loss of a self-sustaining, natural recruitment of the species.

3.9.5.4 PRESENCE OF SPECIES RELATIVE TO ACTION AREA

The present population has adapted to specific local conditions in the Kootenai River. The range of this population extends from Kootenay Lake upstream 184 miles to Kootenai Falls, but they are primarily found in the low gradient reach (Meander Reach) downstream from Bonners Ferry and in Kootenay Lake (Kootenai Tribe 2009).

3.9.6 BURBOT

Burbot (*Lota lota*) were proposed for ESA listing in 2000; however, USFWS determined that the population was not eligible for listing as it does not comprise a Distinct Population Segment. Instead the Kootenai Valley Resource Initiative Burbot Subcommittee, in coordination with other stakeholders, proposed to evaluate a Conservation Strategy for Lower Kootenai River Burbot in lieu of an ESA listing. Burbot is considered a focal species for this project (Kootenai Tribe 2009).

The burbot is a landlocked species of cod that inhabits the Kootenay River Basin. Historic population estimates exceeded 200,000, but burbot now number fewer than 1,000 in the Kootenai River and Kootenay Lake and may be nearing demographic extinction. The Kootenai River and Kootenay Lake once provided popular and important sport, subsistence, and commercial burbot fisheries. The Kootenai Tribe relied heavily upon this fishery as burbot were a main stable for the Kootenai Tribe in the late winter/early spring months.

3.9.6.1 DISTRIBUTION AND ABUNDANCE

Historically, burbot were distributed throughout the Kootenai subbasin; although not as contiguous populations. At least two distinct burbot stocks likely existed in Idaho and British Columbia, one a lacustrine population in Kootenay Lake, the other a fluvial or adfluvial population in the Kootenai River. 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. (Kootenai Tribe 2009).

3.9.6.2 HABITAT REQUIREMENTS

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 over substrate of fine silt, sand, or gravel. In lakes, spawning usually occurs over near-shore shallows or over shallow offshore reefs and shoals over substrate that is usually sand, gravel, or cobble (Kootenai Tribe 2009).Burbot are cold water spawners that display highly synchronized communal spawning periods. Eggs are thought to drift in the water column and lodge in interstitial spaces in the substrate. 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) (Kootenai Tribe 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 reside in and 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 (Kootenai Tribe 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. 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 (Kootenai Tribe and MFWP 2004).

3.9.6.3 FACTORS OF DECLINE

Flow management at Libby Dam was probably the greatest factor of decline for burbot as it interferes with burbot spawning migration during winter (Kootenai Tribe 2009). However, currently, the extremely low numbers of remaining burbot appear to pose a greater risk due to lack of natural recruitment potential.

3.9.6.4 PRESENCE OF SPECIES RELATIVE TO ACTION AREA

Meander Reach 1 of the Kootenai River has been identified as potential habitat for migrating and spawning adult burbot (Kootenai Tribe 2009). Therefore, burbot may be migrating through the action area in fall and winter and spawning between December and May.

3.10 CULTURAL RESOURCES AND HISTORIC PROPERTIES

Cultural resources are locations of past human activities on the landscape. The term generally includes any material remains that are at least 50 years old and are of archaeological interest. Examples include archaeological sites such as lithic scatters, villages, procurement areas, resource extractions sites, rock shelters, rock art, and shell middens; and historic era sites such as trash scatters, homesteads, railroads, ranches, levees and any structures that are more than 50 years old. Under the National Historic Preservation Act (NHPA) as amended, 2006, federal agencies must consider the effects of federally regulated undertakings on cultural resources that are eligible for listing on the National Register of Historic Places (NRHP).

The National Park Service has established three main standards that a resource must meet to qualify for listing on the NRHP (36 CRR 60): age, integrity, and significance. To meet the age criteria, a resource generally must be at least 50 years old. To meet the integrity criteria, a resource must possess integrity of location, design, setting, materials, workmanship, feeling, and association. Finally, a resource must be significant according to one or more of the following criteria:

- Be associated with events that have made a significant contribution to the broad patterns of our history;
- Be associated with the lives of persons significant in our past;
- Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; and
- Have yielded, or may be likely to yield, information important in prehistory or history.

The project area is located in a moderate to high probability area for cultural resources such as short-term camp sites, and historic homestead remains. USACE archaeologists completed a cultural resource inventory of the entire Area of Potential Effect for the project in September of 2011. A portion of the Kootenai River Levee system is located in the project area. USACE has determined that the project will have "No Adverse Effect" to the dike/levee portion and has recommended monitoring for the creation of the temporary access road along the riverward side of the levee and any shoreline excavation. Further information regarding the inventory can be found in Section 6.8 of this document.

3.11 SOCIO-ECONOMICS AND ENVIRONMENTAL JUSTICE

3.11.1 SOCIO-ECONOMICS

The original inhabitants of the county were members of what is now known as the Kootenai Tribe of Idaho. The Kootenai Tribe of Idaho is one of seven bands of the Kootenai or Ktunaxa Nation present in northern Idaho, B.C., and northwest Montana. The Kootenai Tribe has inhabited the study area for thousands of years and used the natural resources for hunting, fishing and gathering edible, medicinal and cultural plants. Currently, a modern village is located about three miles from Bonners Ferry on 12.5 acres. The majority of the Kootenai Tribe members live in this village, which is the former site of and is often referred to as the Mission. The Kootenai Tribe make a significant contribution to the local economy through its Kootenai River Inn, Casino and Spa in Bonners Ferry, through its government and other economic operations, and through its natural resources programs (all information derived from [Kootenai Tribe et al. 2006]).

The population of Boundary County in 2010 was 10,972. The rate of population increase in the county is lower than for the State of Idaho as a whole, with the county increasing by 11 percent from 2000 to 2010, while the state increased by 21 percent (U.S. Census Bureau 2011). The per capita income is also less than the state per capita, while the poverty level is slightly higher at the county versus the state levels. Table 3-10 shows relevant population data from the 2010 Census (U.S. Census Bureau 2011) and relevant socioeconomic data from 2009 estimates as the 2010 data has yet to be published.

Table 3-10. Boundary County and State of Idaho Population and Income Statistics

Location	Population	Per Capita Income	Individuals Below Poverty Level
Boundary County	10,972	$17,853	15.9%
State of Idaho	1,492,573	$22,262	14.9%

Note: 2010 Census data was only available for the population numbers, the remainder of the data are based on 2009 estimates.

Industries in the study area include forestry, health care, retail and services, professional/technical services, agriculture and mining (U.S. Census Bureau 2011). Forestry has been a driver of the economy since early settlement in the 1880s. Employment in the forestry industry reached an all-time high in 1997 in the county (Kootenai Tribe et al. 2006). Agriculture is the dominant industry in the floodplain, with grain crops and livestock accounting for the primary agricultural outputs. High value crops such as hops are also grown in the area (Kootenai Tribe and MFWP 2004). Mining was historically an important component of the economy with several mines in the area for minerals such as gold, lead, silver, zinc and copper (Kootenai Tribe et al. 2006). Tourism and recreation are burgeoning areas of the economy with hunting, fishing, and camping opportunities available throughout the county.

3.11.2 ENVIRONMENTAL JUSTICE

Federal agencies are required by Executive Order 12898 (Environmental Justice, 59 FR 7629, 1994) to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and

activities on minority populations and low income populations." Providing environmental justice means ensuring that existing local and market area minority and low income populations must be actively protected from adverse human health or environmental effects of any management strategy undertaken or authorized within the project area.

The Council on Environmental Quality (CEQ), identifies minority groups as Asian, American Indian or Alaskan Native, Pacific Islander, Black not of Hispanic origin, and Latino (CEQ 1997). It defines a minority population as any group of minorities that exceed 50 percent of the existing population within the market area or where a minority group comprises a meaningfully greater percentage of the local population than in the general population. Additionally, CEQ (Council on Environmental Quality 1997) identifies low income using 2010 census data for "individuals living below the poverty level." For the purposes of this study, a low income population will be defined similarly as a local or market area population with more than 50 percent of people living below the poverty level.

According to the data assembled in Table 3-10, there are no communities surrounding the project area which would quality as a minority or low income populations as defined by CEQ (1997) or for the purposes of this report.

3.12 LAND USE

The majority of Boundary County is forested and includes USFS lands within the Panhandle National Forest (over 394,000 acres). Within the study area, the floodplain of the Kootenai River is primarily dominated by agricultural uses on privately owned lands (approximately 55,000 acres of floodplain plus over 100,000 acres of forest lands). Other major public ownership includes IDFG, IDL, USFWS, and BLM. The City of Bonners Ferry occupies a small proportion of the study area (all information derived from [Kootenai Tribe et al. 2006]). The Kootenai Tribe also holds land within the study area including allotments for agriculture, wildlife protection, housing, and government services.

It is not likely that land uses will change significantly over the 50-year period of analysis for this study, although population increase will likely lead to some expansion of the City of Bonners Ferry and residential development.

3.13 AIR QUALITY AND NOISE

In northern Idaho, air quality monitoring for the National Ambient Air Quality Standards (NAAQS) is focused on particulate matter due to the large amount of debris and waste burning that takes place related to agriculture in the region (IDEQ 2004). The Kootenai Tribe operates an air quality and meteorological monitoring station on the reservation (upstream end of the Meander Reach 1). Data are collected and submitted to the EPA Air Quality Database, with emphasis on PM. The Kootenai Tribe collaborates with other agencies including the Idaho Department of Environmental Quality (IDEQ) and Boundary County to monitor and maintain air quality (Kootenai Tribe 2010a).

Available monitoring data points for Boundary County between 2000 and 2004 indicate that the area met EPA national standards for air quality with regard to the following pollutants: carbon monoxide, lead, and PM (EPA 2010). Monitoring data for other air pollutants is not available in the study area, but given the rural setting and low population density, it is anticipated that the study area air quality is generally within EPA attainment levels for all air pollutants, with moderate risk of PM pollution from smoke during periods of frequent agricultural burning.

The study area is located in a rural and agricultural area. The primary source of noise at potential study sites and staging areas is from recreational boat traffic passing through the study area. Some agricultural fields adjacent to the river in the study reach may occasionally produce noise. The portion of the study

area nearest to a town is at Deep Creek (approximately RM 149), where staging may occur. The nearest town, Bonners Ferry, is located at RM 152 to RM 153. The principal sources of noise in Bonners Ferry are vehicle traffic on U.S. Route 2/95 that runs through town and the Union Pacific/Burlington Northern railroad that runs parallel to the Braided Reaches through Bonners Ferry.

3.14 TRANSPORTATION AND UTILITIES

U.S. Hwy 95 crosses the Kootenai River at the upstream end of the study area. The Union Pacific and Burlington Northern Railroad lines run east-west and parallel to the Braided Reaches upstream of the study area and constrain channel migration to some extent. Within the City of Bonners Ferry there are several roadways adjacent to the river including, North River Drive, Riverside Street, and Hwy 95/ U.S. Hwy 2.

Several water supply intakes and wastewater and irrigation water discharges are located within the study area including the Bonners Ferry water supply intake at the downstream end of the Braided Reach, and its wastewater treatment plant discharge at the downstream end of the Straight Reach. The Kootenai Tribe maintains a water intake for the sturgeon hatchery at the upstream end of the Meander Reach. The Kootenai Tribe is proposing to build a new hatchery facility near the Moyie River confluence, but this facility will not be completed for several years (Kootenai Tribe 2009).

Avista Corporation maintains a number of electrical power transmission lines and natural gas lines within and adjacent to Bonners Ferry. A cable-suspended gas line crosses the Kootenai River near the downstream end of the Straight Reach. An overhead electrical power transmission line crosses the Kootenai River near the Highway 95 crossing (Kootenai Tribe 2009).

3.15 RECREATION

Recreational opportunities abound in Boundary County on the Panhandle National Forest, Kootenai National Wildlife Refuge and other public lands. More than 360 miles of trails are available in the Lower Kootenai River Ranger District of the U.S. National Forest and 60 miles of motorized accessible trail are available. Camping, picnicking, hiking, white water rafting, canoeing, bird watching, skiing, snowmobiling, hunting, fishing, and other recreational pursuits are popular (USFS 2010).

Within the project area itself, recreational activities include fishing, boating, and wildlife and bird watching. The Kootenai National Wildlife Refuge receives over 20,000 visitors per year and has bird watching and hiking activities available, as well as hunting and fishing (USFWS 2010b).

3.16 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

A preliminary Hazardous, Toxic, and Radioactive Waste (HTRW) investigation was conducted to document any current and/or historical contamination from activities in the project area. The preliminary investigation was primarily based on: (a) review of previous documents relevant to the proposed project; (b) review of relevant environmental databases maintained by federal and state regulatory agencies; (c) examination of historical aerial photos and topographic maps of the project area; (c) preliminary site reconnaissance; and (d) in-person discussion with a current/historical landowner.

Review of documents and databases indicated that there is no record of any current or historical HTRW contamination in the proposed project site and surrounding area. Historical maps and photos indicated that the study area has been developed only for use as non-irrigated farm land, with associated drainage and access roads. Site reconnaissance and interviews indicated similarly minor HTRW contamination potential, such as isolated incidents of junk vehicles used as riprap, minimal reported use of fungicide-

pesticides, isolated oils and grease contamination from agricultural equipment, and minimal abandoned farm infrastructure/equipment.

If the proposed restoration project is not implemented, the baseline conditions regarding HTRW would likely continue as at present into the foreseeable future.

4 PLAN FORMULATION

Following the development of problems and opportunities (Step1) and inventory and forecast conditions (Step 2), the next step in the planning process is the formulation of alternative plans (Step 3) to address identified objectives. This is followed by evaluation (Step 4) and comparison (Step 5) of plans. Based on the evaluation and comparison, a selection of a tentatively recommended plan is made.

Alternative plans are typically comprised of individual restoration measures. Restoration measures are the building blocks of alternative plans which are then evaluated and compared. Preliminary screening of the initial set of measures is often necessary and appropriate in order to focus on measures that are complete, acceptable, efficient, and effective, as well as relate directly to the identified project goal and objectives. Once a final array of measures is identified, they are evaluated in more detail with regard to cost and environmental outputs (habitat benefits) through a cost-effectiveness and CE/ICA. The results of the CE/ICA are used to help identify and select a recommended plan.

This chapter presents the development and evaluation of measures and alternatives that are related to the specified Section 1135 project goal of improving the early life stage survival of the ESA-listed KRWS. The identified objective is to provide suitable aquatic habitat in Meander Reach 1 for egg attachment and early life stage survival of KRWS to support recovery efforts. A brief overview of the formulation process detailed in the remainder of this chapter is provided in the following paragraphs below.

The actions to restore ecosystem function described in the Master Plan are intended to create conditions that support all life stages of KRWS. As noted in Chapter 2 and above, the focus for plan formulation for this investigation is limited to those measures that could support early life stage survival of the ESA listed KRWS. Broader ranging measures such as wetland restoration, floodplain reconnection, bank erosion control and riparian restoration were eliminated from consideration for the Section 1135 authority project in the Meander Reach 1. These types of projects provide benefit to other life stages of KRWS or secondary benefits to the early life stage by improving the food-web, but do not directly address failure of KRWS to survive through the early life stages. Consideration or development of measures that focus on broader Master Plan objectives are outside of the scope of this Section 1135 investigation and are not presented as part of the plan formulation for the Section 1135 project. Measures considered in this study are screened based on their applicability to the study area under consideration (i.e. the Meander Reach 1), and their focus on the identified project objective.

Sections 4.1 and 4.1.1 begin the chapter with consideration of the full array of measures that have been considered to date that are focused on spawning and early life stages of KRWS. In Sections 4.1.2 through 4.1.4, following initial screening, the retained measures are considered in additional detail and again screened against three criteria: (1) how well each supports early life stages of KRWS, (2) sustainability of the measure, and (3) constructability. As discussed in Section 4.2, channel material/sediment facies and egg deposition density data were assessed to identify potential placement locations in the reach for the final array of measures. Based on an assessment of this information, five sites (shown in Figure 4-1) were identified within the Meander Reach 1, including:

- Shorty's Island North,
- Shorty's Island South,
- Myrtle Creek,
- Refuge and
- Downstream of Refuge.

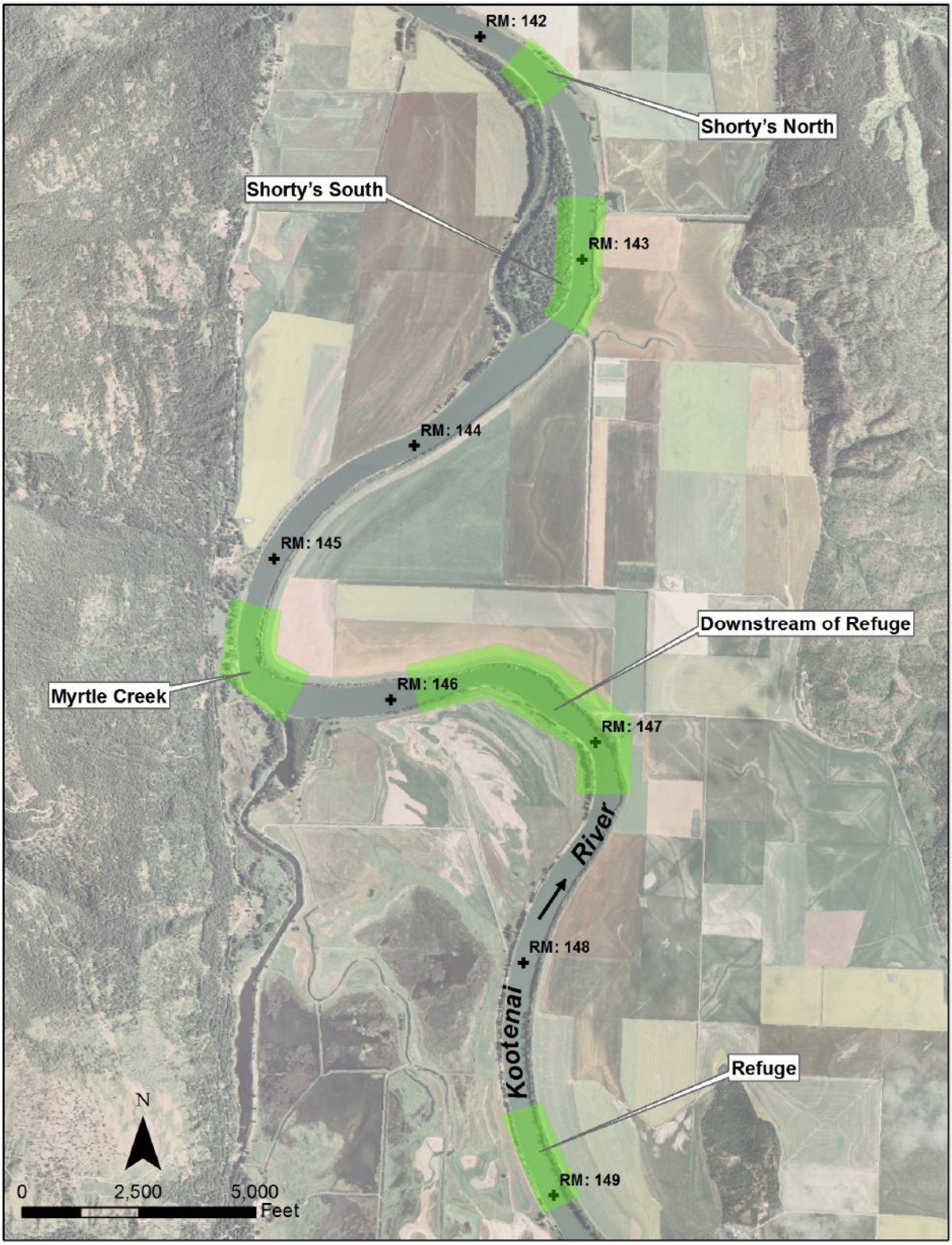


Figure 4-1. Identified Restoration Sites

As described in Section 4.5, the selected methodology for quantifying benefits involved application of a Habitat Evaluation Procedure (HEP) and development of Habitat Suitability Indices (HSIs) using different combinations and scales. Section 4.6 details the costs and habitat benefits, or outputs, that were developed for each of the sites. In Section 4.7, the evaluation methodology included development of site specific and reach-wide cost effectiveness and CE/ICA. The identified plans of interest based on the results of the CE/ICA were then assessed for their acceptability, completeness, efficiency and effectiveness. The chapter concludes with the identification of a tentatively recommended plan.

4.1 DEVELOPMENT AND SCREENING OF MEASURES

As discussed in Chapter 2, the geographical focus of this study is Meander Reach 1. The identified objective is to provide suitable habitat to support early life stage survival of KRWS. The availability of suitable substrate for early life stage survival was identified as the first bottleneck in the survival of KRWS, and therefore, was selected as the highest priority restoration action for this feasibility study.

Broader restoration actions and larger scale projects that address other aspects of the Kootenai River ecosystem are considered in the Master Plan (Kootenai Tribe 2009). The set of preliminary measures and screening of preliminary measures in Section 4.1 are presented to provide historical context in relation to the Master Plan. These preliminary measures were also presented at a May 2010 stakeholder workshop where participants reviewed restoration measures most applicable to address the identified bottleneck and to focus on substrate suitability.

Since the Habitat and Ecosystem Restoration Strategies process was undertaken in 2003 (Tetra Tech 2004b), a variety of measures have been considered for improving the spawning and early life stage habitat for KRWS. The measures have included those centered on creating suitable substrate conditions for spawning and early life stages, attracting KRWS to areas of existing suitable substrate, and providing other habitat improvements that may benefit spawning and early life stages. In general, suitable substrate consist of larger gravels, cobbles and small boulders that have interstitial space relatively free of sands and finer sediments (specific requirements for suitable substrate are presented in Section 4.5.1.1). Measures developed to date that are related to spawning and early life stage survival can be sorted into several categories and are described below:

Place Material for Egg Attachment Measures

- **Substrate Placement on the Bed:** This measure includes placing suitable substrate in areas of known spawning to provide the proper conditions for egg attachment, incubation and free-embryo hiding.
- **Placement of Bank Stone for Spawning:** This is similar to the previous measure, except the stone or suitable substrate is placed on the banks instead of in the main flow area of the channel. This is an approach that has been used in the Great Lakes region for lake sturgeon.
- **Placement of Piles or Concrete Jacks for Egg Attachment:** This type of structure was considered since it would provide a surface for eggs to attach and would remain above sand traveling as dunes or waves through the system.
- **Use of Sunken Large Woody Debris (LWD) for Egg Attachment:** This would be similar to the use of piles or concrete jacks, but created of a natural material. The LWD would provide surface for egg attachment and some potential area for hiding of free-embryos.

Flow/Scour Measures

- **Improvement of Areas of Existing Coarse Substrate:** This approach utilizes boulders, rock vanes or flow deflectors to promote scour of sand from areas of existing coarse substrate that would be suitable for KRWS with the sand removed.

- **Dredge and Improve Areas of Existing Coarse Substrate:** This measure is an extension of the measure Improvement of Areas of Existing Coarse Substrate, by including a onetime mechanical removal of the sand covering the existing coarse substrate prior to installing the vanes.

Riparian Habitat Measures

- **Lower and Create Floodplain Areas within the Levees to Satisfy the "Riparian Hypothesis:"** The measure involves physically lowering areas of the floodplain by excavation. The areas would be limited to few locations where the existing levees are setback from the main channel. This approach was developed to address the riparian hypothesis (Coutant 2004) that suggests that submerged riparian habitat during the seasonal high water is needed for early life stage development of white sturgeon.
- **Setback Levees to Create Floodplain Connectivity to Satisfy the "Riparian Hypothesis:"** This approach was also developed to address the riparian hypothesis (Coutant 2004) and would involve setting back levees to reconnect the floodplain rather than lowering the floodplain.

Side Channel or Tributary Habitat Measures

- **Side Channel Restoration with Substrate Placement:** This measure or approach was based on information from the Fraser River in Canada that indicated that sturgeon were spawning in low velocity side channels (Perrin et al. 2003). This approach was geared primarily toward increasing connectivity of the left side channel at Shorty's Island. In addition to increasing the connectivity and flow in the side channel, suitable substrate would be placed.
- **Tributary Restoration Adjacent to the Meander Reach:** This effort would restore tributaries crossing the Kootenai River floodplain. Its purpose was to address larger ecosystem restoration issues and potential needs of later KRWS life stages.

Attraction to Areas of Suitable Substrate Measures

- **Improve Passage and Spawning Conditions through the Braided Reach:** This effort would provide a "horizontal" ladder through the Braided Reach to encourage KRWS to pass into and access suitable spawning habitat in the Canyon Reach and access suitable spawning habitat there. The efforts could also result in creation of suitable substrate in the Braided Reach by hydraulic sorting of gravels and cobbles.

4.1.1 Screening of Initial Array of Measures

Several of the measures in the initial array were not focused on restoration of ecosystem function or creation of suitable substrate for early life stage, and thus, did not address the project objective. Although these measures were identified to address the "Riparian Hypothesis," the PDT indicated the "Riparian Hypothesis" does not apply to spawning and free-embryo life stage since there is no evidence that white sturgeon spawn in floodplains. Therefore, it does not address the project objectives. There are also other factors that would make large scale riparian restoration difficult in the Meander Reach. Lack of broad landowner support for restoration actions in the adjacent floodplain make these measures challenging. The USACE requirement for dike maintenance of flood risk management works also limits potential to restore riparian habitat. Finally, total cost for these measures put them beyond the scope of the Section 1135 program. The following measures were eliminated for the above reasons:

- Lower and Create Floodplain Areas Within the Levees to Satisfy the "Riparian Hypothesis;"
- Setback Levees to Create Floodplain Connectivity to Satisfy the "Riparian Hypothesis;" and
- Tributary Restoration Adjacent to the Meander Reach.

Two of the initial measures intended to address spawning were screened out for the Meander Reach 1 because they were formulated to address conditions in other portions of the critical habitat reach that do not exist in Meander Reach 1. The Meander Reach 1 contains the only area where significant evidence of KRWS spawning has been documented. The measures addressing conditions in critical habitat areas outside the Meander Reach are:

- **Dredge and Improve Areas of Existing Coarse Substrate:** This measure was eliminated because it was aimed at modifying conditions in the Straight Reach and possibly portions of Braided Reach 1, not Meander Reach 1.
- **Improve Passage and Spawning Conditions through the Braided Reach:** Eliminated since it was formulated to address conditions in the Braided Reach and is not applicable to Meander Reach 1.

The final measure that was eliminated initial screening process was:

- **Side Channel Restoration with Substrate Placement:** Eliminated because of potential to negatively alter hydraulics on the main channel (right side) of Shorty's Island by diverting flow into the side channel. This is of particular concern since the main channel around Shorty's Island has one of the highest levels of KRWS spawning documented over the past decade. Additionally, the measure could increase sedimentation in the main channel due to reduction in its flow.

The initial screening process is summarized in Table 4-1.

Table 4-1. Summary of Screening of Initial Array of Measures

Measure	Result of Screening	Comment
Substrate Placement on the Bed	**Retain**	Addresses restoration of function/creation of suitable substrate in Meander Reach 1.
Placement of Bank Stone for Spawning	**Retain**	Addresses restoration of function/creation of suitable substrate in Meander Reach 1.
Placement of Piles or Concrete Jacks for Egg Attachment	**Retain**	Provides surface for egg attachment that would not be buried by sedimentation.
Use of Sunken LWD for Egg Attachment	**Retain**	Provides surface for egg attachment that would not be buried by sedimentation.
Improvement of Areas of Existing Coarse Substrate	**Retain**	Addresses restoration of function/creation of suitable substrate in Meander Reach 1; limited to areas with existing coarse substrate in Meander Reach 1.
Dredge and Improve Areas of Existing Coarse Substrate	Eliminate	Formulated for conditions in the Straight Reach; need to select areas in the Meander Reach that have been documented to scour sand from existing coarse substrate and do not require dredging/maintenance.
Lower and Create Floodplain Areas within the Levees to Satisfy the "Riparian Hypothesis"	Eliminate	Does not address spawning and incubation; the PDT indicated "Riparian Hypothesis" does not apply to spawning and free-embryo life stage since there is no evidence that white sturgeon spawn in floodplains.
Setback Levees to Create Floodplain Connectivity to Satisfy the "Riparian Hypothesis"	Eliminate	Does not address spawning and incubation; the PDT indicated Riparian Hypothesis does not apply to spawning and free-embryo life stage since there is no evidence that white sturgeon spawn in floodplains.
Side Channel Restoration with Substrate Placement	Eliminate	Increasing flows in the side channel would decrease flows in the main channel and reduce the hydraulic conditions that currently cue KRWS to spawn in the main channel. Additionally, the measure could increase sedimentation in the main channel due to reduction in its flow.
Tributary Restoration Adjacent to the Meander Reach	Eliminate	Does not directly address spawning, incubation and early life stage needs as KRWS have not been documented to spawn in these areas.
Improve Passage and Spawning Conditions through the Braided Reach	Eliminate	The measure is outside study area and was formulated for conditions in the Braided Reach to promote KRWS passage into the Canyon Reach.

4.1.2 SECONDARY ARRAY OF MEASURES

The retained measures from the initial array are thought to provide or improve substrate conditions for spawning and egg attachment. After the screening of the initial array, refinement was made to several of the measures. The refinement is based on more in-depth understanding of the conditions in the Kootenai River and also the needs of the early life stages of KRWS. In particular, the requirement for providing interstitial space between the substrate for the free-embryo cover became an important consideration, in addition to providing substrate for egg attachment.

A very important aspect of the refinement involved using sediment facies or bed conditions that was developed by USGS. This information revealed that there are areas where lacustrine clays are exposed, typically in bends where secondary currents cause scour and likely result in lower levels of suspended sediment along the outside of the bend. The clay is exposed in both the thalweg of the channel and a series of near vertical steps and flat shelves on the outside of the bends (Barton et al. 2004; Barton et al.

2011). There are two significant aspects of the formulation of measures that can be taken from this information. First, the areas that have exposed clay are relatively free of sand deposition. As a result of the natural hydraulics in these areas, including flow paths and currents, dunes have not been observed over the clay beds. Additionally, results of videography show little bed load in these areas and greatly reduced suspended load. Consequently, suitable substrate placed in these areas will not be exposed to burial by dunes or sand waves and should remain relatively free of sand. A second important aspect of the clay beds are relatively firm and provide a much better foundation for placing substrate than the areas covered with sand. If substrate were placed on sand, besides the issues associated with the higher transport in these areas, the placed substrate could sink into the bed or be displaced if sand were scoured away from the edges of the placement.

In addition, the USGS investigations found a narrow lag deposit (residual accumulation of coarse material left behind by the winnowing of finer material) of gravel and cobble on the clay bed below the Myrtle Creek confluence and smaller patches at the Refuge. The presence of existing coarse substrate provides for an opportunity to formulate a substrate improvement measure in Meander Reach 1. Improvement in this case consists of providing features that help scour sand from the existing coarse substrate. The presence of coarse substrate also provides for a substrate placement measure that is on existing coarse substrate, rather than the clay bed. This could be beneficial if the existing coarse substrate is not of optimal size or placing suitable substrate will reduce the likelihood of sand burying the substrate (Note: Later interpretation of videography of this area by USGS indicated that the extent of the lag deposit at Myrtle Creek was only on the order of 100 feet in length rather than over 1,000 feet as initially indicated and that the gravels were relatively free of deposited sand.).

Based on the refinement to the substrate placement measures there are a total of seven measures that focus on restoring/creating suitable substrate or provide a suitable surface for egg attachment. However, not all of the measures provide voids or interstitial space for free-embryo cover. Each of the measures is briefly described below.

- **Measure 1: Substrate Placement on Clay Bed:** This measure consists of placing suitable substrate in the area of the thalweg over the clay bed. The bed may be totally exposed or have a thin covering of sand. In addition to the suitable substrate, boulders would be placed on top of the substrate to help scour the sand by increasing the scale and intensity of turbulence near the bed. Suitable substrate and boulders would be placed from a barge.
- **Measure 2: Substrate Placement on Clay Shelves:** This measure consists of placing suitable substrate on the relatively flat clay shelves that exist on the outside of the bend, above the thalweg. In addition to the suitable substrate, boulders may be placed on top of the substrate similar to Measure 1. Construction methodology is also similar to Measure 1 assuming that the clay shelves do not require removal of material to modify or enlarge them. If removal of some clay is necessary to shape the shelves, this will increase construction complexity.
- **Measure 3: Improvement of Existing Coarse Substrate:** This measure consists of placing large boulders over the areas of existing coarse (gravel and larger) substrate which may help prevent sand deposition or help scour deposited sand from the coarse substrate by increasing the scale and intensity of turbulence near the bed. Boulders would be placed from an anchored barge.
- **Measure 4: Substrate Placement on Existing Coarse Substrate:** This measure consists of placing suitable substrate in the thalweg over existing coarse substrate. Placement of boulders on top of the substrate may help prevent sand deposition and promote. Placement of material would be from a barge.
- **Measure 5: Placement of Bank Stone for Spawning:** This is similar to Measure 1, except the suitable substrate is placed on the banks (underwater slide-slopes) instead of in the main

flow area of the channel. To remain stable on the banks, the material may need to be larger than material placed on the bed, but still within the range of suitable substrate sizes. This approach has been used in the Great Lakes region for lake sturgeon. Since material is being placed on the bank, it may be possible to place the material from heavy construction equipment working from the bank. A barge may not be necessary.

- **Measure 6: Placement of Piles or Concrete Jacks for Egg Attachment:** This measure consists of concrete or wooden piles driven into the bed of the Kootenai. The piles would be terminated sufficiently below the low water level to avoid creating a navigation hazard. An alternative to piles would be to dump a series of concrete jacks (sometimes referred to as Kelner jacks or jetty jacks). Both materials would provide surfaces for KRWS eggs to adhere, but would not provide a hiding place for free-embryos. In the case of piles, construction would require barge with pile driving capability that could be anchored in the main channel current. Pile installation could also be complicated by the depth of water and the length of pile required. The construction complexity for the concrete jacks would be similar to substrate placement associated with Measure 1 with placement from a barge required.
- **Measure 7: Use of Sunken LWD for Egg Attachment:** This would be similar to the use of piles or concrete jacks, but would mimic a more natural situation. The LWD would provide surfaces for egg attachment and some potential area for hiding of free-embryos. Construction would require weighting LWD to sink it to the bed and to anchor it against displacement by the flow. The LWD would be deployed from a barge anchored in the river. Control of the configuration of the LWD could be difficult as the depth of water exceeds 30 feet in many locations and some current is present.

4.1.3 Screening the Secondary Array of Measures

For the final array of measures, the screening criteria were refined based on the additional understanding of the needs for KRWS egg attachment and early life stage survival. The screening criteria were developed for three categories which include the ability of a measure to address spawning and early life stage needs, sustainability, and constructability of the measure. Each of these criteria is discussed below.

- **Ability of the measure to address the needs of KRWS spawning and early life stages.** This criterion includes four different aspects, with the first three representing physical attributes for successful egg attachment and free-embryo cover. The fourth aspect is related to hydraulic effects and if the measure would adversely affect hydraulic conditions needed to maintain spawning while supporting the early life stages. For spawning, it is important that the measure continue to mimic the type of hydraulic conditions that sturgeon are already cued to spawn in. Additionally, they must not interfere with the spawning behavior which involves the sturgeon continuously passing over the substrate while releasing eggs.
- **Sustainability of the measure.** The primary concern with sustainability is the long-term functionality of the measure in the Meander Reach 1environment where the bed is dominated by sand that may include dunes several feet high. There are two aspects of the sand bed that need to be addressed for sustainability. The first is whether the materials will remain relatively free of sand during the early life stages. The second is whether the material is likely to sink into a sand bed or be launched from its position as sand is scoured away from its edges. These are of most concern if the suitable substrate is placed on the sand bed. Sustainability of the measures is assessed relative to the other measures under consideration and the likelihood that over the long term the measure would function as intended.

In applying the first two screening categories just presented, each measure was judged to either fulfill or not fulfill the criterion. The third category, constructability is described below and was rated on a scale from easy to difficult.

- **Constructability of the measures.** Constructability was rated as easy, moderate or difficult based on anticipated construction methods. All measures, except for the placement of bank stone will require a barge as a work platform since the materials will be installed away from the banks. If placement was from land based equipment it was considered in easy. If it required a barge, the constructability was rated moderate, unless there were additional circumstances that could add to the difficulty such as lowering wood into deep, flowing water or driving piles from a barge.

Measure 1: Substrate Placement on Clay Bed

- *Addresses Spawning and Early Life Stage Needs:* Meets criteria. This measure mimics suitable substrate lying on the bed of the channel over an appreciable distance that the fish can swim above and continuously release their eggs, which is the typical spawning behavior. This measure includes the physical attributes necessary for egg attachment and free-embryo cover. This measure should not have adverse hydraulic effects if it only occupies a small portion of the channel cross-sectional area.
- *Sustainability:* Meets criteria. Addresses sustainability by limiting placement of suitable substrate to areas where exposure of either a clay bed or coarse substrate bed has been documented. In addition, large boulders included in the design to increase the scale and intensity of the turbulence near the bed and may help maintain the substrate free of sand.
- *Constructability:* Will require placement from an anchored barge, but the level of difficulty was identified as moderate. The substrate could be dumped over the side of the barge and no additional special consideration would be required.

Measure 2: Substrate Placement on Clay Shelves

- *Addressees Spawning and Early Life Stage Needs:* Meets criteria. This measure mimics suitable substrate lying on the bed of the channel over an appreciable distance that the fish can swim above and continuously release their eggs, which is the typical spawning behavior. This measure includes the physical attributes necessary for egg attachment and free-embryo cover. This measure does not have adverse hydraulic effects.
- *Sustainability:* Meets criteria. Addresses sustainability by limiting placement of suitable substrate to areas where exposure of clay shelves has been documented. In addition, large boulders have been included in the conceptual design to increase the scale and intensity of the turbulence near the bed and may help maintain the substrate free of sand.
- *Constructability:* Will require placement from an anchored barge, but the level of difficulty was identified as moderate. The substrate could be dumped over the side of the barge and no additional special consideration would be required. If removal of some clay is necessary to shape the shelves, this will increase construction complexity.

Measure 3: Improvement of Existing Coarse Substrate

- *Addressees Spawning and Early Life Stage Needs:* Meets criteria. This measure enhances suitable substrate lying on the bed of the channel over an appreciable distance that the fish can swim above and continuously release their eggs, which is the typical spawning behavior. This measure includes at least some (although not optimal since existing gravels are smaller than optimal) physical attributes necessary for egg attachment and free-embryo cover. This measure does not have adverse hydraulic effects.
- *Sustainability:* Meets criteria. Addresses sustainability by limiting improvement to areas where exposure of an existing coarse substrate bed has been documented. The large boulders increase the scale and intensity of the turbulence near the bed and are may help maintain the existing coarse substrate free of sand.

- *Constructability:* Will require placement from an anchored barge, but the level of difficulty was identified as moderate. The boulders could be dumped over the side of the barge and no additional special consideration would be required.

Measure 4: Substrate Placement on Existing Coarse Substrate

- *Addressees Spawning and Early Life Stage Needs:* Meets criteria. This measure mimics suitable substrate lying on the bed of the channel over an appreciable distance that the fish can swim above and continuously release their eggs, which is the typical spawning behavior. Measure 4 may have two advantages over Measure 3 in some situations. First, if the existing coarse substrate is not of optimal size, substrate placement of optimal size will improve the suitability of the material. Second, by placing substrate it will be elevated above the existing bed and possibly above the zone of highest sand transport, thus increasing the likelihood of the interstitial voids staying free of sand. This measure includes the physical attributes necessary for egg attachment and free-embryo cover. This measure does not have adverse hydraulic effects.
- *Sustainability:* Meets criteria. Addresses sustainability by limiting placement of suitable substrate material to areas where exposure of either a clay bed or coarse substrate bed has been documented. In addition, large boulders have been included in the design to increase the scale and intensity of the turbulence near the bed and may help maintain the substrate free of sand.
- *Constructability:* Will require placement from an anchored barge, but the level of difficulty was identified as moderate. The suitable substrate could be dumped over the side of the barge and no additional special consideration would be required.

Measure 5: Placement of Bank Stone

- *Addressees Spawning and Early Life Stage Needs:* This measure includes some of the physical attributes necessary for egg attachment and free-embryo cover. This measure does not have adverse hydraulic effects. Placing spawning stone on the bank may provide suitable substrate for egg attachment; however, the vast majority of documented KRWS spawning activity has occurred in the main channel and not on the banks. The bank spawning stone approach is successful for lake sturgeon, but the sturgeon experts at the May, 2010 workshop felt the preference for KRWS to spawn in the main flow made it unlikely bank stone would be used by spawning KRWS. At the December, 2010 workshop, the sturgeon experts on the PDT again confirmed that bank stone was not a measure to retain.
- *Sustainability:* Meets criteria. Bank stone would be placed outside of the portion of the channel carrying the heavy sand load and placed on the outside of bends where deposition of sediment is least likely.
- *Constructability:* It is anticipated that the stone could be placed from heavy equipment operating from the top of bank and this was considered to be relatively easy construction since it did not require the barge.

Measure 6: Placement of Piles or Concrete Jacks for Egg attachment

- *Addressees Spawning and Early Life Stage Needs:* Meets some criteria including egg attachment and does not cause adverse hydraulic effects. Spawning behavior could make it unlikely that the piles or concrete jacks would be used effectively for spawning unless much of the jack or pile was sunk in the bed so they did not protrude more than several feet above the bed. It would also be difficult or impractical to make these structures sufficiently dense to collect the majority of the eggs released. The effectiveness of these structures to collect eggs would be less than substrate, since many of the eggs would quickly sink to the bed and not

attach to the jacks or piles. These structures would not provide interstitial space for cover or hiding spaces for free-embryos.

- *Sustainability:* Meets criteria. Piles or Jacks would be sized to protrude above the bed and to accommodate scour.
- *Constructability:* Rated difficult based on the use of piles in a deep river environment. This would require a much more stable anchoring of the barge than Measures 1 through 4. In addition, the depth could approach 60 feet which would pose difficulties with that length of pile exposed to the force of the flow as well as in obtaining piles of adequate length. Concrete jacks were assigned moderate constructability rating as methods would be similar to substrate placement. The jacks would be dumped from a barge.

Measure 7: Use of Sunken LWD for Egg Attachment

- *Addressees Spawning and Early Life Stage Needs:* Meets some criteria including egg attachment and would not cause adverse hydraulic effects. Spawning behavior could make it unlikely that the LWD would be used effectively for spawning unless much of the LWD was sunk in the bed so it did not protrude more than several feet above the bed. It would also be difficult or impractical to make these structures sufficiently dense to collect the majority of the eggs released. The effectiveness of these structures to collect eggs would be less than substrate, since many of the eggs would quickly sink to the bed and not attach to the LWD. Additionally, these structures would not provide significant small void space that free-embryo use for cover.
- *Sustainability:* Meets criteria. LWD would be sized to protrude above the bed and to accommodate scour.
- *Constructability:* Rated difficult since control of the placement of the weighted LWD would be difficult. The density of even weighted LWD would be such that significant drift could occur if they were dropped over the barge. This might be overcome by constructing a unit of LWD with many pieces bound together prior to launching from the barge, but this would also increase the difficulty of construction.

4.1.4 Screening Results

The results of applying the screening criteria are provided in Table 4-2. Based on these results it is clear that Measures 1 through 4 should be retained for further consideration as measures to be combined to formulate alternatives. They all address the required spawning and early life stage needs, are viewed as sustainable, and are of moderate construction difficulty. Measure 5 was eliminated from further consideration because it is uncertain if it would be suitable for KRWS. Measures 6 and 7 were eliminated because they only address egg attachment and incubation, but do not provide cover for free-embryos. In addition, they are inconsistent with sturgeon spawning behavior and would retain eggs only incidentally. It is not expected that sturgeon would actually swim around them releasing their eggs. In fact, sturgeon would likely avoid a pile of LWD or a mass of concrete jacks because it is unlikely that white sturgeon could navigate through a complex pile of LWD. Conceptual sketches of Measures 1 through 4 which have been retained for development of alternatives have been provided in Figure 4-2 through Figure 4-9. These four measures are proposed for further technical evaluation. They will also be further evaluated in regard to habitat benefit and cost and will form the basis for the CE/ICA. The more detailed evaluation will provide the basis for identifying a recommended plan.

Table 4-2. Summary of Screening of Initial Array of Measures; "X" Indicates the Measure Meets a Criterion

Measure	Addressees Spawning and Early Life Stage Needs				Sustainability		Constructability			Comment	Retain Measure (Yes/No)
	Spawning	Egg Attachment	Free-Embryo Cover	No Adverse Hydraulic Effects	Unlikely to Be Buried by Sand	Unlikely to Require Replacement for Displacement	Easy	Moderate	Difficult		
1. Substrate Placement on Clay Bed	X	X	X	X	X	X		X		Addresses all early life stage needs and sustainability	Yes
2. Substrate Placement on Clay Shelves	X	X	X	X	X	X		X		Addresses all early life stage needs and sustainability	Yes
3. Improvement of Existing Coarse Substrate	X	X	X	X	X	X		X		Addresses all early life stage needs and sustainability	Yes
4. Substrate Placement on Existing Coarse Substrate	X	X	X	X	X	X		X		Addresses all early life stage needs and sustainability	Yes
5. Placement of Bank Stone for Spawning		X	X	X	X	X	X			Not in main flow area so KRWS unlikely to utilize	No
6. Placement of Piles or Concrete Jacks for Egg Attachment		X[2]		X	X	X		X[1]	X	Efficiency of each collection would be lower than substrate, not type of structure that KRWS would spawn over, minimal free-embryo cover	No
7. Placement of Sunken LWD for Egg Attachment		X[2]		X	X	X			X	Efficiency of each collection would be lower than substrate, not type of structure that KRWS would spawn over, minimal free-embryo cover	No

Notes: [1] Jacks have "moderate" constructability rating
[2] Meets some criteria

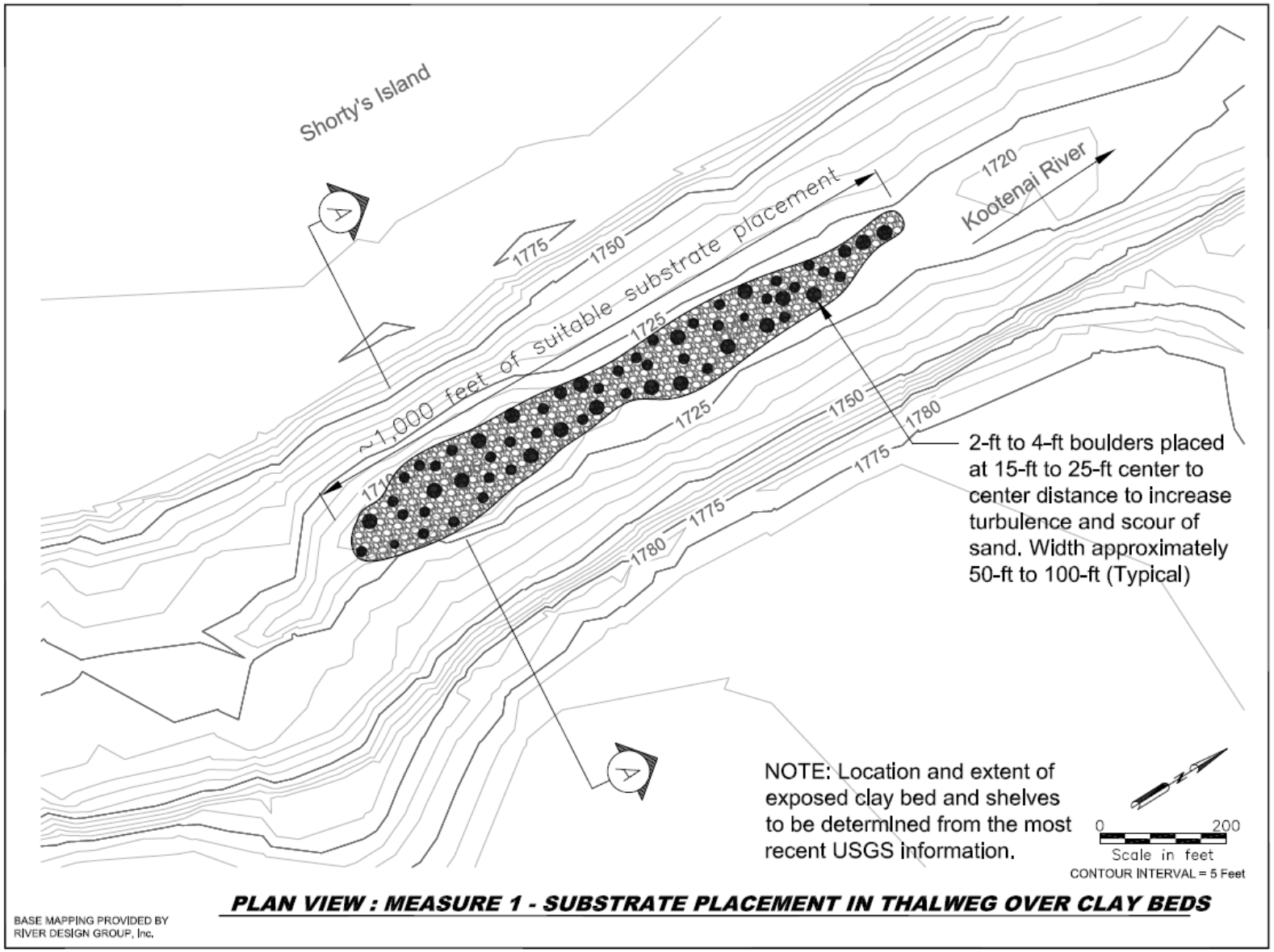


Figure 4-2. Concept Plan View of Measure 1, Substrate Placement on Clay Bed

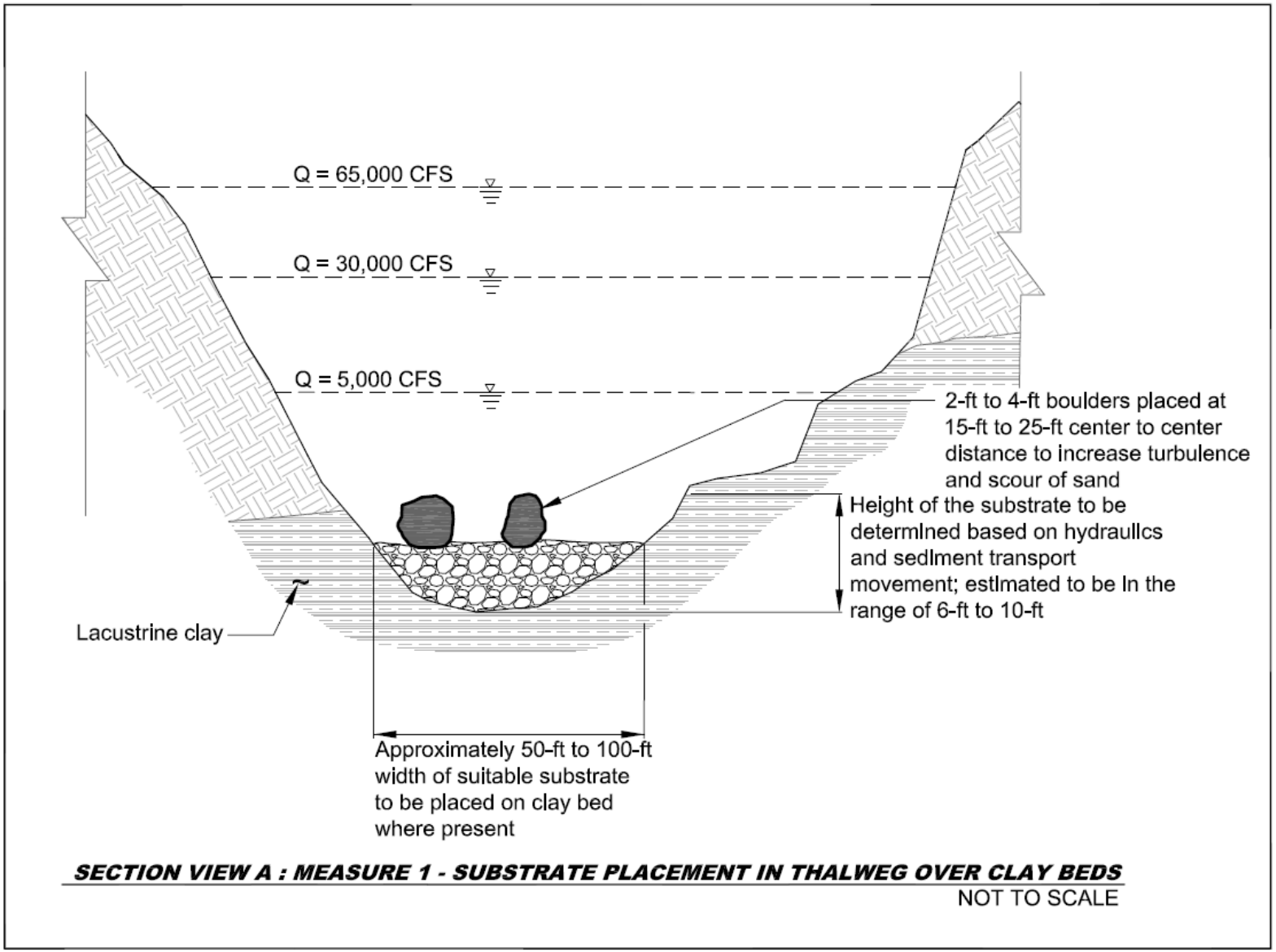


Figure 4-3. Concept Cross Section View of Measure 1, Substrate Placement on Clay Bed

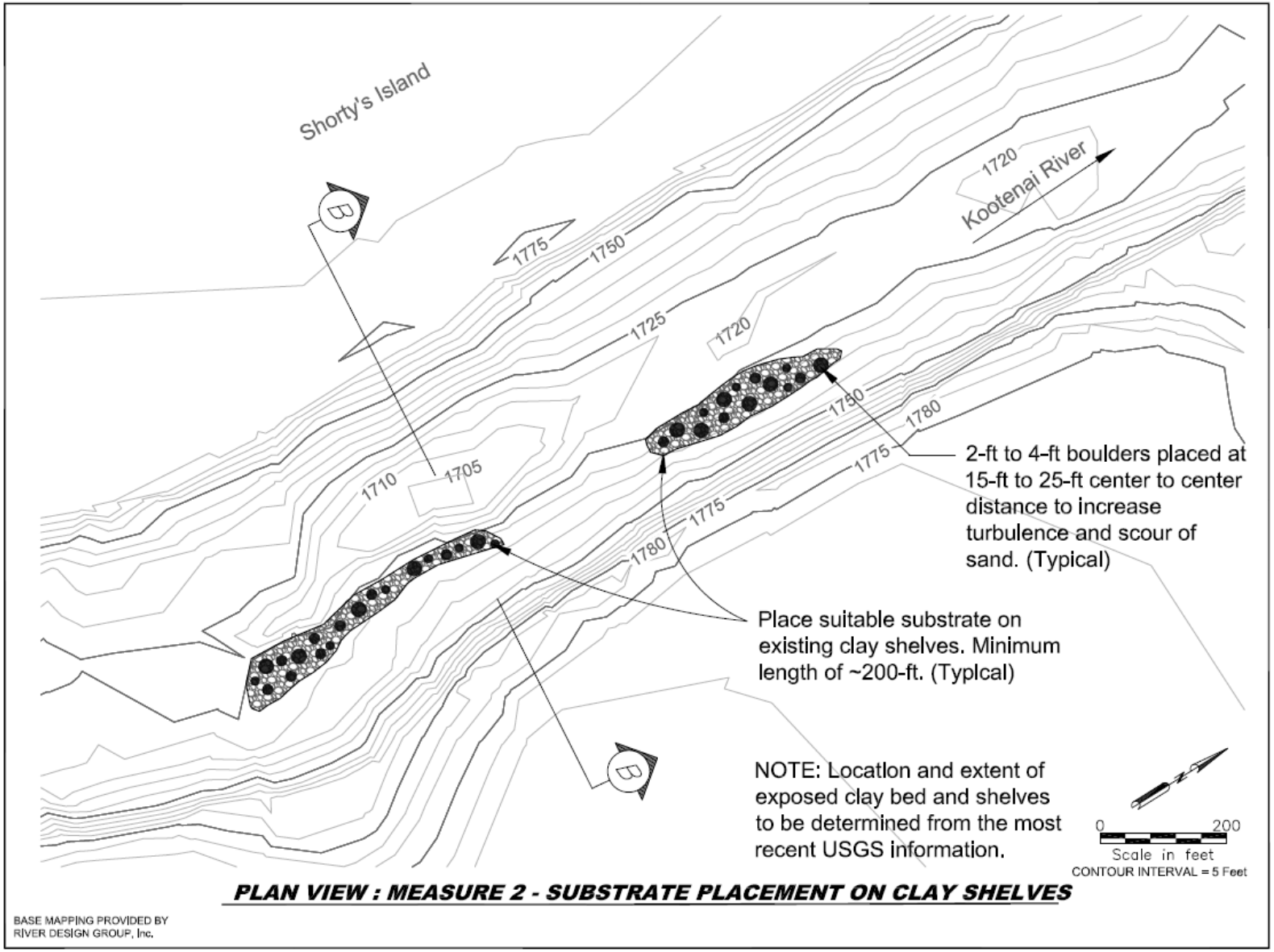


Figure 4-4. Concept Plan View of Measure 2, Substrate Placement on Clay Shelves

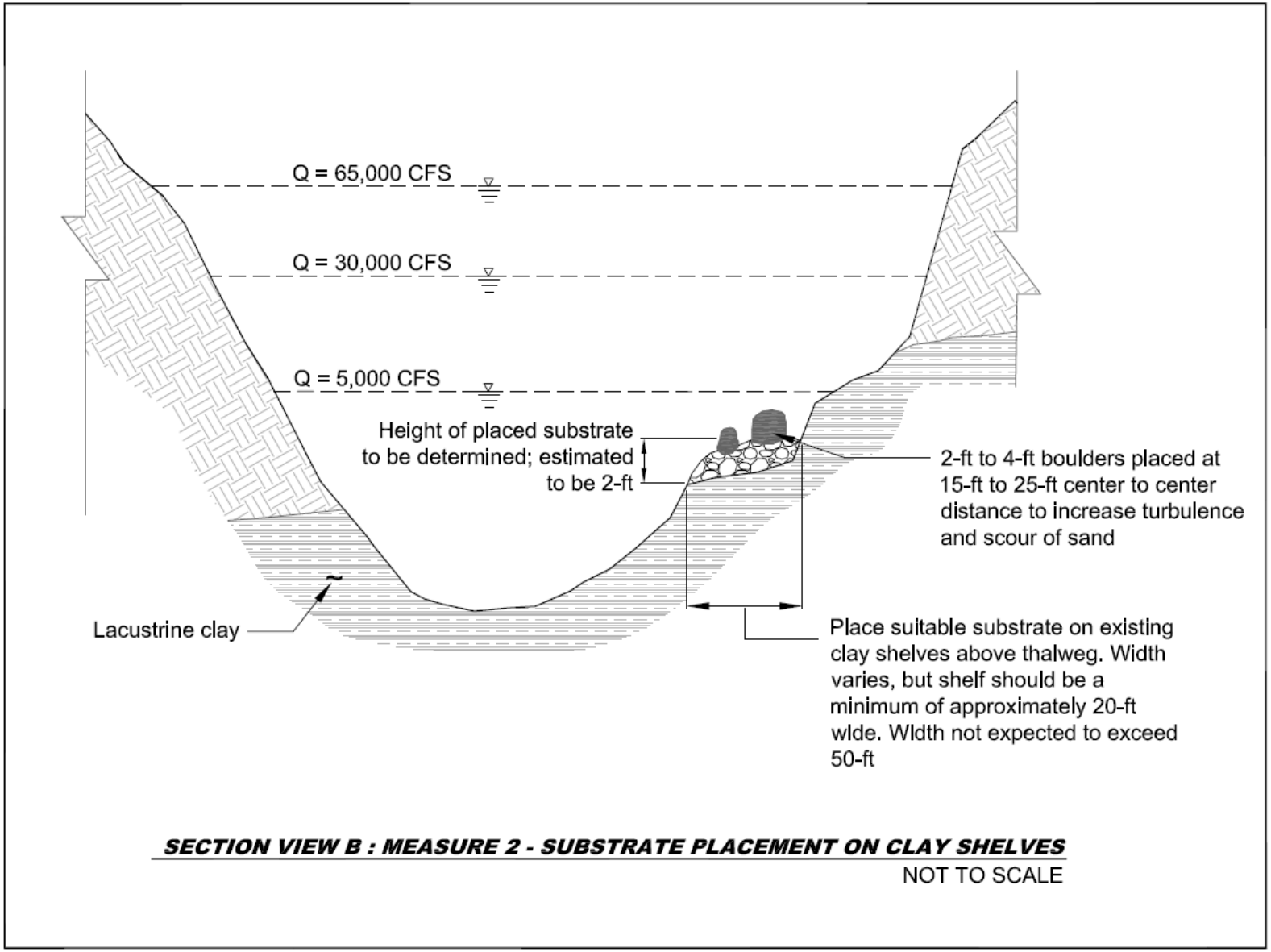


Figure 4-5. Concept Cross Section View of Measure 2, Substrate Placement on Clay Shelves

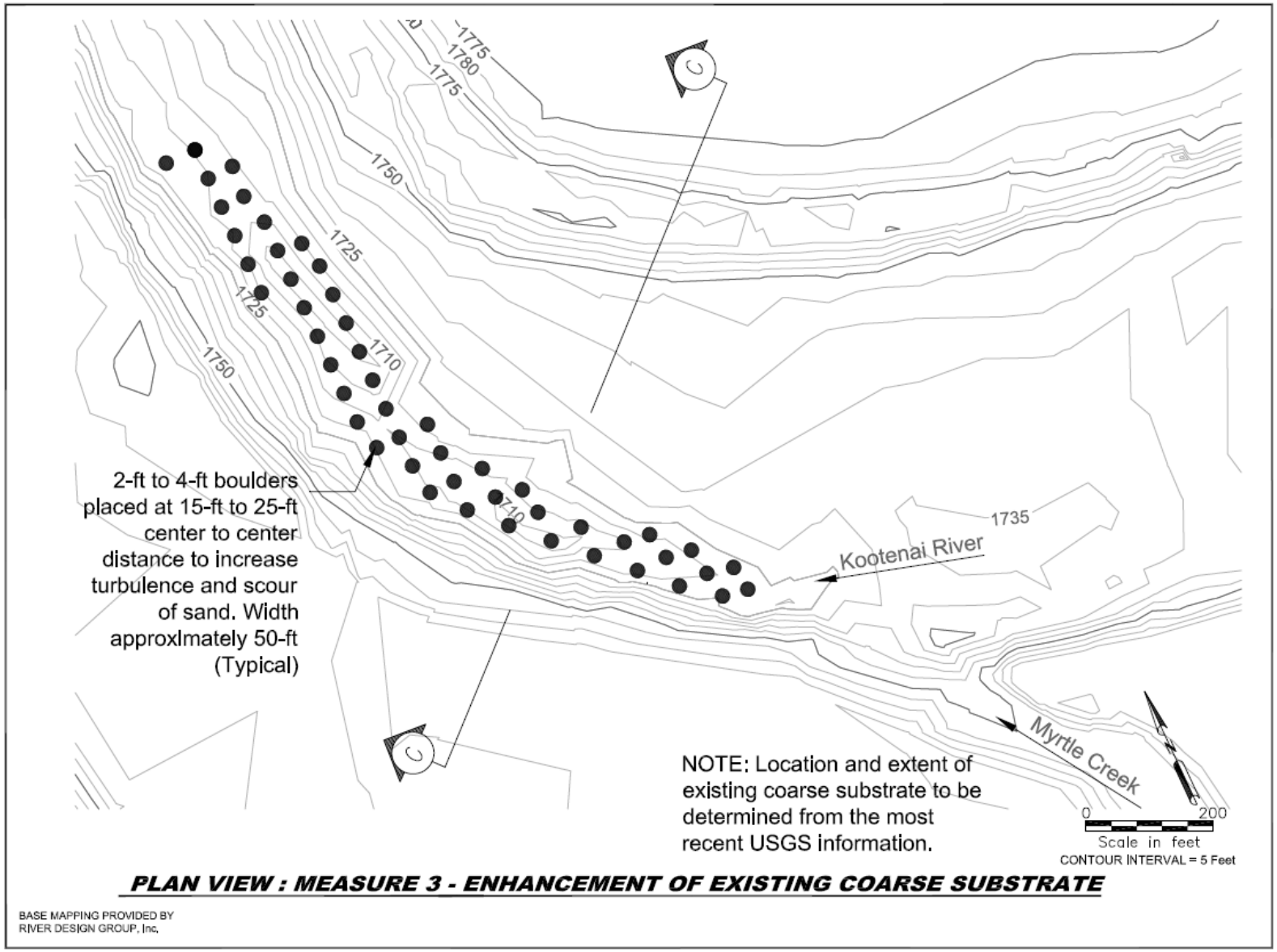


Figure 4-6. Concept Plan View of Measure 3, Improvement of Existing Coarse Substrate

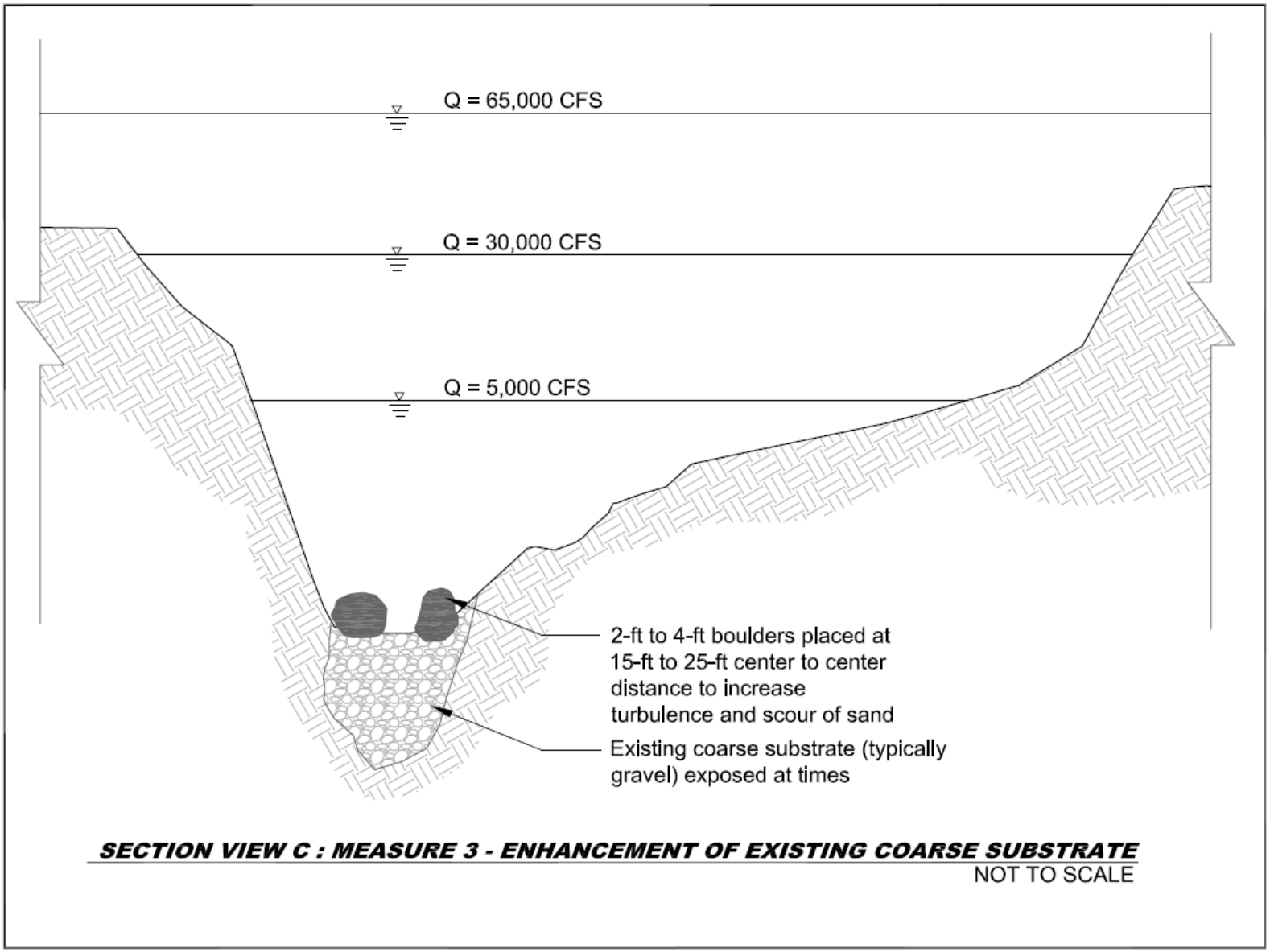


Figure 4-7. Concept Cross Section View of Measure 3, Improvement of Existing Coarse Substrate

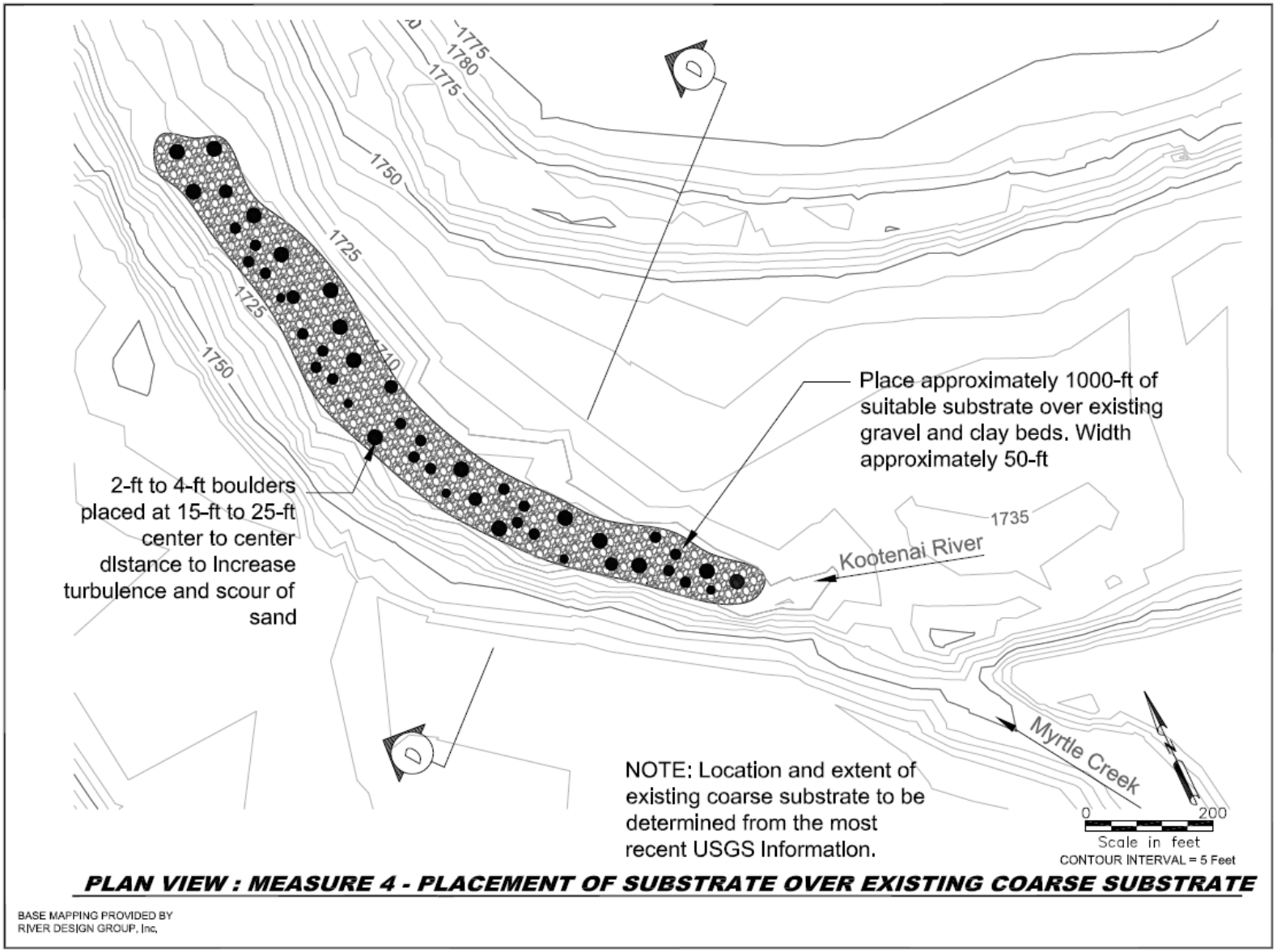


Figure 4-8. Concept Plan View of Measure 4, Improvement of Existing Coarse Substrate

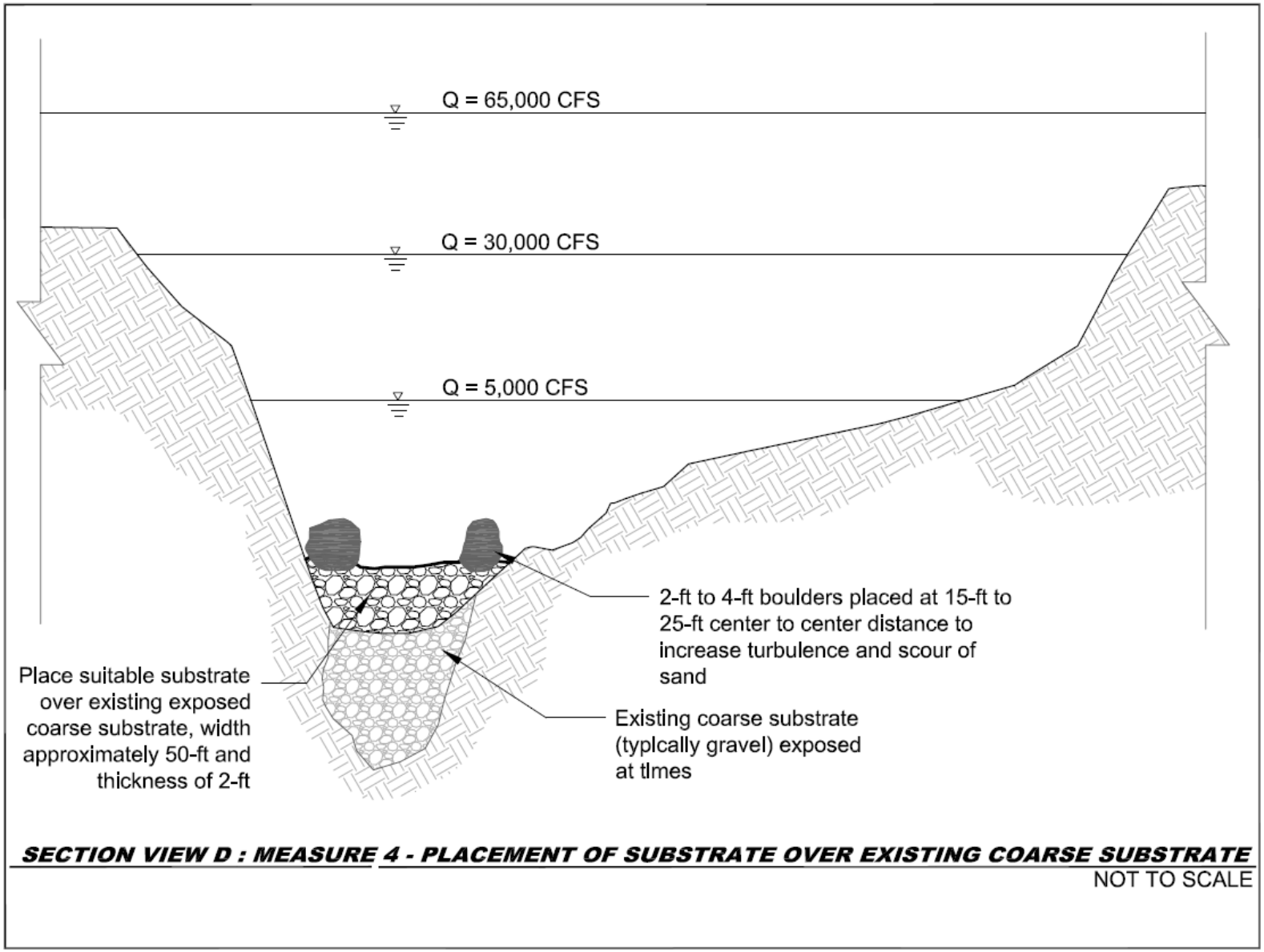


Figure 4-9. Concept Cross Section View of Measure 4, Improvement of Existing Coarse Substrate

4.2 EVALUATION APPROACH FOR FINAL ARRAY OF MEASURES AND SITE IDENTIFICATION

Preliminary screening of restoration measures for this study resulted in focusing on those restoration actions that would address early life history stage needs of KRWS. Other entities in the watershed, including the Kootenai Tribe, are addressing other aspects of ecosystem restoration; however, the measures considered in this study would also contribute incrementally to overall food web and ecosystem productivity through an increase in habitat complexity, macroinvertebrate and algal production, and forage base for native fish species. With this in mind, the need to address the early life stages is critical to the survival of the species and remains the goal of this investigation. Following identification of study objectives, several other measures were eliminated from consideration because they were not viewed as sustainable or did not adequately address spawning or early life history stages. The four retained restoration actions from Section 4.1 are included in the final evaluation of measures. The other parameter to be assessed as part of the final evaluation is the identification of suitable sites within the Shorty's Island/Meander Reach. The evaluation of these measures, sites and reach-wide alternative plans has been considered using a CE/ICA.

USACE does not consider monetary benefits or the generation of benefit to cost ratios when evaluating restoration projects. Rather than putting a monetary value on habitat benefits, the focus of the final evaluation is on the relationship of habitat benefits to project costs to ensure cost-effective and justified plans are put forth for recommendation for implementation. Although benefits are not monetized, they are quantified. For this study benefits (or outputs) have been quantified using an HSI and the area restored to develop habitat units.

Within the Meander Reach, potential restoration sites were identified based on existing channel bed conditions and the presence of egg data. Once specific sites were identified, an assessment of which measures could be applied to the site was made. This assessment also included identification of potential lengths and widths of suitable substrate placement or improvement. From this information "effective" area was determined based on potential length and width of each implementation of a measure. Effective area is the portion of the placement that is at the appropriate elevation. It does not include side slopes. Preliminary designs were developed, and costs were developed for each measure, scale, and slope that was specific to the site under consideration. To quantify benefits, the effective area was multiplied by the HSI score to arrive at habitat units for each measure, slope and scale. This information was developed for each site and separate CE/ICA analyses for each site were then completed. This resulted in an array of site-based plans that were cost-effective and incrementally justified (referred to as "best buy" plans). Reach-wide alternatives were then considered by taking best buy plans for each site and completing a reach-wide incremental evaluation (CE/ICA). Following completion of this evaluation other considerations and factors can be considered to arrive at a recommended plan. Efficiency, effectiveness, acceptability, and completeness were considered.

4.3 PLANNING AND DESIGN CONSIDERATIONS

A number of planning and design considerations and variables have been identified to date which help inform the final stage of plan formulation and evaluation. A number of these considerations or variables are best addressed as design or biological criteria while others are more suited to be addressed through the CE/ICA. These are presented in the following subsections.

4.3.1 GENERAL: IDENTIFICATION OF SUITABLE SITES FOR RESTORATION

The identification of suitable sites is primarily based on the combination of two conditions being present; appropriate channel material or sediment facies and evidence of KRWS spawning. The former data

consist of sediment facies and bathymetry collected and analyzed by USGS. The latter data were collected by Idaho Department of Fish and Game (IDFG) and analyzed by both IDFG and USGS. For more detailed information please see Appendix A Sediment Facies and Egg Catch per Unit Effort (EPCUE) at Potential Substrate Restoration Sites.

4.3.1.1 CHANNEL MATERIAL / SEDIMENT FACIES

The first major criterion to identify suitable areas for restoration of ecosystem function is the existing channel material or sediment facies. To help ensure sustainability, restoration efforts should be focused on locations where the bed has exposed lacustrine clay (for suitable substrate placement/augmentation) or exposed coarse substrate (for substrate improvement). As previously indicated concentrating the substrate restoration efforts in areas with exposed clay or substrate provides the highest level of assurance of success since these areas have the hydraulic conditions with low supply of sediment and scour sand rather than depositing it. The areas with exposed lacustrine clay or exposed coarse substrate also provide a firm foundation for placement of suitable substrate in contrast to a sand bed where placed substrate can sink into the bed as sand is scoured away. The areas with exposed lacustrine clay and exposed coarse substrate were mapped by USGS and overlaid on the bathymetry and aerial photographs to further assist in site evaluations.

4.3.1.2 EGG CATCH PER UNIT EFFORT DATA

The second major criterion for identifying potential sites was the evidence of use by KRWS sturgeon for spawning. Substrate function restoration efforts will be evaluated only in areas where spawning is expected to occur. Spawning areas were identified through the egg collection data. Mats to collect KRWS eggs have been placed on the bed and the resulting collection of eggs on the mats analyzed by IDFG. This effort has been conducted annually since 1994. The mats were initially placed throughout the Meander Reach, but over time, concentrated in areas where KRWS were observed during the spawning period and egg collection had occurred. The data have been analyzed by both IDFG and USGS. USGS provided GIS shape files showing ECPUE results aggregated at 100 meter (328 feet) intervals within the Meander Reach (Note: Subsequent to the alternative evaluation effort, egg mat data collected in 2008 through 2011 that had precise coordinates of each egg mat were analyzed and made available. These later data were used in the 35% design of the recommended measures).

4.3.1.3 SCREENING OF SITES

Figures showing the sediment facies, egg deposition density data, bathymetry, and aerial photographs are presented in Appendix A. Initially seven potential sites were identified solely on the basis of the sediment facies and the planform. (Note: See Figure A-1 of Appendix A for site locations). The sites are listed below.

Site Name	RM
Fleming Creek	139.6
Downstream of Shorty's	141.0
Shorty's Island North	142.4
Shorty's Island South	143.3
Myrtle Creek	145.5
Downstream of Refuge	146.8
Refuge	148.5

When the egg density deposition data were considered, the two downstream most sites – Fleming Creek and Downstream of Shorty's – were eliminated. Both sites had some exposed gravel with the Fleming Creek site also having bedrock and the Downstream of Shorty's site have a significant amount of clay along the thalweg and inside bank. Both sites were located in sharp bends and would likely have complex hydraulics. However, no eggs have been collected at the mats placed in either of these locations.

Therefore, these two sites were screened from consideration. The remaining five sites all have had eggs collected in the mats placed along their lengths.

4.3.2 DESIGN AND SITE SPECIFIC CONSIDERATIONS

The five retained sites all have suitable bed conditions to support sustainable restoration actions and each has evidence of spawning based on egg deposition data. Site specific conditions were used to identify appropriate potential measures and to develop the preliminary designs. This section presents the identification of the potential measures to be applied at the five sites along with the site conditions that were used to determine the configuration of the potential measures.

4.3.2.1 IDENTIFICATION OF POTENTIAL MEASURES FOR EACH SITE

Based on the sediment facies, and bathymetric characteristics at each site, the potential measures to be applied at the five remaining sites were determined. Table 4-3 provides the identification of the potential measures to be evaluated and a brief discussion of the key site characteristic. The actual number of sites and the extent of restoration at each site will be addressed as part of the CE/ICA.

4.3.2.1 HYDRAULIC MODELING

A HEC-RAS model was used to evaluate hydraulic conditions across each site. The HEC-RAS model was obtained from the River Design Group and includes the entire Kootenai River. The model is based on a previous USGS model which was updated in August 2010 for the current investigation. The model was previously calibrated and published in several USGS papers (Berenbrock 2005; Berenbrock 2006; Berenbrock and Bennett 2005).

The modeled flows for this study ranged from 5,450 cfs to 70,000 cfs which are representative of an extreme low and a high flow at the Porthill USGS gage. Flows in the Shorty's Island/Meander reach have been reduced by approximately 7 percent to account for inflow between the study reach and Porthill which results in the corresponding study reach flows of 5,050 cfs and 64,900 cfs. The extreme low flow value was used as an elevation cutoff point for placing material that would pose a navigation hazard during low flow conditions. The high flow value was used to determine particle mobility and bank protection sizing calculations to ensure that the proposed material sizes would not mobilize during the high flow event.

The hydraulic model was also used to evaluate habitat benefits. Habitat benefits and the HSI which includes velocity, depth and substrate is discussed in Section 4.5. A flow of 30,000 cfs at Porthill, or 27,800 cfs in the study reach, was used as a representative spawning season flow for the HSI calculations. The hydraulic model was utilized to determine velocity and depth for the various measures in order to calculate the HSI associated with each of these variables. Several representative cross sections were used to determine hydraulic conditions for each substrate restoration measure. As an example, Figure 4-10 provides the location of the representative cross sections used to determine hydraulic conditions for HSI calculations at the Shorty's Island South site. The HEC-RAS flow distribution option was used to estimate the velocities and depths for each of the measures with the main channel divided into 40 width intervals. Figure 4-11 illustrates the HEC-RAS flow distribution results to determine the average velocity and depth in the area of potential suitable substrate placement.

Table 4-3. Summary of Site Characteristics and Identification of Potential Measures

Site	~RM[1]	Notes				
		Substrate on Clay Bed (Y/N)	Substrate on Clay Shelves (Y/N)	Improvement of Existing Coarse Substrate (Y/N)	Substrate on Existing Coarse Substrate (Y/N)	
Shorty's Island North	142.4	Y	N	N	N	This location is 1,500 feet downstream of Shorty's Island South. It consists of a 2,400 feet long strip of clay bed along the right bank. It starts just as the flow from the left side channel around Shorty's Island rejoins with the main channel. The upstream end of the site has a slight bend, but it becomes nearly straight at the downstream end. The egg data collected here shows a much lower density than at Shorty's Island South.
Shorty's Island South	143.3	Y	Y	N	N	Right bank with complex hydraulics and bathymetry. The clay extends for nearly 4,500 feet, but upper 1,000 feet and lower 500 feet of clay appear to be on the bank and not down in the thalweg. There is about 3,000 linear feet of clay in the thalweg area with width varying up to about 150 feet. Clay shelves have been documented. This site has the highest density of egg deposition of all locations monitored in the Meander Reach.
Island Myrtle Creek	145.5	N	Y	N	N	Left bank with sharp initial bend transitioning to nearly straight. There is significant clay shelf. This site has the potential for application of placement on clay shelves. Documented egg deposition data are similar to the Downstream of Refuge Site, but less than Shorty's Island South.
Down-stream of Refuge	146.8	Y	Y	N	N	The main feature at this site is a sharp compound bend comprised of two nearly 90˚ bends along the right bank. Each bend has its own distinct clay bed, each about 3,000 feet long, but only separated by ~400 feet. The bathymetry and facies mapping indicate that a clay shelf exists in the lower portion of the downstream bend. Collection of eggs has occurred throughout the length of this site, though not at as high of densities as for Shorty's Island South, but similar to Myrtle Creek.
Refuge	148.5	Y	N	Y	Y	Left bank, large radius bend downstream of Deep Creek. Clay bed is fairly narrow, less than 100 feet wide and about 1,000 feet long. There is a narrow strip of clay near the downstream end of the site that is about 1,000 feet long and a narrow strip of existing gravel about 1,500 feet long near the upstream end of the site. Both features are near the outside of the bend along the left side of the channel.

Note: [1] River Miles (RMs) are identified at the center of each site.

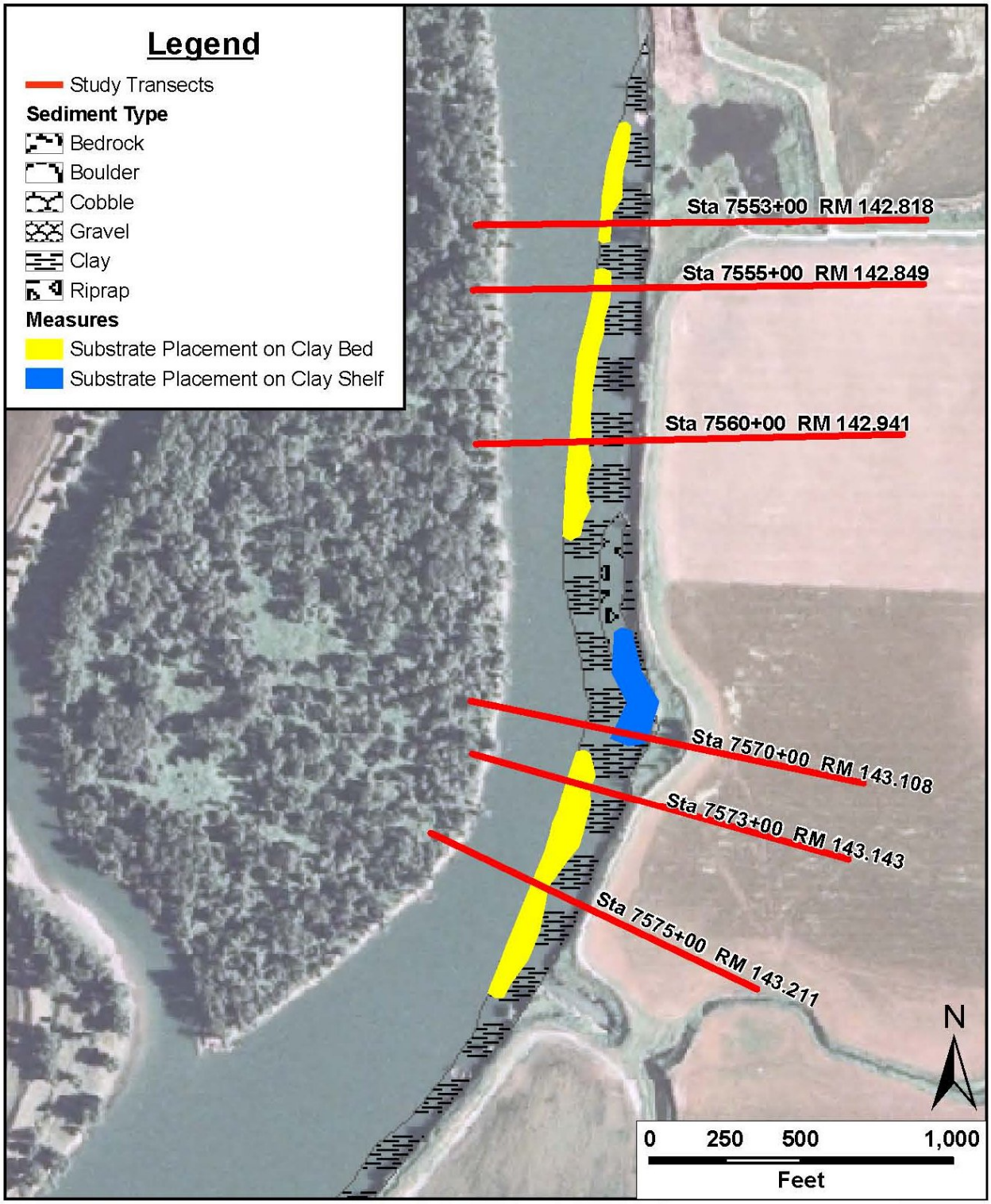


Figure 4-10. Locations of Cross Sections used for Determining Representative Velocity and Depth for Determination of HSI Values for the Substrate Restoration Measures at Shorty's Island South

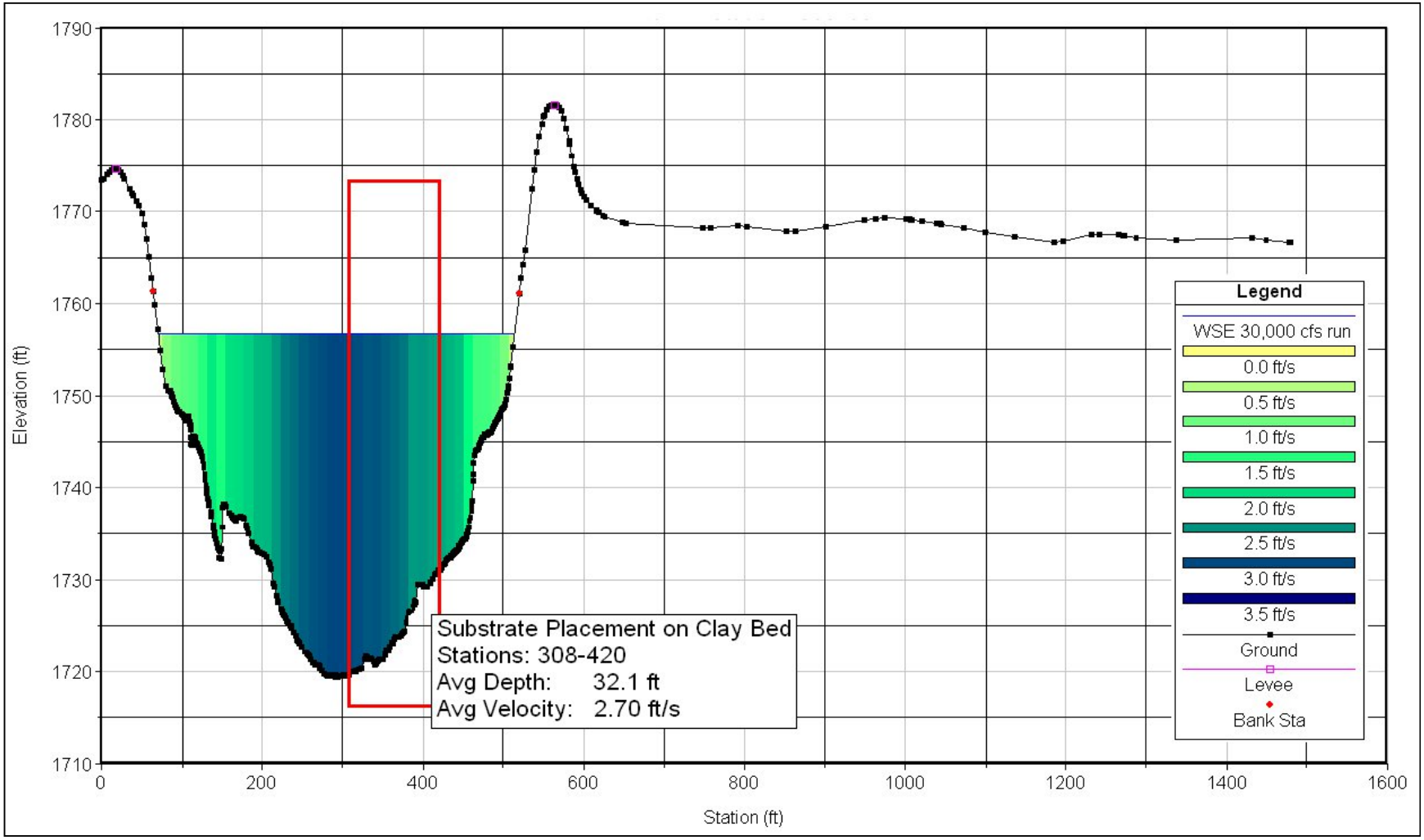


Figure 4-11. Example of the Use of the HEC-RAS Flow Distribution Option to Determine the Average Velocity and Depth in the Area of Potential Substrate Restoration

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4.3.2.2 SUBSTRATE COMPOSITION, HEIGHT AND SIDE SLOPE

The restoration substrate composition is based on the suitability for white sturgeon and hydraulic modeling to ensure the material creates sufficient complexity and is not mobilized. The specification for the proposed suitable substrate gradation has an upper and lower bound to support egg adherence (larger material) and also to support free-embryo cover and survival (smaller material). Figure 4-12 shows the particle size distribution for the upper and lower bound of the suitable substrate to be placed (The gradations were developed from the substrate HSI information presented in Section 4.5.1.1 and represent mixtures providing ranges of sizes suitable for both egg attachment and free-embryo hiding.). These limits will be used as construction specifications to ensure placement of that material in the optimum size range for the substrate restoration efforts.

Substrate Placement on Clay Beds. For the substrate placed in the thalweg, which includes suitable substrate placement on clay beds, the height or thickness of the restored substrate for the alternative evaluation was based on an elevation to be above sand waves and dunes, but not so high as to have sturgeon avoid the area. The height to meet both of these considerations was chosen to be approximately eight feet. The top of the mat is laid flat. The side slopes are also a design parameter to ensure sustainability of the measure, and are anticipated to be on the order of 2:1. The side slopes are not included in the restored area. The restored area is referred to as the "effective area" dimension. Figure 4-13 illustrates the configuration for suitable substrate placement on clay bed.

The original design for the suitable substrate placement on clay bed incorporated a flat surface across the top of the mat. In applying the design to the various sites it was found that the available width for placement on clay beds was generally less than anticipated and often times limited the effective width to less than 50 feet. As a means to increase the width, an alternative geometry was developed which utilizes a sloping surface for the mat with a slope of up to 10 percent. This slope allows extending the effective width portion of the placement up the side slopes of the channel. To keep the placement close to the bed of the channel, the elevation gain over the sloping portion of the mat was limited to 10 feet.

Substrate Placement on Clay Shelves. The substrate thickness used for placement at locations with clay shelves is two feet. The two-foot thickness is used in this case to provide sufficient thickness for use of the substrate by the free-embryo. A greater thickness was not considered to because the clay shelves are located above the zone occupied by sand waves and the major portion of the bed load. Suitable substrate placement on clay shelves is illustrated in Figure 4-14.

Improvement of Existing Coarse Substrate. Improvement of existing coarse substrate (primarily gravel) involves the placement of boulders over areas of existing coarse substrate that is currently periodically scoured free of sediment. The improvement involves placement of boulders to increase turbulence with the intent to scour sediment from the suitable substrate more effectively and to increase hydraulic complexity. For preliminary design purposes, the boulders are assumed to average three feet in diameter and to be placed at a density of one boulder per eight square yards of surface area.

Substrate Placement on Existing Coarse Substrate. For the substrate placement on existing coarse suitable substrate the thickness was taken as two feet compared with eight feet of substrate placement on clay bed. The lesser thickness was used because the purpose of placing the suitable substrate over the existing coarse substrate (primarily gravels) is to increase the size of the substrate from a suboptimum median substrate size (D_{50}) of about 25 mm to an optimum D_{50} in the 80 to 115 mm range. This measure relies on the natural scouring that occurs in these areas along with the potential improvement of hydraulics with boulder placement to keep the substrate relatively free of sand.

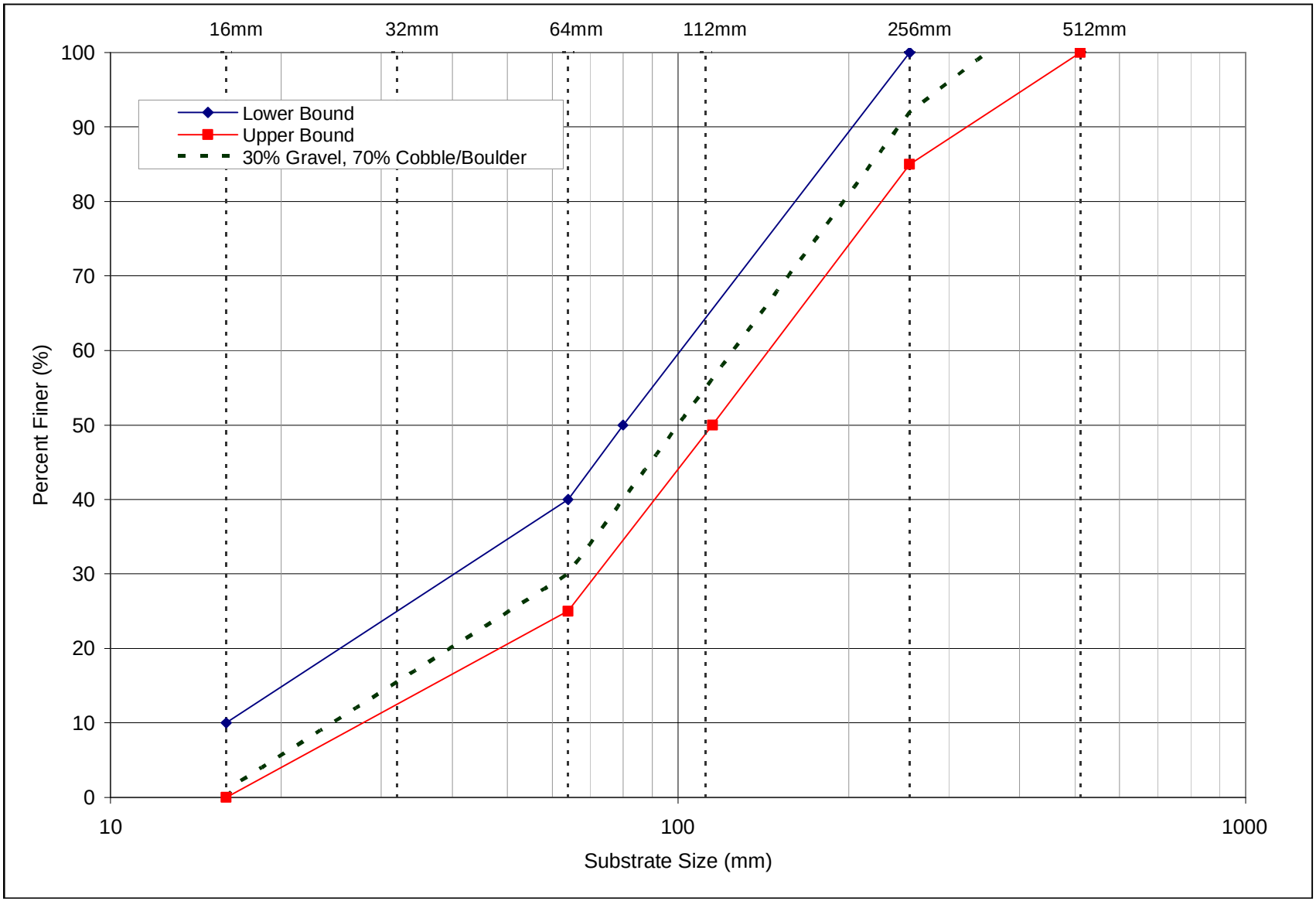


Figure 4-12. Upper and Lower Bounds of the Particle Size Distribution for Substrate Restoration

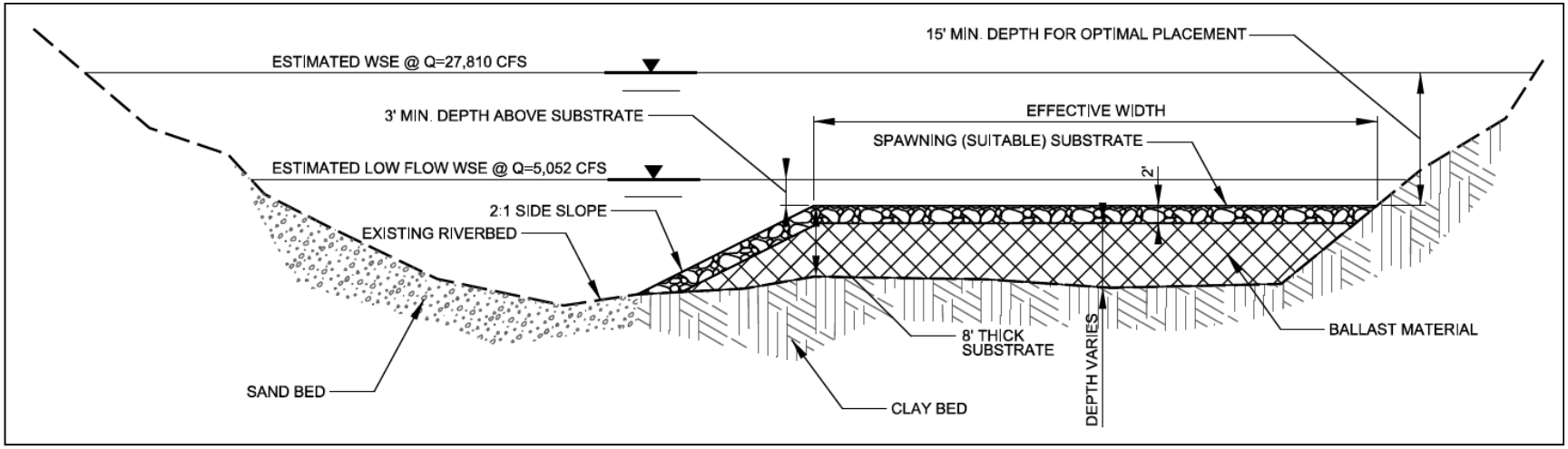


Figure 4-13. Cross Section View of Substrate Placement on Clay Bed, 0 Percent Slope Condition

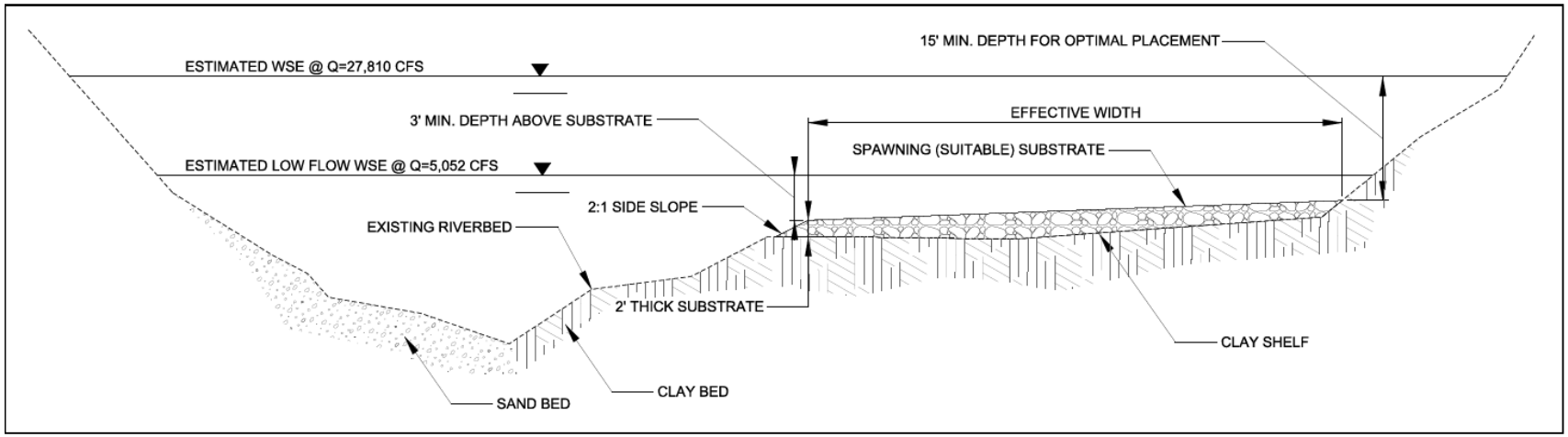


Figure 4-14. Cross Section View of Substrate Placement on Clay Shelves

4.3.2.3 DEPTH CONSIDERATIONS FOR EACH MEASURE

Depth is an important aspect of the suitable substrate placement to maximize the likelihood that KRWS will spawn over the suitable substrate. The upper limit of the placement of all the measure types was set at 15 feet below the modeled 30,000 cfs water surface elevation. This results in a maximum elevation for the measures ranging from 1,741.6 feet at the downstream end of the study reach and 1,742.9 feet at the upstream end. By limiting the placement to deeper areas within a cross section, the measures will generally be located be in the higher velocity areas.

The other consideration for depth is to avoid creating navigation hazards by placing material that could damage boat hulls if the large boulders were insufficiently covered with water. To address this concern, the water surface elevations for an extreme low flow condition, lowest flow and stage at the Porthill gage since 1990, was modeled. The resulting water surface elevation is 1,743.8 feet at the downstream end of the study reach and 1,744.4 feet at the upstream. Placement of large boulders is included as part of the substrate restoration measures to improve hydraulic complexity and to promote scouring of sands from the suitable substrate. Placement of the boulders could pose a navigation hazard. To prevent this from occurring, the boulders must be adequately submerged during low flow periods. To ensure safe navigation, a submergence of the boulders of at least three feet was assumed to be required. Boulders will not be placed in areas where the extreme low flow condition will not submerge them by at least three feet. This criterion is not a factor for the measure types located in or near the thalweg, but does become a factor for the measure types that involve placement outside of the thalweg, primarily placement of suitable substrate on clay shelves. In a few locations, the criteria can also limit the placement of boulders over the suitable substrate on clay bed for the 10 percent slope condition.

4.3.2.4 PLACEMENT SIZE AND GEOMETRIC CONSIDERATIONS VS. ACTUAL SITE CHARACTERISTICS

The length of the suitable substrate placement is important for two aspects of KRWS early life stages. First is the provision of lengths sufficient to support spawning behavior as the fish make passes over the substrate and to collect eggs as they drift downstream after being released. Secondly, the free-embryos emerge and may drift with the current, though they tend to stay within the suitable substrate matrix as they are highly photonegative. Based on these two needs, some suggested lengths were discussed at the May 2010 workshop. The suggested minimum length was on the order of 600 to 800 feet but placements can be 1,000 to 2,000 feet long.

The length scale at each site is also based on the suitability of existing channel material. In developing the substrate restoration measures at each site, lengths as short as 400 feet were used in some cases in order to isolate areas with specific characteristics and to provide varying scales for the CE/ICA. As a result, some longer areas of potential suitable substrate placement were divided into two or three subareas. In the case of suitable substrate placement on clay shelves, due to the limited extent of these bathymetric features, the minimum length requirement was relaxed and placements as short as 200 feet were evaluated.

A minimum width has not been established and will vary depending on the site conditions. However, for suitable substrate placement on clay beds, areas were generally chosen where the average effective width over the length of placement was on the order of 35 feet or more. The widths for suitable substrate placement on clay shelves was limited by the extent of these features and ranged from about 34 feet to 94 feet. Similarly, the width of suitable substrate placement or improvement of existing coarse substrate was limited by the width of this feature which resulted in measures that ranged from 28 feet to 74 feet.

4.4 PRELIMINARY DESIGNS

Using the available information and the design considerations previously discussed, preliminary designs (10% design level) of measures were developed for each of the five sites. This level of design is appropriate for the CE/ICA and allows for comparison of the costs and benefits among the various measures and sites. Once a plan is selected, the measures comprising the selected plan will be taken to a 35% design level.

The preliminary designs are presented in Appendix B and include a map showing the location of each of the sites in the Meander Reach and a plan view for each site illustrating the various measures evaluated (Note: Facies mapping used to develop the 10% design and depicted in Appendix B was subsequently replaced by more accurate mapping performed by the USGS in 2011 and used for the 35% design.).

In order to efficiently summarize characteristics such as effective areas, costs, and habitat benefits in tables, a coding system was developed to designate each measure. These codes are also included on the plan view to identify the location and extent of each measure (Appendix B). The measure identification code consists of three parts: a two letter site ID, a three letter measure type ID, and a single letter to distinguish between specific locations for a measure in cases where the measure type is applied more than once at a site (Note: A continuous length of a measure type may be divided into multiple applications in order to evaluate various lengths in the CE/ICA.). The various measure lengths at a site are designated A, B, C, etc. The Site ID and Measure Type codes are presented below.

<u>Site ID</u>

Shorty's North	= SN
Shorty's Island South	= SS
Myrtle Creek	= MC
Downstream of Refuge	= DR
Refuge	= RF

<u>Measure Type Code</u>

Substrate Placement on Clay Bed, Flat Slope	= SPC(0)
Substrate Placement on Clay Bed, 10% Slope	= SPC(10)
Substrate Placement on Clay Shelves	= SPS
Improvement of Existing Coarse Substrate	= EES
Substrate Placement on Existing Coarse Substrate	= SPE

Using this coding, the three locations for placement of suitable substrate on clay bed at Shorty's Island North on a flat slope are designated as SN-SPC(0)-A, SN-SPC(0)-B, and SPC(0)-C. Similarly, the alternate placement at a 10 percent slope are designated as SN-SPC(10)-D, SN-SPC(10)-E, and SPC(10)-F. The letter codes continue alphabetically for all measures on a site and do not restart at "A" for each measure type. This allows the CE/ICA software to use the last letter of the code to perform its identification of the measures.

Sections 4.4.1 through 4.4.5 summarize the measures that could be applied at each site along with the increments and locations considered based on channel characteristics at each of the sites.

4.4.1 SHORTY'S ISLAND NORTH

One basic type of treatment, placement of suitable substrate on clay bed was evaluated at Shorty's North. The plan view of the measures evaluated is provided on page B-2 of Appendix B. Table 4-4 presents the general dimensions and effective areas of each of these measures. Suitable substrate placement subtypes, placement on flat slope and placement on 10 percent slope were investigated. The condition of the clay

bed at the site is such that a continuous mat of restored substrate 1,300 feet long can be placed. This length was divided into three measures with each measure varying from 400 to 500 feet in length. The average effective widths ranged from 36 to 63 feet for the flat placement and 55 to 83 feet for the 10 percent slope placement. The total area possible with all three suitable substrate placements on clay beds at the flat slope is 66,000 square feet and 91,500 square feet by placing at up to a 10 percent slope.

Table 4-4. General characteristics of potential measures at Shorty's North

Code	Measure Type	Station		Length (feet)	Effective	
		Begin	End		Area (square feet)	Width (feet)
SN-SPC(0)-A	Substrate on Clay (0% slope)	7514+50	7519+50	500	18,000	36
SN-SPC(0)-B	Substrate on Clay (0% slope)	7519+50	7523+50	400	23,000	58
SN-SPC(0)-C	Substrate on Clay (0% slope)	7523+50	7527+50	400	25,000	63
SN-SPC(10)-D	Substrate on Clay (10% slope)	7514+50	7519+50	500	27,364	55
SN-SPC(10)-E	Substrate on Clay (10% slope)	7519+50	7523+50	400	30,846	77
SN-SPC(10)-F	Substrate on Clay (10% slope)	7523+50	7527+50	400	33,334	83

4.4.2 SHORTY'S ISLAND SOUTH

A larger variety of measures were possible at Shorty's Island South compared to Shorty's Island North. At Shorty's Island South, measure types evaluated included both subtypes (0 percent slope and 10 percent slope) of suitable substrate placement on clay beds and placement of suitable substrate on clay shelves. The plan view showing the location of the various measures is provided on page B-3 of Appendix B. Table 4-5 summarizes the general characteristics of the measures evaluated at Shorty's Island South.

Table 4-5. General characteristics of potential measures at Shorty's Island South

Code	Measure Type	Station		Length (feet)	Effective	
		Begin	End		Area (square feet)	Width (feet)
SS-SPC(0)-A	Substrate on Clay (0% slope)	7549+50	7554+50	500	13,000	26
SS-SPC(0)-B	Substrate on Clay (0% slope)	7554+50	7559+50	500	18,500	37
SS-SPC(0)-C	Substrate on Clay (0% slope)	7559+50	7563+50	400	22,500	56
SS-SPC(0)-D	Substrate on Clay (0% slope)	7570+50	7574+50	400	33,000	83
SS-SPC(0)-E	Substrate on Clay (0% slope)	7574+50	7578+50	400	17,500	44
SS-SPC(10)-F	Substrate on Clay (10% slope)	7549+50	7554+50	500	27,861	56
SS-SPC(10)-G	Substrate on Clay (10% slope)	7554+50	7559+50	500	39,304	79
SS-SPC(10)-H	Substrate on Clay (10% slope)	7559+50	7563+50	400	38,309	96
SS-SPC(10)-I	Substrate on Clay (10% slope)	7570+50	7574+50	400	39,801	100
SS-SPC(10)-J	Substrate on Clay (10% slope)	7574+50	7578+50	400	29,354	73
SS-SPS-L	Substrate on Clay Shelves	7566+50	7570+50	400	37,493	94

The presence of clay beds at the site is such that two separate continuous mats of restored substrate on clay bed can be placed. The downstream mat consists of three 400 to 500 feet lengths with average effective widths of 26 to 56 feet for the flat placement and 44 to 96 feet for the placement on a slope of up to 10 percent. The combined effective areas of the three downstream placements is 54,000 square feet. for the flat condition and nearly doubles to 105,500 square feet for the 10 percent slope condition. The upstream suitable substrate placement on clay bed has a total length of 800 feet and is divided into two lengths, each 400 feet long with effective widths of 56 and 83 feet at 0 percent and 73 and 100 feet at 10 percent. The combined areas are 50,500 square feet for the flat slope placement and 69,200 square feet for the 10 percent slope placement.

One large clay shelf was located by reviewing the bathymetry and facies maps. There may be other smaller clay shelves present, but they were not apparent in the available information. Further coordination with USGS may lead to identification of additional, but smaller clay shelves. The clay shelf identified is rather large but may be of marginal usefulness as it is adjacent to the area where large stone was placed in 2004 by BPA and USACE that had no documented spawning (based on no eggs being collected on mats placed at the site). The total area of suitable substrate placement on the clay shelf is 37,500 square feet with a length of 400 feet and effective width of 94 feet.

4.4.3 MYRTLE CREEK

Based on the conditions at Myrtle Creek (reflecting conditions identified in spring 2011 by the USGS that indicated the extent of existing coarse substrate was much smaller than originally believed), it was possible to evaluate only one type of measure: placement of suitable substrate on clay shelves. Placement of suitable substrate on flat slopes (zero percent) and 10 percent slopes were not examined, since all locations were suited to placement on clay shelves. The placement on clay shelves is more efficient since only a two foot thickness of substrate is required compared to eight feet for placement on clay beds. The plan view showing the location of the various measures is provided on page B-4 of Appendix B. Table 4-6 summarizes the general characteristics of the measures evaluated at Myrtle Creek.

Table 4-6. General Characteristics of Potential Measures at Myrtle Creek

Code	Measure Type	Station		Length (feet)	Effective	
		Begin	End		Area (square feet)	Width (ftee)
MC-SPS-K	Sub on Clay Shelves – 1	7672+50	7678+50	600	18,500	31
MC-SPS-L	Sub on Clay Shelves – 2	7678+50	7685+50	700	43,500	62

The placement of suitable substrate on clay shelves was evaluated over two segments totaling 1,300 feet. These lengths were 700 and 600 feet. The effective widths range from 31 feet for the downstream placement to 62 feet for the upstream placement. The total effective areas of this measure type at Myrtle Creek is 62,000 square feet.

4.4.4 DOWNSTREAM OF REFUGE SITE

Two different measure types were evaluated at the Downstream of Refuge Site. The plan view showing the location of the various measures is provided on page B-5 of Appendix B. Table 4-7 summarizes the general characteristics of the measures evaluated at the Downstream of Refuge Site. The two types of potential measures at the Downstream of Refuge Site include placement of suitable substrate on clay bed (both subtypes of 0 percent and 10 percent slope) and placement of suitable substrate on clay shelf. No existing coarse substrate was located at this site so improvement of existing coarse substrate or placement of suitable substrate on existing coarse sediments were not evaluated.

Four distinct locations for placement of suitable substrate on clay bed were evaluated. Each location consisted of a single measure ranging from 400 to 500 feet long. For the flat placement option, the effective areas of the individual measures ranged from 16,500 square feet to 35,000 square feet with effective widths of 33 to 70 feet. The combined total area for the flat condition is 90,500 square feet. The placement on a slope of up to 10 percent configuration has effective widths ranging from 45 to 92 feet and a combined effective area of 126,900 square feet which is a 40 percent increase over the flat placement condition.

There were two small areas for placement of suitable substrate on clay shelves identified at the Downstream of Refuge Site. The upstream area is the largest with an area of 19,300 square feet over a length of 300 feet and an effective width of 64 feet. The smaller upstream site has a length of about 100

feet with effective area and width of 3,400 square feet and 34 feet, respectively. The total area of suitable substrate placement on clay shelves represented by the measures is 22,700 square feet.

Table 4-7. General Characteristics of Potential Measures at the Downstream of Refuge Site

Code	Measure Type	Station		Length (feet)	Effective	
		Begin	End		Area (square feet)	Width (feet)
DR-SPC(0)-A	Substrate on Clay (0% slope)	7725+50	7730+50	500	18,000	36
DR-SPC(0)-B	Substrate on Clay (0% slope)	7741+50	7746+50	500	16,500	33
DR-SPC(0)-C	Substrate on Clay (0% slope)	7767+50	7771+50	400	21,000	53
DR-SPC(0)-D	Substrate on Clay (0% slope)	7771+50	7776+50	500	35,000	70
DR-SPC(10)-E	Substrate on Clay (10% slope)	7725+50	7730+50	500	28,359	57
DR-SPC(10)-F	Substrate on Clay (10% slope)	7741+50	7746+50	500	22,388	45
DR-SPC(10)-G	Substrate on Clay (10% slope)	7767+50	7771+50	400	30,349	76
DR-SPC(10)-H	Substrate on Clay (10% slope)	7771+50	7776+50	500	45,772	92
DR-SPS-K	Substrate on Clay Shelves	7733+50	7736+50	300	19,320	64
DR-SPS-L	Substrate on Clay Shelves	7737+50	7738+50	100	3,360	34

4.4.5 REFUGE

Two distinct locations for potential substrate restoration measures were identified at the Refuge Site. They include a narrow strip of clay at the downstream end of the site and a strip of gravel at the upstream end of the site both along the right bank. These conditions allowed for the application of placement of suitable substrate on clay bed, improvement of existing coarse substrate and placement of suitable substrate on existing coarse substrate. The plan view showing the location of the various measures is provided on page B-6 of Appendix B. Table 4-8 summarizes the general characteristics of the measures evaluated at the Refuge Site.

Table 4-8. General Characteristics of Potential Measures at the Refuge Site

Code	Measure Type	Station		Length (feet)	Effective	
		Begin	End		Area (square feet)	Width (feet)
RF-SPC(0)-A	Sub on Clay (0% slope)	7847+50	7854+50	700	26,000	37
RF-SPE-B	Substrate on Ex Coarse Sub	7859+50	7862+50	300	8,500	28
RF-SPE-C	Substrate on Ex Coarse Sub	7862+50	7867+50	500	37,000	74
RF-SPE-D	Substrate on Ex Coarse Sub	7867+50	7869+50	200	8,000	40
RF-EES-E	Improvement of Ex Coarse Sub	7859+50	7862+50	300	8,500	28
RF-EES-F	Improvement of Ex Coarse Sub	7862+50	7867+50	500	37,000	74
RF-EES-G	Improvement of Ex Coarse Sub	7867+50	7869+50	200	8,000	40

At the Refuge Site, only the placement of suitable substrate on clay bed at a flat slope was evaluated. The configuration of the bed and location of the clay bed did not provide conditions in which application of the 10 percent slope configuration would increase the effective area of the suitable substrate placement. A single segment 700 feet long with an area of 26,000 square feet was applied. The effective width is 37 feet.

Both types of measures associated with existing coarse substrate were applied to the Refuge Site, improvement of existing coarse substrate and placement of suitable substrate on existing coarse substrate. The 1,000 feet long strip of gravel with an estimated D_{50} of 25 mm was divided into three separate measures with lengths of 300, 500 and 200 feet. The total effective area of the three measures combined is 53,500 square feet with the majority of the area represented by the 500 feet long measure in the middle

with 37,000 square feet. The middle measure also has an effective width of 74 feet which is about triple to double the effective widths of the downstream and upstream measures, respectively.

4.5 Conceptual Habitat Model Framework and Benefit Evaluation Methodology

To facilitate the selection of a preferred alternative and to ensure that the federal government is investing funds in the most cost-effective plans, USACE requires that the benefits be quantified so that relative levels of habitat benefit (output) can be compared to the costs. Each habitat restoration measure will be analyzed using the following HSI model that was developed following the HEP methodology.

HEP was developed by USFWS (1980) to facilitate the identification of impacts from various federal actions on fish and wildlife habitat. HEP can provide numeric scores for existing conditions at a project site, potential future without-project conditions, and various action alternatives for a species or assemblage of species in a particular geographic area. HEP is implemented by the use of one or more HSIs, which are mathematical relationships designed to represent the habitat suitability of an area for a single species or assemblage of species as well as different life stages of a species or assemblage of species. A set of variables that represent the habitat requirements for the species (e.g. percent cover, water depth, tree height) is combined into a mathematical model. The variables are then measured in the field and their corresponding index values are inserted into the model to produce a score that describes existing habitat suitability. The value is an index score between 0 and 1.

Although approval of planning models under EC 1105-2-412 is not required for CAP projects (Civil Works Policy Memorandum #1 [January 19, 2011]), the principles to ensure quality continue to be necessary. Models and analysis must be compliant with USACE policy, theoretically sound, computationally accurate, and transparent. The mathematical model proposed for this HSI is derived from existing data and were developed specifically for KRWS. The variables developed for this HSI are based upon data in the literature of species habitat requirements and preferences and are inherently based on best professional judgment. The basis for the HSI and its application was reviewed by USACE discipline specialists, federal and state agency representative technical experts, and non-federal sponsor technical experts familiar with habitat evaluation procedures and KRWS.

Suitable HSI models must include habitat variables for which data collection is possible or data are already available. Variables must also show a change in score between the existing and proposed condition. If the project does not affect the suitability index score for a species, it will not be possible to quantify an effect. The suitability indices (SIs) for various habitat parameters for the species are combined arithmetically or geometrically to yield an overall index score for the species.

The purpose of this project is to identify and implement self-sustaining ecosystem-based habitat improvement actions that would provide the attributes necessary to support successful spawning and survival to early life stages of wild KRWS. Therefore, the HSI that has been developed and is described below is specific to KRWS and describes habitat suitability for adult spawning, egg incubation and free-embryo habitats. As there is no existing HSI that was previously developed for KRWS, this new suitability index has been developed that is based on information available for KRWS whenever available. However, as KRWS data are limited, it was assumed that information on other white sturgeon populations and other similar sturgeon species would be applicable for the development of this HSI.

4.5.1 KRWS Habitat Suitability Indices

Since the 1970s, research shows that most KRWS appear to spawn over sandy substrates in Meander Reach 1 below Bonners Ferry (USFWS 2008). Meander Reach 1 has a low gradient profile and substrates are composed primarily of sand and other fine materials overlying lacustrine clay (Barton 2004; Barton et

al. 2004; USFWS 2008). Many of the eggs that were captured in this reach were found drifting along the river bed, covered with fine sand particles in sites without coarse substrate (Paragamian et al. 2001), and where mean water column velocities seldom exceeded 3.3 feet per second (ft/s) (1.0 meters per second [m/s]) (Paragamian et al. 2001; Barton et al. 2005; USFWS 2008).

The present altered river flow and thermal regime of the Kootenai River differs from historic conditions. It is unclear if this difference has affected spawning success or the ability of KRWS to complete their life cycle in the Kootenai River-lake system.

White sturgeon are generally known to spawn in fast-flowing water, and water velocity appears to act as an important cue for spawning (USFWS 2008; Parsley and Beckman 1994). Water velocities greater than or equal to 3.3 ft/s (1.0 m/s) may also reduce predation on eggs by limiting access of some predators to spawning and incubation areas (Brannon et al. 1984; Miller and Beckman 1996; Anders et al. 2002; Parsley et al. 2002). Fast flowing waters also help to maintain the open interstitial space of the exposed coarse substrate essential for successful egg incubation and the free-embryo hiding phase of the KRWS' reproduction cycle (USFWS 2008). Parsley and Beckman (1994) created suitability indices for the Columbia River white sturgeon and also determined that velocities suitable for sturgeon spawning ranged from 0.8 to 2.7 m/s.

Water depth is also thought to be an important factor in spawning site selection for KRWS. USFWS (2008) identified a minimum water depth of 23 feet (7 m) as a requisite for successful spawning in their 2008 revised critical habitat designation for KRWS. However, white sturgeon have been found to spawn between 4 and 24 meters in depth (Parsley et al. 1993; Parsley and Beckman 1994). Results of hydraulic data correlations with egg collection location data suggest that KRWS are keying in on spawning at regions of highest velocity and greatest depth (Paragamian et al. 2009).

Water temperature was not selected as a factor to include in the HEP model because KRWS are presently spawning at the available temperatures, which are within the range that is natural for other sturgeon species. Thus, this factor does not seem to be limiting KRWS spawning and rearing of early life stages and there is no information available that states otherwise. Additionally, because this project will not affect temperatures, including temperature as a parameter in the HEP model would not help to differentiate between potential alternatives.

Three parameters, substrate (V_1), bottom water velocity (V_2), and depth (V_3) were selected to develop HSIs for inclusion in the KRWS HEP model as they are important for spawning and for survival of two early life stages (eggs and free-embryos) at the spawning and egg deposition site. For KRWS (and for shortnose sturgeon), the habitat where females spawn is also the rearing site (1) for eggs that attach to rocks, and (2) for free-embryos, following hatching. Therefore, the habitat conditions suitable for spawning are also suitable for early life stages.

Field and artificial stream observations on spawning habitat used by KRWS, other white sturgeon populations, and female shortnose sturgeon form the details of the HSI parameters. Shortnose sturgeon are good surrogates for KRWS as their ontogenetic behavior mimics KRWS, and also, shortnose sturgeon females have eggs that are similar in size to KRWS (Kynard et al. in press a). Information on habitat reported to be selected by female white sturgeon in other populations is less precise than that for shortnose sturgeon, but support the more detailed information from shortnose sturgeon. Thus, this HEP relies heavily on data from research on both white sturgeon and shortnose sturgeon spawning and rearing.

4.5.1.1 SUBSTRATE

White sturgeon are broadcast spawners and release demersal eggs (eggs that are negatively buoyant and sink to the bottom; rate dependent on hydraulic conditions) that are initially adhesive upon exposure to

water (Paragamian et al. 2001; Anders et al. 2002). Successful reproduction appears to depend on KRWS 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). Coarse rocky substrates provide fixed surfaces for the attachment of the adhesive eggs during incubation and also provide shelter for the ''hiding phase'' period following hatching in which free-embryos seek cover from predators in the inter-gravel spaces (McAdam 2011; Kynard et al. 2008; Kynard et al. 2009; Kynard et al. 2010; Brannon et al. 1984; Parsley et al. 2002), increasing survival.

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 coarse substrate comprised of gravels, cobbles, and boulders that provide shelter and cover during this free-embryo hiding phase (USFWS 2008). Only limited areas of potential suitable substrate have been identified to occur within the areas that evidence of KRWS spawning has been documented. Initial USGS core samples and videography identified an area of existing gravels in the bed downstream of Myrtle Creek that was believed to be about 2,000 feet long and typically less than 50 feet wide. More detailed data collection and interpretation of videography collected in 2011, showed the actual patch of substrate to be less than one tenth the size initially indicated. Portions of this substrate are exposed during larger peak flow events.

Because spawned eggs and free-embryos are both at the spawning area, the substrate HSI has been developed to incorporate habitat complexity to capture both the coarse bed material requirement for egg attachment and incorporate various substrate sizes that will provide optimal cover to free-embryos in the interstitial spaces. The preference of yolksac larvae for small interstitial spaces would presumably be met by mixed substrates expected to occur within and beneath preferred spawning substrates (McAdam 2011). Data for the substrate sizes used during spawning are from white sturgeon (Parsley et al. 1993) and shortnose sturgeon, i.e., field observations on substrate size used by spawning females (Kieffer and Kynard in press), and also, experimental studies on shortnose sturgeon spawning in an artificial stream with a known substrate size composition (Kynard, et al. in press, b). Parlsey et al. (1993) show a mixture of gravel, cobble, boulders, and bedrock to be suitable spawning substrate for white sturgeon with most spawning observed over cobble and boulder substrates with some observations over sand, gravel, and bedrock. Kieffer and Kynard (in press) observed in the field that shortnose sturgeon selected spawning substrate with a mixture of sand-silt (<2 mm), gravel (2 to 64 mm), cobble (65 to 256 mm), and boulders (>256 mm), with cobble being the preferred dominant substrate. Data for the substrate size needed for free-embryos was from artificial stream studies on substrate preference and suitability of various combinations of substrate sizes for white sturgeon free-embryos (McAdam 2011; Kynard et al. 2007; Kynard et al. 2008).

The suitability index (SI) for substrate was developed specifically for this study to include both the requirements for egg attachment and free-embryo habitat. To achieve both will require a mixture of substrate sizes. Substrate categories used in the research studies and for the SI are based on a modified Wentworth classification (Orth 1983; Rouse 1950). The fine/medium gravel grain size will be limited to a maximum of 10 percent of the total substrate composition, regardless of the treatment (Table 4-9).

Table 4-9. Substrate Size Classes

Substrate Size	
Class	**Diameter (mm)**
Sand	≥0.06 to <2
Fine/Medium Gravel	≥2 to <16
Coarse Gravel	≥16 to <64
Cobble	≥64 to <256
Boulder	≥256

Figure 4-15 displays the suitability index value curve of the D_{50} for the substrate size mixtures proposed for the HSI. Table 4-10 outlines the sizes and mixtures of substrate and their corresponding HSI value.

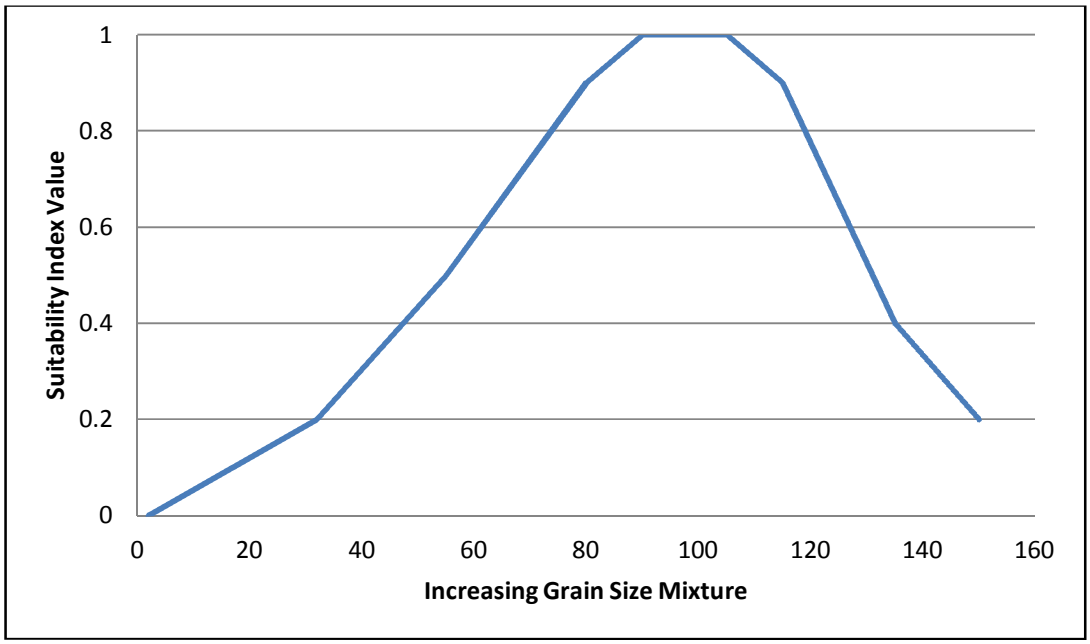


Figure 4-15. Substrate (V1)

Table 4-10. Substrate Suitability Index for KRWS Egg Attachment and Early Life Stages Substrate (V1)

Substrate Size				Substrate HSI V_1
Class	**Diameter (mm)**	**D_{50} (mm)**	**Percent in Size Class**	
100% Sand	≥0.06 to <2	2	100	0
100% Gravel	16 to 64	32	100	0.2
70% Gravel 30% Cobble/Boulder	16 to 64 >64	55	70 30	0.5
40% Gravel 60% Cobble/Boulder	16 to 64 >64	80	40 60	0.9
30% Gravel 70% Cobble/Boulder	16 to 64 >64	90-105	30 70	1.0
25% Gravel 75% Cobble/Boulder	16 to 64 >64	115	25 75	0.9
10% Gravel 90% Cobble/Boulder	16 to 64 >64	135	10 90	0.4
100% Cobble/Boulder	>64	150	100	0.2

4.5.1.2 BOTTOM WATER VELOCITY

Water velocity likely plays an important role in the success of KRWS spawning and survival of early life stages. Most critical appears to be the velocity at the bottom of the water column where eggs would be released and fertilized (Kynard et al. in press). While there is no data for KRWS on velocity used during spawning, tracking shows that pre-spawning (and maybe spawning adults) are near the bottom. Of 209 radio contacts with tagged KRWS in spawning condition, 75 percent were within the lower one-third of the water column, and they tended to be found even closer to the bottom during the actual spawning period (Paragamian and Duehr 2005).

The bottom water velocity HSI is derived from research on velocities selected by spawning white sturgeon in the Columbia River and (Parlsey et al. 1993); and spawning shortnose sturgeon measured in two rivers (0.5 m above the bed); and also on water velocities selected by shortnose sturgeon females in a large artificial stream (5 cm above the bed) (Kieffer and Kynard in press; Kynard et al. in press-b). These bottom water velocities were found to range between 0.5 and 2.4 m/s (1.6 and 7.9 ft/sec) in the Columbia River; 0.2 and 1.3 m/s (0.7 and 4.3 ft/sec) in two Massachusetts rivers (Kieffer and Kynard in press); and 0.3 and 1.2 m/s (1.0 and 3.9 ft/sec), as observed in artificial streams (Kynard et al. in press-b).

Egg characteristics of KRWS and shortnose sturgeons appear similar, thus it is likely that velocity factors will affect the two species' similarly. Thus, bottom velocities utilized by shortnose sturgeon for spawning and rearing should be a reasonable surrogate for KRWS suitability. Also, even though female KRWS are much larger than female shortnose sturgeon, there is abundant evidence that large and small sturgeons select similar water velocities for spawning (Parsley and Beckman 1994; Yang et al. 2006; Kieffer and Kynard in press).

Bottom water velocities are defined as those measured from 1.0 meter above the bottom. KRWS are larger fish than shortnose and, as a result, will detect the bottom water velocities to cue spawning at a higher depths from the bottom based on their physiology.

Figure 4-16 displays the suitability index value curve for bottom water velocity proposed for the HSI. Table 4-11 outlines the velocities and their corresponding HSI value.

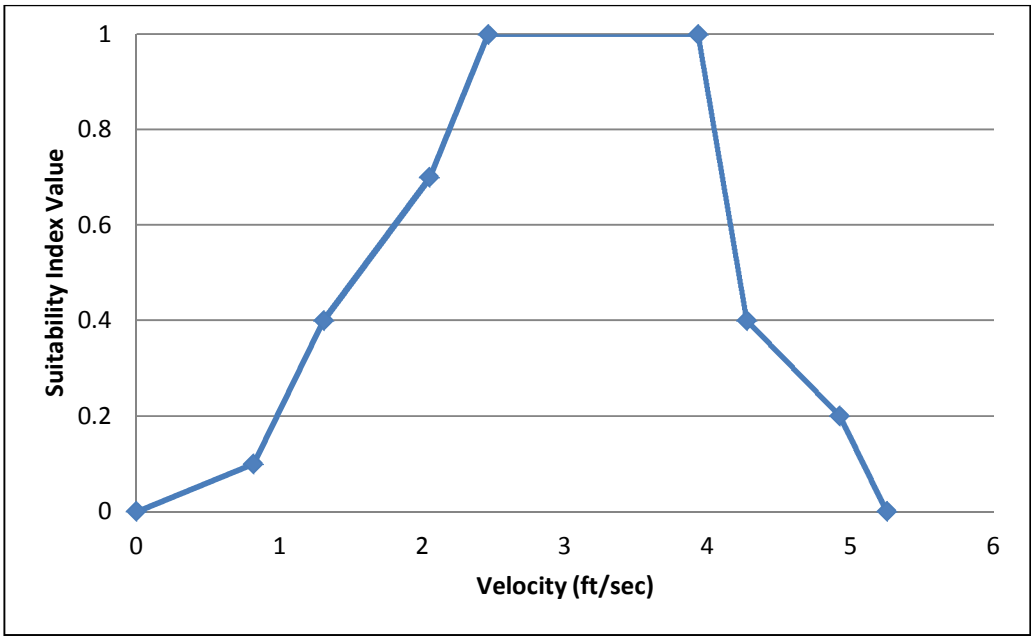


Figure 4-16. Velocity (V2)

Table 4-11. Velocity Suitability Index for KRWS Spawning and Early Life Stages (V2)

Bottom Water Velocity		Velocity HSI V_2
cm/sec	feet/sec	
<20	<0.66	0
≥20 to <30	≥0.66 to <0.98	0.1
≥30 to <50	≥0.98 to <1.64	0.4
≥50 to <75	≥1.64 to <2.46	0.7
≥75 to <120	≥2.46 to <3.94	1
≥120 to <140	≥3.94 to <4.59	0.4
≥140 to <160	≥4.59 to <5.25	0.2
>160	≥5.25	0

4.5.1.3 DEPTH

Depth is another important factor to consider based on evidence that KRWS spawn in the deeper, higher velocity areas of the Kootenai River, with no evidence of spawning found along the river margins. Egg capture locations in the Kootenai River between 1991 and 1998 between RM 141.6 and an undefined point upstream of RM 149.4, indicated that most spawning events occurred in water usually greater than 16.5 feet deep (Paragamian et al. 2001; Barton et al. 2005). In addition, Parsley and Beckman (1994) found that white sturgeon in the Columbia River spawn in water depths greater than three meters.

Figure 4-17 displays the suitability index value curve for bottom depth proposed for the HSI. This curve is based on the work of Parsley et al. (1993). Table 4-12 outlines the depths and their corresponding HSI value.

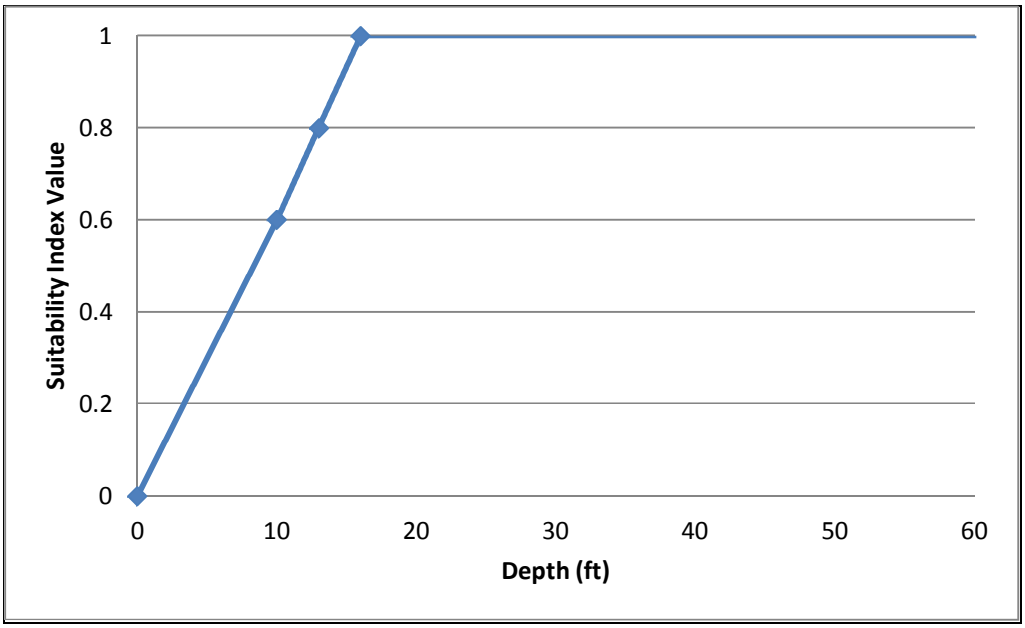


Figure 4-17. Depth (V3)

Table 4-12. Depth Suitability Index for KRWS Spawning and Early Life Stages (V3)

Depth		Depth HSI V_3
meters	feet	
0	0	0
3	10	0.6
4	13	0.8
>5	>16	1.0

4.5.1.4 KOOTENAI RIVER WHITE STURGEON HEP MODEL EQUATION

Table 4-13 summarizes the HEP model proposed for use in the evaluation of measures, where each HSI score for substrate, bottom water velocity, and depth is utilized. The result of the equation shown in the table is a score between 0 and 1. The final HEP score is based on the lowest limiting parameter score of the three parameters. The HEP model will be run for current and projected future conditions. Future projections include without-project conditions after 50 years and with-project conditions after 10, 25, and 50 years.

Table 4-13. HEP Model and Equation for KRWS Spawning and Early Life Stages

HEP Model for KRWS Spawning and Early Life Stages	
KRWS	V_1 = Substrate Categories V_2 = Bottom Water Velocity V_3 = Depth HSI = Lowest value of V_1, V_2, or V_3

HSI values were determined for the existing condition and the with-project condition at each site over the life of the project. The difference between the with-project HSI and the existing condition HSI was used to quantify the net benefits of the project.

The substrate HSI (V_1) was determined for the existing condition based on the sediment facies mapping provided by USGS and the USGS estimates of the D_{50} of existing gravels in the Myrtle Creek and Refuge areas. For the existing condition, all substrate HSIs were 0.0 (sand) except for the few areas of existing gravels which were assigned a value of 0.15 based on the 25 mm estimate of the D_{50}. All with-project condition SI values for substrate were set at 1.0, representing placement of optimum sized material, except for substrate improvement of existing coarse substrate (primarily gravel), which remained at 0.15. The habitat benefit of the substrate improvement measure is uncovering the existing coarse sediment more frequently with the placement of the boulders. To account for the benefit, it was assumed that under existing conditions, the coarse substrate is exposed on the order of every other year. Under the with-project condition, it was assumed that the existing coarse substrate would be exposed essentially every year.

To determine the other two HSI values, a hydraulic model was run and velocity (V_2) and depth (V_3) from representative cross sections in the area of each substrate measure were determined. Section 4.3.2.2 provides further details on the application of the hydraulic model.

The limiting HSI for existing conditions was always substrate and was either 0.0 for sand or 0.15 for the limited areas of gravel at Myrtle Creek and the Refuge sites. For the with-project condition, the limiting SI was typically velocity and typical values ranged between 0.50 to 0.85 with a minimum value of 0.21 and a maximum of 0.92. The exceptions, as previously discussed, are the 0.15 values that correspond to improvement of the existing coarse substrate

4.5.2 HABITAT UNITS

Habitat Units (HUs) are typically calculated by multiplying the results of the HSI score for each alternative by the total acreage of suitable habitat available or created through restoration. Square feet are used as the unit of area in the calculation of habitat units for this study. This is because spawning habitat for KRWS is primarily monitored using square footage measurements and has been used to inform the design of minimum areas required to provide habitat for the eggs from the expected number of fish spawning in the reach in the future. While square feet could be converted to acres that are more commonly used in the development of habitat units, it would yield very small numbers that would be more difficult for reviewers to understand.

The suitable habitat available is defined as the "effective area", which is estimated based on the horizontally measured surface area of the placed substrate. This is determined by multiplying the horizontal width of the placement by the length represented by that width. In the case of the placement of the eight foot thick substrate mats on the clay bed, the 2:1 side slopes are excluded from the width determination. Total HUs are calculated using the following equation:

HUs = HSI Score x Effective Area

For example, under a with-project condition scenario with a HSI score of 0.50 and an effective area of 12,000 square feet, the HUs would equal 6,000 (HUs = 0.50 x 12,000 = 6,000).

The HU values are used in the CE/ICA. Habitat unit values for measures evaluated in the CE/ICA can be found in Section 4.7.

The acreage can be compared to the spawning area required by a specific population of KRWS in order to determine the effectiveness of the project. Individual or a combination of measures can be used to achieve the desired amount of spawning area to sustain a specific population. The spawning area required for specific population levels has been calculated using the rationale below.

4.5.3 SUBSTRATE AREA TO SUPPORT SPAWNING FEMALE POPULATION

During initial planning a minimum area parameter measure was included in the HSI. However, based on comments received at the May, 2010 workshop and further consideration, this factor is really more of a target or threshold that should be considered in order to select an appropriate alternative. The scope of this project is to provide the greatest extent of suitable substrate that would be feasible under the project constraints. The overall restored area should/needs to at least be sufficient to provide appropriate egg density for 125 spawning females, an estimate of the current population of spawning females per year. If a restored population of 600 hundred females is considered, the area of suitable substrate needed will increase accordingly to accommodate their spawning needs. This information is used to help provide context for the potential scale of contribution to recovery this project may have and is not used as a screening criteria. Providing enough suitable substrate for a recovered population is beyond the scope of this project. The following section outlines the basis for these figures.

Spawning survival rates are also related to the density of eggs. The spawning area parameter is based on egg-larva survival data obtained in eight years of artificial stream tests on shortnose sturgeon, which have eggs that are similar in size to white sturgeon (Kynard et al. in press).

The spawning area parameter is based on the following assumptions:

1. The minimum number of KRWS females that require spawning habitat annually on the Kootenai River equals approximately 71 to 125 (P. Rust, IDFG, pers. comm. July, 2010).
2. The average Sacramento River white sturgeon female (36 kg, 153 cm FL) produced 5,684 eggs/kg body weight (Chapman et al. 1996).
3. The average weight of a female spawned in Kootenai Hatchery is about 60 kg and about 5,000 eggs/kg body weight (C. Lewandowski, Kootenai Tribal Hatchery, pers. comm., July 2010). Thus, an average Kootenai female has about 341,040 eggs (5,684 eggs x 60 kg body weight = 341,040 eggs).
4. The density of eggs per square meter (m^2) spawning area that gives the highest survival (spawned egg to dispersing larvae of shortnose sturgeon) is ~5,000 (Figure 4-18). Results were obtained in a semi-natural spawning-rearing channel where all natural factors (temperature, insects, turbidity and sedimentation, etc.) were present except for the absence fish predating sturgeon eggs (Kynard et al. in press).

Table 4-14 shows the area needed for one spawning female to place eggs at a certain egg density (m^2). For example, the spawning area for one female = total # of eggs (60 kg avg. weight x 5,684 avg. # of eggs = 341,040 eggs) / increasing egg density at 5,000 eggs/m^2 interval (5,000 to 25,000 eggs/m^2), as shown by the regression curve in Figure 4-18. For example, at 5,000 eggs/m^2 one female requires ~ 70 m^2 (~750 square feet) of spawning area. However, based on the uncertainty of the suitability of placed substrate, sedimentation rates, and other unknown factors, this number will be doubled. Therefore, the area required for one female to spawn at a density of 5,000 eggs/m^2 is 140 m^2 (1,500 square feet).

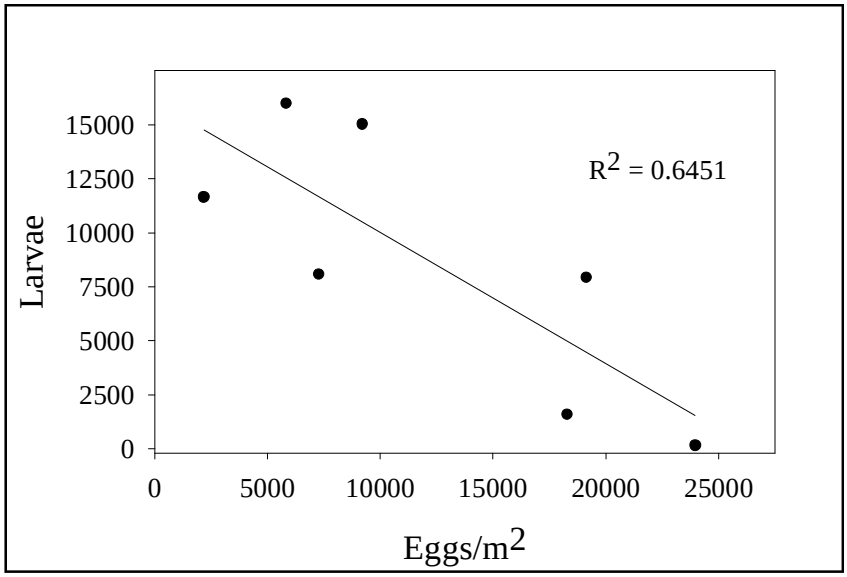


Figure 4-18. Density of Shortnose Sturgeon Eggs Versus Survival of Larvae

Table 4-14. Area Required to Support Spawning KRWS Females at Various Population Targets

Area per Female square feet (m^2)	Area per 71 Females square feet (m^2)	Area per 125 Females square feet (m^2)	Area per 375 Females square feet (m^2)	Area per 1,200 Females square feet (m^2)
>1,500 (>140)	>170,600 (>10,000)	>188,400 (>17,500)	565,100 (>52,500)	1,808,000 (>168,000)

In Table 4-14, column one, the spawning area required for one female is calculated at an egg density of 5,000 eggs/m^2. In the second column of the table, the area used by one female is multiplied by 71 (the minimum annual estimate of females requiring spawning habitat on the Kootenai River) to indicate the spawning area needed for 71 females. The third column of the table shows the area expanded to 125 females (the maximum annual estimate of females requiring spawning habitat on the Kootenai River) (Paragamian et al. 2005). Finally, the fourth and fifth columns shows the area expanded to the minimum (375) viable population target of female spawners per the working recovery goals for KRWS and maximum assumed carrying capacity of female spawners based on historical numbers (1,200) (Kootenai Tribe 2010).

This analysis indicates that an optimal density of 5,000 eggs/m^2 (which produces the greatest number of larvae) could be provided for 71 females by a total area of approximately 10,000 m^2. As egg density increases, spawning area decreases, and habitat suitability decreases greatly (Figure 4-18).

The area analysis was based on annual observations for eight years on egg-larvae survival in a fixed area with the same substrate and bottom velocity conditions each year. Actual conditions (particularly, bottom velocity) during spawning and rearing will vary from year to year, in river, as will the distribution of eggs. The fixed environmental parameters in the artificial stream will not exist in the river. While the area analysis provides a minimum value under fixed conditions and shows a clear relationship between area and survival, variation in riverine and spawning factors suggest that the area estimate should be increased as expert opinion deems appropriate to provide sufficient habitat in the river. Furthermore, the results of this project will provide the first actual quantification of survival compared to area.

HUs can then be calculated using the area values for different levels of KRWS populations. This will enable the comparison of restoration costs at various recovery levels. These values were considered in size of spawning habitat needed.

4.6 COST OF MEASURES BASED ON 10% DESIGN

This section provides an overview of assumptions and methodology used to develop project implementation costs at the 10% design level. Costs were developed in Q2 FY11 prices at the 10% design level.

Implementation or construction costs of each of the restoration measures are divided into two primary components; materials costs and the cost of placement. The material costs are based on the cost to have material delivered to the site, and as such they include material and transportation. Placement costs include mobilization and demobilization of necessary equipment, equipment and labor costs to transport the material from the staging area to the placement locations in the river, placing the material, material handling costs at the stockpile location, site access, and staging costs.

As the measures are not of constant lengths, for the purposes of comparing costs for restoration measures against those same measures on different sites, or to contrast the cost of different measures, the metric of cost/square foot of effective area is used. Effective area is the area that a measure encompasses based on its potential length and width of implementation. The cost/square foot metric is calculated independently for both material costs and placement costs.

4.6.1 MATERIAL COSTS

The primary materials used in the construction of the measures are suitable substrate material and improvement boulders. To determine the costs for these materials several local suppliers were contacted and a range of unit costs per ton were determined. Costs to transport the material to the staging area as well as contractor markups were included in the estimate. Quarries and sources for the spawning habitat material within the "ideal" classification and distribution are available within 20 miles of the Meander Reach. In order to satisfy boulder placement everywhere it could be utilized, local quarries may need to rely on sources outside the immediate area (more than 30 miles from the Meander Reach). Costs to transport the material to the staging area, as well as contractor markups were included in estimating the costs of materials delivered to the staging/storage area. Table 4-15 summarizes preliminary estimated material costs including delivery.

Table 4-15. Summary of Material Costs and Material Delivery Costs to the Staging Site

Material	Unit	Material Cost (Including Haul)	Mark-Up	Total Delivered Cost	Comments
Substrate Material	$/Ton	$11.50	30%	$14.95	Used for suitable substrate placement on clay beds, existing coarse substrate, and clay shelves - Material costs may be revised based on local prices and availability
Improvement Boulders	$/Ton	$65.00	30%	$84.50	The costs for boulders are based on higher possible costs associated with purchases made outside the region and transported in. Material costs may be revised based on local prices and availability

In most cases the placement quantities are in cubic yards, while quarries and stone sources generally sell their products based on cost per ton. Densities for the materials have been estimated to convert from cost per ton to costs per cubic yard. Table 4-16 contains the material density estimates and summarizes costs per cubic yard for the materials under consideration.

Table 4-16. Summary of Aggregate Material Densities and Total Material Costs

Material	Estimated Material Density (tons/cubic yard)	Material Cost (Including Haul)	Comments
Substrate Material	1.2	$17.94/cubic yard	For use with suitable substrate placement on clay, existing coarse substrate, and clay shelves
Improvement Boulders	2.23	$188.23/cubic yard ($98.30/Boulder)	Used in all measures to provide local scour of sediment and sand. The density for boulders is based on granite for cost purposes (165 lbs/cubic foot) – and is not an aggregate density. Cost/Boulder generated assuming a 36-inch diameter boulder.

4.6.2 PLACEMENT COSTS

The placement costs are broken into two categories: fixed and time dependent. Fixed costs include mobilization/demobilization, transport, equipment assembly, site prep, and any other cost that is necessary regardless of the volume of material to be placed. Time dependent costs are those costs that can be reasonably identified in cost/day, such as equipment lease rates, labor costs, fueling, etc. Assumptions include:

- All placement activity will be conducted from a barge system (at this level of design barge placement was assumed to be the most cost-effective – later phases of design also evaluated other placement options);
- A single staging area will be utilized; and
- Material barges will circulate between the staging area and crane location to limit crane down-time.

In order to develop unit based placement costs which could be applied to the variety of measures and combination of measures at each site, an estimate of a likely final project scale was employed. Referred to as the base project, this simulated project is used for cost estimating purposes only. Use of the base project allows the calculation of a single fixed cost per square foot and a single time dependent costs per cubic yard that can be applied across all measures and sites.

For cost estimating purposes, the base project was assumed to include placing approximately 100,000 cubic yards of material for a total cost of approximately $5.5 million. This base project is estimated and then total time dependent costs and total fixed costs are divided by the total placement volume and the total placed effective square footage, respectively. The time dependent cost/cubic yard, representing the time dependent costs resulting from the base project are applied to the placement volume required for each individual measure, such that the larger the volume required to be placed for a measure the larger the time dependent costs for that measure. The cost/square foot, representing the fixed costs for nearly any size of project operating under the construction methods discussed previously, are applied to the effective square footage generated by individual measures independent of the length of time or volume of material

required to produce that area. The base project from which the unit cost metrics were derived, is described by the following:

Total Volume to Be Placed (estimating purposes only)…….	105,000cy
Total Effective Square Footage Generated……...	320,000SF
Total Number of Days for Placement……...	61-Days
Estimated Total Mob/Demob Cost……..	$1,403,600
Est. Staging, Storage and Access Land Costs (16.5-Acres)……	$150,000
Estimated Site and Access Prep. Costs……..……..	$120,000
Estimated Total Cost/Day (lease, operation, labor, etc.)...……..	$31,746/day
Total Project Cost Estimate Including Material and Placement…	$5,500,000

Under the base project using the assumptions above, the fixed cost/square foot is calculated to be $4.39 per square foot. Under the method and assumptions discussed in this section, this cost is relatively independent of the volume of material that might be placed as all the fixed costs are generally required regardless of the length of time on-site. Under the base project the time dependent cost is calculated to be $18.17/cubic yard.

4.6.3 Other Costs (Contingency, Life Cycle, Real Estate, Monitoring)

4.6.3.1 Contingency

Both the material and the placement costs include a 30 percent contingency to account for uncertainty for the 10% level cost estimate. Refinements during the 35% design effort will address several facets of the cost model including the exact construction methods, and the locations of those operations depending on the specific sites selected. The practice of delivering suitable substrate to a deep (>30 feet) and wide (>500 feet) river bottom is not common and many assumptions were made associated with methodology and functional placement rates. Though initial research was done to find reasonable costs for material to be used in this restoration, material costs and availability are not static, and while the quality of the stone deliverable from a typical pit-run today may be high with little screening or processing required, significant processing may be required to deliver usable material in the timeframe where construction begins. Some other uncertainties which could have a significant impact on the project pricing at this stage include the following:

- Altering the construction window to either a short window in a single season, or applying confining restrictions on the construction times/season/method.
- Environmental permitting, monitoring which requires extraordinary measures.
- Any requirements forcing the staging/storage and material charging site to be in a location on the far upstream or downstream of the reach, or outside the reach.

4.6.3.2 Sustainability and Life Cycle Evaluation considerations

The evaluation period for costs and benefits are over a 50-year period of analysis. The need for rehabilitation through the period of analysis has been addressed through preliminary screening based on sustainability considerations. For the final array of measures, the primary maintenance or rehabilitation needs associated with the retained sites is due to the potential deposition of sand over restored substrate. A qualitative evaluation of risk of sediment deposition was used to assess expected performance and maintenance relative to each other. No maintenance costs are assumed for the evaluation. Table 4-17 presents a relative qualitative assessment of the measures' expected sustainability over the period of analysis.

The relative ratings were based on a qualitative assessment for sedimentation to adversely impact the long term suitability of the substrate for egg attachment and free-embryo hiding. The placement on clay

shelves was given the highest sustainability rating since this measure is located the greatest height above the thalweg and therefore generally in the area of lowest sediment transport. The placement on clay beds was rated the next highest, because the substrate gradation is much larger than the existing substrate (D_{50} about 4 times greater, nearly 100mm compared to 25mm) and more likely to maintain a greater depth of interstitial space free of sedimentation. All measures were rated with at least moderate sustainability since they are located in areas in which investigations have shown to be typically scoured free of sand.

Table 4-17. Expected Measure Sustainability

Restoration Measure	Sustainability
Substrate Placement on Clay Shelves	High
Substrate Placement on Existing Coarse Substrate	Moderate
Substrate Placement on Clay Bed (no slope)	Moderate-High
Substrate Placement on Clay Bed (10% slope)	Moderate-High
Substrate Improvement	Moderate

4.6.3.3 REAL ESTATE

During the 10% evaluation phase, a construction easement placeholder cost has been included and applied across measures. This cost is based on the scale of project used in the base project or approximately $5.5 million in total implementation cost. The real estate requirements for the in-channel areas where the suitable substrate is being placed have not been included. The river bottom is owned by the State of Idaho. Real estate values are not expected to vary across the reach, and as such would not be expected to influence the evaluation of plans.

4.6.3.4 MONITORING

Post project monitoring costs were not anticipated to vary between the measures, sites or alternatives, and were not included in the 10% level costs.

4.6.3.5 INTEREST DURING CONSTRUCTION

Interest during construction is assumed constant across alternative plans that are similar in scale and scope as the base project; as such these costs are not included in the evaluation of the final array of alternatives.

4.6.4 SUMMARY

Both the material and the placement costs at the concept level are adjusted with a 30 percent contingency to account for uncertainty for the 10% level cost estimate. Monitoring and interest during construction was assumed to be similar across measures and sites..

Because of the variety of conditions at each site and even between placements of the same measure type at different locations within a single site, each measure type has a range of costs to install. Complete costs for all of the individual measures at the five sites are provided in Appendix C. Table 4-18 presents the range of costs for each measure type as determined by the total cost (material, fixed, and time dependent) for a measure divided by the total effective square footage for that measure.

Table 4-18. Summary of Measure Type Costs

Measure Type	Minimum		Maximum	
	ID	Cost[1]	ID	Cost
Substrate on Clay Bed (0% slope)	SS-SPC(0)-D	$18.77	SN-SPC(0)-A	$23.17
Substrate on Clay Bed(10% slope)	SS-SPC(10)-G	$17.85	DR-SPC(10)-F	$24.36
Substrate on Clay Shelves	SS-SPS-L	$10.47	MC-SPS-L	$11.13
Improvement of Ex Coarse Substrate	RF-EES-G	$6.51	RF-EES-F	$6.51
Substrate on Existing Coarse Substrate	RF-SPE-C	$10.20	RF-SPE-D	$10.20

Note: [1] Cost is total of materials and placement costs and expressed in dollars per square foot of effective area created.

Several general observations can be made from reviewing Table 4-18. The measures with the highest variability involve placement of suitable substrate on clay bed. This is due to the side slopes that are created when the suitable substrate is placed and the assumption that this portion of the placement does not contribute to the effective area, as well as the variability in bathymetry, and clay bed location relative to the thalweg and bank. The lowest cost measures per unit effective area are improvements of existing coarse substrate, each falling in the six to seven dollar range per square foot of effective area created. There is less difference in the minimum costs between the measure types, which range from about $6.51 to $18.77 per square foot of effective area, than for the maximum costs which range between $6.51 and $23.17 per square foot of effective area. Overall, this indicates that some applications of the substrate placement that are likely inefficient on a cost basis due to the specific conditions at a site resulting in using large quantities of materials to create a relatively small effective area. For the suitable substrate placement measures in the channel thalweg, the inefficiency occurs when the effective width is limited to a narrow strip, or where significant additional volume is necessary to reach the effective elevated placement height. Therefore, the selection of the most cost-effective measures will be highly dependent on the habitat benefits resulting from each of the measures.

4.7 Cost Effectiveness and Incremental Cost Analysis

The final evaluation of measures and alternative plans includes a CE/ICA consistent with USACE guidance. The CE/ICA is an evaluation tool which considers and identifies the relationship between changes in cost and changes in quantified, but not monetized, habitat benefits. The evaluation is used to identify the most cost-effective alternative plans to reach various levels of restoration output and to provide information on whether different (increasing) levels of restoration are worth the added cost. The CE/ICA is a planning tool to help identify cost-effective plans which provide a certain level out habitat output at the least cost. The results do not provide the answer; rather they are a tool to help inform a decision. The results provide an array of alternatives which undergo a tradeoff analysis and can be screened out or selected based on other considerations external to the CE/ICA, such as egg density data at individual sites, total costs, and a plan's acceptability, completeness, effectiveness, and efficiency.

For this study, the IWR-Planning Suite software (IWR-Plan; certified version 1.0.11.0) was used to conduct the CE/ICA. The CE/ICA uses costs developed at the 10% design level, which are presented in Q2 FY11 prices using the FY11 discount rate of 4.125 percent. The nature of this study required an evaluation that systematically considered site-specific measures and sub-measures (scales) at each of the five potential restoration sites. In order to consider each site equally at first, it was determined that each site would be optimized individually (site based) before considering multi-site (reach-wide) combinations of measures. The following workflow was developed for the CE/ICA analysis:

1. **Site-based CE/ICA:** Execute five separate IWR-Plan model runs, one for each site, resulting in an array of site-based best buy plans. At each site, only the best buy plans were carried forward.

2. **Reach-wide CE/ICA:** Execute a single CE/ICA using the best buy plans from each site-based model in step one. In this analysis, five "measures," 1 for each site, are entered into the model, with the site-based best buy plans entered as scales. This model run results in an array of reach-wide best buy plans composed of up to 1 site-based plan per restoration site.
3. **Identify Plans of Interest:** Ranking alternative plans from the reach-wide evaluation by total restored area and total cost, a set of reach-wide plans of interest was identified for further consideration where total restored area was above the minimum while total cost remained within the program limit. This exercise resulted in identification of nine plans of interest.
4. **Additional Considerations:** The plans of interest identified reach-wide alternatives with the inherent assumption that all restoration sites were equally desirable, when in fact, some sites may be better candidates for restoration than others. Maximizing continuous lengths was an important consideration to help determine the best mix of sites across the reach. Additional considerations, including length of substrate placement, egg density, and cost per habitat unit were used in this step, resulting in alternative plans that met requirements across a range of factors important to KRWS spawning and early life stage survival.
5. **Recommended Restoration Plan:** The analysis in step four resulted in four alternative plans to choose from. In addition to the above considerations, the acceptability, effectiveness, efficiency, and completeness of each plan was considered to identify the tentatively recommended plan.

The following subsections provide an overview of these steps in order to describe the rationale for selection of a recommended plan.

4.7.1 SITE-BASED CE/ICA

Following identification of potential restoration sites based on existing channel bed conditions and the presence of egg data, an assessment of which measures could be applied to the site was made. This assessment also included identification of potential lengths and widths of suitable substrate placement or improvement (Section 4.3.1). Preliminary designs and site and measure specific costs were developed in Sections 4.4 and 4.6.

In order to quantify habitat benefits using IWR-Plan, an evaluation is completed to estimate the annual habitat units (output) that implementation of each measure would yield. As described in Section 4.5.1.4, with-project HSI scores account for habitat variability over time by projecting with and without-project scores for each measure over the period of analysis. The average with-project score over the period of analysis is used as the final HSI for the measure. To yield net HSI, the without-project condition is given an HSI score and then is subtracted from the with-project average HSI score. In most cases, the no action HSI score was zero, because the measures involved substrate placement where none currently existed. For example: Myrtle Creek measure K has a with-project HSI score of 0.50, less the existing condition HSI score of 0, leaves a net HSI of 0.50.

Next, habitat units are calculated using the effective area of each measure multiplied by the HSI score of that measure to arrive at annual habitat units for each measure, slope and scale. The annual habitat units are summed over the 50-year period of analysis to arrive at total habitat units. The cost assumptions outlined in Section 4.6 for material and placement costs, real estate, interest during construction and monitoring are applied and used as input to IWR-Plan. For the alternative evaluation, the outputs are assumed constant over the period of analysis for the retained measures. Once a recommended plan is identified, further hydraulic evaluation related to sustainability of the plan elements will be conducted. The federal discount rate for FY2011 of 4.125 percent was used to annualize project costs.

The cost and output information was developed for each site and separate CE/ICAs for each site were then completed. Summary CE/ICA IWR-Plan input data along with measure combinability and other

information for each of the measures at each of the five sites are provided in Table 4-19 though Table 4-23. The IWR-Plan input data includes only the annual cost and output information.
The Site ID and Measure Type codes used in the tables are shown again below.

<u>Site ID</u>

Shorty's North	= SN
Shorty's Island South	= SS
Myrtle Creek	= MC
Downstream of Refuge	= DR
Refuge	= RF

<u>Measure Type Code</u>

Substrate Placement on Clay Bed, Flat Slope	= SPC(0)
Substrate Placement on Clay Bed, 10% Slope	= SPC(10)
Substrate Placement on Clay Shelves	= SPS
Improvement of Existing Coarse Substrate	= EES
Substrate Placement on Existing Coarse Substrate	= SPE

The site-based CE/ICA evaluation resulted in an array of site-based plans that were cost-effective and are the most efficient at producing increasing levels of output which are referred to as "site-based best buy" plans. Between seven and 11 best buy plans were identified for each of the five sites. The detailed results of the individual site-based CE/ICA are presented in Appendix C. Table 4-24 follows the input tables and provides a summary of the best buy plans resulting from the site-based evaluation. As discussed in the following section, a reach-wide CE/ICA was utilized to combine the results of the site-based evaluation.

Table 4-19. Shorty's Island North Input Data Summary

Code	Measure	Begin Station	End Station	Length (feet)	Total Cost PV[1]	Average Annual Cost[1]	Net HSI	AAHUs
SN-SPC(0)-A	Sub on Clay Bed (0% slope) - 1	7514+50	7519+50	500	$417,089	$19,833	0.87	15,629
SN-SPC(0)-B	Sub on Clay Bed (0% slope) - 2	7519+50	7523+50	400	$478,854	$22,770	0.92	21,149
SN-SPC(0)-C	Sub on Clay Bed (0% slope) - 3	7523+50	7527+50	400	$514,241	$24,453	0.72	18,091
SN-SPC(10)-D	Sub on Clay Bed (10% slope) - 1	7514+50	7519+50	500	$661,948	$31,476	0.87	23,760
SN-SPC(10)-E	Sub on Clay Bed (10% slope) - 2	7519+50	7523+50	400	$711,755	$33,845	0.92	28,363
SN-SPC(10)-F	Sub on Clay Bed (10% slope) - 3	7523+50	7527+50	400	$729,237	$34,676	0.72	24,121

Relationships

A	not combinable	D
B	not combinable	E
C	not combinable	F

Notes: AAHU – average annual habitat unit, HSI – Habitat Suitability Index, PV – Present Value

[1] Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

Table 4-20. Shorty's Island South Input Data Summary

Code	Measure	Begin Station	End Station	Length (feet)	Total Cost PV[1]	Average Annual Cost[1]	Net HSI	AAHUs
SS-SPC(0)-A	Sub on Clay Bed (0% slope) - 1	7549+50	7554+50	500	$299,392	$14,236	0.65	8,415
SS-SPC(0)-B	Sub on Clay Bed (0% slope) - 2	7554+50	7559+50	500	$405,261	$19,271	0.73	13,491
SS-SPC(0)-C	Sub on Clay Bed (0% slope) - 3	7559+50	7563+50	400	$460,490	$21,897	0.87	19,537
SS-SPC(0)-D	Sub on Clay Bed (0% slope) - 4	7570+50	7574+50	400	$619,320	$29,449	0.83	27,446
SS-SPC(0)-E	Sub on Clay Bed (0% slope) - 5	7574+50	7578+50	400	$369,730	$17,581	0.73	12,762
SS-SPC(10)-F	Sub on Clay Bed (10% slope) - 1	7549+50	7554+50	500	$526,694	$25,045	0.65	18,034
SS-SPC(10)-G	Sub on Clay Bed (10% slope) - 2	7554+50	7559+50	500	$701,730	$33,368	0.73	28,663
SS-SPC(10)-H	Sub on Clay Bed (10% slope) - 3	7559+50	7563+50	400	$772,754	$36,745	0.87	33,263
SS-SPC(10)-I	Sub on Clay Bed (10% slope) - 4	7570+50	7574+50	400	$812,006	$38,612	0.83	33,103
SS-SPC(10)-J	Sub on Clay d (10% slope) - 5	7574+50	7578+50	400	$540,175	$25,686	0.73	21,407
SS-SPS-L	Sub on Clay Shelves - 1	7566+50	7570+50	400	$392,382	$18,658	0.69	25,941

Relationships

A	not combinable	F
B	not combinable	G
C	not combinable	H
D	not combinable	I
E	not combinable	J

Notes: AAHU – average annual habitat unit, HSI – Habitat Suitability Index, PV – Present Value
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

Table 4-21. Myrtle Creek Input Data Summary

Code	Measure	Begin Station	End Station	Length (feet)	Total Cost PV[1]	Average Annual Cost[1]	Net HSI	AAHUs
MC-SPS-K	Sub on Clay Shelves - 1	7672+50	7678+50	600	$202,630	$9,635	0.50	9,243
MC-SPS-L	Sub on Clay Shelves - 2	7678+50	7685+50	700	$484,048	$23,017	0.63	27,405

Relationships

None

Notes: AAHU – average annual habitat unit, HSI – Habitat Suitability Index, PV – Present Value
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

Table 4-22. Downstream of Refuge Input Data Summary

Code	Measure	Begin Station	End Station	Length (feet)	Total Cost PV[1]	Average Annual Cost[1]	Net HSI	AAHUs
DR-SPC(0)-A	Sub on Clay Bed (0% slope) - 1	7725+50	7730+50	500	$403,455	$19,185	0.77	13,785
DR-SPC(0)-B	Sub on Clay Bed (0% slope) - 2	7741+50	7746+50	500	$338,648	$16,103	0.71	11,791
DR-SPC(0)-C	Sub on Clay Bed (0% slope) - 3	7767+50	7771+50	400	$398,348	$18,942	0.65	13,678
DR-SPC(0)-D	Sub on Clay Bed (0% slope) - 4	7771+50	7776+50	500	$678,556	$32,266	0.61	21,236
DR-SPC(10)-E	Sub on Clay Bed (10% slope) - 1	7725+50	7730+50	500	$662,909	$31,522	0.77	21,719
DR-SPC(10)-F	Sub on Clay Bed (10% slope) - 2	7741+50	7746+50	500	$545,481	$25,938	0.71	15,999
DR-SPC(10)-G	Sub on Clay Bed (10% slope) - 3	7767+50	7771+50	400	$683,467	$32,500	0.65	19,768
DR-SPC(10)-H	Sub on Clay Bed (10% slope) - 4	7771+50	7776+50	500	$1,005,406	$47,808	0.61	27,772
DR-SPS-K	Sub on Clay Shelves - 1	7733+50	7736+50	300	$208,844	$9,931	0.41	7,884
DR-SPS-L	Sub on Clay Shelves - 2	7737+50	7738+50	100	$36,336	$1,728	0.42	1,398

Relationships

A	not combinable	E
B	not combinable	F
C	not combinable	G
D	not combinable	H

Notes: AAHU – average annual habitat unit, HSI – Habitat Suitability Index, PV – Present Value
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

Table 4-23. Refuge Input Data Summary

Code	Measure	Begin Station	End Station	Length (feet)	Total Cost PV[1]	Average Annual Cost[1]	Net HSI	AAHUs
RF-SPC(0)-A	Sub on Clay Bed (0% slope) – 1	7847+50	7854+50	700	$563,964	$26,817	0.62	16,092
RF-SPE-B	Sub on Existing Gravel – 1	7859+50	7862+50	300	$86,679	$4,122	0.39	3,969
RF-SPE-C	Sub on Existing Gravel – 2	7862+50	7867+50	500	$377,307	$17,941	0.53	22,225
RF-SPE-D	Sub on Existing Gravel – 3	7867+50	7869+50	200	$81,580	$3,879	0.42	3,995
RF-EES-E	Sub Improvement – 1	7859+50	7862+50	300	$55,316	$2,630	0.00	666
RF-EES-F	Sub Improvement – 2	7862+50	7867+50	500	$240,785	$11,450	0.00	2,898
RF-EES-G	Sub Improvement – 3	7867+50	7869+50	200	$52,062	$2,476	0.00	627
Relationships								
none								

Notes: AAHU – average annual habitat unit, HSI – Habitat Suitability Index, PV – Present Value
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

Table 4-24. Summary of Site-based Evaluation Best Buy Plans

#	Plan	Total Cost[1]	Average Annual Cost[1]	AAHUs	Average Cost per Habitat Unit	Inc. Cost ($)	Inc. Habitat Units ($)	Inc. Cost / Inc. Habitat Units
Shorty's Island North								
1	No Action	$0	$0	0	$0	$0	0	$0.00
2	B	$478,854	$22,770	21,149	$1.08	$22,770	21,149	$1.08
3	A+B	$895,943	$42,603	36,778	$1.16	$19,833	15,629	$1.27
4	A+B+C	$1,410,184	$67,056	54,869	$1.22	$24,453	18,091	$1.35
5	B+C+D	$1,655,043	$78,699	62,999	$1.25	$11,643	8,130	$1.43
6	C+D+E	$1,887,944	$89,774	70,214	$1.28	$11,075	7,215	$1.54
7	D+E+F	$2,102,940	$99,997	76,244	$1.31	$10,223	6,031	$1.70
Shorty's Island South								
1	No Action	$0	$0	0	$0	$0	0	$0.00
2	L	$392,382	$18,658	25,941	$0.72	$18,658	25,941	$0.72
3	D+L	$1,011,702	$48,107	53,387	$0.90	$29,449	27,446	$1.07
4	D+H+L	$1,784,455	$84,853	86,650	$0.98	$36,745	33,263	$1.10
5	D+G+H+L	$2,486,186	$118,221	115,314	$1.03	$33,368	28,663	$1.16
6	D+G+H+J+L	$3,026,360	$143,906	136,720	$1.05	$25,686	21,407	$1.20
7	D+F+G+H+J+L	$3,553,054	$168,951	154,755	$1.09	$25,045	18,034	$1.39
8	F+G+H+I+J+L	$3,745,741	$178,114	160,411	$1.11	$9,162	5,657	$1.62
Myrtle Creek								
1	No Action	$0	$0	0	$0	$0	0	$0.00
2	L	$484,048	$23,017	27,405	$0.84	$23,017	27,405	$0.84
3	L+K	$686,677	$32,652	36,648	$0.89	$9,635	9,243	$1.04
Downstream of Refuge								
1	No Action	$0	$0	0	$0.00	$0	0	$0.00
2	L	$36,336	$1,728	1,398	$1.24	$1,728	1,398	$1.24
3	K+L	$245,180	$11,659	9,282	$1.26	$9,931	7,884	$1.26
4	B+K+L	$583,828	$27,762	21,074	$1.32	$16,103	11,791	$1.37
5	B+C+K+L	$982,175	$46,703	34,752	$1.34	$18,942	13,678	$1.38
6	A+B+C+K+L	$1,385,631	$65,888	48,538	$1.36	$19,185	13,785	$1.39
7	A+B+C+D+K+L	$2,064,187	$98,154	69,774	$1.41	$32,266	21,236	$1.52
8	B+C+D+E+K+L	$2,323,640	$110,491	77,707	$1.42	$12,337	7,933	$1.56
9	B+D+E+G+K+L	$2,608,759	$124,049	83,796	$1.48	$13,558	6,089	$2.23
10	D+E+F+G+K+L	$2,815,592	$133,884	88,004	$1.52	$9,835	4,208	$2.34
11	E+F+G+H+K+L	$3,142,442	$149,426	94,540	$1.58	$15,542	6,536	$2.38

#	Plan	Total Cost[1]	Average Annual Cost[1]	AAHUs	Average Cost per Habitat Unit	Inc. Cost ($)	Inc. Habitat Units ($)	Inc. Cost / Inc. Habitat Units
Refuge								
1	No Action	$0	$0	0	$0.00	$0	0	$0.00
2	C	$377,307	$17,941	22,225	$0.81	$17,941	22,225	$0.81
3	C+D	$458,887	$21,821	26,220	$0.83	$3,879	3,995	$0.97
4	B+C+D	$545,566	$25,942	30,188	$0.86	$4,122	3,969	$1.04
5	A+B+C+D	$1,109,530	$52,759	46,280	$1.14	$26,817	16,092	$1.67
6	A+B+C+D+E	$1,164,846	$55,390	46,946	$1.18	$2,630	666	$3.95
7	A+B+C+D+E+F	$1,405,631	$66,839	49,844	$1.34	$11,450	2,898	$3.95
8	A+B+C+D+E+F+G	$1,457,692	$69,315	50,471	$1.37	$2,476	627	$3.95

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

4.7.2 REACH-WIDE CE/ICA

Following completion of the site by site evaluation, reach-wide alternative plans were then considered by taking all of the best buy plans for each site (Table 4-24) and completing a reach-wide CE/ICA. Best buy plans for individual sites were not combinable with one another, but were combinable with best buys at all other sites. This evaluation resulted in identification of 31 new "best buy" plans for the overall Meander Reach, including a reach-wide no action plan. Table 4-25 summarizes these 31 reach-wide best buy plans, labeling each reach-wide best buy plans according to the site-based best buy plans it contains. This labeling allows mapping to Table 4-24 as follows:

SN# = Shorty's Island North site-based best buy plan number
SS# = Shorty's Island South site-based best buy plan number
DS# = Downstream of Refuge site-based best buy plan number
MC# = Myrtle Creek site-based best buy plan number
RF# = Refuge site-based best buy plan number

For example, the reach-wide best buy plan named "SS2 RF2" contains Shorty's Island South site-based Best Buy Plan 2 and Refuge site-based Best Buy Plan 2.

Table 4-25. Reach-Wide Evaluation Best Buy Plans Summary

#	Plan	Total Cost[1]	AAHUs	Inc. Cost / Inc. Habitat Units
1	No Action Plan	$0	0	$0.00
2	SS2	$392,379	25,941	$0.72
3	SS2 RF2	$769,700	48,166	$0.81
4	SS2 MC2 RF2	$1,253,728	75,571	$0.84
5	SS2 MC2 RF3	$1,335,324	79,565	$0.97
6	SS2 MC2 RF4	$1,421,989	83,534	$1.04
7	SS2 MC3 RF4	$1,624,635	92,777	$1.04
8	SS3 MC3 RF4	$2,243,949	120,223	$1.07
9	SN2 SS3 MC3 RF4	$2,722,803	141,372	$1.08
10	SN2 SS4 MC3 RF4	$3,495,553	174,635	$1.10
11	SN2 SS5 MC3 RF4	$4,197,284	203,298	$1.16
12	SN2 SS6 MC3 RF4	$4,737,462	224,705	$1.20
13	SN2 SS6 MC3 DR2 RF4	$4,773,802	226,103	$1.24
14	SN2 SS6 MC3 DR3 RF4	$4,982,630	233,987	$1.26
15	SN3 SS6 MC3 DR3 RF4	$5,399,719	249,616	$1.27
16	SN4 SS6 MC3 DR3 RF4	$5,913,967	267,707	$1.35
17	SN4 SS6 MC3 DR4 RF4	$6,252,614	279,499	$1.37
18	SN4 SS6 MC3 DR5 RF4	$6,650,966	293,177	$1.38
19	SN4 SS7 MC3 DR5 RF4	$7,177,663	311,211	$1.39
20	SN4 SS7 MC3 DR6 RF4	$7,581,104	324,997	$1.39
21	SN5 SS7 MC3 DR6 RF4	$7,825,978	333,127	$1.43
22	SN5 SS7 MC3 DR7 RF4	$8,504,534	354,364	$1.52
23	SN6 SS7 MC3 DR7 RF4	$8,737,420	361,578	$1.54
24	SN6 SS7 MC3 DR8 RF4	$8,996,889	369,511	$1.56
25	SN6 SS8 MC3 DR8 RF4	$9,189,567	375,168	$1.62
26	SN6 SS8 MC3 DR8 RF5	$9,753,530	391,260	$1.67
27	SN7 SS8 MC3 DR8 RF5	$9,968,520	397,291	$1.70
28	SN7 SS8 MC3 DR9 RF5	$10,253,645	403,380	$2.23
29	SN7SS8MC3DR10RF5	$10,460,476	407,588	$2.34
30	SN7SS8MC3DR11RF5	$10,787,325	414,124	$2.38
31	SN7SS8MC3DR11RF8	$11,135,499	418,315	$3.95

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

Figure 4-19 shows a graphical representation of the reach-wide best buy plans. The vertical axis on this graph is the incremental cost divided by the incremental output moving from one plan the next plan. The horizontal axis represents the total habitat units produced by each plan over the 50-year period of analysis

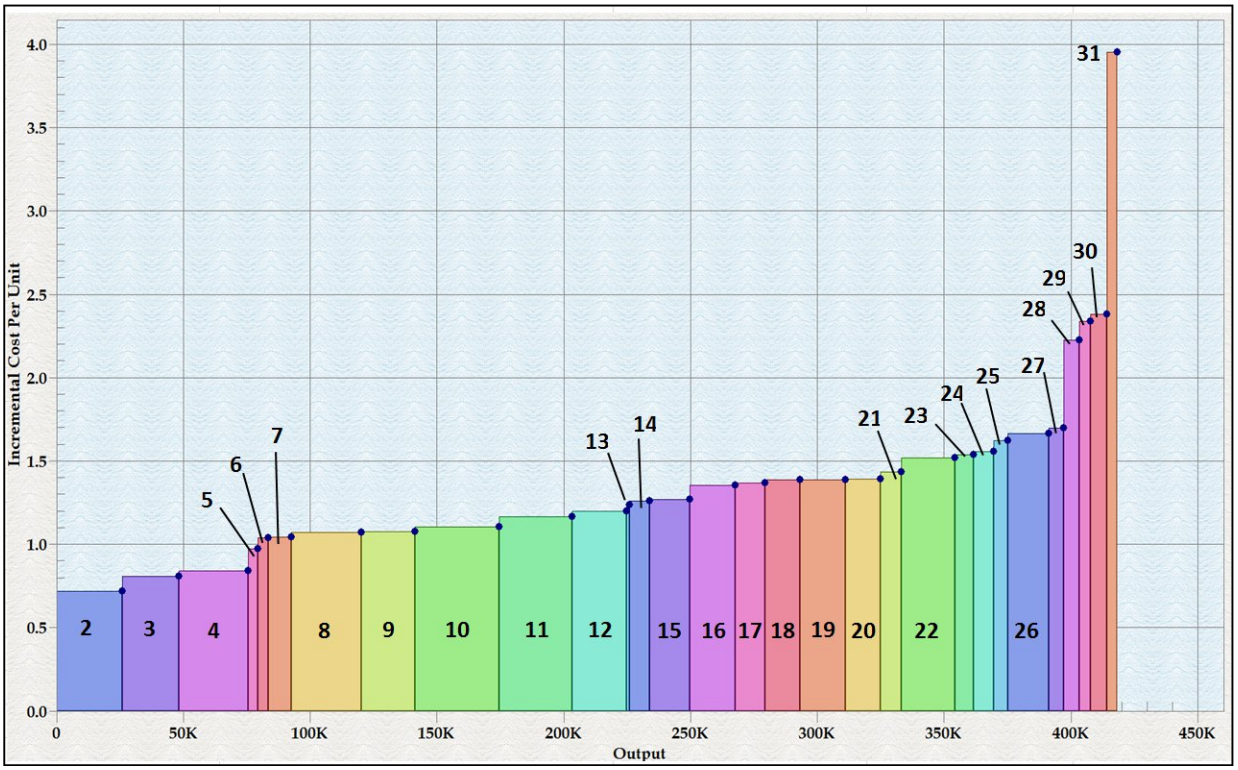


Figure 4-19. Reach-Wide Best Buy Plans

Excluding the No Action Alternative, construction costs range $392,000 to $11.1 million dollars. The incremental cost per incremental habitat unit ranged from $0.72 to $3.95. The incremental costs per incremental output versus total output curve can be used to identify changes in slope of moving from one best buy plan to the next. Substantial slope changes along the incremental curve can often indicate preferred levels of output or investment, especially when there are obvious changes or jumps. Several substantial jumps in the curve appear at the higher end for plans between $9.9 million and $11.1 million. Incremental cost changes for plans with lower costs are more subtle and not as helpful to identify one recommended plan. Supporting information for the reach-wide evaluation is provided in Appendix C.

To help identify plans to consider further from the many best buy plans in the reach-wide evaluation, total restored area and program cost limits were considered. The maximum federal cost participation for an individual Section 1135 project is five million dollars. This cost limit applies to the study, plans and specifications and construction. The program cost-share is 75 percent federal and 25 percent non-federal, for planning purposes a construction cost of around five million would result in an overall implementation cost around the federal cost limit. Total restored area is also a consideration. As outlined in Section 4.5, the restored area or suitable habitat provided should be sufficient to provide appropriate egg density for spawning females. At a minimum this would be 91,500 square feet for the current population. If a fully recovered population is considered, the area which coincides with the appropriate egg density increases to 440,000 square feet.

Based on these two considerations, as well as some subtle changes in the incremental cost per incremental output, a number of "plans of interest" have been identified for further evaluation. These plans, Reach-wide plans 11 to 19 of the 31 best buy plans, have a range in total construction cost between $4.2 million and $7.2 million. These plans provide a restored effective area between 302,000 and 463,000 square feet of effective area. The incremental cost per incremental output range from $1.16 to $1.39 for these plans of interest. The average cost per habitat unit ranged from $0.98 to $1.10. Although a number of these plans

were included even though they exceed the program cost limit by up to two million dollars, the variation in the components and level of restoration at each site provides helpful information for identifying one recommended plan. The plans of interest are seen graphically as numbers 11 through 19 in Figure 4-19.

Table 4-26 shows general cost and output information for each of the plans of interest. This table includes both the total output in habitat units as well at the total restored area. Each of these plans provide a total restored area to support the desired egg density for the current population (91,000 square feet). Several of the plans could support a fully recovered population providing in excess of 440,000 square feet of area. A reach-wide plan is considered complete if it provides at least the minimum area to support the ideal egg density for the current population.

Table 4-26. Reach-Wide Plans of Interest

Plan #	Total Restored Area (square feet)	Total Construction Cost[1]	AAHUs	Inc. Cost per Inc. Habitat Unit
11	302,105	$4,197,284	203,298	$1.16
12	331,459	$4,737,462	224,705	$1.20
13	334,819	$4,773,802	226,103	$1.24
14	354,139	$4,982,630	233,987	$1.26
15	372,139	$5,399,719	249,616	$1.27
16	397,139	$5,913,967	267,707	$1.35
17	413,639	$6,252,614	279,499	$1.37
18	434,639	$6,650,966	293,177	$1.38
19	462,500	$7,177,663	311,211	$1.39

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

Each of the nine plans of interest above are comprised of a set of best buy plans defined by the site-based CE/ICA. Furthermore, each site-based best buy plan is set of individual measures. Thus it is the combination of individual measures in each reach-wide plan of interest that comprises a reach-wide best buy plan.

If no other information were considered outside the CE/ICA to identify at a recommended plan, and assuming that some restoration at each of the sites is the preferred restoration philosophy to meet the identified study objective, then reach-wide alternative plan 13 or 14 could be identified as a recommended plan based on project cost considerations and the incremental cost box plot. However, there were other important factors requiring consideration in the decision process that were not measurable in the CE/ICA. The results of the CE/ICA were considered in addition to further evaluation of factors outside the CE/ICA. Thus the decision process was informed by input from study stakeholders with regard to the restoration philosophy within the study reach. Section 4.7.3 addresses these other considerations and input from the PDT, which include egg density mapping data, average cost per unit output (as opposed to incremental cost), and sufficient substrate placement site length.

4.7.3 Evaluation of Preferred Site Plans

The above reach-wide plans of interest are comprised of a subset of the site-based best buy plans. The site best buy plans included in the reach-wide plans of interest were listed, and this smaller set of plans of was evaluated. This evaluated is helpful to identify a recommended reach-wide alternative plan that falls within the five million dollar federal project cost threshold. This evaluation includes a comparison of total costs, average costs, incremental costs and other qualitative considerations. To compare costs between

sites, average costs are appropriate. Other considerations include egg density data and the length of restored area. The sites that have been included in the final evaluation all include sufficient egg density data as represented by the EPCU to warrant consideration, however across the five sites the egg density data does vary. A qualitative rating of moderate or high was applied to the five sites. Shorty's Island South, Myrtle Creek and Downstream of Refuge were rated as 'high' and Shorty's North and Refuge were rated as 'moderate.' The total length at each site was also considered, with a minimum being 500 feet.

Figure 4-20 provides an overview of the site-based best buy plans that were included in the reach-wide plans of interest. Labeling in the figure is consistent with Table 4-24 and 4-25. Following that, Table 4-27 through Table 4-31 summarizes the above considerations for the measures constituted the site-based best buy plans at each site. This allows tracing of individual measures all the way through to reach-wide plans of interest. Additionally, a figure for each site accompanies the tables to show the specific locations of the measures in each site-based best buy plan (Figure 4-21 through Figure 4-25). Finally, Table 4-32 provides an overall summary of the site-based best buy plans that were identified as components of the reach-wide plans of interest.

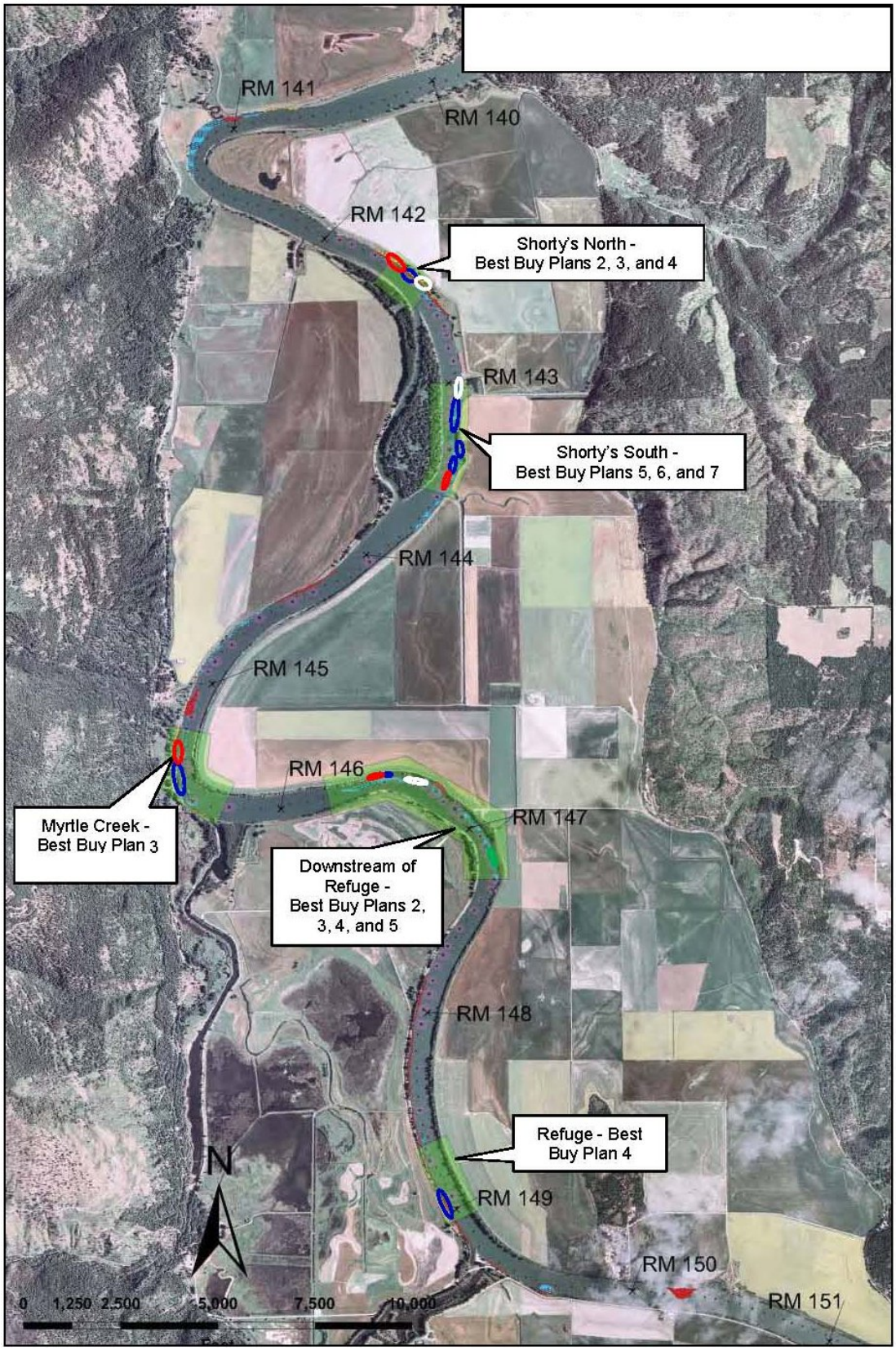
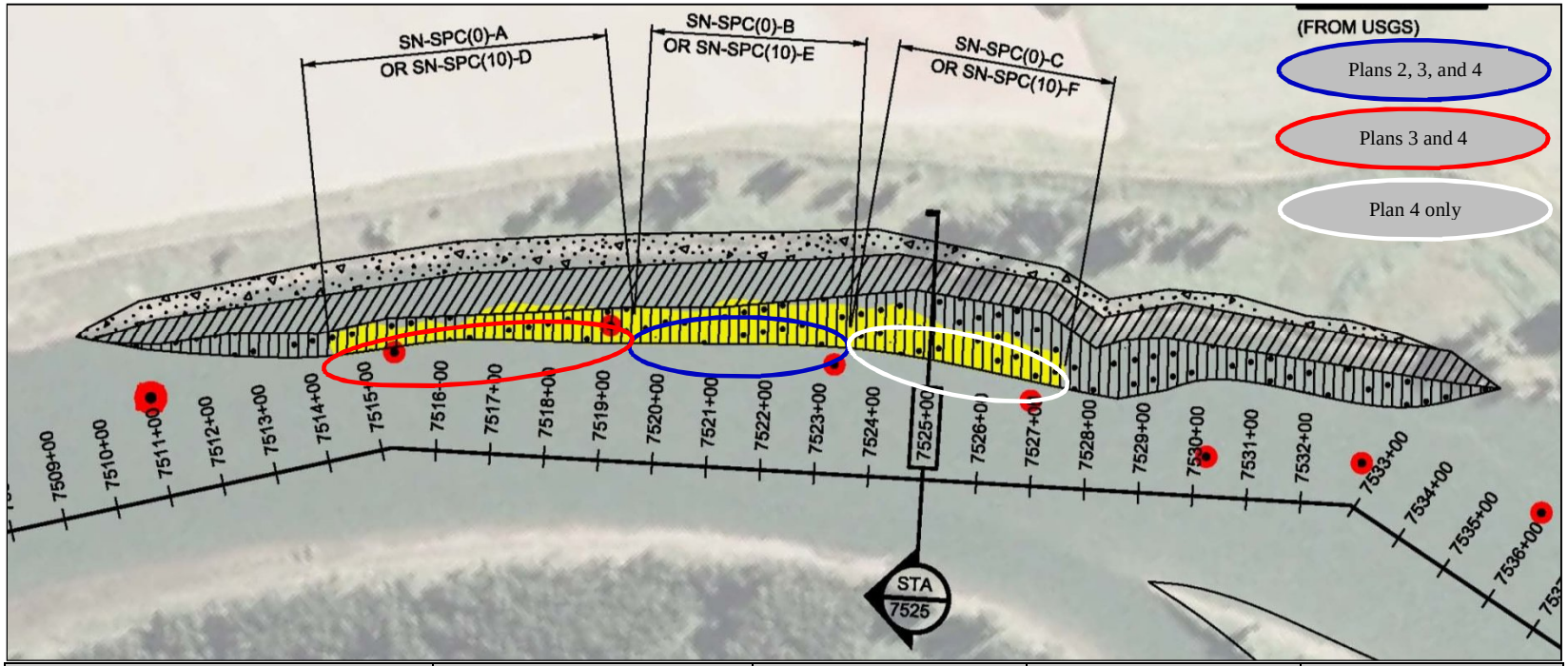


Figure 4-20. "Best Buy" Site Plans of Interest

Table 4-27. Shorty's Island North Measures in Plans of Interest

Code	Description	Site-Based Best Buy Plans		
		Plan 2	**Plan 3**	**Plan 4**
SN-SPC(0)-A	Sub on Clay Bed (0% slope)		x	x
SN-SPC(0)-B	Sub on Clay Bed (0% slope)	x	x	x
SN-SPC(0)-C	Sub on Clay Bed (0% slope)			x
SN-SPC(10)-D	Sub on Clay Bed (10% slope)			
SN-SPC(10)-E	Sub on Clay Bed (10% slope)			
SN-SPC(10)-F	Sub on Clay Bed (10% slope)			
	Total Cost[1]	$478,854	$895,943	$1,410,184
	Incremental Cost	$1.08	$1.27	$1.35
	Egg Density	Moderate	Moderate	Moderate
	Sufficient Length?	No (400ft)	Yes (900 feet)	Yes (1,300 feet)
	Restored Area (square feet)	23,000	41,000	66,000
	Average Annual Cost/AAHU	$1.08	$1.16	$1.22

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.



Code	Effective Area (square feet)	Plan 2	Plan 3	Plan 4
SN-SPC(0)-A	18,000		X	X
SN-SPC(0)-B	23,000	X	X	X
SN-SPC(0)-C	25,000			X
SN-SPC(10)-D	27,364			
SN-SPC(10)-E	30,846			
SN-SPC(10)-F	33,334			

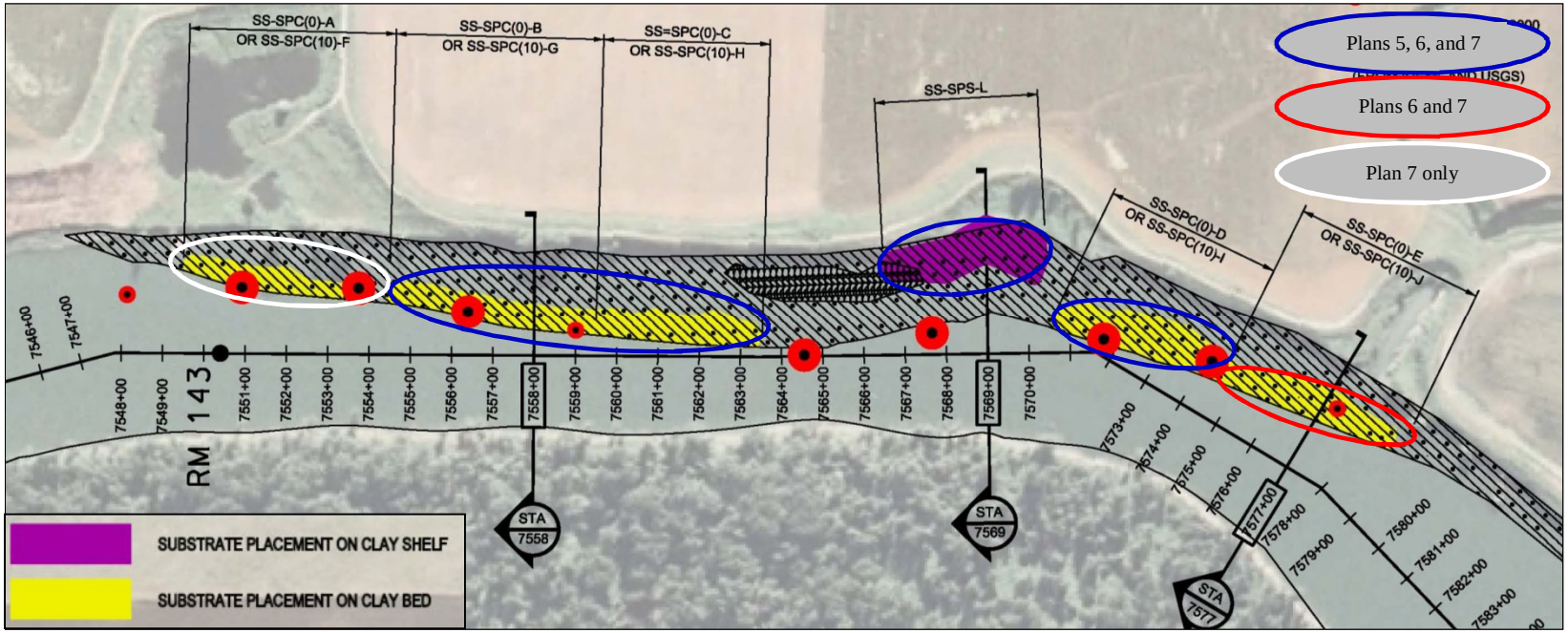
Figure 4-21. Shorty's Island North "Best Buy" Plans of Interest

Table 4-28. Shorty's Island South Measures in Plans of Interest

Code	Measure	Site-Based Best Buy Plans		
		Plan 5	Plan 6	Plan 7
SS-SPC(0)-A	Sub on Clay Bed (0% slope)			
SS-SPC(0)-B	Sub on Clay Bed (0% slope)			
SS-SPC(0)-C	Sub on Clay Bed (0% slope)			
SS-SPC(0)-D	Sub on Clay Bed (0% slope)	x	x	x
SS-SPC(0)-E	Sub on Clay Bed (0% slope)			
SS-SPC(10)-F	Sub on Clay Bed (10% slope)			x
SS-SPC(10)-G	Sub on Clay Bed (10% slope)	x	x	x
SS-SPC(10)-H	Sub on Clay Bed (10% slope)	x	x	x
SS-SPC(10)-I	Sub on Clay Bed (10% slope)			
SS-SPC(10)-J	Sub on Clay Bed (10% slope)		x	x
SS-SPS-L	Sub on Clay Shelves	x	x	x
	Total Cost[1]	$2,486,186	$3,026,360	$3,553,054
	Incremental Cost	$1.16	$1.20	$1.39
	Egg Density	High	High	High
	Sufficient Length?	Yes (1,700 feet)	Yes (2,200 feet)	Yes (2,600 feet)
	Restored Area (square feet)	148,105	177,459	205,320
	Average Annual Cost/AAHU	$1.03	$1.05	$1.09

Notes: AAHU – average annual habitat unit

[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.



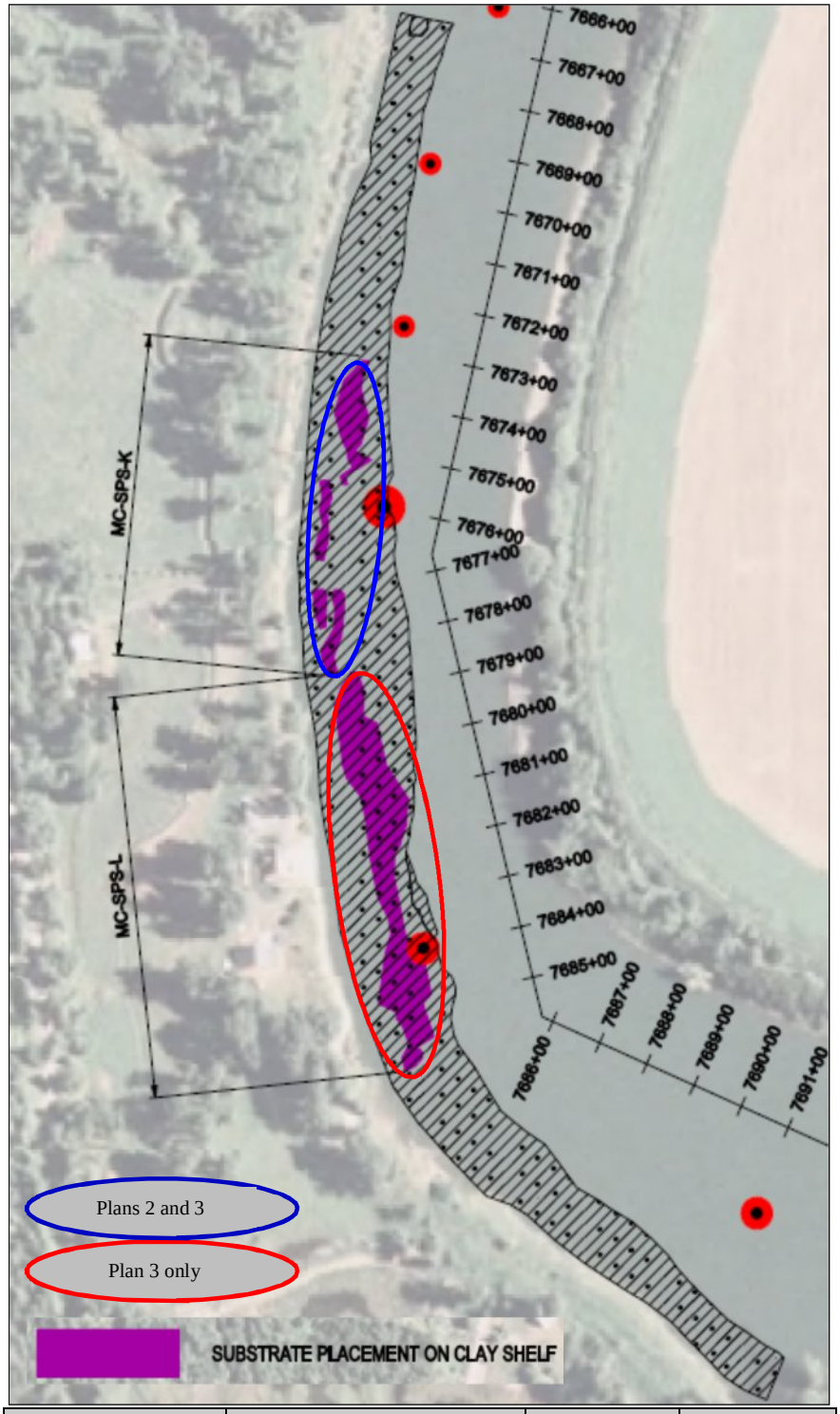
Code	Effective Area (square feet)	Plan 5	Plan 6	Plan 7
SS-SPC(0)-A	13,000			
SS-SPC(0)-B	18,500			
SS-SPC(0)-C	22,500			
SS-SPC(0)-D	33,000	X	X	X
SS-SPC(0)-E	17,500			
SS-SPC(10)-F	27,861			X
SS-SPC(10)-G	39,304	X	X	X
SS-SPC(10)-H	38,309	X	X	X
SS-SPC(10)-I	39,801			
SS-SPC(10)-J	29,354		X	X
SS-SPS-L	37,493	X	X	X

Figure 4-22. Shorty's Island South "Best Buy" Plans of Interest

Table 4-29. Myrtle Creek Measures in Plans of Interest

Code	Measure	Site-Based Best Buy Plans	
		Plan 2	**Plan 3**
MC-SPS-K	Sub on Clay Shelves		x
MC-SPS-L	Sub on Clay Shelves	x	x
	Total Cost[1]	$484,048	$686,677
	Incremental Cost	$0.84	$1.04
	Egg Density	High	High
	Sufficient Length?	Yes (700 feet)	Yes (1,300 feet)
	Restored Area (square feet)	43,500	62,000
	Average Annual Cost/AAHU	$0.84	$0.89

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.



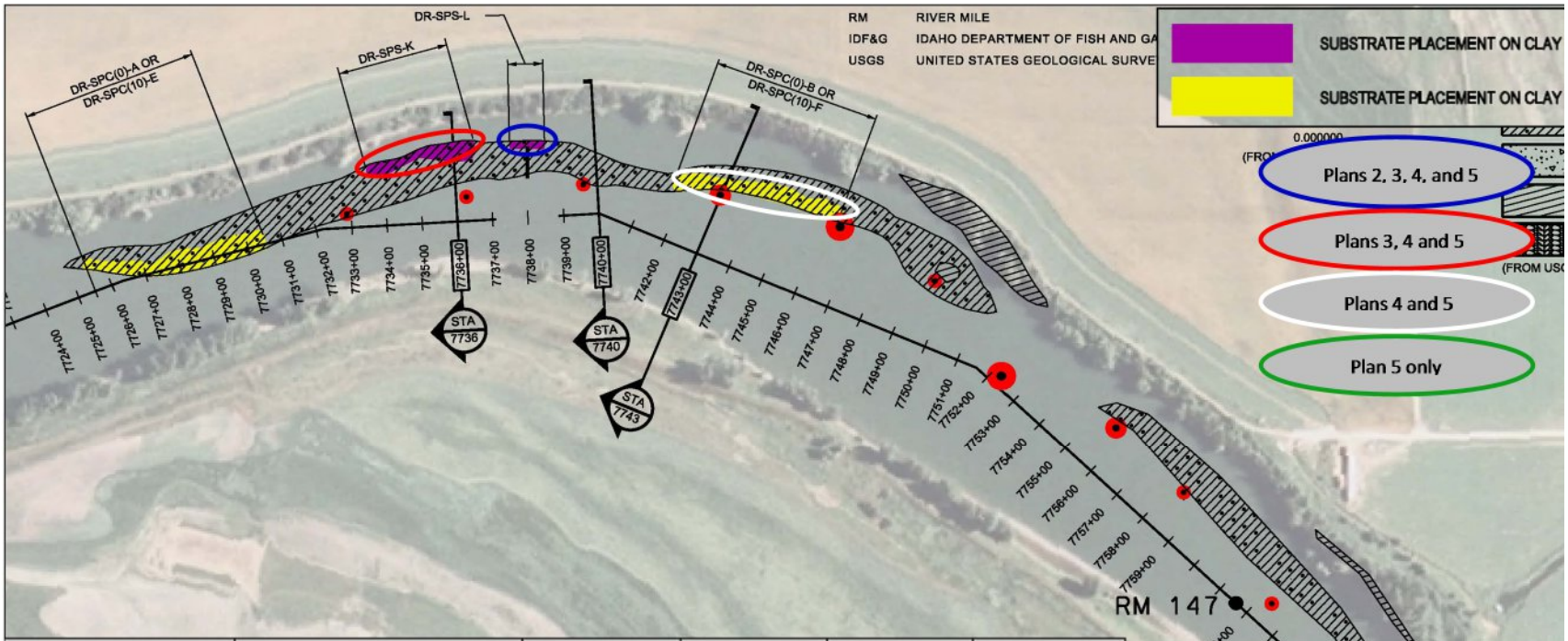
Code	Effective Area (square feet)	Plan 2	Plan 3
MC-SPS-K	18,500		X
MC-SPS-L	43,500	X	X

Figure 4-23. Revised Myrtle Creek "Best Buy" Plans of Interest

Table 4-30. Downstream of Refuge Measures in Plans of Interest

Code	Measure	Site-Based Best Buy Plans			
		Plan 2	**Plan 3**	**Plan 4**	**Plan 5**
DR-SPC(0)-A	Sub on Clay Bed (0% slope)				
DR-SPC(0)-B	Sub on Clay Bed (0% slope)			x	x
DR-SPC(0)-C	Sub on Clay Bed (0% slope)				x
DR-SPC(0)-D	Sub on Clay Bed (0% slope)				
DR-SPC(10)-E	Sub on Clay Bed (10% slope)				
DR-SPC(10)-F	Sub on Clay Bed (10% slope)				
DR-SPC(10)-G	Sub on Clay Bed (10% slope)				
DR-SPC(10)-H	Sub on Clay Bed (10% slope)				
DR-SPS-K	Sub on Clay Shelves		x	x	x
DR-SPS-L	Sub on Clay Shelves	x	x	x	x
	Total Cost[1]	$36,336	$245,180	$583,828	$982,175
	Incremental Cost ($)	$1.24	$1.26	$1.37	$1.38
	Egg Density	High	High	High	High
	Sufficient Length?	No (100 feet)	No (400 feet)	Yes (1,000 feet)	Yes (1,300 feet)
	Restored Area (square feet)	3,360	22,680	39,180	60,180
	Average Annual Cost/AAHU	$1.24	$1.26	$1.32	$1.34

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.



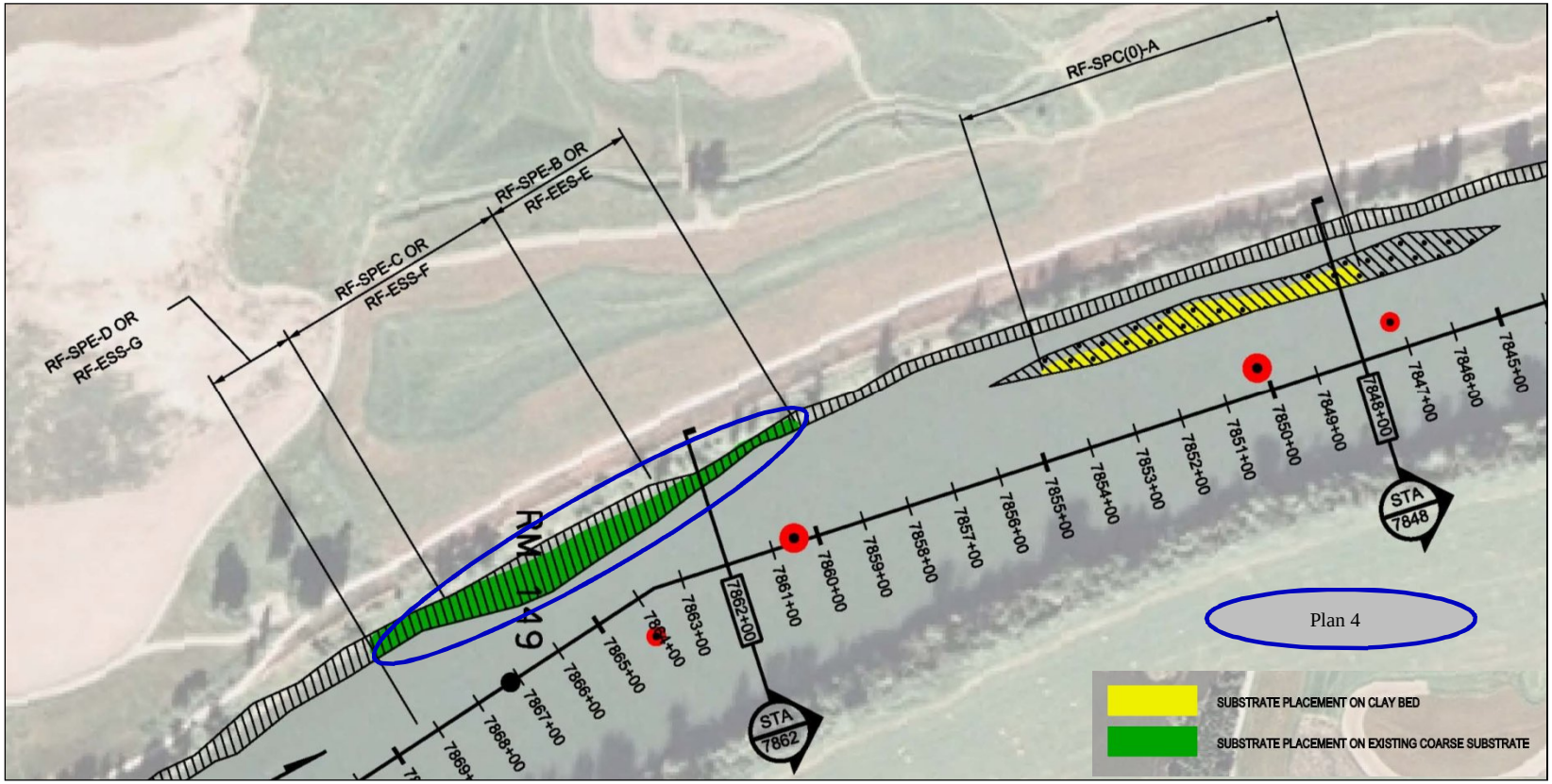
Code	Effective Area (Sq Ft)	Plan 2	Plan 3	Plan 4	Plan 5
DR-SPC(0)-A	18,000				
DR-SPC(0)-B	16,500			X	X
DR-SPC(0)-C	21,000				X
DR-SPC(0)-D	35,000				
DR-SPC(10)-E	28,359				
DR-SPC(10)-F	22,388				
DR-SPC(10)-G	30,349				
DR-SPC(10)-H	45,772				
DR-SPS-K	19,320		X	X	X
DR-SPS-L	3,360	X	X	X	X

Figure 4-24. Downstream of Refuge "Best Buy" Plans of Interest

Table 4-31. Refuge Site Measures in Plans of Interest

Code	Measure	Site-Based Best Buy Plans Plan 4
RF-SPC(0)-A	Sub on Clay Bed (0% slope)	
RF-SPE-B	Sub on Existing Gravel	x
RF-SPE-C	Sub on Existing Gravel	x
RF-SPE-D	Sub on Existing Gravel	x
RF-EES-E	Sub Improvement	
RF-EES-F	Sub Improvement	
RF-EES-G	Sub Enhancement	
	Total Cost[1]	$545,566
	Incremental Cost	$1.04
	Egg Density	Moderate
	Sufficient Length?	Yes (1,000 feet)
	Restored Area (square feet)	53,500
	Average Annual Cost/AAHU	$0.86

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.



Code	Effective Area (square feet)	Plan 4
RF-SPC(0)-A	26,000	
RF-SPE-B	8,500	X
RF-SPE-C	37,000	X
RF-SPE-D	8,000	X
RF-EES-E	8,500	
RF-EES-F	37,000	
RF-EES-G	8,000	

Figure 4-25. Refuge "Best Buy" Plans of Interest

Table 4-32. Summary Site-Based Best Buy Plan Options

Site-Based Best Buy Plans within Reach-Wide Plans of Interest	Total Cost [1]	Average Annual Cost/AAHU	Restored Area (square feet)	Sufficient Length?	Egg Density
(SN) Shorty's Island North Plan 2	$478,854	$1.08	23,000	N (400ft)	Moderate
(SN) Shorty's Island North Plan 3	$895,943	$1.16	41,000	Y (900ft)	Moderate
(SN) Shorty's Island North Plan 4	$1,410,184	$1.22	66,000	Y (1,300ft)	Moderate
(SS) Shorty's Island South Plan 5	$2,486,186	$1.03	148,105	Y (1,700ft)	High
(SS) Shorty's Island South Plan 6	$3,026,360	$1.05	177,459	Y (2,200ft)	High
(SS) Shorty's Island South Plan 7	$3,553,054	$1.09	205,320	Y (2,600ft)	High
(MC) Myrtle Creek Plan 2	$484,048	$0.84	43,500	Y (700ft)	High
(MC) Myrtle Creek Plan 3	$686,677	$0.89	62,000	Y (1,300ft)	High
(DR) Downstream of Refuge Plan 2	$36,336	$1.24	3,360	N (100ft)	High
(DR) Downstream of Refuge Plan 3	$245,180	$1.26	22,680	N (400ft)	High
(DR) Downstream of Refuge Plan 4	$583,828	$1.32	39,180	Y (1,000ft)	High
(DR) Downstream of Refuge Plan 5	$982,175	$1.34	60,180	Y (1,300ft)	High
(RF) Refuge Plan 4	$545,566	$0.86	53,500	Y (1,000ft)	Moderate

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

Table 4-32 compares and summarizes the site-based best buy plans that make up the plans of interest, which were plans 11 to 19 from the reach-wide evaluation). As has been detailed, the site-based analysis optimized measure combinations at each site. The reach-wide evaluation was then used to identify the plans of interest based on the project cost limit across all sites. Those plans of interest were broken down into their component site-based best buys, and each site-based best buys of interest was characterized and shown graphically.

In comparing average costs (see table column "Average Annual Cost/AAHU") across the sites, Myrtle Creek site-based Best Buy Plan 2 and Refuge site-based Best Buy Plan 4 have the lowest average cost, ranging from $0.84 to $0.86. The best buy plans for each of these sites include the placement of suitable substrate on clay (Myrtle) and existing gravel (Refuge). The Myrtle Creek site has high egg density data and the suitable area for restoration exists in long continuous lengths. At Refuge, there are concerns regarding this measure's sustainability over the period of analysis in comparison to the other measures considered in the final array.

Average annual costs per average annual habitat unit (AAHU) for the Shorty's Island South site-based best buy plans are the next lowest and range from $1.03 to $1.09. This site also has significant contiguous stretches of restored substrate and high egg density data.

Shorty's Island North is the site with the next lowest costs, ranging from $1.08 to $1.22 for the site-based best buy plans. This site has moderate egg density data but shorter lengths (relative to other sites) of area for potential restoration. An advantage of this site is its close proximity to Shorty's Island South.

Downstream of Refuge has the highest average annual cost per AAHU for its site-based best buy plans, with costs ranging from $1.24 to $1.34. The site has high egg density data but only moderate section lengths suitable for restoration.

4.8 EVALUATION AND IDENTIFICATION OF A RECOMMENDED RESTORATION PLAN

The evaluation of site-based plans includes consideration of the results from the incremental evaluation, egg density information and whether a suitable length of restored substrate is provided with each increment and the overall plan. The evaluation of reach-wide alternative plans also depends on the results of the CE/ICA but additionally includes a portfolio investment consideration of how to allocate the mix of restoration between sites.

To gain insight into this portfolio investment decision, a workshop was held December 2 and 3, 2010 to present the results of the CE/ICA and get input on other important considerations including the restoration philosophy among sites. Based on input from the workshop, the most critical information to consider to help ensure an alternative plan is effective to support successful spawning and early life state survival is to maximize the contiguous length of suitable restored substrate to provide a better chance for eggs to adhere to the appropriate substrate in the current and to provide cover sites for larvae as they hatch and drift. Sites with high egg density data should be considered as a priority. Another important consideration identified at the workshop was construction efficiency. Focusing restoration at sites in close proximity to one another would maximize construction efficiency and result in potential cost-savings by reducing the travel time from the central staging area.

The information from the CE/ICA along with the other identified considerations including egg density data, contiguous length and construction efficiency, were used to help prioritize locations and to build alternative best buy plans to consider for implementation. The following section summarizes the considerations for each site. Once preferred best buy plans are identified at the site level, four alternative plans for the reach were developed.

Shorty's Island South. Shorty's Island South has significant section lengths, high egg density data, and low average annual cost per AAHU data. For these reasons, Shorty's Island South was identified as the highest priority site. The best buy plans identified at this site would provide between 1,700 and 2,600 linear feet of habitat. Average annual costs per AAHU at this site range from $1.03 to $1.09. The incremental cost between site-based Best Buy Plan 5 and plan 6 is $1.16 while the incremental costs moving from plan 6 to plan 7 are $1.39. Because of the minimal increase in incremental costs between plan 5 and plan 6, plan 6 was preferred over plan five. The total cost of plan 6 at the 10% design level was estimated at $3.026 million. The five sections (D, G, H, J and L) that comprise plan 6 are included in all of the best buy alternative plans. The added increment of moving from plan 6 to plan 7 increases length by 500 feet (Section F), while total costs increase to $3.55 million. The additional increment of adding Section F is considered in two of the best buy alternative plans.

Shorty's Island North. Shorty's Island North was identified as the second highest priority site primarily due to its proximity to Shorty's Island South. Average annual costs per AAHU are slightly higher than Shorty's Island South and range from $1.08 to $1.22. To obtain sufficient length, plan 3 or 4 would need to be implemented. The total cost for plan 3 (Sections A and B) is estimated at $896,000, while the costs for plan 4 are estimated at $1.410 million (Sections A, B and C). The incremental costs of moving from plan 3 to plan 4 are $1.27. Sections A and B that comprise plan 3 are included in all of the best buy alternative plans. Given the higher incremental costs of moving to plan 4, which adds Section C, plan 4 is included in only one of the best buy alternative plans.

Myrtle Creek. The plans for Myrtle Creek are substantially different from those presented at the workshop held on December 2 and 3, 2010. In January 2011, detailed review of underwater videography revealed that the vast majority of the existing "gravel" substrate originally mapped was actually clay rubble. However, at the same time, the USGS work also revealed that the clay shelves were much more extensive than originally mapped. Therefore, the Myrtle Creek measures were reformulated to take advantage of the clay shelves. The resulting revised Myrtle Creek plan is presented below.

The Myrtle Creek site was identified as a priority site-based on its relative proximity to the two Shorty's Island sites and also because of the large contiguous lengths, 1,700 to 2,300 linear feet and the high egg density data. Extensive investigation at Myrtle Creek revealed that the site has significant areas of clay shelves. Substrate placement on clay shelves can be implemented between stations 7672+50 and 7685+50. Within this 1,300-foot range two scales were identified. The first is a 600-foot length (7672+50 to 7678+50) that yields 462,130 HUs at a total cost of $202,630. The second is a 700-foot length that yields an additional 1,370,250 HUs at a cost of $484,048. The average annual costs per AAHU of output are $1.04 for the 600-foot section, $0.84 for the 700-foot section, and $0.89 over the total section. Figure 4-23 provides a view of the measures at Myrtle Creek. Figure A-5 in Appendix A shows the sediment facies for the Myrtle Creek Site. The combined average cost of the two sections is low relative to other sites and very similar to earlier measures identified based on superseded sediment facies data. Given the low cost per output, both sections K and L have been included in three of the four best buy alternative plans.

Downstream of Refuge. Although the Downstream of Refuge site has high egg density data the site also has the highest average cost per output. The section lengths are also more limited at this site, ranging from 100 to 1,300 linear feet. The site is also a more substantive distance from the Shorty's Island sites. None of the plans at this site were included in the best buy alternative plans.

Refuge. Only 1 site-based best buy plan was identified as part of the reach-wide plans of interest. The best buy plan of interest at the Refuge site includes only placement of suitable substrate on existing gravel. The average annual cost per AAHU for this plan is one of the lowest at $0.84 per habitat unit. However, due to the distance from the other recommended sites in the reach the refuge was not a priority site and therefore not included in any of the best buy alternative plans considered for recommendation.

4.8.1 Preliminary Alternative Plans

The identified preferred site plans at the priority sites, based on input at the December workshop as well as the results of the CE/ICA were compiled into four alternative plans. Each of the alternative plans represents a best buy plan that takes into account the other considerations including s egg density, contiguous length, and construction efficiency in addition to total cost and the results of the CE/ICA. These alternatives range in cost from $3.922 million to $5.650 million. The average annual cost/average annual habitat unit of the plans ranges from $1.04 to $1.09. The total area restored ranges from 218,459 square feet to 333,320 square feet. These alternatives are presented in Table 4-33.

Each of these plans meets the identified planning objectives, all are considered best buys, and all optimize continuous length at the priority sites for different levels of output. All of the identified plans provide sufficient spawning area for a recovering population. Each of the identified plans can be supported as the recommended or National Ecosystem Restoration (NER) plan.

Alternative Best Buy Plan 2 was identified as the tentatively recommended plan. This plan has the lowest average annual cost per average annually habitat unit at $1.04. The plan would include creating suitable substrate for spawning and early life stages over 4,400 linear feet and create 280,459 square feet of

effective area. The total construction cost of this plan is $4,608,980. Figure 4-26 summarizes the features of the tentatively recommended plan.

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Table 4-33. Alternative Best Buy Plans Comparison

Alternative Best Buy Plans	Total Cost[1]	Average Annual Cost[1]	AAHU	Average Annual Cost/AAHU	Restored Area (square feet)	Sufficient Length?	Egg Density
Alternative Best Buy Plan 1							
Shorty's North Plan 3 *SN-SPC(0)-A* *SN-SPC(0)-B*	$895,943	$42,603	36,778	$1.16	41,000	Yes (900 feet)	Moderate
Shorty's Island South Plan 6 *SS-SPC(0)-D* *SS-SPC(10)-G* *SS-SPC(10)-H* *SS-SPC(10)-J* *SS-SPS-L*	$3,026,360	$143,906	136,720	$1.05	177,459	Yes (2,200 feet)	High
Plan 1 Summary	**$3,922,303**	**$186,509**	**173,498**	**$1.07**	**218,459**		
Alternative Best Buy Plan 2 (Recommended)							
Shorty's North Plan 3 *SN-SPC(0)-A* *SN-SPC(0)-B*	$895,943	$42,603	36,778	$1.16	41,000	Yes (900 feet)	Moderate
Shorty's Island South Plan 6 *SS-SPC(0)-D* *SS-SPC(10)-G* *SS-SPC(10)-H* *SS-SPC(10)-J* *SS-SPS-L*	$3,026,360	$143,906	136,720	$1.05	177,459	Yes (2,200 feet)	High
Myrtle Creek Plan 3 *MC-SPS-K* *MC-SPS-L*	$686,677	$32,652	36,648	$0.89	62000	Yes (1,300 feet)	High
Plan 2 Summary	**$4,608,980**	**$219,162**	**210,146**	**$1.04**	**280,459**		
Alternative Best Buy Plan 3							
Shorty's North Plan 3 *SN-SPC(0)-A* *SN-SPC(0)-B*	$895,943	$42,603	36,778	$1.16	41,000	Yes (900 feet)	Moderate
Shorty's Island South Plan 6 *SS-SPC(0)-D* *SS-SPC(10)-G* *SS-SPC(10)-H* *SS-SPC(10)-J* *SS-SPS-L*	$3,026,360	$143,906	136,720	$1.05	177,459	Yes (2,200 feet)	High
Myrtle Creek Plan 3 *MC-SPS-K* *MC-SPS-L*	$686,677	$32,652	36,648	$0.89	62000	Yes (1,300 feet)	High
Shorty's Island South Plan 7 Section F *SS-SPC(10)-F*	$526,694	$25,045	18,035	$1.39	27,861	Yes (500 feet)	High
Plan 3 Summary	**$5,135,674**	**$244,206**	**228,181**	**$1.07**	**308,320**		
Alternative Best Buy Plan 4							
Shorty's North Plan 3 *SN-SPC(0)-A* *SN-SPC(0)-B*	$895,943	$42,603	36,778	$1.16	41,000	Yes (900 feet)	Moderate
Shorty's Island South Plan 6 *SS-SPC(0)-D* *SS-SPC(10)-G* *SS-SPC(10)-H* *SS-SPC(10)-J* *SS-SPS-L*	$3,026,360	$143,906	136,720	$1.05	177,459	Yes (2,200 feet)	High
Myrtle Creek Plan 3 *MC-SPS-K* *MC-SPS-L*	$686,677	$32,652	36,648	$0.89	62000	Yes (1,300 feet)	High
Shorty's Island South Plan 7 Section F *SS-SPC(10)-F*	$526,694	$25,045	18,035	$1.39	27,861	Yes (500 feet)	High
Shorty's North Plan 4 Section C *SN-SPC(0)-C*	$514,241	$24,453	18,091	$1.35	25,000	No (400 feet)	Moderate
Plan 4 Summary	**$5,649,915**	**$268,659**	**246,271**	**$1.09**	**333,320**		

Notes: AAHU – average annual habitat unit
[1]Formulation conducted using 10% design level costs and outputs, Q2FY11 price level and FY11 interest rate of 4.125%.

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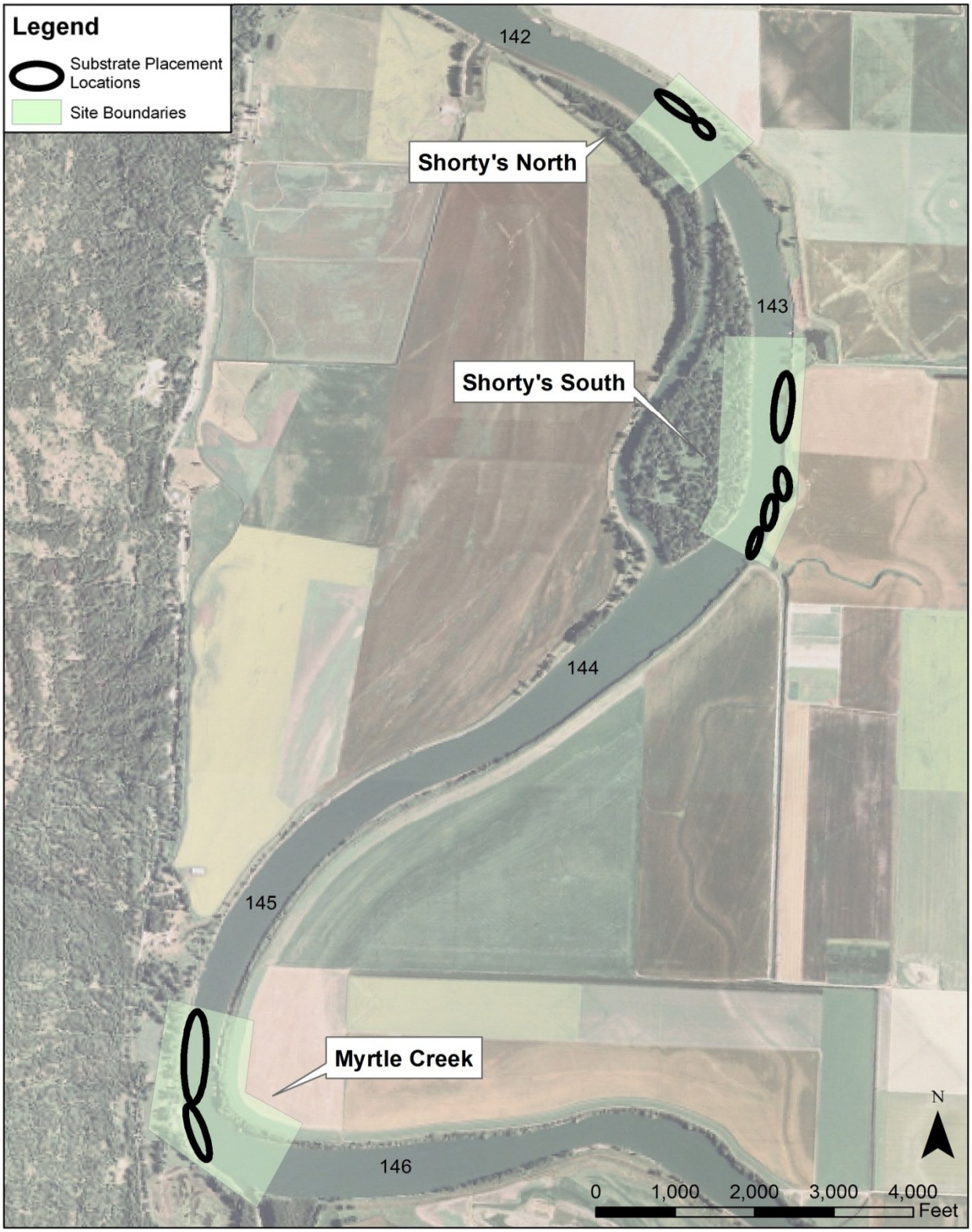

Figure 4-26. Preliminary Recommended Plan Features

4.8.2 Final Alternative Plans and Recommendation

Following the identification of the tentatively recommended plan the design was advanced to the 35% level (see Chapter 5 for detailed discussion of 35% design). During 35% design it became apparent that the cost of the tentatively recommended plan would exceed the program cost ceiling and the non-federal sponsor could not support a recommended plan where their contribution would exceed 25 percent of the total costs.

In order to identify a plan with reduced scope, the components of Alternative Best Buy Plan 2 were revisited. Looking at the components of the plan, the Shorty's North site was identified as having the highest average cost per habitat unit, making it a candidate to removal from the plan. Although Shorty's Island North was identified as the second highest priority site due to its proximity to Shorty's Island South the total cost and average cost at Shorty's Island North, egg density data and the length of the identified section needed to be re-considered and compared to those attributes at Myrtle Creek. Given the larger length, higher egg mat density data, and lower average and total cost, the Myrtle Creek site was retained and the Shorty's Island North site dropped from consideration.

The revised Alternative Best Buy Plan 2 was identified as the tentatively recommended plan. This scaled-down alternative still meets the identified planning objectives, all of its components are considered best buys, and all optimize continuous length at the priority sites for different levels of output. The plan would include creating suitable substrate for spawning and early life stages over 3,351 linear feet and create 288,040 square feet of effective area. The identified plan can be supported as the recommended or NER plan. Figure 4-27 summarizes the features of the recommended plan.

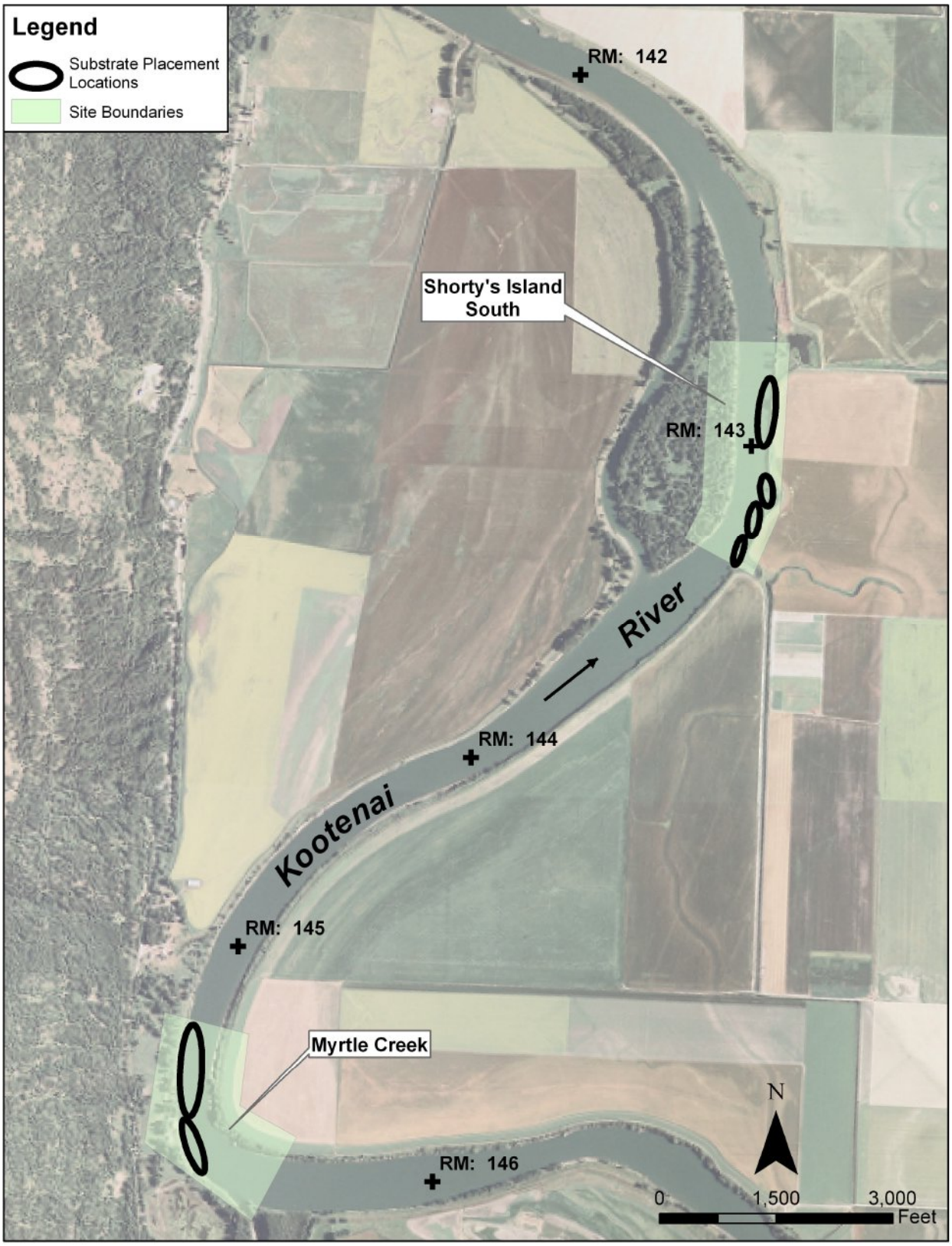

Figure 4-27. Final Recommended Plan Features

4.8.3 ACCEPTABILITY, COMPLETENESS, EFFICIENCY, EFFECTIVENESS

The concepts of acceptability, completeness, efficiency, and effectiveness are helpful to summarize the evaluation and justification for the tentatively recommended plan, revised Best Buy Alternative Plan 2. These concepts, in accordance with the Planning Guidance Notebook (ER 1105-2-100, Planning Guidance Notebook, dated April 22, 2000), are presented below along with specific considerations for the Shorty's Island/Meander Reach Restoration Project.

Acceptability. An ecosystem restoration plan should be acceptable to state and federal resource agencies, the Kootenai Tribe, and local government. A recommended plan must be acceptable to the non-Federal cost-sharing partner (however, this does not mean that the recommended plan must be the locally preferred plan). Acceptable plans are compatible with existing laws, regulations, and public policies.

- The Shorty's Island/Meander Reach study is being planned in coordination with state and federal resource agencies, the local sponsor and other KRWS experts to inform and provide input on evaluation criteria and considerations in order to ensure a plan is identified which is acceptable not only to the federal government but also has broad based acceptability among study stakeholders. The tentatively recommend plan is supported by the local sponsor and state and federal resource agency representatives. Representatives from each of these entities along with other KRWS experts and representatives from USACE all participated in the selection of the recommended plan. In identifying the elements of the recommended plan, stakeholders recognize that the measures and measure locations included in the plan provide the greatest opportunity to address the first identified bottleneck to KRWS recovery by providing substantial and suitable early life stage habitat.

Completeness. A plan must provide and account for all necessary investments or other actions needed to ensure the realization of the planned restoration outputs. This may require relating the plan to other types of public or private plans if these plans are crucial to the outcome of the restoration objective.

- As documented in Chapters 1 and 2 this feasibility study addresses the first known bottleneck to KRWS recovery and is an important element of the larger and more broadly based *Kootenai River Habitat Restoration Project Master Plan*. The Master Plan utilizes an ecosystem restoration approach to KRWS recovery. The recommended plan is consistent with the Master Plan.
- All of the best buy alternative plans under consideration are considered to be complete; all plans meet the objective of providing suitable aquatic habitat for egg attachment and early life history stages of KRWS within the area.
- Sustainability issues and related uncertainties have been considered throughout the plan formulation and evaluation process. The features included in the recommended plan have been designed to be as sustainable as possible. Monitoring and adaptive management to address project performance are outlined in Chapter 5.
- The recommended plan would improve food web and ecosystem productivity through increased habitat complexity via substrate placements.

Efficiency. An ecosystem restoration plan must represent a cost-effective means of addressing the restoration problem or opportunity.

- All of the preferred alternative plans identified in Section 4.8.1 represent a cost-effective means to address the identified problems and opportunities. In addition to being cost-effective, each of these plans, as well as the recommended plan, are also "best buy" plans which provide the most efficient means of producing increasing levels of output.

- The close proximity of sites included in the recommended plan also provides for construction efficiency during implementation.
- The recommended alternative also can also be implemented at a reasonable cost. The project costs are also within the federal-funding limit.

Effectiveness. An ecosystem restoration plan must make a significant contribution to addressing the specified restoration problems or opportunities (i.e., restore important ecosystem structure or function to some meaningful degree).

- *Preliminary Screening*. The preliminary screening criteria resulted in an array of measures that were focused on addressing egg attachment and early life stage survival; these measures were viewed as sustainable and did not have major constructability concerns. These screening criteria helped ensure measures would be effective at meeting the objective.
- *Substrate Design*. The suitable substrate design for each measure was based on best available information to mimic substrate, depth, and velocity where other sturgeon populations successfully spawn and survive. The design of the suitable substrate helps ensure effectiveness.
- *Site Suitability*. The identification of suitable sites for restoration was based on existing channel material/sediment facies to help ensure sustainability. Egg deposition density data, which provides evidence of use by KRWS, was also used to identify suitable areas for restoration. Placement of suitable substrate at sites with appropriate characteristics to sustain the proper substrate conditions help ensure the recommended plan is effective.
- Long contiguous reaches of suitable substrate helps ensure early life stage survival. The recommended plan includes significant section lengths in close proximity to one another supporting successful survival and plan effectiveness.

4.8.4 Risk and Uncertainty

A Risk Management Plan was developed to assess (identify and analyze), prioritize, and monitor risk drivers; develop risk-handling approaches; and apply adequate resources to handle risks associated with the Shorty's Island/Meander Reach Ecosystem Restoration Project. The Risk Management Plan assigns specific responsibilities for these functions and prescribes the documenting, monitoring, and reporting process to be followed. The Risk Management Plan and project Risk Register can be found in Appendix I.

The objectives of the Risk Management Plan are to minimize threats to achievement of the project objectives and provide and approach for identifying and assessing risks, determining cost-effective risk reduction actions, and monitoring and reporting progress in reducing risk.

The risk management strategy for this project is to handle program risks, both technical and non-technical, before they become problems, causing serious cost, schedule, or performance impacts. This strategy is an integral part of project success, and will be executed primarily through the PDT. The PDT will continuously and proactively assess critical areas to identify and analyze specific risks and will develop options to mitigate all risks designated as moderate or high. Monitoring of risk will be updated continually using a risk register managed by the PDT. When the project reaches the closeout phase, the project manager and PDT will document the final results of the execution of the Risk Management Plan for inclusion in the final project records and the District and/or Enterprise Lessons Learned database. At a minimum, this information will include risk assessment documents (including the risk register), risk-handling plans (including the project watch list), contract deliverables, if appropriate, and any other risk-related reports.

The primary area of risk and uncertainty identified at the December 2010 workshop related to the sustainability and function of the placing suitable substrate on existing coarse material at the Myrtle Creek site. However, given the changes in the conditions at Myrtle Creek, sustainability of substrate on clay shelves is of less concern. Sustainability considerations related to the recommended plan are further addressed as part of the 35% design presented in Chapter 5. Table 4-34 summarizes key risk areas and the mitigation response strategy identified during the conceptual alternative development and evaluation. The mitigation response strategies are further addressed during the 35% design phase for the recommended plan. A sustainability workshop, discussed in Chapter 5, was also conducted during the 35% design effort to address the areas of risk and uncertainty.

Table 4-34. Technical Risk with High Risk Level

Risk	Risk Analysis	Mitigation Response Strategy
Operation and Maintenance	The project O&M must be minimized. If the selected alternative requires substantial O&M, it could preclude implementation. BPA is not willing to fund a project that requires substantial O&M.	(1) Design the substrate placements to remain in place. (2) Design the substrate placements so they have minimum exposure to conditions that could result in deposition of sand.
Additional Studies	There are incomplete studies as it relates to the substrate conditions, hydraulic (river issues), etc. This could jeopardize design decisions and scope development.	Many uncertainties were resolved during 35% using refined bathymetry and videography data. The following will be addressed during plans and specifications phase: (1) Substrate Placement: height, release point, preparation, ballast material. (2) Staging/Site Access: engineering survey, geotechnical evaluations, material conveyor, haul routes.
Construction (Environmental Work Window)	Project construction must occur within the established in-water work window. Currently this is from August through November. However, this could change depending on dynamic conditions.	The construction schedule has been established based on the in-water work window and can be modified accordingly if that window is adjusted.

Notes: BPA – Bonneville Power Administration, O&M – Operation and Maintenance

5 RECOMMENDED RESTORATION PLAN

The recommended plan includes substrate placements at the Shorty's Island South and Myrtle Creek sites that will provide the physical attributes necessary to support wild KRWS early life stage survival and contribute to the recovery of a sustainable natural population of the species. The plan will create 3,351 new linear feet of suitable substrate and provide 288,040 square feet of effective area suitable for egg attachment and support KRWS early life stage survival within Meander Reach 1 of the lower Kootenai River. Figure 5-1 provides an overview of the refined 35% design recommended plan and identifies the locations of clay beds (CB) and clay shelves (CS) at the two sites.

As noted in Chapter 4, the Shorty's Island North site was removed from the recommended plan during the 35% design phase due to cost considerations. Additionally, the eight-foot-thick substrate placements on clay beds was reduced to two feet thick based on comments on the draft 35% design, input received during the sustainability workshop (see Section 5.1.2), and reconsideration of the potential for burial by dunes. The reduction in the substrate placement thickness also represents a significant cost reduction.

This chapter begins with a summary of the data, design assumption, and sustainability consideration refinements that occurred during the 35% design phase and informed the recommended plan (5.1). This summary is followed by a detailed discussion of the design considerations and features (5.2) and construction considerations (5.3) which form the basis of the 35% design. The construction considerations in Section 5.3 also include alternative placement methods, staging, and access. These sections are followed by implementation considerations for the recommended plan, including construction sequence and schedule (5.4), real estate requirements (5.5), implementation costs (5.6), final design considerations (5.7), and monitoring, adaptive management and operation and maintenance (5.8).

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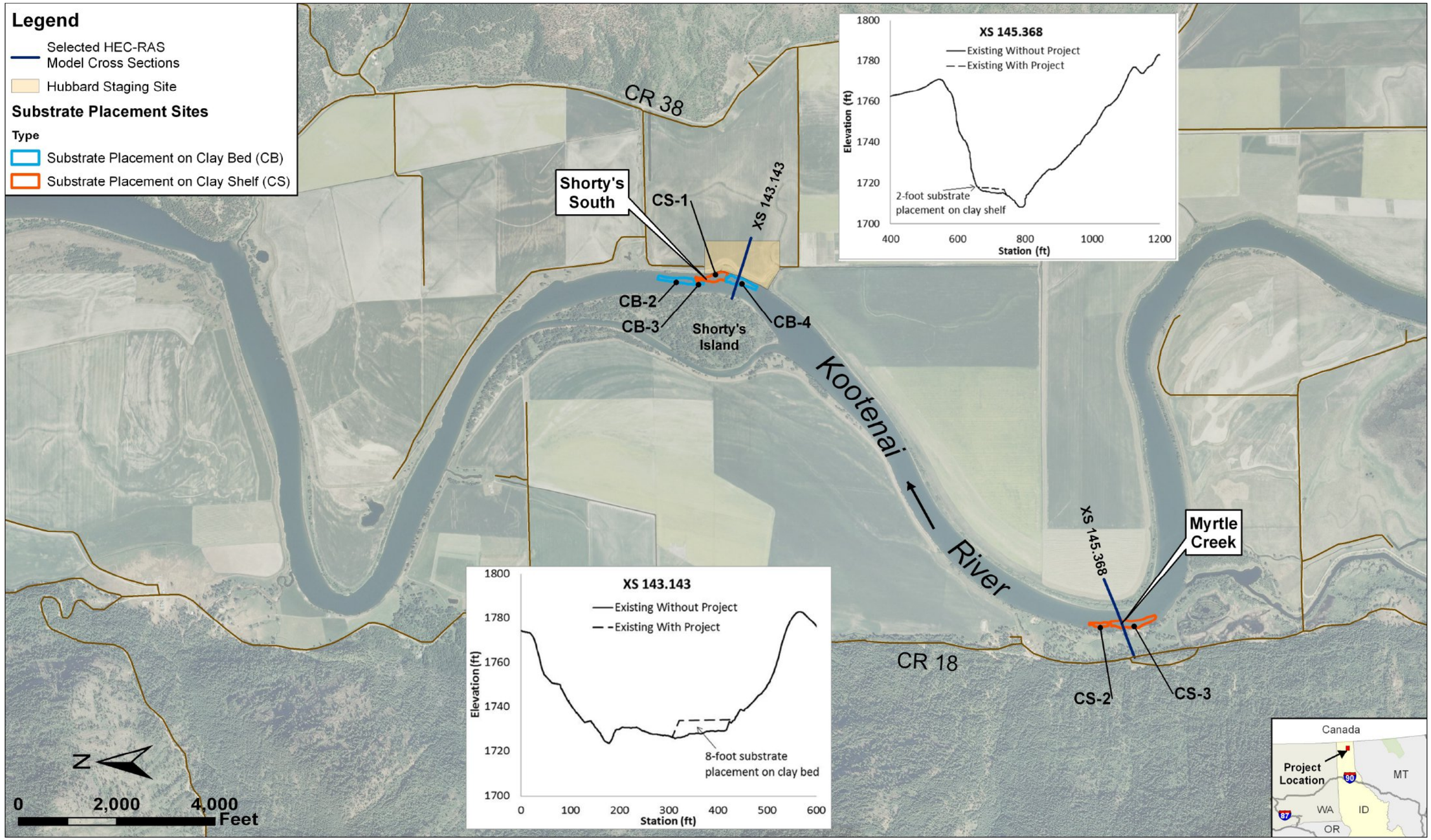

Figure 5-1. Overview of Recommended Plan: Substrate Placement Sites at Shorty's Island South and Myrtle Creek

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5.1 Refinements and Considerations for 35% Design of the Recommended Plan

5.1.1 Updated Facies Mapping and Egg Mat Data

Recently updated data from USGS and IDFG not available in earlier design phases were used to support the 35% design effort of the recommended plan. USGS updated the specific locations of the clay beds and clay shelves using extensive videography to inspect the condition of the bed and map the clay shelves with more accuracy and resolution. Updated facies maps were created (Appendix A) using the videography for the proposed project sites under consideration: Shorty's Island South, and Myrtle Creek. In 2011, IDFG and USGS also analyzed egg mat data collected between 2008 and 2011. Earlier data provided egg deposition data at 0.1-kilometer interval accuracy. The more recent egg mat data collection protocol allowed areas of KRWS egg deposition to be much more precisely located. Additionally, in the 2008 to 2011 data, egg mats which did not collect eggs were recorded in addition to mats that collected eggs. This allowed a much more complete assessment of the optimal locations to place substrate.

The alignments and shapes of the substrate placements in the recommended plan were adjusted based on the refined data. The adjustments caused minor changes to the precise locations, lengths, widths, and effective areas of each element of the plan.

5.1.2 Sustainability Workshop and Design Revisions

A sustainability workshop was held to address uncertainty related to how the substrate placements would perform their intended purpose over the 50-year project period. Following development of the initial (draft) 35% design and associated supporting analysis, uncertainty remained as to the sustainability of the proposed placements without significant maintenance. Although considerable hydraulic analysis was performed—including two-dimensional hydraulic modeling and evaluation of historical sand-dune bed-form movement in the area of the proposed substrate placements to support the 35% design effort—questions still remained related to the long-term ability of the placed substrate to remain sufficiently free of sediment deposition to support both egg attachment to clean substrate surfaces and free-embryo hiding within open (sediment free) interstitial spaces.

The primary source of uncertainty was whether sand would accumulate on and within the placed substrate to the extent that the egg attachment and free-embryo hiding functions would be negated. This concern arises since the placed substrate would have a median diameter (D_{50}) in the range of 80 to 110 mm (three to four inches), whereas the maximum bed material size mobilized in the areas of the placements range from two to four mm for typical spawning period flows and up to six mm for the 100-year peak flow. Since the flows would not mobilize the placed substrate, sediment deposited within the substrate cannot be flushed from the substrate by mobilizing the substrate, the typical mechanism by which substrate is cleaned of deposited fines. To address this issue, a workshop was organized that brought together experts in the fields of hydraulics and sediment transport to address the issue of the sustainability of the placed substrate. The specific issues addressed were (1) filling of interstitial spaces, (2) burial of the substrate by migrating dunes, and (3) the gradation of the substrate to maximize its sustainability. These issues were items that had been previously identified in the project risk register Appendix I.

The workshop was conducted on February 8 and 9, 2012, at the Seattle District USACE. National geomorphology, sedimentology, river engineering, hydraulics, and modeling subject matter experts were present to evaluate and report on the sustainability of the draft 35% design. The experts in attendance are listed in Table 5-1.

Table 5-1. Subject Matter Experts in Attendance at Sustainability Workshop, February 8 and 9, 2012

Subject Matter Expert	Affiliation	Position
Dr. Jon Nelson	USGS Geomorphology and Sediment Transport Laboratory , Golden, Colorado	Director
Rich McDonald	USGS Geomorphology and Sediment Transport Laboratory , Golden, Colorado	Hydrologist
Gary Barton	USGS	Hydrologist/Geophysicist and Kootenai River sediment researcher
Sean Welch	BPA	Program Engineer
Dr. Stanford Gibson	USACE Institute of Water Resources; Hydraulic Engineering Center (HEC), Davis, California	HEC-RAS Team Sediment Specialist
Karl Eriksen	USACE Seattle District	Senior Hydraulic/River Engineer
Bill Fullerton	Tetra Tech and consultant to USACE and Kootenai Tribe for Shorty's Island/Meander Reach Restoration Project design	Discipline Leader: Hydrology, Hydraulics and Sediment Transport
Matt Daniels	River Design Group and consultant to USACE and Kootenai Tribe for Shorty's Island/Meander Reach Restoration Project design	Principal and Senior Water Resources Engineer
Mitch Price	River Design Group and consultant to USACE and Kootenai Tribe for Shorty's Island/Meander Reach Restoration Project design	Senior Water Resources Engineer

Notes: BPA – Bonneville Power Administration, USACE – U.S. Army Corps of Engineers, USGS – U.S. Geological Survey

Based on input received at the workshop, the substrate thickness at the clay bed locations was reduced to two feet. It was agreed that any potential changes to substrate gradation would be assessed during final design. The ability to maintain interstitial spaces over the project period remains an area of uncertainty that can best be addressed through post-project monitoring and an adaptive management approach. The overall benefits of the substrate placements to address early life stage survival must be weighed against these uncertainties. Additional discussion of the workshop results for each of the areas of uncertainty and recommendations to reduce or address the level of uncertainty for the project are further described in Section 5.2.

5.2 Substrate Design Considerations and Features

This section describes the design considerations that were used to advance the conceptual (10%) design presented in Chapter 4 to the 35% design level. It also presents a summary of the characteristics of the placement sites that were developed during 35% design and refinements to the design based on the sustainability workshop.

5.2.1 Physical Characteristics of Suitable Substrate Placements

The following section considers the actual physical characteristics of the substrate placement, including location of substrate placement, mobilization of substrate, suitable substrate gradation, layout, substrate placement thickness, depths at which to place substrate, potential floodplain impacts, and sustainability considerations. Placement methodology is addressed as part of the construction approach (see Section 5.3).

5.2.1.1 LOCATION OF SUBSTRATE PLACEMENTS IN CURRENT SPAWNING LOCATIONS AND TO MINIMIZE SAND DEPOSITION

Criteria used to identify locations for suitable substrate placement included (1) areas where KRWS are known to spawn, and (2) areas where substrate will be least likely to be compromised by deposition of sand. Two suitable placement area types were identified: clay beds, and clay shelves.

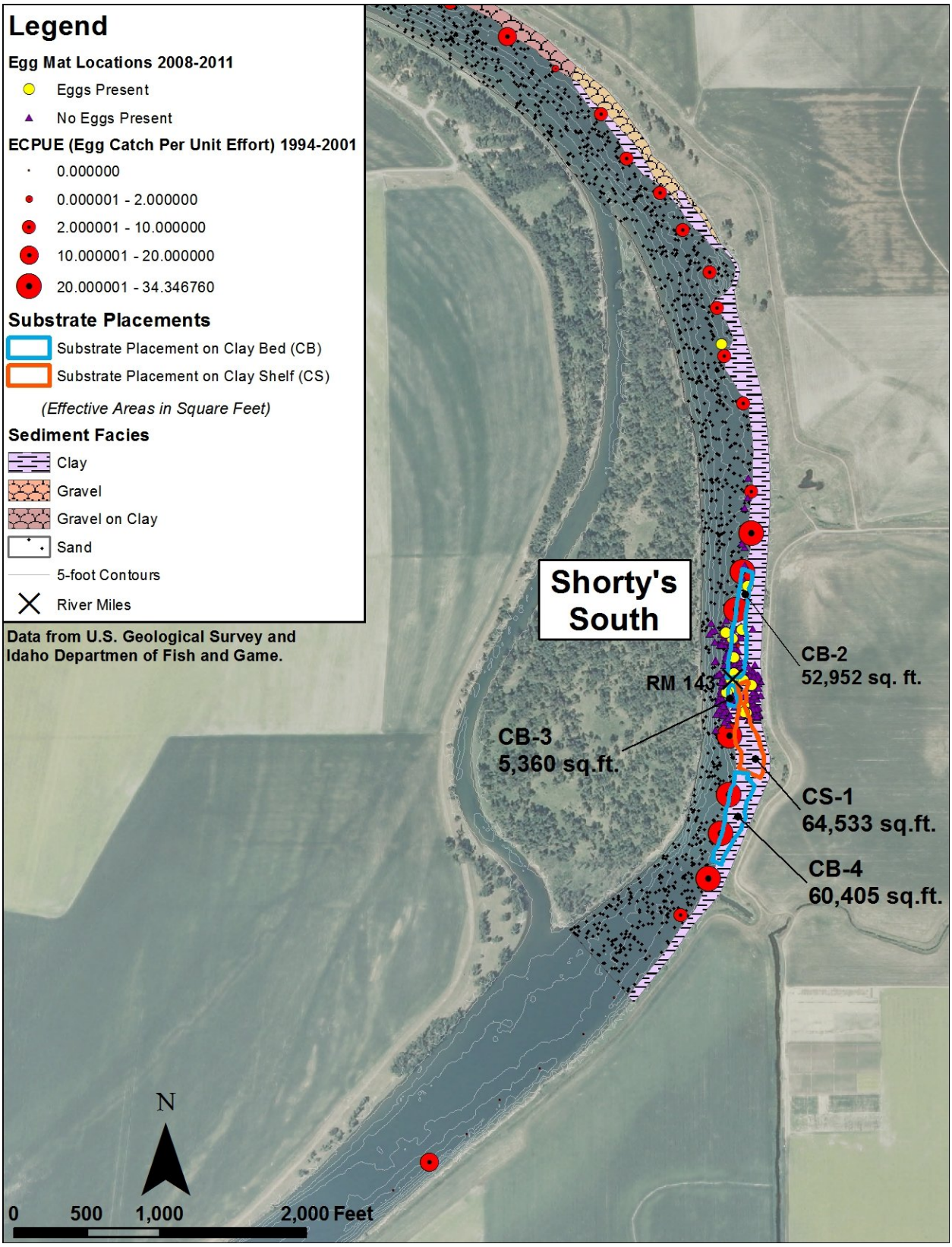
Current Spawning Locations

Results of collecting KRWS eggs on mats placed in the Kootenai River by IDFG were used to identify areas where KRWS currently spawn. The vast majority of the eggs collected in the Shorty's Island South and Myrtle Creek sites during the 2008 to 2011 period in which egg collection mats were accurately located with geographical positioning system (GPS) were on the clay beds and clay shelves. Therefore, these sites were prioritized not only because spawning is occurring in these areas but also due to the much higher potential for sustainability on the clay features compared to the sand bed areas. Areas that have been scoured down to the clay bed have little sediment traveling as bed load or suspended load and do not have large sand dunes moving through the area. Clay beds also have the advantage of providing a firm foundation to support the placement of the substrate. (Appendix A presents maps with the egg mat data from 1994 through 2001 and 2008 through 2011 and the 2011 facies mapping).

In some areas, the river has carved a series of steps (steep to nearly vertical slopes) and shelves (relatively flat areas) into the clay bed. As a result, there are flat areas on which substrate can be placed. These clay shelves lie above the channel thalweg outside of areas with greater sand transport. The potential to place substrate on clay shelves was identified during the conceptual design phase, though the extent of existing clay shelves was difficult to determine and only limited areas had been identified. As discussed in Section 5.1, USGS conducted extensive videography to inspect the condition of the bed and map the clay shelves with more accuracy and resolution during the 35% design phase. Updated facies maps were created using the videography for the three proposed project sites still under consideration at the beginning of 35% design: Shorty's Island North, Shorty's Island South, and Myrtle Creek. Because the clay shelves are located higher in the water column than the clay bed, suspended sediment transport is likely to be lower than over the clay beds. This makes the clay shelves likely the placement locations with the highest level of sustainability.

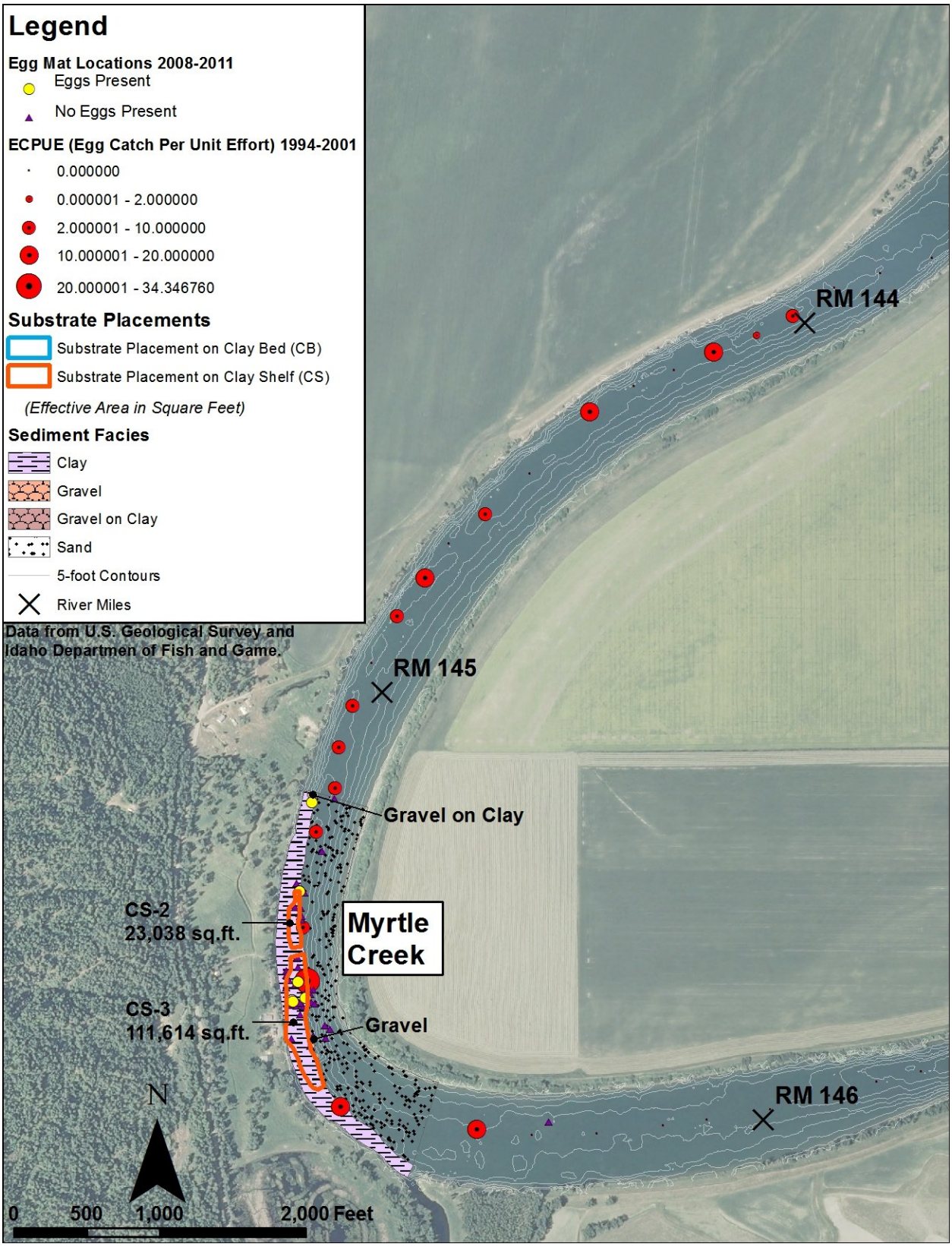
In 2011, IDFG and USGS analyzed recent egg mat data collected between 2008 and 2011. Earlier data provided egg deposition data at 0.1-kilometer interval accuracy. The more recent egg mat data collection protocol allowed areas of KRWS egg deposition to be much more precisely located as well as track locations at which marts did not collect eggs as well as where they did collect eggs.

Figure 5-2 and Figure 5-3 provide the revised facies mapping showing the locations of the clay beds and clay shelves for Shorty's Island South and Myrtle Creek, as well as both the original (aggregated at nearest 0.1 km intervals) and more recent egg mat data (individual mats with positive and negative egg catch accurately located by GPS). The location of the proposed substrate placements are also outlined in these figures and include both placement on clay beds, designated as CB-1 through CB-4, and clay shelves, designated as CS-1 through CS-3. To the extent allowable by topography and the general locations identified by the CE/ICA analysis, the substrate placement was located where more precise data showed that egg deposition occurred on the collection mats and clay beds or clay shelves were exposed.



Source: IDFG and USGS 2011

Figure 5-2. Updated Facies Map and Egg Mat Data for Shorty's Island South



Source: IDFG and USGS, 2011

Figure 5-3. Updated Facies Map and Egg Mat Data for Myrtle Creek

As previously mentioned, two types of egg mat data are displayed in Figures 5-2 and 5-3. The differences are based on the methodology used to locate the egg mats and the information recorded. In the earlier data set, 1994 to 2001, the locations shown for the ECPUE are aggregated at 0.1 RK. Markers were placed in the channel and each collection mat was associated with the closest RK marker. The number of eggs collected along with the number of mats and time period during which the mats were placed were used to calculate ECPUE for each 0.1 RK interval. In the more recent data, 2001 to 2011, the location of individual mats was determined using GPS. Both mats with eggs collected and mats with no eggs collected were recorded to better identify where eggs were actually being deposited. The more recent data with GPS locations identifying mats with and without eggs collected was extremely useful for designing the substrate placements.

Sand Deposition

Whether the surface of the substrate placement would be relatively free of sand during KRWS spawning and early life stage periods was an area of uncertainty evaluated during the 35% design phase. The upper surface of the substrate must be free of fines to allow KRWS egg attachment. Design considerations were adopted and analyses were conducted to address the ability of the substrate to remain relatively free of sand during the critical periods for use by KRWS.

Based on data collected and research conducted by USGS, the sand dunes that are present across much of the Kootenai River and are thought to hinder KRWS spawning success do not persist in the areas of exposed clay beds and clay shelves. Bathymetry from 2008 and 2010 shows these areas were free of large dune beds. Additionally, detailed close-up videography of beds taken by USGS in 2010 and 2011 reveals very little bed load moving across clay beds. As a result, these exposed clay beds and clay shelves were selected for the location of substrate placements and are anticipated to provide a substrate with minimal sand transport or deposition, thereby increasing the functional life of the material.

USGS FaSTMECH modeling confirmed that the proposed substrate placements were located in areas where the capacity to transport sediment t is high as compared to surrounding areas; indicating that sediments would tend to be scoured from these areas Modeling also suggests that the ability of river flows to suspend sand-sized sediment (0.2 mm to 0.25 mm) is low at flows up to 50,000 cfs (the highest flow modeled). This size range is approximately the median diameter of the existing bed material, thus the modeling suggests that the typical sand-sized or fine bed material will not be transported in suspension in significant quantities, even at the highest flows. More details about the USGS two-dimensional modeling performed and the results are presented in Appendix E.

After reviewing information concerning the hydraulics, sediment transport conditions, facies mapping in the areas of proposed substrate placements, and video of the bed during spring flows (supplied by USGS), the experts at the February 2012 workshop agreed that the exposed substrate surfaces would remain sufficiently free of sedimentation during the spawning season and allow appropriate surfaces for egg attachment. It was the opinion of many at the workshop, that the configuration of the river bed in the areas of the proposed substrate placements results in the dunes (which occur at other locations) being dissipated and/or directed around the clay beds; thus minimizing the potential for burial by dunes.

5.2.1.2 SUBSTRATE GRADATION

The gradation of the suitable substrate to be placed was developed from the work presented in Section 4.5.1.1 concerning the optimum substrate for egg attachment and free-embryo cover. A gradation curve was developed that matched the characteristics of the optimum substrate and allowed for a reasonable range in the gradation to make it practical for an aggregate supplier to meet the specifications (see Figure 4-12) as part of the conceptual design.

As part of the discussion at the February sustainability workshop about the potential for maximizing the depth of interstitial spaces and maximizing the area available for free-embryo hiding, the question was posed whether increasing the D_{90} (the D_{90} represents the material size that 90 percent of the material in the gradation in finer than and represents the largest 10 percent of the material present) of the substrate would also increase the depth and amount of hiding space. This question was based on the logic that the flow should be sufficient to clean the placed substrate to a D_{90} of approximately 0.5. Consensus could not be reached on this topic as several attendees felt that there must be a limit to how deep the flow could clean sediment down to half of the D_{90}. This debate about a limit is part of the reason there was not consensus on the ability of the flow to clean fine sediments from the interstitial space down to a depth of four to six inches. Further, if the substrate gradation were modified then biologists would need to be consulted to ensure that the substrate would still provide the range of substrate sizes best suited to provide egg attachment and free-embryo interstitial hiding spaces.

Based on insufficient justification to modify the substrate gradation, the 35% design reflects the gradation curve used in the conceptual design. This aspect of the design may be revised during final design.

5.2.1.3 MOBILIZATION OF SUBSTRATE

There is no naturally occurring supply to replenish the placed material if it is moved by the flow; therefore, placed substrate must be designed such that it will not be mobilized by the flow. Incipient motion calculations were conducted to determine the maximum substrate size mobilized at various high flows (see Appendix E). The results for the incipient motion calculations were very similar for each of the sites considered for the initial 35% design. The results of the calculations show the following maximum-sized particles mobilized on the top of the substrate placement for flows ranging from the typical spawning season flow to the 100-year flood peak.

<u>Substrate Incipient Motion for the Top of the Placement</u>

- 27,810 cfs maximum substrate moving is 5 mm (0.20 inches).
- 45,500 cfs maximum substrate size moving is 5 mm (0.20 inches).
- 65,000 cfs maximum substrate size moving is 6 mm (0.24 inches).

Since particles are more easily mobilized on a slope, the maximum size of substrate mobilized on the 2:1 side slopes at the edge of the substrate placement was also determined.

<u>Substrate Incipient Motion for the 2:1 Side Slopes of the Placement</u>

- 27,810 cfs maximum substrate moving is 16 mm (0.63 inches).
- 45,000 cfs maximum substrate size moving is 17 mm (0.67 inches).
- 65,000 cfs maximum substrate size moving is 21 mm (0.83 inches).

In the most severe case, the 65,000 cfs 100-year peak flow, the largest size of material that can be moved from the side slope is 21 mm. This represents approximately five to 15 percent of the surface material within the allowable limits of the substrate distribution. Minor amounts of the material would be removed from the substrate at peak flows and may be beneficial in flushing fine sediments from the substrate.

To summarize, the analysis showed that the placed substrates will remain stable and will not be washed downstream, even by large floods such as the 1-percent chance exceedance event (100-year).

5.2.1.4 SUBSTRATE PLACEMENT GEOMETRY

The primary geometric aspects of the substrate placements considered were thickness, width, and length. The top slope and maximum elevation of the substrate placements were also considered.

Thickness of Substrate Placement on Clay Beds and Clay Shelves

In the conceptual design, the thickness or height of the substrate placement on clays beds was eight feet. This thickness was established to satisfy two considerations. The first consideration was to elevate the river bed to an elevation sufficient enough to prevent the top layer of the substrate from being inundated by sand dunes. Review of bathymetric information collected by USGS had suggested that the largest dunes were on the order of four to six feet high. The second consideration was to place the substrate at an elevation not so high that KRWS would avoid the areas or existing hydraulic conditions, which currently attract spawning KRWS to these areas, would be disrupted.

More detailed review of the bathymetry by USGS (see Appendix E) has confirmed that the largest dunes in Meander Reach 1 are on the order of four to six feet. The information also suggests that the dunes dissipate along the outside of river bends where the proposed substrate placement sites are located. Bathymetry taken in 2008 and 2010 shows that these sites are free of large bed forms. Review of the videography collected in 2010 and 2011 also confirmed that the clay beds did not have dunes and had experienced little bed load transport.

USGS used its FaSTMECH two-dimensional hydraulic model to evaluate the effect of the originally proposed eight-foot-high placements on local hydraulics. The modeling effort, detailed in Appendix E, showed that the substrate placements had little effect on local water velocities, size of bed material mobilized, or maximum size of sediment suspended.

As part of the sustainability workshop participants were asked whether it was necessary to place the eight-foot-thick substrate on the clay beds. This question was posed since comments on the initial 35% design indicated that some reviewers thought the substrate placements were overdesigned. The workshop attendees agreed that the substrate placement on the clay beds could be reduced to two feet thick, similar to the substrate placement on the clay shelves, without increasing the potential for burial by sand.

Placement of substrate on clay shelves since the conceptual design phase has been proposed at a thickness of two-feet. Since the clay shelves are elevated above the channel thalweg, three was never a concern for the potential burial of the substrate placed in these locations by dunes. The two-foot thickness was based on providing the maximum practical depth for use by the free-embryo.

Width of Substrate Placement

In the conceptual design phase, the minimum width of the clay beds investigated for substrate placement was set at approximately 35 feet. This dimension was chosen to provide areas where substrate could be efficiently placed.

For the 35% design, the objective of allowing maximum continuous substrate placement resulted in the reduction of minimum width criteria for substrate placement on clay beds. The narrowest width of placement on clay beds is CB-3 at Shorty's Island South where a portion of the placement has a width of 34 feet. The widest placement on clay bed is CB-2 at Shorty's Island South where a portion of the placement has a width of 134 feet.

On average, the width of the substrate placement on the four clay beds is 70 feet. For the clay shelves, the narrowest placement width is 30 feet at Myrtle Creek placement CS-2. The widest clay shelf placement is CS-1 at Shorty's Island South and has a maximum width of 146 feet. The average width for all three clay shelf placements is 82 feet.

Length of Substrate Placement

In the conceptual design phase, the length of contiguous substrate was an important consideration. The minimum length of substrate placement on clay beds was identified in 400-foot increments with the objective of creating continuous lengths of substrate placement on the order of 600 to 800 feet. A longer placement length makes it more likely that KRWS eggs will fall onto the suitable substrate and not drift downstream to areas of sand. Additionally, the longer lengths provide a greater distance for free-embryos to drift and still be perched over substrate that provides adequate cover.

By using the revised facies mapping and refining design based on detailed bathymetry, it was possible to increase the contiguous lengths of substrate placement from the conceptual design. The placement at Shorty's Island South is nearly 2,000 of contiguous substrate on a combination of clay beds and clay shelves. The placement at Myrtle Creek includes two placements, one at 308 feet and the larger at 910 feet of contiguous substrate. These two placements provide over 1,200 feet of nearly continuous substrate with only a minor break. The increase in area of the substrate placements on the clay shelves that occurred between the conceptual and 35% designs was possible due to the bathymetry and videography interpretation effort conducted by USGS.

Top Slope of Substrate Placement

In the conceptual design, which included the eight-foot-thick substrate placements on clay beds were sloped up to 10 percent to conform to the slope of the native substrate. During the draft 35% design phase this approach was reviewed and it was decided that the top of the substrate could be placed at a flat slope and does not need to maintain eight feet of thickness over the clay bed. With the reduction in placement to two-feet thick, the criteria used for the current design considers achieving a minimum thickness of approximately two feet and keeping the slope at 10 percent or less. Figure 5-4 shows the conceptual design and current 35% design approaches to handling the placement of substrate over a sloping clay bed.

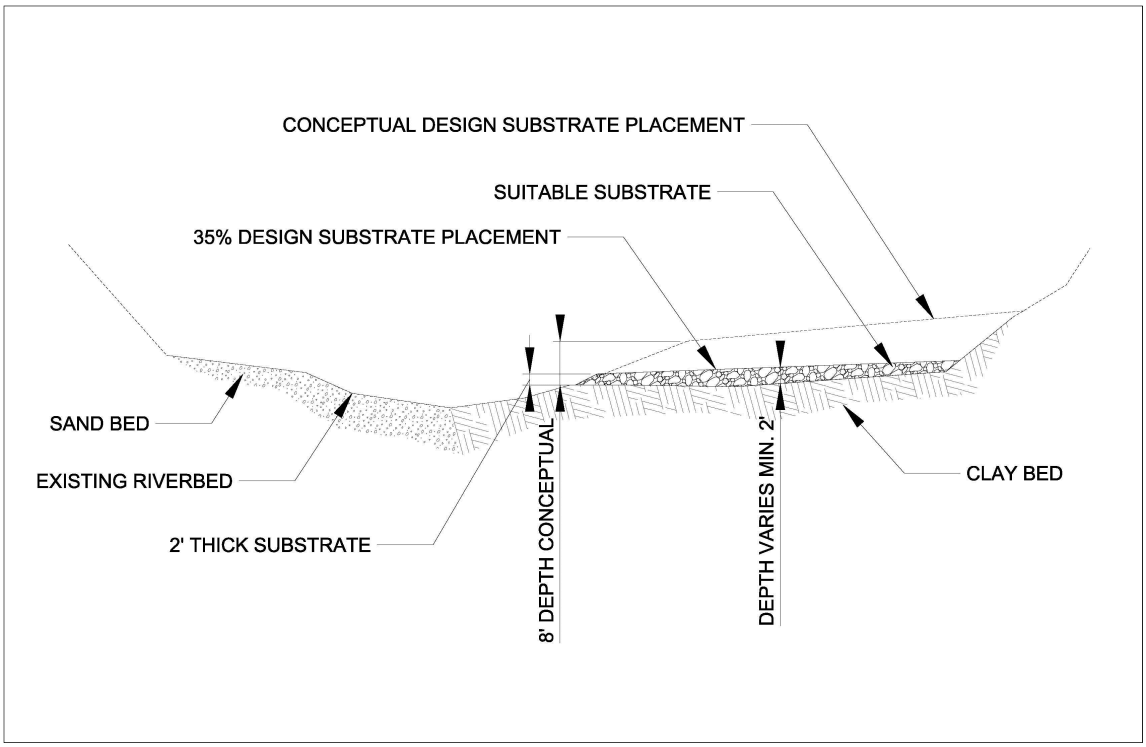


Figure 5-4. Illustration of Approaches Applied for Substrate Placement on Clay Beds for the Conceptual and 35% Designs

Maximum Elevations for Substrate Placement

Two criteria were established to determine the highest elevation that the substrate placements can extend into the water column, both driven by water surface elevations. The first criterion involved maintaining a minimum depth over the substrate relative to the water surface identified for the typical spawning flow. A depth of 16 feet or greater over the placed substrate provides the optimal HSI depth value of approximately 1. Therefore, for substrate placement a minimum depth was set at 15 feet below the modeled 27,810 cfs water surface elevation. Placing the substrate in deeper areas of the channel also optimizes the use of higher velocity areas of the channel where the higher velocities and complex hydraulics occur that serve to attract KRWS for spawning. The second criterion was to maintain a minimum water depth of three feet over the substrate placement to prevent the substrate from creating a navigation hazard. To identify this elevation, a low flow of 5,052 cfs with a low water surface elevation at Porthill was modeled. Further discussion of the hydraulic analyses associated with the determination of these elevations is provided in Appendix E. The two depth criteria are illustrated in Figure 5-5.

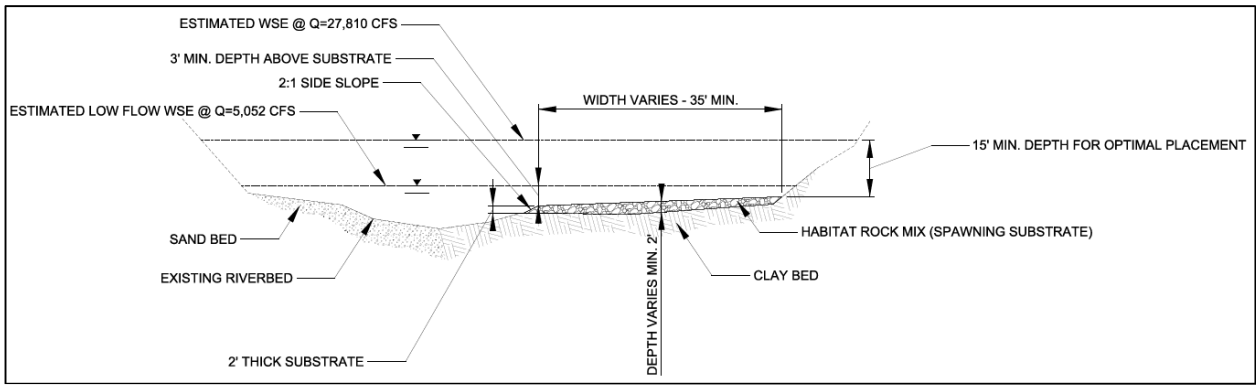


Figure 5-5. Illustration of Depth Criteria Used to Establish Maximum Substrate Placement Elevations for a Typical Two-Foot Thick Clay Shelf Placement

5.2.1.5 BOULDER PLACEMENT

The conceptual design included placement of boulders to create hydraulic complexity and possibly create additional turbulence to scour sand from the placed substrate. Increased hydraulic complexity could benefit KRWS egg deposition and early life stage survival by providing refugia from predators and possibly by scouring fine materials from substrate. During the 35% design phase it was decided to eliminate the boulders placed on top of the substrate from the design.

Although boulders would increase the scouring in areas of flow acceleration around the boulders, they would also create shadows of lower velocity that would be prone to sand deposition. There was also some concern that the boulders would increase roughness and result in less flow over the areas of placed substrate. This alteration to the physical bed could have an overall detrimental effect on the hydraulic conditions that currently attract KRWS to the area and help maintain the clay free of sand.

Furthermore, clay beds and shelves have their own inherent hydraulic complexity due to being located in bends and as a result of the irregular bathymetry resulting from differential erosion of the clay beds. Therefore, there is no need to create additional hydraulic complexity by adding boulders. Review of the videography showed areas where "clay balls" lie on the bed, similar to gravel and cobbles. The areas where clay balls were observed were relatively free of sand and fine sediments, thus indicating the propensity in the area for not only relatively smooth clay beds free of sand, but also areas of clay balls mostly free of sand.

Including the initially proposed two-to-four-foot-diameter boulders would also complicate construction. Boulders greater than 24 inches would be too large to transport to the barge via the conveyor belt and would require being placed on the barge by a loader. Use of the loader would require a larger pad at the loading dock and additional encroachment into the existing agricultural levee along the left bank. Additional discussion about construction considerations is provided in Sections 5.3 and 5.4.

It should be noted that the specific substrate for placement does contain large material that is in the boulder range. This is the portion of the distribution that falls in the 256-mm (10-inch) to 512-mm (20-inch) range. Therefore, the placed substrate will have some boulder-sized material placed as part of the substrate matrix, but not as individual boulders placed on top of the substrate.

5.2.1.6 IMPACT OF SUBSTRATE PLACEMENT ON FLOOD ELEVATIONS

Since the recommended plan involves placement of material in the Kootenai River, the potential for increasing flood elevations was investigated. Water surface elevations during high flows is not only a concern associated with damage to or overtopping of levees, it is also a concern because high-water elevations can result in high groundwater levels and seepage that hinder adjacent agricultural operations and can damage crops.

To investigate the influence of the proposed substrate placements on water surface elevations during high flows, the HEC-RAS existing conditions without-project model was modified to reflect the cross-section geometry with substrate in place. A total of 23 cross sections were modified to account for substrate placement. The modifications were made at the time that the clay bed placemat thickness was set at eight feet. The HEC-RAS model was executed for three discharges that represented a range of high flows: a typical high flow during the spawning season (27,810 cfs), an intermediate high flow (45,000 cfs), and the 1-percent chance exceedance event (65,000 cfs) as defined by the FEMA Flood Insurance Study for Bonners Ferry (FEMA 1985).

The results of the high flow modeling showed no significant impact on flood elevations resulting from the proposed substrate placement. The largest increase in flood elevation was 0.01 feet just upstream of Shorty's Island South. Of the 89 cross sections modeled from Shorty's Island North upstream to Myrtle Creek, 28 showed no increase in water surface elevation and 61 increased 0.01 foot. Based on this information, the proposed substrate placement will have no perceptible influence on water surface elevations at high flows and consequently will not impact the levees, seepage or ground water elevations. Since these results are based on the larger eight-foot thick placements for the clay beds, they are actually a conservatively high estimate of the project effects since the thickness has been reduced to two feet.

5.2.1.7 SEDIMENTATION OF INTERSTITIAL SPACES

An additional area of uncertainty considered during project planning and the sustainability workshop is related to the ability of the proposed substrate placements to provide interstitial spaces sufficiently free of sediment for free-embryo cover. After reviewing and discussing the information presented at the February workshop and additional background research and expert knowledge, there was no consensus regarding this issue. The experts agreed that the deepest (lowest) portions of the placements would eventually fill with sand; however, there was disagreement about the likelihood and extent to which a portion of the surface (on the order of 0.5 D_{90} [4 to 6 inches] identified as a biological requirement corresponding to a D_{90} of 8 to 12 inches) would remain sufficiently free of sediment to support free-embryo hiding.

Some experts felt that further analysis could reduce the level of uncertainty about future sedimentation. However most felt that if this remaining area of uncertainty was unacceptable, then the means with the highest certainty to address the concern would be to actually place a test or pilot substrate placement and

monitor sedimentation. Monitoring the sedimentation could then be used to assess the extent to which the flow will maintain interstitial spaces relatively free of sediment. The recommendations from the workshop on steps to reduce uncertainty concerning the sustainability of interstitial spaces in the proposed substrate placements are listed below:

- Place a small plot of suitable substrate and monitor it for sedimentation. The test plot would be small enough that special barges or other equipment would not be required. The possibility of lowering a pre-constructed test box with substrate was brought up, but some thought lowering the test box to the bed would be problematic.
- Place a reduced size substrate project that could be referred to as a pilot project and monitor it for sedimentation as well as collection of egg mat data. This would be larger than the previously mentioned test plot and would likely require special equipment, but not the large scale operation required for the full project identified in the 35% design.
- Calculate the time to fill emplaced sediment up to 0.5 D_{90} based on existing suspended sediment data and possibly local measurements (point samples near the bed) of suspended sediment concentrations. This would provide an estimate of the project life even if the flow did not scour the upper 0.5 D_{90} free of fines. It might be possible to use USGS acoustic survey data to provide additional estimates of suspended sediment load.
- Revisit USGS videography to extract stills for evidence of sediment on existing "clay balls" (worn clay rubble) and gravels or lack thereof.
- Conduct literature search for additional methods for analyzing the ability for flow to maintain interstitial space free of sediment.
- Investigate whether modifying the gradation of the placed substrate would increase the depth of substrate free of sediment in the interstitial space.

Another approach to addressing the sustainability issue would be to implement the full project and adopt an adaptive management approach that not only includes monitoring of substrate placement, but also includes provisions for identifying and performing various maintenance procedures for removing or reducing the effects of sedimentation on the substrate. This approach would put a higher amount of substrate at risk if concerns over sedimentation proved valid and maintenance was not economically feasible. However, it has the advantage of not waiting to construct a large scale project and risk further decline in the adult population of the KRWS. Maintenance, monitoring and adaptive management are further discussed in Section 5.8.

5.2.2 Summary of Substrate Placement Characteristics and Locations

The following section summarizes the substrate placement characteristics at the Shorty's Island South and Myrtle Creek sites based on the final 35% design analysis and sustainability considerations.

5.2.2.1 Shorty's Island South (Sheets V-102, V-103, C-102, and C-103)

Shorty's Island South placements are located in the main channel east of Shorty's Island between RM 143 and RM 143.5. Placements at this location provide for a total of 183,537 square feet of effective area, of which 119,065 square feet is placement on clay beds and 64,472 square feet is placement on clay shelves. There are three thalweg placements and 1 shelf placement in this area for 2,133 linear feet total of substrate placement. The total volume at this site is 12,300 cubic yards. The resulting ratio of effective area to placement volume is 14.9 square feet to 1 cubic yard. Table 5-2 summarizes the Shorty's Island South placement characteristics.

All clay bed placements occur at the Shorty's Island South site. Substrate placements on clay beds have a two-foot depth adjacent to the channel thalweg. The depth of the substrate varies through the rest of the section depending on the river bed bathymetry. The intent of the design is to provide a minimum two-foot

depth closest to the thalweg of the river. The substrate placement sections are designed with to maintain a two-foot minimum thickness and follow the configuration of the bed, sloping up to a maximum of 10 percent until the intersection with a steep portion of the river bed or bank as previously shown in Figure 5-4.

5.2.2.2 MYRTLE CREEK (SHEETS V-101 AND C-101)

The Myrtle Creek substrate placements are located approximately 1,000 feet downstream of the Myrtle Creek confluence with the Kootenai River at RM 145.5. The substrate placements at this site provide 104,503 square feet of effective area. The Myrtle Creek placements include clay shelf placements with an average depth of two feet for a total of 1,218 linear feet and a volume of 8,400 cubic yards. The ratio of effective area to placement volume is 12.4 square feet to 1 cubic yard. Table 5-2 summarizes the Myrtle Creek placement characteristics.

Table 5-2. Characteristics of Substrate Placements at Shorty's Island South and Myrtle Creek

Placement Site	Station (D/S to U/S)	Type	ID	Length (feet)[1]	Min/Avg/ Max Effective Width (feet)[2]	Effective Area (square feet)	Volume (cubic yards)	Ratio of Effective Area (square feet) to Volume Substrate (cubic yards)
Shorty's Island South	7555+ 80 to 7563+50	Bed	CB-2	740	47/69/100	51,407	3,300	15.6
Shorty's Island South	7564+00 to 7565+50	Bed	CB-3	140	34/38/65	5,651	300	18.8
Shorty's Island South	7564+50 to 7570+00	Shelf	CS-1	623	43/104/146	64,472	4,500	14.3
Shorty's Island South	7570+00 to 7575+00	Bed	CB-4	630	57/97/138	62,007	4,200	14.7
Myrtle Creek	7673+00 to 7676+00	Shelf	CS-2	308	41/51/68	15,489	1,100	14.1
Myrtle Creek	7677+00 to 7685+00	Shelf	CS-3	910	53/88/134	89,014	7,300	12.2
Total	**-**	**-**	**-**	**3,351**	**-**	**288,040**	**20,700**	**-**

Notes: D/S – downstream, U/S - upstream

[1] Station distance may not match length as the station line of the river and the centerline of the substrate are not parallel in all placements.

[2] Effective width is defined as the substrate area useable for spawning which is the top of the substrate placement and does not include the width of the 2:1 side slope.

5.2.2.3 COMPARISON FROM CONCEPTUAL TO 35% DESIGN

As shown in Table 5-3, the total length of placement in the recommended plan is very similar between the 10% and 35% design phases. The increase in effective area is attributable to increased width available for placement as identified by the revised facies mapping developed by USGS based on extensive review of recent videography.

Table 5-3. Comparison of Conceptual 10% and 35% Design Placement Locations, Lengths, and Areas

Phase	Site	Station Range		Length (feet)	Effective Area (square feet)
10%	Shorty's Island South	7554+50	7578+50	2,100	177,460
	Myrtle Creek	7672+50	7685+50	1,300	62,000
	TOTAL	**-**	**-**	**3,400**	**239,460**
35%	Shorty's Island South	7555+80	7575+00	2,133	183,537
	Myrtle Creek	7673+00	7685+00	1,218	104,503
	TOTAL	**-**	**-**	**3,351**	**288,040**

5.3 CONSTRUCTION APPROACH

The following section outlines the construction approach, including placement method, placement equipment, infrastructure and operation, material staging location and access, and construction sequencing. This information was required to design the staging and access components and to support the development of the feasibility level cost estimate of the tentatively recommended plan.

5.3.1 EVALUATION AND SELECTION OF PLACEMENT METHOD

Both shore-based and river-based methods were considered for installation of the substrate placements. Shore–based placement options considered included placement by excavator, crane, and "rock-shot" vehicle. The river-based placement option considered included the use of barges to transport and deliver substrate.

5.3.1.1 PLACEMENT BY EXCAVATOR

Crane and excavator placement both have reach limitations and could only place 5 to 15 percent of the material identified in the 35% design. The 35% design placements generally begin from 60 to 80 feet from the edge of water and extend into the river between 140 and 200 feet. The existing levee crown road is the best and most expedient access parallel to the river but generally lies 50 to 100 feet landward from the edge of water. A normal reach for a large excavator would be between 30 to 40 feet. A long-reach excavator may provide up to 70 feet of horizontal reach. This precludes excavator use from the levee since none of the material placement sites could be fully reached from the levee crown. The excavator placement method would require that the material fall through the water column which is not preferred due to material sorting and layering by size. There would also likely be significant costs to prevent negative impacts to water quality associated either with use of washed material or implementation of turbidity curtains.

5.3.1.2 PLACEMENT BY CRANE

A 500-ton crane has approximately a six cubic yard volume capacity to reach 200 feet with a minimum track width of 30 feet and boom in excess of 230 feet. A crane of this size under these lift parameters would operate relatively slowly, perhaps moving six cubic yards every three to four minutes when stationary. It would only be possible to place on the order of 40 percent of the project from the levee crown with a crane of this size. Additionally, access roads would require a width of 35 feet and improvements to support the weight of the crane. However, the crane would be able to place materials to depth, significantly reducing any issues with turbidity or water quality. An alternative to using the levee crown as the base for crane operations would be to construct a suitable access road along the shoreline. The pad would be constructed of substrate material which would support the crane and serve as the source of material in the adjacent placement. Working backwards, the crane would travel along the access road and relocate the substrate into the water column. However, bathymetric conditions at the shoreline and the width and depth of the river make constructing a temporary in-water access road at the shoreline an impractical solution.

5.3.1.3 PLACEMENT BY ROCK-SHOT VEHICLE

The rock-shot vehicle is a modified haul truck capable of delivering material up to six inches in diameter up to a distance of 180 feet by high-speed conveyor. Given its projection of materials through the air, the rock-shot vehicle could potentially reach 30 to 40 percent of the recommended project placement area. However, the rock-shot vehicle would be unable to deliver materials over a size of six inches in diameter. Furthermore, the delivery method precludes sorting of sizes needed for adequate function of the substrate and would result in issues with water quality.

5.3.1.4 RIVER-BASED PLACEMENT FROM BARGES

River-based placement would involve barges to transport material to the placement sites and to serve as a platform for placement equipment. Since the site is remote, modular barges that could be transported to the site by land would be required. Modular barges would be delivered by truck and assembled on site. Barges would then support a marine crawler-crane to place material and transport material to the placement sites. Tugs would be used to move the crane and material barges between the staging and placement sites. This river-based option allows the entire recommended project to be completed from the river. The mobilization costs associated with the modular barges and tugs are high, but significantly less than the ancillary, support, material handling, and mobilizations costs associated with shore-based placement options.

5.3.1.5 SELECTION AND DESCRIPTION RIVER BASED PLACEMENT OF SUBSTRATE MATERIAL

Given the inability to construct the entire project from land and the costs associated with all land based options, a river-based placement method is preferred and has been used to estimate costs and to establish operational criteria for the recommended plan. The considerations discussed below were used to further develop the equipment and facilities requirements for the river-based placement of the substrate material.

Material barges should not be larger in any dimension than half of the narrowest river width where the barge is expected to travel. This restriction is both to ensure that barge traffic does not pose a navigation hazard or impediment to other river traffic and to allow the barges to be turned if necessary. Based on the minimum river width in the project area of 320 feet, the maximum barge dimension would be 160 feet. For development of the cost estimate, the barges are Flexi-float Series 70 with seven-foot-deep modules. Material barge sizing was based on the necessity of maintaining nearly continuous crane placement operation and the distance from the likely staging site to the furthest substrate placement site. To maintain productivity of the crane, the material barge is sized to carry a material volume slightly in excess of what the crane can place during a material barge cycle from the furthest placement area to staging area dock and back again. Given the maximum barge length of 160 feet and the importance of to maintaining continuous substrate placement operation, the material staging site should not be further than 2.5 river miles from the furthest placement location.

It is assumed that modular barge decks will be of insufficient thickness to withstand the impacts of a large clamshell bucket so a plate-steel barge cover will be necessary. Additionally, in order to maximize the volume carried by the barges inside a minimal footprint it is assumed that "box" containment for the substrate will be constructed on the material barges. For the cost estimate the box is made of stacked concrete blocks (six feet high). Assuming that the maximum distance to be traveled from the staging site to the furthest placement is 2.5 miles, the material barges should be roughly 80 by 160 feet with a material-isolation area in the middle. This preliminary barge design is capable of transporting approximately 650 cubic yards of material per cycle with a five-foot draft.

The crane barge is sized based on overturning moment calculations performed by the modular barge manufacturer, assuming that the crane size necessary to place the material is a 150-ton maximum lift with a 100-foot boom. The preliminary crane barge is estimated to require a surface area of approximately 40 by 100 feet with the crane in the center.

Given the high cost of mobilization for barges and the relatively high cost of leasing or renting barges, the in-water work is assumed to take place during 1 construction season and within the in-water work window (August 1 through November 30). Due to the limited availability of local source material that can meet the substrate placement material gradation and quality specifications, as well as the limited timeframe for substrate placement, placement material must be staged at the staging site prior to the beginning of the in-water work window. Substrate material may need to be staged several months to a year prior to the placement operation so that traffic impacts to the community or the agricultural industry can be reduced. Therefore, the staging area needs to have adequate capacity to stockpile the majority of materials prior to commencing placement. Timing is also a consideration to minimize community disruption, with special sensitivity to the agricultural industry and trucking/haul traffic. The selected crane will be able to place the required material volume within a single season using a 16-hour-per-day swing-shift.

In order to avoid substrate placement material "separation" or sorting and layering by size, and to reduce turbidity in the river during placement operations, material will be placed near the river bottom. The crane would have a capacity to place approximately six cubic yards every two to 2.5 minutes with a clamshell and the material would be lowered to depth in order to minimize sorting by size and turbidity issues.

The crane-barge will be shuttled to the various sites along the river by a tug. Once positioned, the crane-barge will employ multi-directional anchoring winches to move itself locally at a site. Two material barges were determined to be sufficient to mobilize source material for crane placement, rotating back and forth to a single loading location. The barges will each be fitted with multi-directional anchoring systems to allow the barges to be stabilized at the crane-barge.

A material transfer operation will be located at the selected staging site. The staging area will be located no farther than 2.5 miles from any of the three project sites. The operation will need to have the ability to load the required volumes onto the material barge within a timeframe allowing the material barges to cycle within the project operational considerations outlined above to achieve placement of the entire tentatively recommended plan in a single in-water work window.

5.3.2 Shoreline Excavation (Sheets C-106, C-107, C-108, C-109)

To charge the material barges with a conveyor belt requires that they be docked as close to the shoreline as possible. In order to accomplish this and allow vehicular access to the barges, the bathymetry in the selected barge docking location needs to be nearly vertical down to at least elevation 1,744 feet. Since this bathymetry does not exist at the site some of the river bank must be excavated to allow the barge to dock.

The river area beneath the proposed material barge docking location and approximately 50 feet downstream and 35 feet upstream would be excavated to elevation 1,744 feet at a slope of 2:1. Extending the excavation upstream and downstream of the dock allows space for the barge and tug to approach and leave the dock. It may be necessary to have a second tug to assist with docking in this limited space. The excavation from the river to provide barge access is expected to yield approximately 2,500 cubic yards of material and to impact an in-water work area of approximately 0.71 acres.

5.3.3 Barge Loading Dock/Bulkhead (Sheets C-106, C-108, C-109)

The dock's purpose is to provide the closest possible access for material loading and vehicle access to the barges. The dock also provides a flat and stable surface for the crane to assemble the barges and for the crane to mount the barge. The dock is currently conceptualized as having a face (parallel to the river) of 30 feet and a top-operating elevation of 1,753 feet, which is approximately three feet above the mean water surface elevation expected during the in-water work window. This elevation will require side supports approximately 15 to 20 feet in length on both the upstream and downstream sides of the face to tie back into the bank slope.

The dock is expected to be composed of driven support piles (steel or vinyl) and sheet piling (vinyl) to contain fill/surface material. The sheet and support piles are expected to be driven to an estimated elevation of 1,729 feet with the dock face panels having nine vertical feet exposed and 16 feet buried for a total length of 24 feet. The dock sheet pilings are expected to be vibro-hammer driven in 36-inch sections resulting in roughly 25 piles driven (for a total of 70 linear bulkhead feet). Pile driving is expected to require no more than three days. Removal of the piles is expected to require no more than two days. The crane operating loads on the dock may require the additional support of dead-man anchor tie-backs, which have been included in the costs. The tie-backs will be a matter of temporary excavation under the access road and are not expected to require additional shoring or cause additional impacts.

The dock/bulkhead will be temporarily installed for project construction and the entire dock will be removed at the end of the project.

5.3.4 Material Transfer Equipment

The current transfer operation is conceptualized to reduce the time necessary to load a barge. The cycle time from the crane to the staging site and back is a critical cost driver: the longer the cycle time, the larger the material barges have to be to complete the project in a single in-water work window. As the barge size increases mobilization and operation costs escalate accordingly.

A conveyor system can meet the required loading rates and transfer approximately 1,000 tons of material per hour onto the barge within the tight confines of the site. As the conveyor on the land side must transfer material over the levee to the river, at least one conveyor-to-conveyor transfer will be required. Because the material needs to be delivered to the center of a barge with an 80-foot width, the conveyor delivering material to the barge is unsupported out over the water for a distance of approximately 50 feet. The conveyor support closest to the river is conceptualized as a temporary timber or steel support matrix with a connection apparatus.

In order to keep the conveyor transferring while a barge is docked, a hopper with a capacity of at least 30 cubic yards will be situated over the conveyor feed. Loaders will transport material from the pile into the hopper during material transfer. At least two loaders are likely required to feed the hopper. An excavator may be necessary to keep the hopper fed or functional.

5.3.5 Staging Site Evaluation and Selection

The staging site for this project must accommodate the entire volume of substrate to be used in the recommended plan. Recommended placement locations span approximately 3.2 river miles in length. In order to remain within 2.5 miles of any restoration site the staging site must be within the proposed project limits. Stored substrate should also be located to minimize local agricultural industry disruption and community impact to the degree possible.

Staging and storage sites must also allow access to the river without significant impact to levees. Locations with set-back levees are necessary in order to allow an access road to be graded from the levee

crown to the river edge completely on the river side of the levee. Additionally, the river-based placement operation requires material barges to be as close to the shoreline as possible to allow substrate materials and equipment to be transferred onto the material barge. The maximum likely barge draft is expected to be five feet. Assuming a water surface elevation of 1,750 feet for the in-water work window, the best bathymetric shore condition would be one where the river bank descends below the water line quickly to an elevation of at least 1,745 feet or lower.

The following is a summary of criteria considered for selection of on-site river-based staging sites and the areas where these conditions exist.

1. In order to ensure that the site and the material is protected from high-water conditions the material storage portion of the staging site must be located on the landward side of the levees.
2. Locations within the Meander and Straight reaches of the river from the Hwy 95 bridge to Fleming Creek offer access areas where levees were set back far enough to accomplish river access from the levee crown.
3. Locations where existing agricultural access roads or other existing accesses could be used to allow project staging without the need to develop new access alignments.
4. Locations within the recommended plan project limits.
5. If possible, the staging site should not be located within 0.25 miles of an existing residence to reduce impact and nuisance to the community and residences.
6. Locations with approximately 10.5 acres available are needed to accommodate material staging requirements.
7. Locations which provide existing river access or bathymetric conditions to suitably accommodate barge access.

5.3.5.1 CONSIDERATION OF COMMUNITY ACCESS ROADS

If a staging site is selected within close proximity to the proposed project site then it must be accessible by either County Road 38 (CR 38) on the east side of the Kootenai River or County Road 18 (CR 18) on the west side of the river (Figure 5-6).

County Road 18

CR 18 is the primary and most direct community collector providing access to the west side of the river between Bonners Ferry and Copeland. The most likely substrate material source pits are east of Bonners Ferry on both the north and south sides of the river (Figure 5-7). The most direct haul route to deliver material from these pits to a staging site would be to head west on Riverside Drive and north on CR 18 to the potential staging site. Riverside Drive is directly adjacent to City Hall and the city, county, and commercial center referred to as Bonners Ferry "City Center" (Figure 5-8).

County Road 38

CR 38 is the only access to agricultural property along the east side of the river. It is accessible from the south end through a portion of Bonners Ferry which is north of the river and west of Hwy 95. CR 38 turns east near Fleming Creek toward Hwy 95, which provides a second potential access route to staging sites on CR 38. The most direct route from material source pits to potential staging sites would be through the northern section of the town of Bonners Ferry with a haul mileage of six miles from the Hwy 95/Chinook Street intersection (Figure 5-8). Although CR 38 is less traveled than CR 18, the most direct access from the material source pits to CR 38 is through an urban residential area where the community hospital is located. Using the northern CR 38 route, the haul distance from the Hwy 95 and Chinook Street intersection is approximately 11 miles. Though it is expected that the minimum distance haul route will

be employed to keep haul and material costs down, the northern route provides an alternative access to sites along the east side of the river and may reduce community impact.

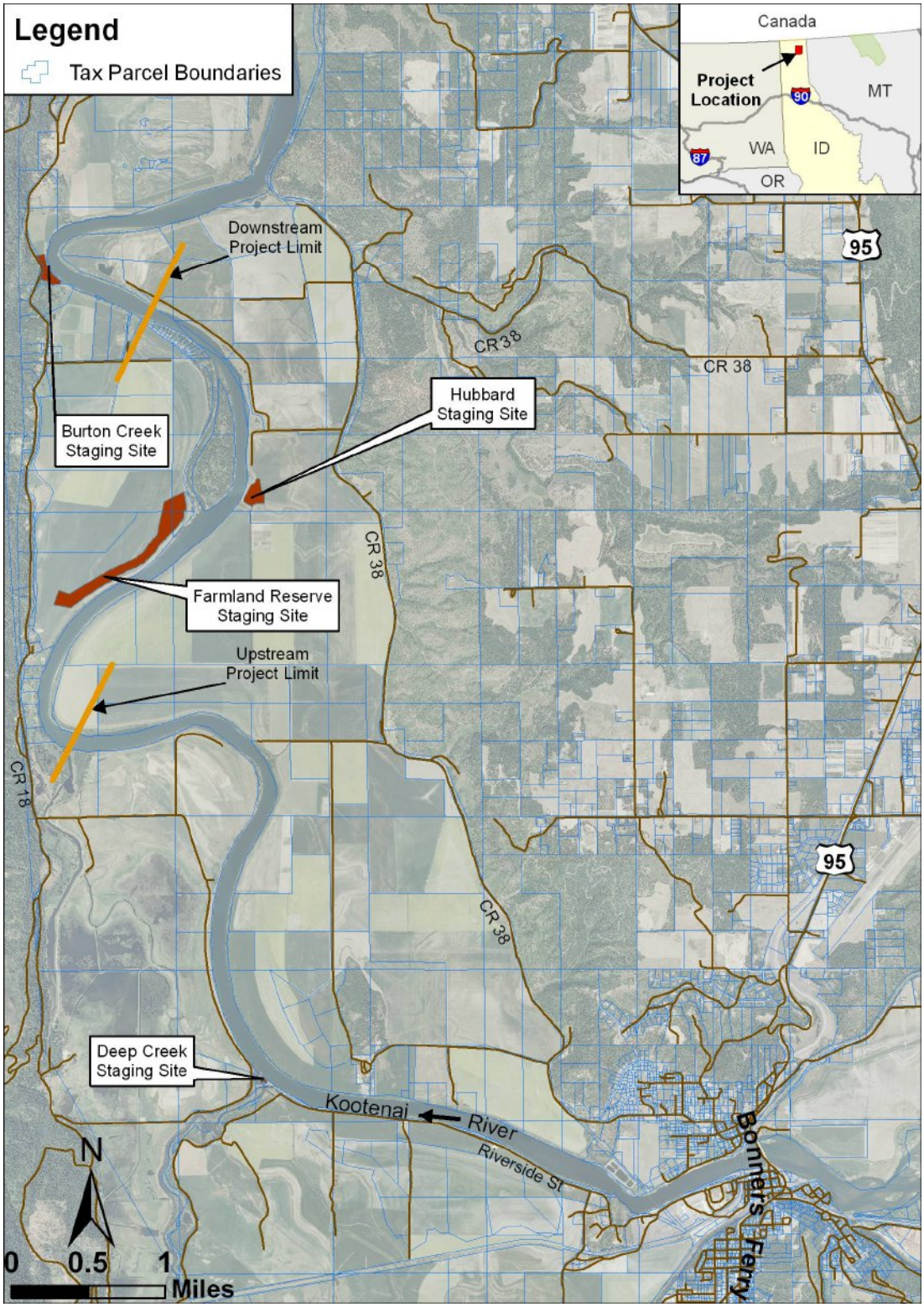


Figure 5-6. Potential Staging Sites and Associated Access Roads

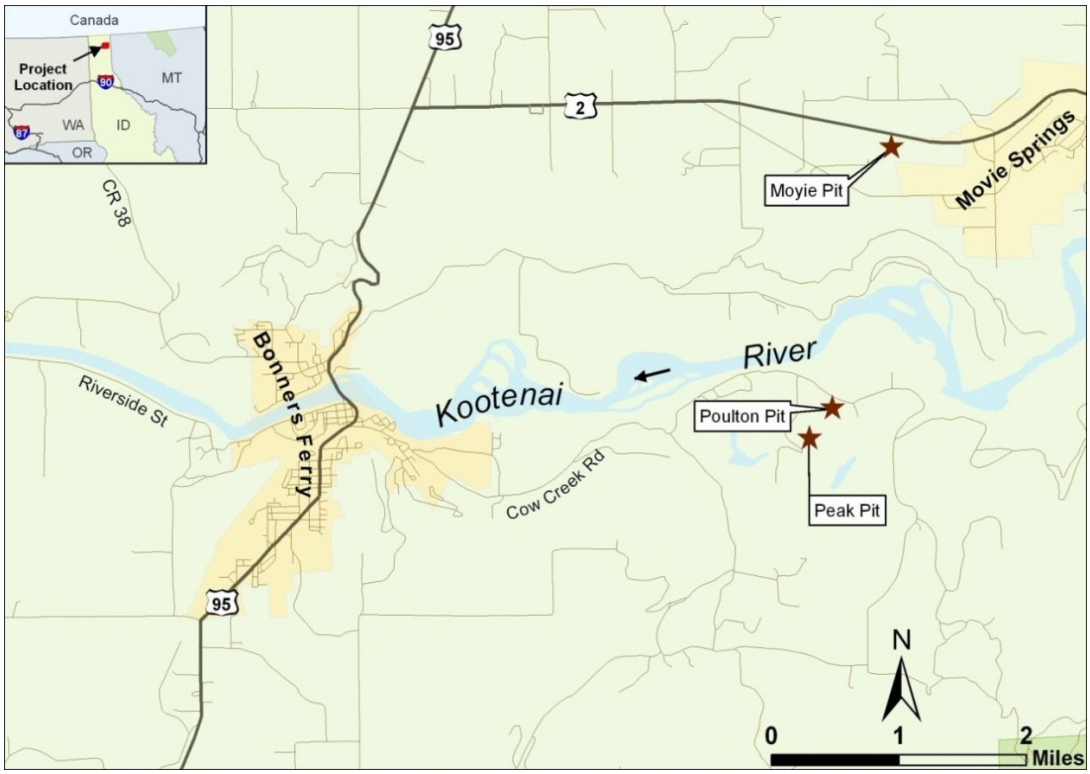


Figure 5-7. Location of Potential Aggregate Pits for Placement Materials

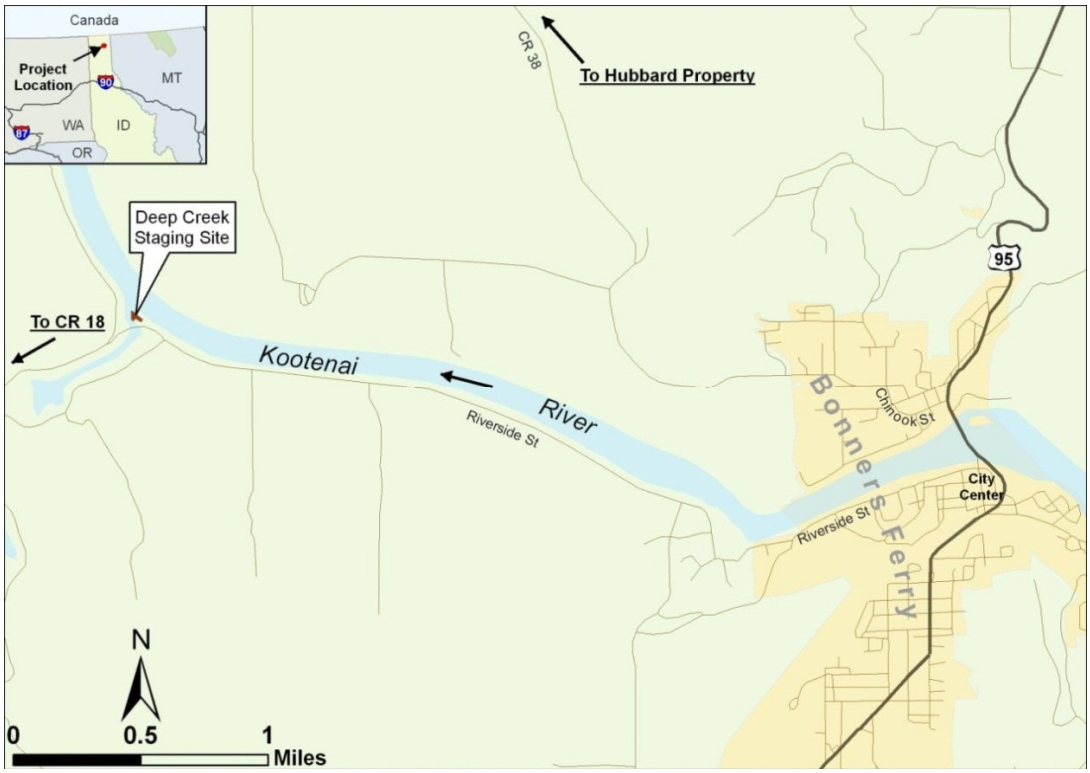


Figure 5-8. Primary Haul Route Accesses to Hwy 95 within Bonners Ferry

5.3.5.2 ASSESSMENT OF POSSIBLE STAGING SITES

Several potential sites were identified and evaluated during on-site investigations. The four sites considered for additional evaluations included the following (Figure 5-9):

1. Burton Creek Property, located just downstream of Burton Creek confluence along the left bank.
2. Hubbard Property, located adjacent to Shorty's Island along the right bank.
3. Farmland Property, located between the Shorty's Island site and the Myrtle Creek site on the left bank.
4. Deep Creek boat-launch (Deep Creek), located upstream of the Myrtle Creek site.

Two of these potential sites (Barton Creek and Farmland) are accessible from CR 18 and are on the west side of the river, 1 site (Hubbard) is accessible from CR 38 on the east side of the river, and 1 site (Deep Creek) is accessible off Riverside Drive on the left bank.

Hubbard Property

The Hubbard Property was used for a BPA/USACE pilot substrate placement project staging site previously and the property owner is willing to participate again to assist USACE and the Kootenai Tribe in their efforts to create habitat to support KRWS spawning and early life stage survival. The site is accessible from CR 38. Existing residences are accessed from the southern portion of CR 38 but are located well south of the proposed staging site. The potential site is within the project limits which would allow the entire recommended plan to be constructed within a single season. This property has a set-back levee with enough distance from the river to provide river access without compromising the levee prism.

Should CR 38 be used, specific signage and speed/traffic controls would need to be developed through the residential area to mitigate the impact to this area and ensure that the haul traffic does not disrupt agricultural traffic, overly tax streets in this neighborhood, or become a nuisance to residences.

The portion of the levee from where river access would be staged is approximately 3,500 feet from CR 38 via the northern access road and nearly 5,500 feet via the southern access road. These are significant distances to improve the haul roads to accommodate construction traffic; however, any near-river staging sites within or near the proposed project limits would require improvement of similar or greater lengths.

The setback levee on the Hubbard Property provides an area riverward of the levee alignment which is large enough for an access road to the river. However, given the shallow grades necessary to provide heavy equipment access to the river and the small available area it may be necessary to use small areas of cut slopes steeper than 2:1 and small turn-radius geometry. This site was retained for further consideration.

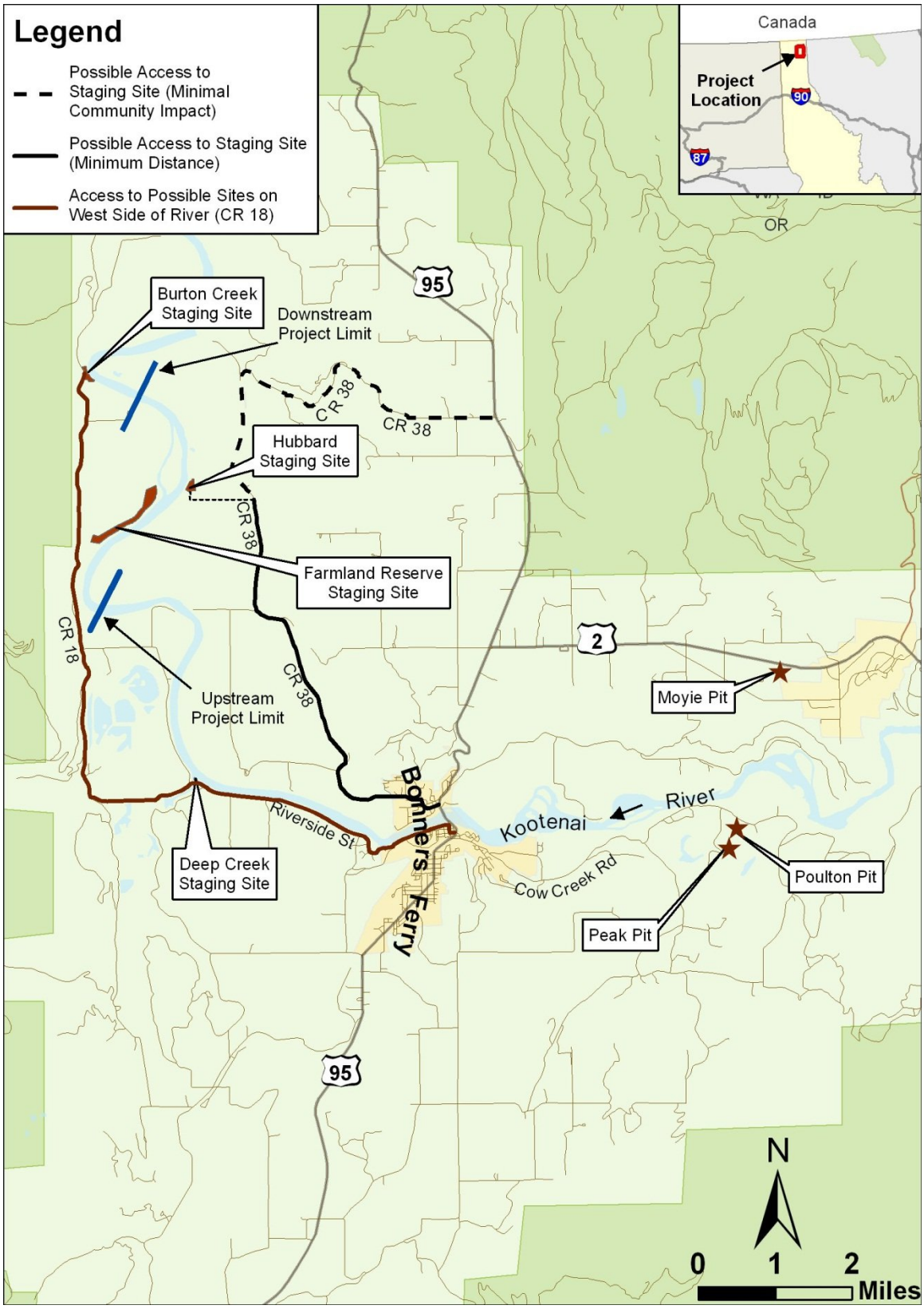


Figure 5-9. Location of Potential Staging Sites, Haul Roads, and Placement Material Source Pits

Burton Creek

The alignment of the river at this location brings the river to within 1,000 feet of CR 18 along the west side of the river. The site is relatively flat and very close to both the river and the primary material haul road (CR 18), which would decrease lengths of site access and haul roads. This property is located outside of a levee but the elevation protects it from most flooding. It is located on the outside of a sharp bend of the river which creates more favorable bathymetry for barge access than the other staging locations considered. However, this site has near vertical shore slopes and is outside of the proposed project area.

The elevation of this site above the river and the resulting steep slopes would require significant access road creation and improvements and slope/site stabilization efforts. Though the site is in favorable proximity to CR 18, the elevation difference between CR 18 and this site would require a significant fill volume to be imported in order to gain access to the site from CR 18; this would also reduce the usable site area for staging. Whether the site would have sufficient area for the project material after access roads were completed would require additional analysis, but appears likely.

This site is beyond the boundaries of the proposed project area which would likely inhibit the completion of the entire project. Additionally, the distance from this potential staging site to possible substrate material pits is significantly further than any other of the other sites considered.

The Burton Creek site was not selected because it is outside the project limits, requires the highest haul costs for material, is likely to cause greater disruption to residences and community traffic due to its location off CR 18, and would require significant additional costs such as heavy shoreline stabilization and additional grading/fill material to gain access to the site and to the river.

Farmland Reserve Property

The Farmland Property is located south (upstream) of Shorty's Island along the left (west) bank. This location is within the recommended project area and would allow placement operations to be completed within a single season. The property has a single existing access along the west bank dike road. There are also locations on the property closer to Shorty's Island where river deposition has built land area riverward of the levee and where it may be possible to develop access to the river.

The only existing access to this property is via CR 18 through a small residential subdivision. Though only a small number of residences are present, the impact to these homes from trucking and hauling would be very concentrated and potentially problematic. The best location for the staging would be on the southern property corner closest to CR 18. However, this location does not provide a setback levee for river access. A location farther north along the river would provide a better chance for river access, but would increase the length of needed improved haul road from approximately 1,300 feet at the southern corner to nearly 8,000 feet near Shorty's Island. The property's shoreline near Shorty's Island is defined by shallow slopes and bars which would require significant excavation to allow docking and loading of barges.

Although this property is within the proposed project boundaries, its limitations and the likely negative impact on residential areas precluded its selection.

Deep Creek

Deep Creek Boat Launch is owned and maintained by Boundary County. The property has an existing access to the river and represents a shorter distance between many of the potential substrate placement material source pits—which would isolate haul traffic to Hwy 95—the roads east of Hwy 95, and Riverside Drive. This site represents the least haul-truck impact to the agricultural industry; however,

construction traffic would have to travel near City Hall and may disrupt commercial interests within the City Center.

Several conditions make this site a poor selection for staging. The site is outside the limits of the project, is less than 1 acre in size, and would require significant alteration of existing structures at the boat launch which itself is not suitable to accommodate barge docking. This small area is insufficient to support the necessary staging volume for the operation so a secondary staging site would be required resulting in double or triple handling of material. The existing boat launch is not a significant advantage for this site since it is too narrow and the bathymetry is too shallow for barges. Bringing heavy equipment into Deep Creek Boat Launch would require the removal of the existing restroom facilities and the relocation of the existing overhead power lines. Due to the small size and required alterations at the site, this location was not selected.

5.3.5.3 SELECTED STAGING SITE

Table 5-4 summarizes the selection criteria discussed and evaluated for each site. Based on the evaluation, the Hubbard Property was selected. The Hubbard Property offers the best conditions to facilitate the efficient construction of the project while providing similar or lesser impacts to the community, residents, and commerce in comparison to the other three sites. All construction, placement, and operational assumptions upon which costs and analysis were made at the feasibility level were based on a single project staging site located on the Hubbard Property.

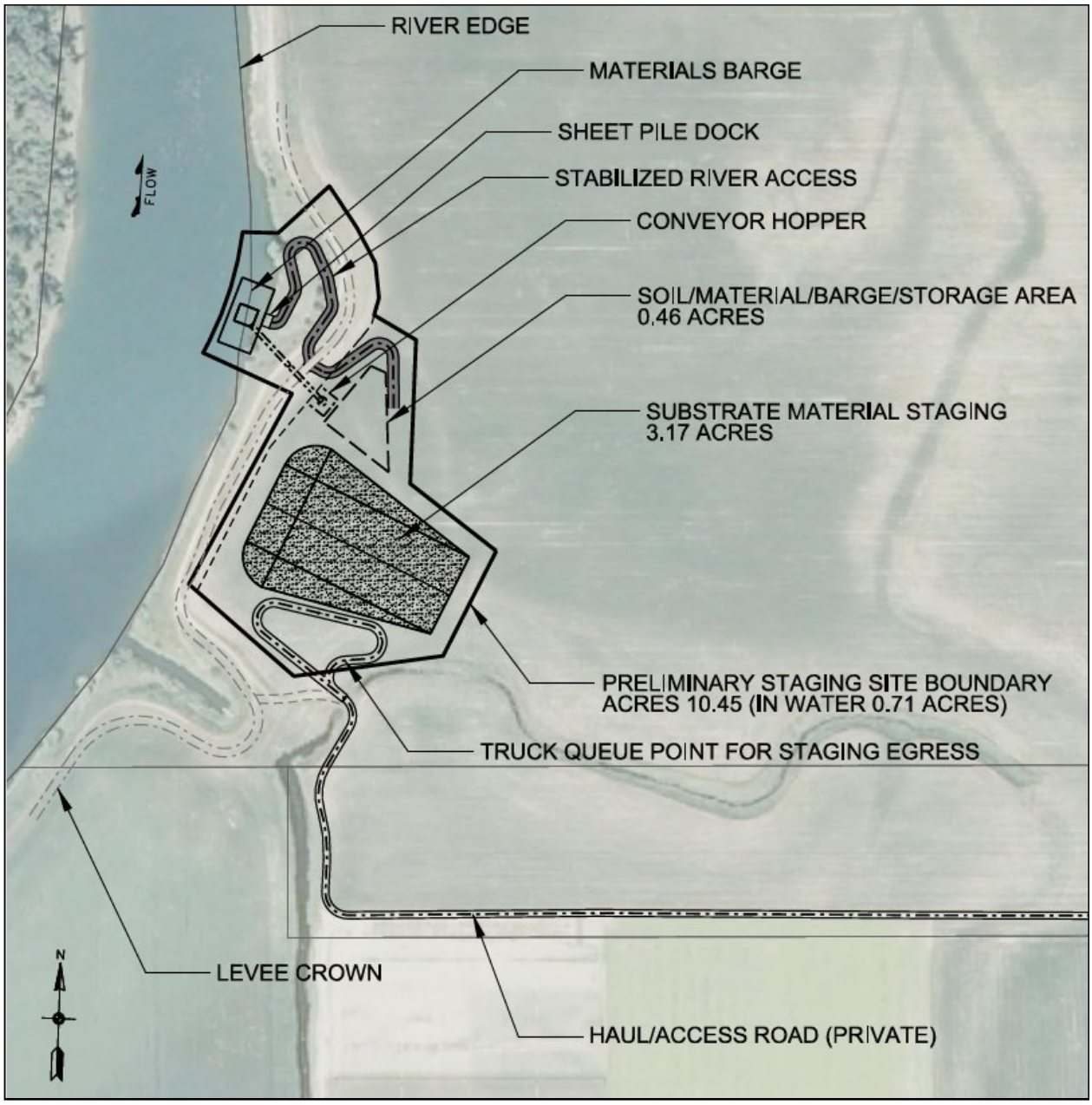
Table 5-4. Staging Site Selection Criteria and Alternatives Assessment

Assessment Criteria	Burton	Hubbard	Farming Reserve	Deep Creek
Site protected from flooding	Yes	Yes	Yes	No
River access without impact to existing levees	Yes	Yes	Unlikely	NA
Existing river access	No	No	No	Yes
Direct access from public right-of-way to site	No	Yes	Yes	Yes
Site is within the recommended plan project limits	No	Yes	Yes	No
Level of community impact likely[1]	Mid	Mid	High	Mid
Site is sufficient in size to contain all material handling, construction, assembly and storage requirements	Likely[2]	Yes	Yes	No
Level of in-water excavation required	Low	Mid	High	Mid

Notes: [1] Level of community impact is a subjective estimate of impact to the community in terms of traffic, noise, and truck/traffic presence and perception.
[2] A site plan would have to be developed in order to determine how much of the existing site could be usable because the site is constrained between the river and CR 18 and the grading impact of the river access is unknown.

The Hubbard Property staging site design and cost estimate has been developed based on likely requirements to stage all project material prior to beginning placement operations, to store the topsoil removed from the site and a portion of material excavated from the river, as well as to allow unhindered operation of the material transfer operation (see Figure 5-10 and Figure 5-11). The staging area is 10.45 acres, which includes 0.71 acres "over water" and 1.3 acres riverward of the levee crown within which the river access would be constructed (Figure 5-11). The staging area landward of the levee is 7.4 acres and will accommodate levee access, material storage and handling, and transfer operations. Where the topsoil of the staging area and future cultivation by the property owner coincide, topsoil will be removed to a depth of six inches before material staging/storage begins. The topsoil will be spread out over the staging site at the end of the project to restore the land for cultivation.

Figure 5-10. Staging Site Overview



Note: This figure does not include buffers and contingencies that are reflected in the real estate requirements.

Figure 5-11. Staging and Construction Area Detail

The areas described as necessary for staging and storage within this section should be considered minimum requirements. The area defined for land, easements, relocation, rights-of-way, and disposal areas (LERRDs) is significantly larger than the acreages described here to accommodate the minimum site requirements, buffers, and contingencies with respect to contractor operation, and roughly rectangular tracts based on maximum site dimensions (see Section 5.5; see Figure 5-10 and Figure 5-11 for visual description of the staging site.

The staging site is designed to accommodate a single ramp pile 40 feet high, with 10-percent access slope, and maximum width and length dimensions of 365 feet and 480 feet, respectively, representing approximately 3.2 acres. A pile with this footprint and 2:1 side slopes would store 91,200 cubic yards. A

secondary storage location is also identified with an available footprint of approximately 0.5 acres (see Figure 5-11).

Landward Staging Site Access (Sheets C-401, C-402, C-105)

Site Access from CR 38 (Sheets C-110, C-111, C-402)

The southern agricultural access to the site is considered the best option for an access road (see Figure 5-10). Although the existing southern agricultural access road is sufficient for occasional agricultural equipment, the road will need to be improved for substrate placement material delivery. The access road is currently conceptualized as a single 16-foot-wide travel lane where ingress and egress from the staging site would be staggered as necessary. The staging site access road will require some fill and excavation to accommodate haul traffic (see Sheets C-110, and C-111). A haul surface of three inches of base course and two inches of surface course is expected to be needed. The easement for work on the access road is based on a 35-foot width to accommodate equipment, embankment slopes near CR 38, unforeseen construction needs, and erosion control installation. The 35% design calls for widening and improvement of approximately 1 mile of haul road.

Culvert Replacement (Sheet C-110)

An agricultural drain exists between the southern site access alignment (Sheet C-402) and the proposed staging site. The channel is approximately 10 to 15 feet deep with a bottom with of approximately 12 feet. The current culvert is a 24-inch corrugated metal pipe (CMP) with 8 to 10 feet of cover. The existing CMP culvert is likely at its maximum performance depth. The vertical alignment over this culvert will need to be improved to create better transition over the channel. The improvement would increase the depth of the culvert to at least 12 feet. With this proposed depth and the heavy haul and equipment traffic anticipated, it may be necessary to replace the culvert with Class 4 reinforced concrete pipe prior to construction. For the purpose of the feasibility design the culvert was replaced with a 36-inch Class 4 reinforced concrete pipe.

Replacing the culvert will disturb delineated wetlands but the expected impact would likely be less than 400 square feet (0.001 acres). Mitigation efforts for the wetland disturbance are discussed in Section 6.5.

Levee Crown Road (Sheet C-105)

Approximately 1,000 feet of the existing levee crown road will need to be lightly prepared for temporary use before the site access ramps are in place in order to get excavation and grading equipment from the southern agricultural road to the area where the river will be accessed from the levee. The temporary equipment access is specifically for the equipment to access the riverbed for excavation. The existing levee crown road will require leveling but is assumed to not need base course, surface course, or compaction as it is intended only as an initial access. Constructed ramps will serve this function through most of the project.

Staging Site to Levee Access (Sheets C-105, C-106)

Access from the staging site to the top of levee at the river access ramp will be necessary. The access is primarily intended for crane use and has the same geometric boundaries as the river access: a 25-foot width, six percent maximum grade, and 26-foot minimum internal turn radius. The alignment should be optimized in future design efforts but the concept provides a working location and conservative estimate for materials and footprint. The site-to-levee access as shown is approximately 350 feet in length. This access has the same surface as the staging site access road: three inches of base course and two inches of surface course. Though the access is not planned as permanent, some portion of the material for its creation will remain landward within the existing levee prism such that it does not diminish the cultivated area landward of the levee.

Riverward Access Road (Sheets C-105, C-106)

Access to the river needs to be provided for the excavation of the shoreline for barge access, hauling away the river excavation, transporting barge modules to the river for assembly, constructing the barge-loading facilities, and access to the loading facilities by the crane. The access road must be designed with grades, widths, and turn radii sufficient for the fully assembled crane. The river access from levee crown to the river was designed at approximately 550 feet in length, a maximum grade of six percent, and a minimum width of 25 feet. The road is currently conceptualized with 20-foot internal turn radii to accommodate articulated trucks, cranes, and excavators (once an engineering survey is completed for the levee and riverward area the design can be optimized). Fill material required for the initial descent of the access road from the levee will be generated from the shoreline excavation. Cut slopes and embankments slopes below the levee crown and OHW elevation will be necessary for river access construction. These exposed slopes will require erosion protection from high river flows and rainfall. All slopes above the in-water work window mean water surface elevation of 1,750 feet are anticipated to be protected with a geo-synthetic turf reinforcement mat (Pyramat, ArmorMax, or equal) to maximize soil contact and slope protection). The slopes below the in-water work window mean water surface elevation are assumed to be stable at 2:1 given the 1:1 and near vertical bathymetry and bank slopes which are stable both up and downstream of the staging site. However, the in-water 2:1 slope will be covered with the substrate placement material as this substrate is stable at this slope and provides additional habitat benefit.

The existing levee prism adjacent to the proposed staging site varies but is generally composed of a crown width and access road approximately 20 feet wide and side slopes both landward and riverward between 1:1 and 4:1. Constructing and maintaining access from the proposed staging site to the river will not require breaching of the levee. Some modifications to the levee embankment are required but they will not impact the elevation of the crown or USACE recommended minimum levee prism. The proposed river access requires that the riverward slope of the existing levee be regraded for approximately 160 feet. In the area requiring regrading, the existing levee riverward slopes are flatter than 2:1. One hundred feet of the riverward slope of levee will be regraded at 2:1 and an additional 60-foot section of the levee will be regraded at 1.5:1. A 20-foot levee crown will be maintained in all locations. Within the 160-foot length where the riverward slope is regraded, the maximum levee toe adjustment landward (associated with the 1.5:1 slope) is approximately 10 feet. The riverward slopes disturbed to construct the river access will be stabilized and protected from erosion by Propex, ArmorMax, or PyraMat matting (or equal) which provides for vegetative growth and structural slope support via soil anchors. Additionally, the landward slopes of the levee where riverward cuts are required will be augmented by spoiled material from the riverward excavations (approximately 400 cubic yards) in order to mitigate concerns about seepage.

5.4 Construction Sequence and Phasing

Construction will take place in four phases over a two-year period. In order to develop a project schedule it is assumed that the project will be approved for construction in June 2012 in time to allow for construction activities during the in-water work window. The in-water work window identified by IDFG and USFWS is between August 1 and November 30. Phase 1: Staging and Site Preparation and Phase 2: Material Delivery and Storage take place during the first year. Phases 3 and 4 are Barge Assembly and Material Placement, and Operation Completion and Site Restoration, which would be completed during the in-water work window the following year. The construction schedule will be revisited during final design.

5.4.1 Phase 1: Staging Site Preparation (September 15 to November 1, 2013)

Site preparation is expected to begin within the in-water work window after agricultural activities are completed for the season at the Hubbard Property staging site. This date is estimated to be before, but no later than October 1 of the first construction year. Material excavated from the river will be used as embankment material for the river access, primary access, and site-to-levee access roads which must be

completed before material delivery can begin. All site preparation activities are expected to be completed within Phase 1, including erosion control, access roads, staging site topsoil removal and stabilization, dock construction, and river exposed slope stabilizations. The primary access road should be complete no later November 1 to allow sufficient time for Phase 2 to be completed.

5.4.2 Phase 2: Placement Material Delivery and Storage (November 1 to December 15, 2012)

Once all site preparation and access road construction has been completed in Phase 1 the substrate placement material can be delivered to the site. This delivery is expected to be primarily from pits located on the east side of Bonners Ferry. Snowfall in Bonners Ferry tends to begin near the end of November. If material delivery is not complete by early December, snow and ice mitigation measures may be necessary. CR 38 is generally closed to truck traffic in the spring due to soft road conditions. If material delivery begins by November 1 material haul should be complete before the middle of December. The material piles should be covered or stabilized once the delivery is complete with the expectation that the site will be inactive until the next in-water work window (or just before).

5.4.3 Phase 3: Barge Assembly and Material Placement (July 15 to September 30, 2014)

The material placement operation is primarily composed of receiving barge modules and tugs, assembling the barges, mobilizing material handling equipment, and then initiating the placement methods discussed in Section 5.3.1. It is anticipated that the barge modules and assembly equipment can be mobilized and barge assembly can be completed on the river prior to the in-water work window and that placement operations can start on the first day of the in-water work window (August 1). Barge assembly is expected to require 10 days and should begin in mid-July.

Placement of material is estimated to take approximately 41 days, which includes a 10-day contingency to account for mechanical problems or operational delays. Assuming that the material barges and transfer equipment can be disassembled and removed from the site within 10 days, the total time to accomplish Phase 3 should not be more than 61 days. The placement operation should be complete by the end of September if barge delivery and assembly and all support equipment and preparation are complete and in place by August 1.

5.4.4 Phase 4: Operation Completion and Site Restoration (September 30 to November 15, 2014)

After the material has been placed and barges and material handling equipment associated with Phase 3 have been removed from the operation area, staging site restoration efforts can take place. Earth-moving equipment used for material handling operations can be utilized for this effort. The topsoil removed from and stored on the site will be spread and graded. The soil will not be seeded as this land area is cultivated for agricultural crops. The access road connecting the site with CR 38 will remain in its improved state and no further road restoration efforts are expected. However, planting and restoration efforts will be implemented for the river access road area, including exposed piling removal (from the dock area), moving some material from the site-to-levee access road (landward of the levee) to the riverward side of the levee, recreating suitable slopes, and planting native vegetation. In-water slopes will remain as they will be similar to natural slopes in this reach of the river and are stable without rip-rap installation or other stabilization measures. Restoration and regrading should be complete within 30 days of the end of Phase 3.

5.5 REAL ESTATE REQUIREMENTS

The Shorty's Island / Meander Reach Ecosystem Restoration Project will affect approximately 27.4 acres of aquatic land within the beds and banks of the Kootenai River, and approximately 30.4 acres of land adjacent to the Kootenai River near the city of Bonners Ferry, Idaho. The Lands, Easements, Rights-of-Way (LER) required for the project are currently in both public and private ownership. The Idaho Department of Lands controls the aquatic land required for the project. A private party owns the upland parcels affected by the proposed temporary access road and temporary work area easements (See, Exhibit A real estate map in the Real Estate Plan, Appendix G of the DPR-EA).

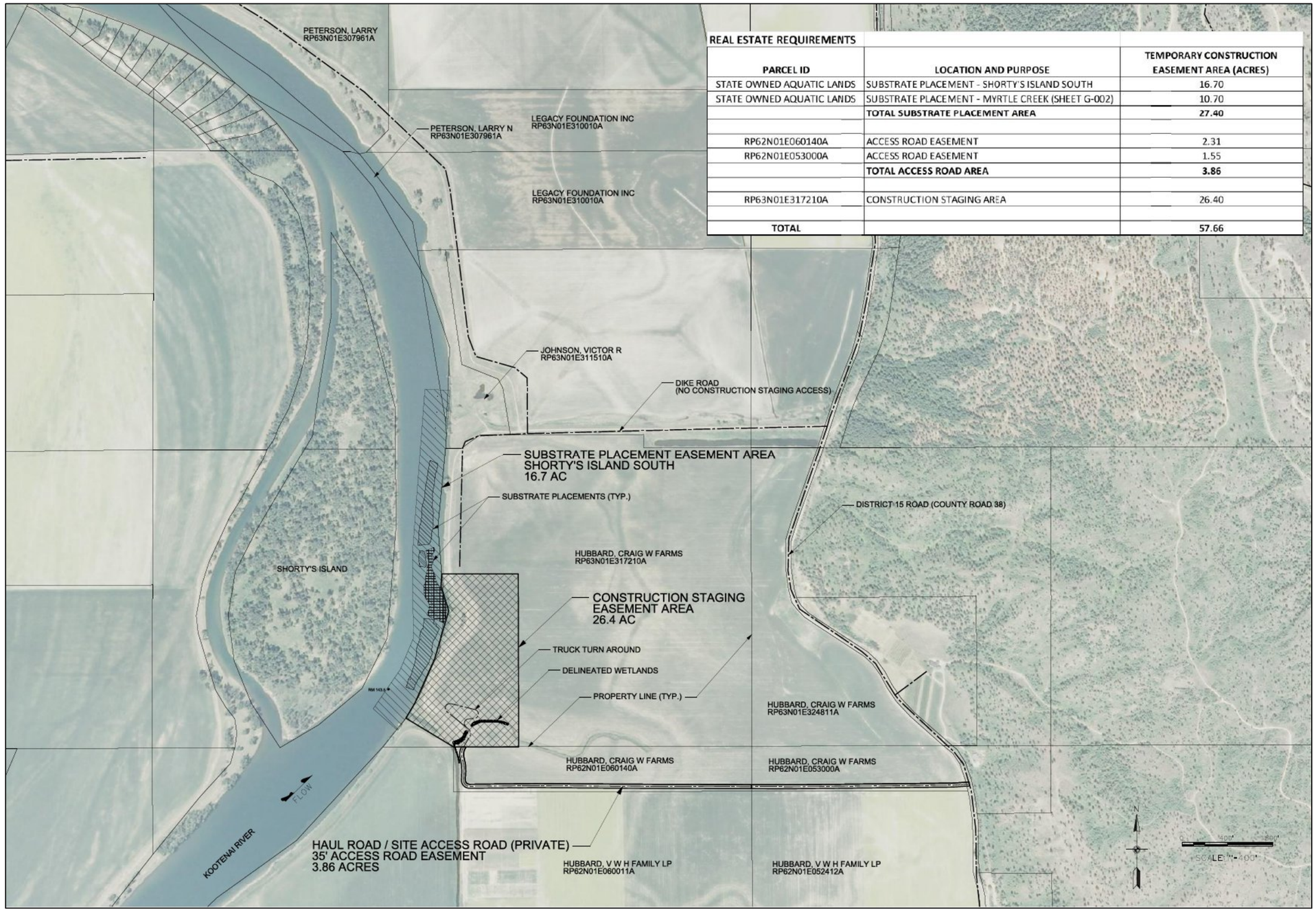
The NFS will need to certify available all property interests necessary for construction, operation and maintenance of the proposed project prior to the opening date for advertisement of the construction contract. The NFS will have approximately 180 days after certifying lands available for construction to provide Real Estate Division with documentation required to support their claim for LER credit. The NFS has been advised in writing of the risks associated with acquiring project lands prior to the full execution of a Project Partnership Agreement. Please refer to Appendix G, Real Estate Plan (REP), for additional real estate information.

The baseline cost estimate presented below provides a breakdown of the estimated cost of project lands, NFS administrative costs associated with LER acquisition activities, and Federal review and assistance costs. NFS acquisition costs include incidental acquisition costs such as title, survey, appraisal, negotiation costs, recording fees and legal fees. Federal review and assistance costs include those costs associated with providing the NFS with LER requirements, review of acquisition and crediting appraisals, coordination meetings, review of right-of-way documents, legal support, and crediting activities. The total estimated cost of both Non-Federal and Federal LER implementation phase activities is approximately $50,400, including a 20% contingency.

Table 5-5 summarizes the real estate requirements for the recommended plan. Figure 5-12 and Figure 5-13 provide a visual description of the easements.

Table 5-5. Real Estate Requirements

Estates	Acres	Lands & Damages	NFS Admin	Fed Admin	Total LER Costs
Aquatic Lands	27.40	$ 0.00			
TWA (24 months)	26.40	$ 18,480			
Temporary Road Easement (24 months)	3.86	$ 2,700			
NFS LER cost subtotal	57.66	$ 21,180	$ 10,000		$ 32,000 (rounded-up)
20% contingency					$ 6,400
NFS Lands & Damages Total					**$ 38,400**
Federal Review & Assistance cost				$ 10,000	
20% contingency				$ 2,000	
Federal Review & Assistance Total				**$ 12,000**	
NFS and Federal LER Cost TOTAL					**$ 50,400**



REAL ESTATE REQUIREMENTS		
PARCEL ID	LOCATION AND PURPOSE	TEMPORARY CONSTRUCTION EASEMENT AREA (ACRES)
STATE OWNED AQUATIC LANDS	SUBSTRATE PLACEMENT - SHORTY'S ISLAND SOUTH	16.70
STATE OWNED AQUATIC LANDS	SUBSTRATE PLACEMENT - MYRTLE CREEK (SHEET G-002)	10.70
	TOTAL SUBSTRATE PLACEMENT AREA	**27.40**
RP62N01E060140A	ACCESS ROAD EASEMENT	2.31
RP62N01E053000A	ACCESS ROAD EASEMENT	1.55
	TOTAL ACCESS ROAD AREA	**3.86**
RP63N01E317210A	CONSTRUCTION STAGING AREA	26.40
TOTAL		**57.66**

Figure 5-12. Real Estate Map North

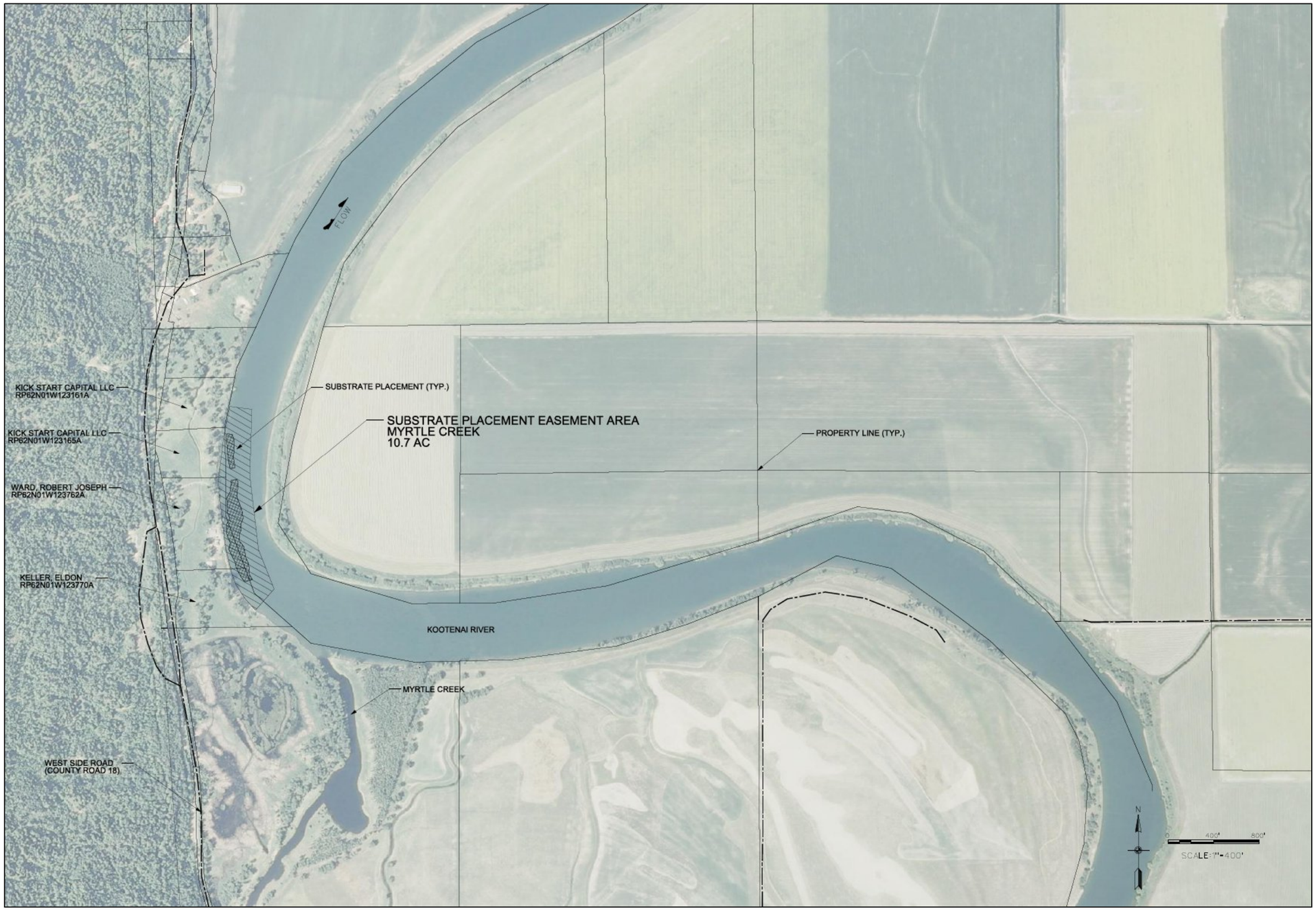


Figure 5-13. Real Estate Map South

5.6 COST ESTIMATE

The implementation costs based on the 35% design are estimated at $4,428,079. Table 5-6 summarizes the costs. The costs are presented by construction phase. Phases 1 and 2 are assumed to be completed during the first construction year. Phases 3 and 4 are expected to be completed the following year. Design, construction administration, and contingency cost percentages are applied to the construction costs subtotal.

Table 5-6. Recommended Plan Preliminary Cost Summary

Item	Item Description	Costs ($; Based on October Q1FY2012 Price Level)				
		Phase 1	Phase 2	Phase 3	Phase 4	Total
1	In-Water Turbidity Controls	30,000	0	0	0	**30,000**
2	Temporary Construction Erosion Control Measures/Stabilization	53,814	14,077	28,000	1,190	**97,081**
3	Equipment	50,000	155,081	1,170,724	26,000	**1,401,806**
4	Placement Material	0	246,246	0	0	**246,246**
5	Site Prep/Operations/Restoration	327,329	0	66,250	64,798	**458,377**
	Construction Cost Subtotal[1]	**461,143**	**415,404**	**1,264,974**	**91,988**	**2,233,510**
6	Contingency (25%)	115,286	103,851	316,244	22,997	**558,377**
7	LERRD	50,400	0	0	0	**50,400**
8	Monitoring (1% for first 10 years)	46,114	41,540	126,497	9,199	**223,351**
9	Planning, Engineering, & Design (26.5%)	122,203	110,082	335,218	24,377	**591,880**
10	Construction Administration (14.5%)	66,866	60,234	183,421	13,338	**323,859**
11	Adaptive Management (20%)	92,229	83,081	252,995	18,389	**446,702**
	TOTAL	**954,241**	**814,192**	**2,479,350**	**180,297**	**4,428,079**

Note: [1]Mobilization and de-mobilization costs are integrated into items 1 through 5.

5.7 FINAL DESIGN CONSIDERATIONS

The following section outlines several areas remaining to be addressed during the plans and specifications phase. These areas are related to substrate placement; staging area and site access;, and general plans, specifications and others.

5.7.1 SUBSTRATE PLACEMENT

- ***Review Available Facies Mapping and Videography***. As part of the final design any videography and facies mapping conducted since 2010 or prior to 2008 should be reviewed to determine if there are any proposed substrate placements on areas that have been covered by sand under the other mapping conditions. Such areas should be excluded from substrate placement in the final design.
- ***Map Sediment Facies for Final Design.*** Prior to placement of substrate videography and facies mapping should be performed to ensure that sand has not encroached onto the clay beds and the placement should be modified if necessary to prevent placement of substrate on sand.
- ***Other Potential Sites to Consider if Substrate Placement is Expanded.*** Besides Shorty's Island South and Myrtle Creek, another potential site with high potential for substrate placement is the Downstream of Refuge site between RM 146 and RM 147. If the extent of

the placement is expanded, this site, along with Shorty's Island North, should be reconsidered.

- ***Details for Substrate Placement Transitions.*** During the final design additional detail on the substrate placement should be incorporated. These details should include (1) development of the shapes of the upstream and downstream transitions to best direct sediment away from the placement and (2) the potential for connecting individual placements to make longer continuous placements (CS-2 and CS-3 at Myrtle Creek, and CB-2 and CB-3 at Shorty's Island South).
- ***Substrate Placement Release Point.*** The 35% design assumes that the substrate is released near the bed. This provides more control of placement location, reduces release of turbidity into the water column from fines in the substrate, and segregation of the substrate by hydraulic sorting is minimized. For specifications, consideration should be given to adding a preliminary placement of substrate during construction, which would further identify the most efficient placement option while optimizing slope and bed gradation as well as water quality requirements.
- ***Surface Preparation.*** The final design needs to consider an appropriate level of irregularity of the finished substrate placement surface and identify means to achieve this whether it requires increasing or decreasing irregularities in the substrate. It may be necessary to "smooth" the substrate by dragging a weighted object across it or it may be found that placements need to increase surface irregularities. This would require inspection of the placed substrate by videography, multi-beam bathymetry, or use of a SCUBA diver.
- ***2005 Pilot Study Material.*** USACE placed fractured boulder-size material on the right river bank just downstream (north) of the river access at the proposed staging site as part of a pilot study in 2005 (see Chapter 1). The material is located on the river bank from below water level nearly up to the levee crown. The material is angular, contains some vegetation, and is of varied uncertain gradation. Later design phases and/or the contractor should consider whether this material can be salvaged to benefit the project.

5.7.2 Staging Area and Site Access

- ***Engineering Survey.*** An on-the-ground engineering survey will be necessary to provide horizontal and vertical detail in the following areas:
    - the levee area adjacent to the staging site,
    - the area riverward of the levee down to the edge of water,
    - the irrigation channel adjacent to the staging site,
    - the existing agricultural access road from CR 38 to the staging site,
    - 200 feet on either side of the proposed access intersection, and
    - the intersection of Chinook Street and Kaniksu Street in Bonners Ferry (for turn radius and traffic control evaluation and possible improvement).
- ***Geotechnical Evaluation.*** Geotechnical evaluations are required for the levee prism to determine slope stability, seepage potential, and structural stability (bearing pressure and for surfacing design). Other areas that require evaluation include the subgrade along the existing agricultural access to determine a surfacing structure/section, and the riverbed/river edge where piles are expected to be driven to determine final dock/bulkhead design.
- ***Material Conveyor.*** The design of the support system for the conveyor in the area it will be suspended over the water to reach the mid-point of the material barge should be explored in the plans and specifications phase.
- ***Haul Routes.*** The City of Bonners Ferry has suggested that a looped haul route be used (CR 38 ingress from the south and egress to the north) to reduce the total truck traffic on city

streets. An analysis of the haul route, proposed route access control, and increased material haul costs need to be considered.

- ***Cultural Resources.*** The cultural resources assessment did not yield any significant cultural material during the course of a pedestrian survey and subsurface testing. However, monitoring during construction is recommended for any ground disturbing activities associated with the creation of the temporary access road along the riverward side of the levee and the shoreline excavation.
- ***HTRW. Interior Drainage.*** Use of the drainage ditch and old pump outlet penetrating the levee near the southeast corner of the site should be considered for control of interior drainage if the need is identified during final design.
- ***Levee Safety Considerations.*** The staging area is located in the Dike District 11 levee. The Dike District 11 levee was inspected in October 2006 and September 2010 and received unacceptable levee ratings due to severe erosion and unwanted vegetation growth on both occasions. Additional caution should be used when working in a leveed area during flood season. An operational emergency action plan with contingency plans if a levee breach occurs should be addressed for the project.
- ***Monitoring Plan.*** Details of the monitoring plan should be developed in the final design phase and include components for monitoring of the staging and access area revegetation, sedimentation of the placed substrate, channel cross sections at the placement sites, egg mat data collection over the substrate, and ideally both presence and drift of free-embryo.

5.7.3 General Plans, Specifications, and Other Considerations

- ***Planting Plan.*** A detailed planting plan including species lists should be developed for the final plans and specifications that cover revegetation of the site and access areas.
- ***Landowner Coordination.*** Coordination should be performed with the landowner regarding restoration of the staging area farm field. The results of this coordination should be reflected in the final plans and specifications.
- **HTRW**. A Preliminary HTRW Assessment was completed in November 2011 (Appendix M). Historical documents, site reconnaissance, and interviews revealed minor HTRW contamination potential on the project site. During construction and installation activities, fuels, oils, lubricants, and other hazardous materials will be used. An accidental release or spill of any of these substances could occur. To minimize the likelihood of potential spills and leaks of petroleum and hydraulic fluids during project construction, construction equipment will be inspected daily for leaks and petroleum contamination. Additionally, a spill prevention control and containment plan designed to reduce impacts from spills (fuel, hydraulic fluid, etc.) will be in place prior to the start of construction.
- ***Road Sections.*** Road section(s) should be added to the final design drawings.

5.8 Operation and Maintenance, Monitoring, and Adaptive Management

Risks and uncertainties related to the project—particularly those related to sustainability of substrate function for its intended purpose—have been considered throughout the plan formulation and project development process. A number of the areas of uncertainty have been addressed through additional analysis; however uncertainty continues to exist for other aspects. The following sections summarize the areas of uncertainty and how they have been addressed through the planning process, those outstanding areas and how they are proposed to be addressed through post project monitoring and adaptive management.

5.8.1 Operation and Maintenance

The Kootenai Tribe and BPA have emphasized their interests in designing and implementing the project to be being as maintenance free as possible. This is an essential design consideration since maintenance would likely be relatively expensive and difficult. This consideration was also identified as a high- risk item in the project risk register. The following provides an evaluation of risks and design considerations to address maintenance requirements.

Multiple design considerations that would make the project as sustainable and maintenance free as practical include:

- Designing the substrate placement to prevent mobilization and remain in place.
- Identifying substrate locations to minimize exposure to conditions that could result in deposition of sand
- Specifying a substrate gradation to promote egg attachment and free-embryo hiding
- Geometry of substrate placements to establish and maintain effective areas for early life stage survival on clay shelves and beds.
-

The first consideration is very important since the placed substrate is larger than the substrate that currently exists in the Meander Reach which is currently almost entirely sand (sediments smaller than two mm). Therefore, there is not a natural supply of the gravel, cobble, and boulders that make up the suitable spawning substrate being placed. If flows are capable of moving the substrate then it will eventually be mobilized and no longer provide suitable habitat for spawning and the early life stage survival. Analysis of hydraulic conditions indicates that the flow velocities and shear forces in the Kootenai River are not capable of mobilizing the 16 mm and larger substrates of which the proposed substrate placements will be comprised. Analysis of sediment mobilization conditions shows that the substrate will remain stable and will not be washed downstream even by large floods such as the 1-percent chance exceedance event (100-year flood; see additional discussion in Section 5.2).

Design considerations were adopted and analyses were conducted to address the sustainability question concerning the ability of the substrate to remain relatively free of fine sediments during critical periods of use by KRWS. The first design provision to address this issue was the decision to only locate the substrate placements in areas of exposed clay beds. Based on data collected and research conducted by USGS, the sand dunes that are present across much of the Kootenai River do not persist in the areas where the exposed clay beds have been mapped. Review of bathymetry from 2008 and 2010 showed that these areas were free of the large dune bed forms during both periods. Additionally, detailed close-up videography of the bed taken by USGS in 2010 and 2011 revealed very little bed load moving across the clay beds. Therefore, the substrate is being placed in areas that have very little sand transport.

USGS used the two-dimensional model FaSTMECH to further address maintenance and sustainability concerns. Results of the modeling confirm the conclusions from the data collection effort that the proposed substrate placements were located in areas that are subject to an excess of sediment transport compared to surrounding areas. These results were true for both the existing without-project and the with-project conditions. Results of the modeling also suggest that the ability of flows to suspend sand-sized sediment is low with the largest sand particles suspended at flows up to 50,000 cfs measuring between 0.2 mm and 0.25 mm. This size range is approximately the median diameter of the existing bed material.

If sand deposition occurs on the substrate placements and persists and actions are required to maintain a sufficient area of substrate for KRWS spawning and free-embryo cover, at least four possible approaches could be pursued, including:

- Placing additional substrate over the previously placed substrate
- Using suction to remove sand from the substrate
- Using a jet to flush sand from the substrate
- Using a mechanical means such as a rake to turn over the substrate and expose clean material

Placement of additional substrate would be the most cost prohibitive and difficult option. Substantial mobilization costs, operation costs, and significant in-water access needs preclude this as a feasible maintenance option.

It may be feasible to flush sand with a jet or remove sediment by suction, although these methods would require complex equipment and extensive labor. The practicality of these maintenance methods would center on several factors. The first would be whether the equipment could be operated form the surface or whether small operations which used a diver to move the suction hose or jetting wand would be required. If divers were employed, maintaining large areas of the substrate mats could be difficult. Equipment size, costs, mobilization needs, and in-water use specifics would need to be evaluated.

The most economical means of maintaining substrate placements would likely be the use of some type of apparatus resembling a rake. This would require towing a large, heavily weighted bar with teeth across the substrate surface to rework the surface and expose coarse material. This device would be very similar to equipment that may be used to create optimum irregularities in the substrate during initial placement.

The ability to maintain interstitial spaces sufficiently free of sediment for free-embryo cover in the substrate gradation continues to be an area of uncertainty as discussed in Section 5.2.2 One approach to address this uncertainty is to implement a pilot project. Another approach to addressing the sustainability issue would be to implement the full project and incorporate an adaptive management approach that not only includes monitoring of substrate placement, but also includes provisions for identifying and performing various maintenance procedures for removing or reducing the effects of sedimentation on the substrate.

In summary, the proposed substrate placements have been designed to be as maintenance free as possible. This includes ensuring that the substrate will not be washed away by high flows. Of even more importance is maximizing the likelihood that the substrate will not be buried by sand deposition. The latter is accomplished by locating substrate placements outside of areas that dunes have been observed, locating it in areas where the transport of sand is low. In the event that deposition does significantly impact the ability of the placed substrate to perform as intended, there are several potential options for to remove the sand. Post project monitoring is proposed to assess project performance related to these items. The remaining area of uncertainty is the ability to maintain the interstitial spaces is also one of the elements proposed for post project monitoring. Adaptive management is also proposed to address this aspect of the project.

5.8.2 MONITORING

A detailed monitoring plan will be developed during the plans and specifications phase of this project. Monitoring will assess the recommended plan's success in meeting project objectives. Physical and biological variables will be monitored and evaluated. Recommended monitoring includes evaluating the several cross sections surveyed in the substrate placement locations by the USGS. These cross sections will be surveyed annually for both for bathymetry and videography. Metrics may include substrate particle size measurements and distribution. This would provide information on whether the substrate is remaining free of sedimentation. In addition, egg mat data should be collected over the substrate placements. This would provide information as to usage of the substrate by KRWS.

Coordination with other partners and agencies will be required to accomplish monitoring goals. In addition to the monitoring activities described above, the following information and data may be collected by others as restoration projects implemented as part of the Master Plan are constructed. Collectively, this information could be used to supplement monitoring efforts for the Shorty's Island/Meander Reach Ecosystem Restoration Project.

- 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.

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., substrate is covered with sand or river flows have washed away placed substrate).
- Ineffective monitoring program (e.g., inappropriate data collection methods, sampling regime, sampling locations not capturing variability, or data analysis).

The monitoring and adaptive management team will interpret monitoring data and results of analyses in the context of success criteria for specific projects that have been completed.

5.8.3 ADAPTIVE MANAGEMENT

Adaptive management is an iterative process by which restoration measures or management actions are systematically evaluated and subsequently modified in response to new information. Adaptive management is about systematically trying different actions to achieve a desired outcome. Adaptive management takes into account the uncertainties that exist regarding decisions made to undertake water resources projects and allows decision making and implementation to proceed with the understanding that project performance will be assessed and evaluated, thereby acknowledging that some structural or operational changes to the project may be necessary to achieve the desired results. Monitoring data will be used to evaluate and potentially modify the Shorty's Island/Meander Reach Ecosystem Restoration Project once it has been designed and implemented. Figure 5-14 shows the adaptive management decision pathway presented in the Kootenai River Habitat Restoration Program's Adaptive Management and Monitoring Plan (March 2012). This framework will be used by the monitoring and adaptive management team to evaluate success of the proposed project.

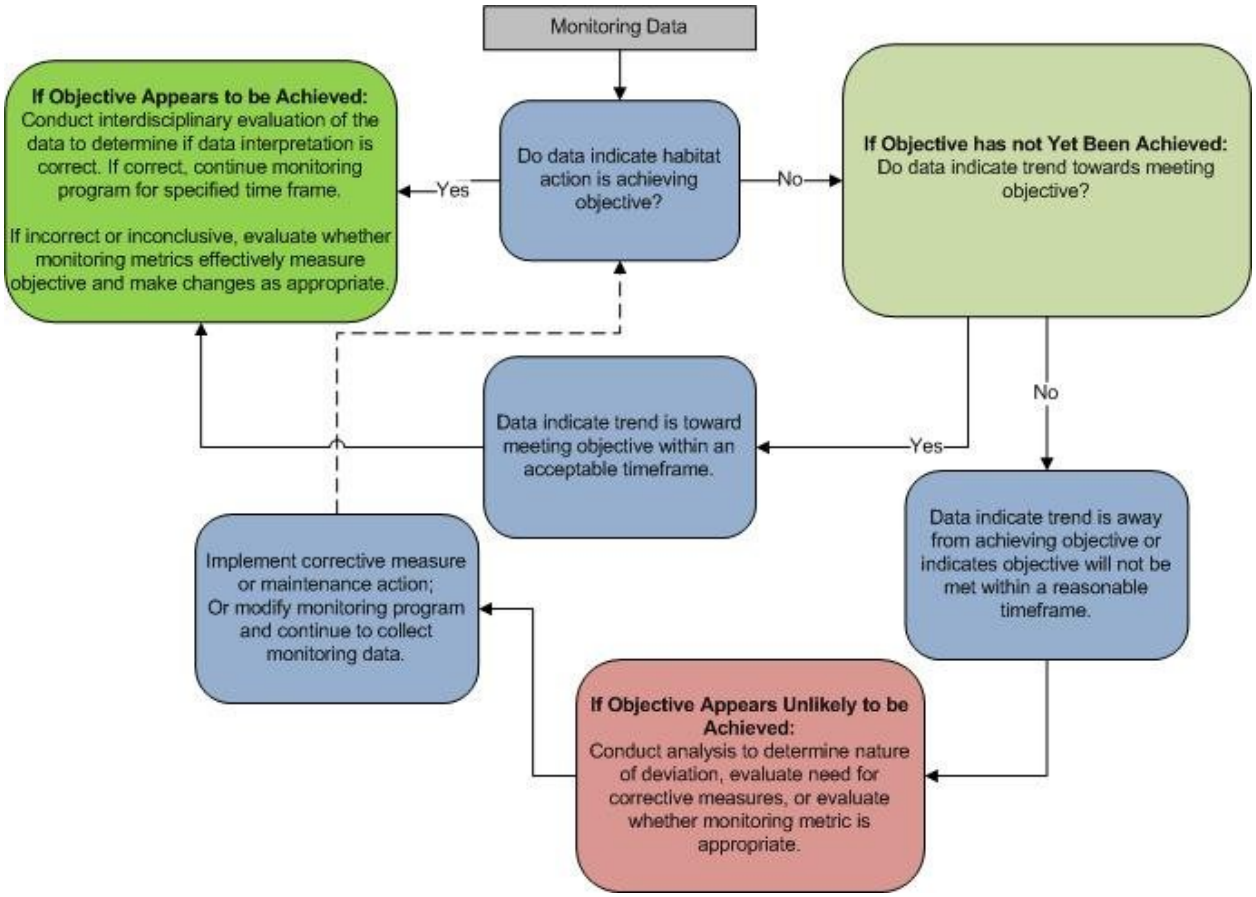


Figure 5-14. Adaptive Management Decision Pathway

If sand deposition occurs on the substrate placements, although not anticipated, or the interstitial spaces are not maintained sufficiently free of sediment and these conditions persist, then intervention may be necessary. If intervention or adaptive management is determined to be necessary to maintain a sufficient area of substrate for KRWS spawning and free-embryo cover, at least four possible approaches could be pursued including:

- Placing additional substrate over the previously placed substrate.
- Using suction to remove sand from the substrate.
- Using a jet to flush sand from the substrate.
- Using a mechanical means such as a rake to turn over the substrate and expose clean material.

Placement of additional substrate would be the most cost prohibitive and difficult option. Substantial mobilization costs, operation costs, and significant in-water access needs precludes this as a feasible maintenance option.

It may be feasible to flush sand with a jet or remove sediment by suction, though these would require complex equipment and extensive labor. The practicality of these methods would center on several factors. The first would be whether the equipment could be operated from the surface or whether small operations which used a diver to move the suction hose or jetting wand would be required. If divers were employed then maintaining large areas of the substrate mats could be difficult. Equipment size, costs, mobilization needs, and in-water use specifics would need to be evaluated.

The most economical means of maintaining substrate placements would likely be the use of some type of apparatus resembling a rake. This would require towing a large, heavily weighted bar with teeth across the substrate surface to rework the surface and expose coarse material. This device would be very similar to equipment that may be used to create optimum irregularities in the substrate during initial placement5.7.

5.8.4 Monitoring and Adaptive Management Timeline and Cost

Once the project is constructed, monitoring may occur yearly for 10 years after construction. USACE and the sponsors may determine that yearly monitoring is not appropriate; if this is the case then the monitoring schedule will be adjusted during the design and implementation phase or after construction is complete. Significant floods and other disturbances (e.g., drought, ice jams, and unseasonal flow events exceeding bankfull) may trigger additional monitoring events. Based on monitoring results, adaptive management techniques will be implemented on an as-needed basis for 10 years after construction is completed. Approximately 10 percent of the total construction cost ($223,351) will be set aside for monitoring activities. Approximately 20 percent of total construction costs ($446,702) will be set aside for adaptive management activities.

Ten years after construction the project will undergo a final evaluation to determine overall success or failure. In the event that all adaptive management strategies have been implemented and are unsuccessful after this time then USACE and the sponsors may determine the project has failed. If this is indeed the case then the non-federal sponsor will not be required to operate and maintain the failed project for the 50-year project lifetime.

6 ENVIRONMENTAL EFFECTS OF THE RECOMMENDED PLAN

Sections 1500.1(c) and 1508.9(a) (1) of the National Environmental Policy Act of 1969 (as amended) require federal agencies to "provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact" on actions authorized, funded, or carried out by the federal government to insure such actions adequately address "environmental consequences, and take actions that protect, restore, and enhance the environment". This section identifies the expected environmental effects of implementing the recommended plan.

The area of concern for the environment effects evaluation is defined as the Meander Reach 1 of the Kootenai River, as described in Section 1.3.2.4. The description of affected environment may describe a larger geographic area as necessary to fully characterize the Meander Reach and the effects of the recommended plan.

The recommended plan is the preferred alternative and therefore recommended for implementation (described as the recommended plan in Section 5). The following discussion evaluates the environmental effects of the recommended plan. In addition to the preferred alternative, the No Action Alternative which addresses future without-project conditions was evaluated for environmental effects.

6.1 GEOLOGY AND SOILS

6.1.1 NO ACTION

Under the No Action Alternative, no changes are expected to occur to existing geology and soils under future without-project conditions.

6.1.2 RECOMMENDED PLAN

The recommended plan would not have significant impacts on the geology at the project site. Final design plans will attempt to balance the amount of cut and fill at the project site (use of excavated materials on site). In order to fill the material barges, a dock must be constructed for the barge to have access to the bank. At the proposed location of the dock, the riverbank needs also to be nearly vertical. The excavation from the river to provide barge access is expected to yield approximately 2,500 cubic yards of material and to impact an in-water work area of approximately 0.71 acres. Suitable excavated material will be used to create the access ramps over the levees and for access road improvements. The remainder of the material will be stockpiled and used to restore the river bank after the project is completed.

It is likely that some amount of sediment erosion may occur during construction as a result of ground disturbance from vegetation clearing, excavation, and the general use of heavy equipment. These impacts are expected to be minimal and temporary. Also, BMPs such as silt fencing or mulching will be implemented to control erosion both during and after construction. These measures will be described in a Stormwater Pollution Prevention Plan (SWPPP).

6.2 CLIMATE AND CLIMATE CHANGE

6.2.1 NO ACTION

Under the No Action Alternative, no measurable effects on climate or climate change would result from not implementing the project. However, according to the United States Global Change Research Program (2011), the Northwest region's average temperature is projected to rise 3 to 10°F in this century, with

higher emissions scenarios resulting in warming in the upper end of this range. Increases in winter precipitation and decreases in summer precipitation are projected by many climate models, although these projections are less certain than those for temperature

6.2.2 RECOMMENDED PLAN

There will be no measurable effects on climate either during construction of the project or as a result of long-term operation of the recommended plan. For every gallon of diesel fuel burned, 22 pounds of CO2 are produced, and every gallon of gasoline produces 19.4 pounds of CO2 (USEPA 2008). The CO2 emissions created by this project are insignificant compared to the emissions generated in Boundary County annually. Nevertheless, diesel fuel consumption by heavy machinery required for construction, material delivery and haul-off, and gasoline consumption for travel to the sites are a small part of world-wide cumulative contributions to change in climate by way of increases in greenhouse gas emission.

The construction associated with this project is not anticipated to have a significant impact on the overall emissions of climate change gasses or the likelihood of regional climate change as assessed in the Air Quality effects section (Section 6.11).

As global climate change occurs, habitat benefits would still accrue, but changes in habitat conditions such as precipitation or river hydrology may alter the suitability of the current plant community. A drier, warmer summer may shift habitat conditions to favor more drought tolerant plant species. After construction, the site will be restored through planting the access road and staging area, in addition to the levee slopes. Vegetation survival at the site should be monitored. Depending on monitoring results, the operation and maintenance activities (solely the responsibility of the non-federal sponsor) would include replanting as necessary with a species list informed by the as-built climate and hydrology at the site. A monitoring plan and an operation and maintenance plan will be developed during the design phase.

6.3 HYDROLOGY/HYDRAULICS/GEOMORPHOLOGY

6.3.1 NO ACTION

Under the No Action Alternative, no impacts to existing hydrology and hydraulics would occur under future-without-project conditions.

6.3.2 RECOMMENDED PLAN

The recommended plan will not change the overall hydrologic regime of the Kootenai River because this project does not include changes to dam operations. This project does not rely on changes being made to the operations of the upstream dams, but can operate within the potential changes that are being currently implemented and/or envisioned for the future, as well as, likely hydrologic changes due to climate change.

The proposed project features, substrate placements, were analyzed for their effect on hydraulics using both 1D and 2D modeling (see Appendix E). The results of the modeling showed no discernible effect on the water surface elevations (including the 100-year), velocities, or shear stresses. These assessments we made based on the eight feet thick placement on the clay beds, which were subsequently reduced to two feet thick based on input from the sustainability workshop conducted in February 2012. At a two foot thick placement, the influences on hydraulics are even smaller. The project also does not alter the sediment supply. Therefore, without altering hydrology, hydraulics, or sediment supply, the project will not alter the geomorphology of the Kootenai River other than changing the localized bed surface in a limited area from clay to gravel and cobble.

6.4 WATER QUALITY

6.4.1 NO ACTION

Under the No Action Alternative, minimal changes in water quality conditions would occur under future without-project conditions. The temperature and sediment TMDL developed for the Lower Kootenai and Moyie River subbasins will improve water quality conditions in the subbasins, however these TMDLs are not for the mainstem Kootenai River in the project area, so improvements may only be minor. On the other hand continued development in the basin may lead to minor reductions in water quality. Overall, the minor improvements from TMDLs and other water quality improvement programs along with the minor impairments caused by development would cancel each other out.

6.4.2 RECOMMENDED PLAN

The overall temperature regime in the river that is highly affected by dam operations and will not be changed as a result of the recommended restoration plan.

There could be temporary impacts to water quality, mainly turbidity, during construction of the project. These impacts will be minimized by implementation of construction stormwater best management practices (BMPs) to the maximum extent practicable. These BMPs will likely include surface stabilization (i.e. mulches), silt fence and other sediment barriers, and by maintaining booms, silt curtains, and absorbent pads on site and implementing appropriate monitoring and maintenance of those BMPs to prevent the generation or release of potential pollutants. Water quality monitoring will take place to meet permit requirements. If water quality standards are exceeded then construction will be halted until additional BMPs can be installed to ensure standards can be met.

Construction equipment may release small amounts of pollutants into the water, including oils and grease or other contaminants, as a result of spills and leakages or the existence of contaminants on machinery that is used within the water column. The installation of containment measures at the staging area and the pollution prevention plans will be used to identify methods and procedures to control contaminants from entering the water through leaks or spills. Materials used for restoration would be clean from approved sources. During the design phase, detailed erosion and pollution control plans will be developed for each site.

6.5 VEGETATION AND WETLANDS

6.5.1 NO ACTION

Under the No Action Alternative, the condition of vegetation and wetlands would remain unchanged, in a degraded state with most of the floodplain areas leveed off and in agricultural production.

6.5.2 RECOMMENDED PLAN

As the majority of the project is located within the Kootenai River channel, only the access routing and staging area will affect existing vegetation and wetlands. Under the recommended plan, the staging area would be located in an area dominated by non-native vegetation (primarily crops) or where little or no native vegetation would have to be cleared.

Wetland impacts of the project are limited to where the access road to the staging area crosses a drainage ditch. These wetlands were classified as Riverine, Flood Plain, Excavated Canal, herbaceous (NRCS 2008) or as Riverine, Lower Perennial, Emergent, Persistent, saturated (Cowardin et al. 1979) and were of low quality. This crossing will be improved by replacing the culvert to accommodate the trucks hauling in the material and the heavy equipment. Replacing the culvert will temporarily disturb these wetlands

during construction. The expected impact would likely be less than 400 square feet and will not require filling or eliminating any wetlands. Following project construction, the river bank would be vegetated with native grass species and willows. The staging area will be restored similar to their existing condition and seeded with natives and mulched to prevent sediment runoff. Agricultural fields will be restored but not reseeded. A Planting Plan that will be prepared during final design.

6.6 FISH AND WILDLIFE

6.6.1 NO ACTION

Under the No Action Alternative the fish and wildlife habitat in the basin will continue to degrade from the effects of development in the basin. However, the restoration actions conducted under the Kootenai Tribe's Master Plan (Kootenai Tribe 2009) and the conditions met through the BiOp will improve the condition of fish and wildlife habitat. The Master Plan and other actions from the Kootenai Tribe will restore floodplain connectivity, restore riparian vegetation, reduce bank erosion and sedimentation, restore the natural river's hydraulic and morphologic condition, create off-channel habitat, improve in-stream structure and remove fish passage barriers. The BiOp provides several RPAs for the operation of Libby Dam that includes a number of flow management and habitat actions to restore natural processes on the river.

6.6.2 RECOMMENDED PLAN

The recommended plan will provide an overall benefit to aquatic species. The project will create additional early life stage habitats for KRWS. In addition, the placement of the habitat substrate will provide habitat for algal and macroinvertebrate species, increasing the diversity and community productivity of the riverine foodweb; hence improving overall ecosystem processes and benefits. Fish populations will increase as a result.

All work below the ordinary high water line will take place only during the in-water work window to minimize possible harm to fish species. Construction stormwater best management practices (BMPs) will be implemented to the maximum extent practicable in order to preserve local water quality, especially with respect to turbidity effects. These BMPs will include surface stabilization (i.e. mulching), silt fence and other sediment barriers, and a source-control program to prevent the generation or release of potential pollutants.

Terrestrial wildlife may be affected during construction primarily by disturbance. Construction equipment, human presence, and increased noise may disturb resident wildlife or discourage migrating wildlife from utilizing the surrounding habitats. Wildlife may also be affected if their habitats are altered during the construction process. Vegetation clearing, earthwork, and debris removal may directly impact foraging or nesting grounds for amphibians, reptiles, birds, and small mammals. However, since few wildlife species are present at the staging area due to the existing land use, it is unlikely than many species or individuals would be disturbed.

Vegetation clearing may reduce the availability of foraging, resting, or nesting habitat. Any clearing conducted for the purposed of access would be carefully planned, leaving native trees or shrubs intact, whenever possible. The majority of the area to be cleared is dominated by non-native plant species, and it is not expected to support a diverse or abundant assemblage of wildlife. Construction activities may require wildlife exclusion or protection to avoid or reduce affects to wildlife species. Wildlife would have many available habitats to disperse to temporarily and would return once construction is complete.

Overall, adverse impacts to fish and wildlife during construction are expected to be minor and temporary. Although fish may be temporarily excluded from habitats, the areas of exclusion would be minimal and

passage up- and down-stream would not be compromised. There would be minimal displacement of resident wildlife and temporary exclusion would be installed if appropriate; thus, there are not expected to be any significant adverse impacts.

6.7 THREATENED AND ENDANGERED SPECIES

6.7.1 NO ACTION

The further development of the Kootenai River basin would continue to negatively influence the conditions for protected species. However, several other restoration programs including the KRHRP Master Plan and the KRWS Conservation Aquaculture Project, combined with this effort, comprise a comprehensive ecosystem initiative intended to restore structure, function, and processes within a time frame intended to prevent KRWS and other species from becoming functionally extinct. These programs are being implemented through cooperative, inter-governmental partnerships that include the Kootenai Tribe, agencies of the United States, British Columbia, Idaho and Montana. In addition, the BiOp provides several RPAs for the operation of Libby Dam that includes a number of flow management and habitat actions to restore natural processes on the river. Overall, cumulative effects are expected to be beneficial to KRWS, bull trout, and other native species in the action area and is the reason the actions are being undertaken. However, due to the critical bottleneck for KRWS during the early life stages, this broader programs may not address KRWS natural recruitment soon enough. The hatchery program will provide juvenile fish to sustain the population, but natural recruitment is critical to the population.

6.7.2 RECOMMENDED PLAN

A biological assessment (BA) has been completed for the recommended plan and will be submitted separately.

The proposed project is designed to benefit KRWS. However, juvenile and subadult KRWS and bull trout are likely to be in the project area during construction. It was determined that the recommended plan may affect, and is likely to adversely affect: KRWS and bull trout as a result of construction activities; but would have no effects on the other listed species.

Designated KRWS critical habitat primary constituent elements (PCEs) and designated bull trout critical habitat PCEs would be either not affected or improved over the long term and the project would not hinder attainment of properly functioning habitat conditions for these species. Therefore, the proposed project would not destroy or adversely modify KRWS designated critical habitat or designated Columbia River bull trout critical habitat. A summary of the preliminary determination of findings is provided in Table 6-1.

Table 6-1. Threatened and Endangered Species Determination of Effects Summary for the Recommended Plan

Species	Effect Determination	Critical Habitat Determination
Canada Lynx *Lynx canadensis*	No effect	No effect
Woodland Caribou *Rangifer tarandus caribou*	No effect	No effect
Grizzly Bear *Ursus arctos horribilis*	No effect	N/A
Kootenai River White Sturgeon *Acipenser transmontanus*	May affect, likely to adversely affect	May affect, not likely to adversely affect
Bull Trout *Salvelinus confluentus*	May affect, likely to adversely affect	May affect, not likely to adversely affect

Canada lynx, woodland caribou, and grizzly bears are not expected to be in the project area during any phase of construction of this project. Therefore, the proposed project will have no effect on Canada lynx, woodland caribou, and grizzly bear.

It is possible that injury to or mortality of bull trout would occur as a result of the recommended plan. This species is unlikely to be in the action area during the late summer/early fall construction period, however, they may be present in the late fall, towards the end of the in-water work period. The species critical habitat PCEs may be slightly improved over the long term as a result of the proposed action. Due to low abundance of bull trout and the large quantity of available habitat in the Kootenai River reaches in relation to the actual area of impact, potential harassment or displacement of individual bull trout would likely be minor.

Because it is a possibility that bull trout could be present in the project area during construction, for the purposes of this consultation it is assumed that adult or subadult bull trout may be startled out of the project area. Some mortality during construction may be expected; and therefore, a few individual bull trout could be killed during construction efforts. Therefore, it has been determined that the project **may affect and is likely to adversely affect** Columbia River bull trout.

Adult KRWS are unlikely to be in the action area during the late summer/fall construction period; however, juvenile and subadult KRWS are likely to be present. The species critical habitat PCEs would be improved over the long term as a result of the proposed action. Due to low abundance of KRWS and the large quantity of available habitat in the Kootenai River reaches in relation to the actual area of impact, potential displacement of KRWS would likely be minor.

Similarly, because it is possible that a few juvenile and subadult sturgeon could be present in the project area during construction and some fish may be startled out of the project area, for the purposes of this consultation is assumed that some mortality during construction can be expected. Thus, some juvenile and subadult sturgeon could be killed during construction efforts. Therefore, it has been determined that the project **may affect and is likely to adversely affect** KRWS.

6.8 CULTURAL RESOURCES AND HISTORIC PROPERTIES

Section 106 of the NHPA as amended requires that federal agencies identify, evaluate, and assess the effects of undertakings on sites, buildings, structures, or objects listed in or eligible for listing on the NRHP. USACE has determined that the Project is a federal undertaking of the type that could affect properties eligible for the NRHP.

USACE archaeologists completed a cultural resource inventory of the entire Area of Potential Effect for the project in September of 2011. The inventory consisted of a pedestrian survey at 10-meter intervals and the excavation of 106 shovel test pits. A portion of the Kootenai River Levee system is located in the project area. USACE has determined and the Idaho State Historic Preservation Officer has concurred that the project will have "No Adverse Effect" to the dike/levee portion located within the Shorty's Island project area. The riverward access route will be temporary in nature and will be removed once the project is completed. The levee will be restored to its original condition, if necessary. In addition, USACE recommends monitoring any ground-disturbing activities associated with the creation of the temporary access road along the riverward side of the levee and shoreline excavation.

USACE sent letter to the Idaho State Preservation Office for Section 106 consultation on July 11, 2011. Knowledge and Concerns letters were sent to the Kootenai Tribe and the Confederated Salish and Kootenai Tribe (CSKT) on July 11, 2011. Follow up phones calls were made to Travis Pitkin of the Idaho State Historic Preservation Office, Josephine Shottanana of the Kootenai Tribe and Francis Auld of the CSKT. A copy of the cultural resource inventory report titled *Cultural Resources Report for the Shorty's Island/Meander Reach Ecosystem Restoration on Kootenai River, Boundary County, Idaho* was sent to the aforementioned tribes, Idaho State Historic Preservation Office and BPA for their review and comment. As of the writing of this EA no comments have been received. The cultural resources report is on file at the Seattle District USACE and Idaho State Historic Preservation Office.

6.8.1 No Action

No disturbance to any cultural and historic resources would occur under the No Action Alternative.

6.8.2 Recommended Plan

The cultural resources assessment did not yield any significant cultural material during the course of a pedestrian survey and subsurface testing. However, USACE recommends monitoring any ground disturbing activities associated with the creation of the temporary access road along the riverward side of the levee and the shoreline excavation. USACE has determined that the Shorty's Island/Meander Reach Ecosystem Restoration Project will have "No Adverse Effect" to the portion of the dike/levee system located within the project area.

6.9 Socio-Economic Conditions

6.9.1 No Action

The No Action Alternative may result in the eventual loss of a sustainable KRWS population. This would impact the subsistence of the Kootenai Tribe, which relies on KRWS as a resource. In addition, tourism and recreation in the area is likely to decrease due to the loss of this fish species.

6.9.2 Recommended Plan

The Kootenai Tribe is a major partner in this project and has a cultural and spiritual interest in the recovery of the KRWS population. This project will support the recovery of this species and will contribute to the continued subsistence of the Kootenai Tribe by maintaining a historic resource.

No significant long-term effects on agriculture, businesses, or other industries in the study area are expected as a result of the recommended restoration plan. The project will occur mainly within the banks of the Kootenai River with staging areas on adjacent property that is currently open space or in agricultural production. The recovery of KRWS may indirectly support the tourism and recreation industry of the area.

During construction, there may be a small number of local construction jobs that would be created or maintained associated with the various construction contracts, which may have direct and indirect effects on the local economy, but these effects are expected to be minor in the scale of overall construction employment in Boundary County and will be temporary.

Because substrate will be sourced from local quarry pits, these businesses will receive increased revenue during construction, but this impact will not be sustained after completion of construction.

There also may be minor traffic effects to adjacent residences when trucks are importing or removing material. There are less than 10 residences that would be impacted along the haul route providing access to the staging area. Impacts to traffic will be minimized to the maximum extent practicable by traffic-control signage and flagging or other methods as necessary. It is not expected that significant adverse economic effects will occur to any businesses or commerce during construction.

6.10 LAND USE

6.10.1 NO ACTION

No effects on land use in the project vicinity would occur as a result of the No Action Alternative.

6.10.2 RECOMMENDED PLAN

There will be no effects or land use changes in the project vicinity or in the study area as a result of the recommended plan.

6.11 AIR QUALITY

6.11.1 NO ACTION

No changes in air quality would occur under the No Action Alternative.

6.11.2 RECOMMENDED PLAN

The recommended plan would have no long-term effects on air quality. The project will not construct any new sources of air pollution. Construction vehicles may temporarily increase air emissions in the immediate project vicinity, through the release of carbon monoxide and other pollutants from fuel combustion. Other emissions under consideration for non-road construction equipment are reactive organic gases (ROGs) (which are ozone precursors), nitrogen oxides (NOx), particulate matter (PM), and sulfur oxides (SOx).

During construction, airborne contaminants, including dust and other particulate matter may be released into the air during clearing of project areas and use of heavy equipment that stirs up exposed soils. Measures would be taken to reduce dust in cleared areas, including the application of water to exposed soils or placement of mulches or other materials to reduce dust.

For every gallon of diesel fuel burned, 22 pounds of CO2 are produced, and every gallon of gasoline produces 19.4 pounds of CO2 (USEPA 2008). The CO2 emissions created by this project are insignificant compared to the emissions generated in Boundary County annually. Overall, no significant adverse impacts are expected for air quality.

6.12 NOISE

6.12.1 NO ACTION

No changes to noise levels would occur under the No Action Alternative.

6.12.2 RECOMMENDED PLAN

Construction vehicles and equipment may temporarily increase noise in the immediate project vicinity. Construction will be restricted to normal working hours to minimize disturbance to residents (i.e. 7 a.m. to 7 p.m.). Some example sources and magnitude of noise arising from construction is summarized in Table 6-2 from the FHWA Construction Noise Handbook (USDOT 2006).

Based on the preliminary project designs, construction may call for the use of excavators, bull dozers, front loaders, a wheel-mounted crane, and a vibratory pile driver. Based on the type and duration of construction activities proposed, temporarily elevated levels of noise are not expected to be an issue for the study area. The land uses adjacent to the construction zones are largely composed of rural residential and agricultural land uses. No sensitive receptors have been identified adjacent to the project sites.

Table 6-2. Example Equipment Noise Levels

Equipment Description[1]	Impact Device?	Spec. 721.560 L_{max} at 50 feet (dBA, slow)
Chain Saw	No	85
Compactor (ground)	No	80
Compressor (air)	No	80
Concrete Pump Truck	No	82
Concrete Saw	No	90
Crane	No	85
Dozer	No	85
Dump Truck	No	84
Excavator	No	85
Flat Bed Truck	No	84
Front End Loader	No	80
Grader	No	85
Impact Pile Driver	Yes	95
Pickup Truck	No	55
Tractor	No	84

Source: Federal Highway Administration 2009.
Note: [1]List of equipment truncated for example purposes. Full list available at source identified above.

In addition, driving piles to construct the dock has the potential to affect fish species. However, measures will be taken to effectively reduce the potential of these impacts. Pile driving effects are dependent on a number of variables, some of which include (1) species of fish, (2) fish size, (3) physical condition of the fish, (4) type of pile driving (vibratory or impact), (5) depth of the water around the pile, (6) depth of the fish in the water column, (7) bottom substrate composition and texture, (8) effectiveness of sound/pressure attenuation technology, and (9) presence of predators (NOAA 2004a). Depending on these factors, effects on fish can range from changes in behavior to immediate mortality.

The dock is expected to be composed of driven support piles (steel or vinyl) and sheet piling (vinyl) to contain fill/surface material. The sheet and support piles are expected to be driven to an estimated elevation of 1,729 feet with the dock face panels having nine vertical feet exposed and 16 feet buried for a total length of 24 feet. The dock sheet pilings are expected to be vibro-hammer driven in 36 inch sections

resulting in roughly 25 piles driven (for a total of 70 linear bulkhead feet). Pile driving is expected to require no more than three days.

Information on the effects of exposure to sound has mainly been focused on listed salmonid species. Information and data on the effects to sturgeon are unavailable. Based on their physiology, sturgeon have a very different ear structure than salmonids, and because their hearing capabilities are unknown, it is difficult to extrapolate their response to pile driving (Hastings and Popper 2005). However, with the amount of data available and the relatively greater sensitivity of salmonids to sound pressure exposure, this effects determination and mitigation recommendations are based on bull trout with the assumption that conservation measures appropriate for bull trout will effectively protect KRWS as well.

Sound pressure levels near or above 180 dB peak are produced by impact pile drivers and have been associated with fish kills (NOAA 2003a; NOAA 2003b; NOAA 2004a; NOAA 2004b; USFWS 2003b). The Federal Highway Administration, NOAA, USFWS, the Departments of Transportation from California, Oregon, and Washington have agreed upon Interim Criteria for Injury to Fish from Pile Driving Activities (NOAA, et al. 2008). The agreed upon criteria identify underwater sound pressure levels of 206 dB peak and 187 dB accumulated sound exposure level (SEL) for all listed fish except those that are less than two grams. In that case, the criteria for the accumulated SEL will be 183 dB. Short-term exposure to SPLs above 190 dB is thought to impose physical harm on fish (Hastings 2002). However, 155 dB (re: 1 µPa) may be sufficient to temporarily stun small fish (pers. comm. between NOAA and J. Miner, Gunderboom, Inc., Anchorage, Alaska, 2002, cited in NOAA 2004a). Stunned fish, while perhaps not physically injured, are more susceptible to predation. Therefore an impact pile driving disturbance threshold was set at 150 dB for behavioral effects (WSDOT 2009; NOAA 2003a; NOAA 2003b; NOAA 2004a; NOAA 2004b; USFWS 2003b).

The use of a vibratory hammer to drive the piles essentially mitigates the potential for harming fish species by reducing the frequency of the sound produced. When compared to impact hammers, the sounds produced by vibratory hammers are of longer duration (minutes versus milliseconds) and have more energy in the lower frequencies (15 to 26 Hertz [Hz] versus 100 to 800 Hz) (Würsig, et al. 2000; Carlson, et al. 2001). In a vibratory pile driving project in Oregon, acoustic monitoring was conducted and it was determined that juvenile salmonids would have an avoidance response within about 30 feet from the pile being driven (Carlson, et al. 2001). A review of the literature does not indicate any fish kills associated with vibratory pile driving. Furthermore, SPL from vibratory drivers have not been shown to exceed the threshold for injury (180 dB re 1 µPa SPL). It is assumed that no sound attenuation device will be necessary during any vibratory pile driving. A vibratory hammer was selected to drive the piles for the dock in order to minimize the impacts on aquatic species.

Another critical aspect of underwater acoustics relevant to work with salmonids and other fish, is that low-frequency sound propagates very poorly in shallow water because the wavelength is larger than the water depth (Rogers and Cox 1988). Low frequency sounds attenuate far more rapidly with distance from the source in shallow than in deep water (Rogers and Cox 1988). Because low-frequency propagation is affected strongly by depth, fish in shallow habitats probably detect lower-frequency sounds only from sources that are extremely close to them. This provides ample opportunity for the fish to move out of the area of disturbance. At the project site the water depth of the pile driving will be six feet on average and will slightly further reduce sound propagation.

Substrate also affects attenuation rates; for a given depth, lower frequencies propagate over soft bottoms better than over hard bottoms. Burgess, et al. 2005 found that the substrate conducts the acoustic energy from the driver. The substrate at the project site consists of sand and lacustrine clay and could propagate sound further than harder substrates, but this is likely to be offset by the shallow water depths at the pile installation location.

6.13 TRANSPORTATION AND UTILITIES

6.13.1 NO ACTION

No changes to transportation and utilities would occur under the No Action Alternative.

6.13.2 RECOMMENDED PLAN

There may be minor traffic effects to adjacent residences when trucks are importing or removing material. There are less than 10 residences that would be impacted along the haul route providing access to the staging area. Impacts to traffic will be minimized to the maximum extent practicable by traffic control signage, and flagging or other methods as necessary.

Utilities will not be affected by the construction of the project. Care will be taken to design the project elements to avoid any utilities during construction.

6.14 RECREATION

6.14.1 NO ACTION

Under the No Action Alternative, changes in recreation may occur with the loss of a naturally occurring KRWS population and potential loss of this fishery. This loss may also have an effect on the economic prosperity of the region.

6.14.2 RECOMMENDED PLAN

The recommended restoration plan does not include any recreational elements. Passive recreation such as fishing, boating, and wildlife and bird watching occurs within the river reach. Indirect/future passive recreational opportunities may be created as a result of increased habitat and fish populations by the recommended restoration plan. However, no long-term negative effects on recreation are expected.

During construction, there may be a minor effect on recreation availability in the construction area. The staging area, barge loading dock, and substrate placements sites may restrict access to those immediate areas for fishing and boating activities, but these effects will be temporary. Additionally, during construction, the quality of recreation opportunities may be altered due to audible and visual observations of the project being built.

6.15 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

6.15.1 NO ACTION

No changes to HTRW are expected to occur in project vicinity as a result of the No Action Alternative.

6.15.2 RECOMMENDED PLAN

A preliminary HTRW Assessment was completed in November 2011 (Appendix M). Historical documents, site reconnaissance, and interviews revealed minor HTRW contamination potential on the project site. During construction and installation activities, fuels, oils, lubricants, and other hazardous materials will be used. An accidental release or spill of any of these substances could occur. A spill could result in potentially adverse impacts to on-site soils (see Section 6.4.2 for a discussion of potential construction-related water quality impacts). However, the amounts of fuel and other lubricants and oils will be limited, and the equipment needed to quickly limit any contamination will be located on site. To minimize the likelihood of potential spills and leaks of petroleum and hydraulic fluids during project construction, construction equipment will be inspected daily for leaks and petroleum contamination.

Additionally, a spill prevention control and containment plan designed to reduce impacts from spills (fuel, hydraulic fluid, etc.) will be in place prior to the start of construction. Finally, the project will not introduce any hazardous materials to the project areas. Therefore impacts to hazardous and toxic materials are expected to be insignificant.

6.16 ENVIRONMENTAL JUSTICE

6.16.1 NO ACTION

There are no effects in regards to environmental justice in relation to the No Action Alternative.

6.16.2 RECOMMENDED PLAN

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. The federal government has this goal for all communities and persons across this nation. It would be achieved when everyone enjoys the same degree of protection from environmental and health hazards, equal access to the decision-making process, and the opportunity to have a healthy environment in which to live, learn, and work.

The demographics of the project area include the 2010 Census population count for Boundary County of 10,972, of which 8,163 are 18 years and older. Based on 2009 Census data, as the 2010 data are not yet available, the median household income is $38,618, with 15.9 percent of individuals below the poverty level. Of the total population aged > 25 years, 80.5 percent has a high school education and 14.4 percent have a bachelor's degree or higher. The majority of the population is white (94.8 percent) with Hispanic or Latinos at 3.7 percent. American Indian, Asian, and African American races at 1.7 percent, 0.6 percent and 0.3 percent, respectively. The Kootenai Tribe is present in the project area and is the sponsor for this project. The project is being undertaken to benefit KRWS and indirectly benefit the Kootenai Tribe by helping to restore a significant resource in their culture.

The project would only temporarily affect noise, traffic, and air quality during construction. The project will not affect human health as it will not involve the siting of a facility or creation of a scenario in which pollutants or contaminants would be discharged. This project will not have a disproportionately negative effect on an ethnic minority, low-income, or subsistence populations and may provide benefits via the contributions to recovery of fishable sturgeon and other fish populations. Therefore the proposed action is in compliance with this order.

6.17 INDIRECT AND SECONDARY EFFECTS

Secondary or indirect impacts of the project include the possible promotion of additional restoration projects in the Kootenai River Basin based on the project's success. Additional fishing opportunities may be provided due to an increase in the fish populations as a result of restoration actions. Future recreation and environmental education enhancements may also be implemented within the project area as a direct result of successful habitat restoration.

6.18 CUMULATIVE IMPACTS

Significant cumulative impacts to the Kootenai River Basin have occurred since Euro-American settlement began in the early 1800s. Key actions have included agricultural and urban development, timber harvesting, construction of dams and revetments/levees, water withdrawals and removal of wood from the rivers. These effects have altered the hydrology and geomorphology of the river, disconnected the river from its floodplain and affected the conditions of the physical habitat. As a result the KRWS population has precipitously declined and does not appear to be naturally reproducing. This proposed

project will incrementally reverse some of the cumulative adverse effects that have occurred in the project area by enhancing the physical habitat of the Kootenai River to promote successful natural spawning and early life history stage survival of KRWS. In addition, in combination with the other restoration actions that are occurring in the broader Kootenai River Basin, this project will have a positive cumulative effect on the watershed.

Several other restoration programs including the KRHRP Master Plan and the KRWS Conservation Aquaculture Project, combined with this effort, comprises a comprehensive ecosystem initiative intended to restore structure, function, and processes within a time frame intended to prevent KRWS and other species from becoming functionally extinct. These programs are being implemented through cooperative, inter-governmental partnerships that include the Kootenai Tribe, agencies of the United States, British Columbia, Idaho and Montana. In addition, the BiOp provides several RPAs for the operation of Libby Dam that includes a number of flow management and habitat actions to restore natural processes on the river. Overall, cumulative effects are expected to be beneficial to KRWS, bull trout, and other native species in the action area and is the reason the actions are being undertaken.

6.19 Unavoidable Adverse Impacts and Mitigation

Unavoidable adverse effects of the proposed project and associated mitigation measures include:

1. Temporary increases in turbidity during construction, of which the effects will be minimized by implementation of pollution prevention measures, water quality monitoring, and working within the designated in-water work window ("fish window").

Temporary noise disturbances to wildlife and homeowners in the vicinity due to operating heavy equipment during excavation and construction of the restoration site. Most wildlife is anticipated to avoid the area while work is in progress. Noise disturbance will be mitigated through limiting construction periods to daylight hours only. In addition, the behavior of wildlife and nesting birds will be monitored to ensure disruption is avoided or minimized.

6.20 Environmental Compliance Requirements

6.20.1 National Environmental Policy Act

This Draft Detailed Project Report and Environmental Assessment (EA), prepared November 2011, is intended to achieve NEPA compliance for the proposed project. As required by NEPA, this EA describes existing environmental conditions at the project site, the proposed action and alternatives, potential environmental impacts of the proposed project, and measures to minimize environmental impacts. No significant adverse effects have been identified.

6.20.2 Endangered Species Act

The Endangered Species Act (ESA) of 1973, as amended, declares that all federal agencies "…utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to Section 4 of this Act.". Section 7 of the ESA requires federal agencies to ensure that any agency action (any action authorized, funded, or carried out by the agency) is not likely to jeopardize the continued existence of any threatened, endangered, or proposed species. Agencies are further required to develop and carry out conservation programs for these species.

In accordance with Section 7(a)(2) of the Endangered Species act of 1973, as amended, federally funded, constructed, permitted, or licensed projects must identify and evaluate any threatened and endangered species, and their critical habitat, that may be affected by an action proposed by that agency. A draft Biological Assessment has been prepared and will be submitted separately. A determination of "may

affect, and likely to adversely affect" was made for KRWS and bull trout as a result of construction activities. The critical habitat of KRWS and bull trout may also be affected, but is not likely to be adversely affected as a result of construction activities. USACE is conducting a Section 7 consultation with USFWS and conservation measures will be performed during construction of the project in order to ensure the protection of endangered and threatened species.

6.20.3 Clean Water Act

Section 404 of the Clean Water Act authorized a permit program for the disposal of dredged or fill material into waters of the United States, and defined conditions which must be met by federal projects before they may make such discharges. USACE retains primary responsibility for this permit program. USACE does not issue itself a permit under the program it administers, but rather demonstrates compliance with the substantive requirements of the Act through preparation of a 404(b)(1) evaluation.

A draft 404(b)(1) evaluation will be prepared that documents findings regarding this project pursuant to Section 404 of the Act as well as Section 10 of the Rivers and Harbors Act of 1899.

Section 401 of the Clean Water Act requires federal agencies to comply with EPA, state, or tribal water quality standards. EPA has delegated implementation of Section 401 to IDEQ. This work will require 401 certification from IDEQ for compliance with Section 401 of the Clean Water Act for work below the OHW line. USACE will obtain a water quality certification and abide by the conditions of that certification to ensure compliance with Idaho water quality standards.

Section 402 of the Act requires a National Pollutant Discharge Elimination System (NPDES) permit and the associated implementing regulations for General Permit for Discharges from large and small construction activities for construction disturbance over one acre. This permit will be obtained by the construction contractor to be required within the specifications of the contract.

6.20.4 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 U.S.C. 661) requires that wildlife conservation receive equal consideration and be coordinated with other features of water resource development projects. This goal is accomplished through USACE funding of a Coordination Act Report which provides the basis for recommendations for avoiding or minimizing such impacts. Coordination with USFWS has been ongoing throughout the study process.

6.20.5 National Historic Preservation Act

The National Historic Preservation Act (NHPA) requires that the effects of proposed federal undertakings on sites, buildings structures, or objects included or eligible for listing in the National Register of Historic Places must be identified and evaluated.

Eligible properties must generally be at least 50 years old, possess integrity of physical characteristics, and meet at least one of four criteria for significance. Regulations implementing Section 106 (36 CFR Part 800) of the NHPA encourage maximum coordination with the environmental review process required by NEPA and with other statutes. In order to comply with the NHPA, USACE has conducted a cultural resource inventory, prepared a report detailing the results of that inventory, and has submitted the report to the Idaho State Historic Preservation Officer. USACE has consulted with the Kootenai Tribe and CSKT.

6.20.6 Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d)

The Bald and Golden Eagle Protection Act prohibits the taking, possession or commerce of bald and golden eagles, except under certain circumstances. Amendments in 1972 added penalties for violations of the act or related regulations.

Although bald eagles are generally known to occur in the study area, no take of either bald or golden eagles is likely during project construction. No nests are known to be present in the staging or construction areas. Therefore, no adverse effects to eagles are anticipated.

6.20.7 Wild and Scenic Rivers Act (16 U.S.C. 1271-1287)

No portions of the Kootenai River have been designated as a Wild and Scenic River so this Act is not applicable to the proposed work.

6.20.8 Executive Order 12898, Environmental Justice

Executive Order 12898 directs every federal agency to identify and address disproportionately high and adverse human health or environmental effects of agency programs and activities on minority and low-income populations. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. The federal government has this goal for all communities and persons across this nation. It would be achieved when everyone enjoys the same degree of protection from environmental and health hazards, equal access to the decision-making process, and the opportunity to have a healthy environment in which to live, learn, and work.

Per the analysis provided in Section 6.6, above, this project will not have a disproportionate adverse effect on low-income, minority, or otherwise disadvantaged populations.

6.20.9 Executive Order 11990, Protection of Wetlands, May 24, 1977

A detailed wetland delineation was conducted at the project site to quantify wetlands present on each site. The results of this assessment are found in Appendix K. The project is in compliance with this executive order because it will not induce adverse effects to wetlands.

6.20.10 Executive Order 11988, Floodplain Management, May 24, 1977

Executive Order 11988 requires federal agencies to avoid, to the extent possible, the long and short-term adverse impacts associated with the occupancy of the floodplain, and to avoid direct and indirect support of floodplain development where there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains."

The proposed action would not create a change that would affect occupancy of the floodplain or induce development in the floodplain.

6.20.11 Native American Graves Protection and Repatriation Act

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001) addresses processes and requirements for federal agencies regarding the discovery, identification, treatment, and repatriation of Native American and Native Hawaiian human remains and cultural items (associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony). Consistent with procedures set forth in applicable federal laws, regulations, and policies, USACE will

proactively work to preserve and protect natural and cultural resources, and establish NAGPRA protocols and procedures.

6.20.12 EXECUTIVE ORDER 13175, TRIBAL COORDINATION AND CONSULTATION, NOVEMBER 6, 2000

Executive Order 13175 reaffirmed the federal government's commitment to a government-to-government relationship with Indian Tribes, and directed federal agencies to establish procedures to consult and collaborate with tribal governments when new agency regulations would have tribal implications.

In accordance with this Executive Order, USACE has engaged in regular and meaningful consultation and collaboration with the Kootenai Tribe throughout the course of the Shorty's Island 1135 study. USACE continues to strive to meet the federal government's trust responsibility by implementing this project.

7 PUBLIC INVOLVEMENT, REVIEW, AND CONSULTATION

7.1 STAKEHOLDER AND PUBLIC INVOLVEMENT

7.1.1 STAKEHOLDER INVOLVEMENT

Two workshops where convened over the course of the Section 1135 study to gain input on each of the major aspects of the project planning process. Participants included USACE discipline specialists, non-federal sponsor representatives as well as Federal and state agency technical experts and representatives.

The first workshop for was held May 18 and 19 2010 in Bonners Ferry Idaho. A site visit was also conducted on May 17th to familiarize participants with the project area. The overall purpose of this workshop focused on project scoping. The specific purpose of the first day of the workshop was to identify problems and opportunities specific to Meander Reach 1, provide input on project constraints and objectives as well as the overall project goal. The second day focused on review of the measures and alternatives that had been considered to date, technical studies available, and the scope of the measures to be considered for the feasibility study as well as design criteria and considerations. Attendees for all or part of the workshop included:

Kootenai Tribe of Idaho	Ron Abraham, Billy Barquin, Sue Ireland, Patty Perry
USACE	Olton Swanson, Alan Coburn, Greg Hoffman, Karl Erickson, Charyl Francois, Stacy Kassover, Kristen Kerns, Jeff Laufle, Evan Lewis, Glen Matlock, Rachel Mesko, Brian Nelson, Rod Perry, Virginia Ryan, Maria Selck
IDFG	Vaughn Paragamian, Pete Rust
MTFWD	Jim Dunnigan
USGS	Gary Barton, Mike Parsley
BPA	John Barco, Scott Bettin, Greg Delwiche,
BC MOE	Matt Neufeld
Consultants	Boyd Kynard - BK-Riverfish, LLC
	Paul Anders – Cramer Fish Sciences
	Dan Warren - DJ Warren and Associates
	Tom Parker - Geum Environmental Consulting
	Joan Nichol - Meridian Environmental
	Matt Daniels - River Design Group
	Bill Fullerton, Merri Martz, Darlene Siegel – Tetra Tech
	Alison Squier - Ziji Creative Resources

The second workshop, alternative evaluation and plan selection workshop, was held December 2 and 3 2010, in Spokane, Washington. The purpose of the workshop was to provide an overview of the formulation and evaluation of the final array of measures and plans and to identify a preferred plan. Information presented included findings of technical studies, of the evaluation of measures and the results of the CE/ICA. Input was also sought on other factors that should be considered in identifying a preferred plan. The expected outcome of the workshop was to identify a recommended restoration plan that could be supported by USACE, local sponsor and stakeholders and could be nationally competitive in the Section 1135 program. Other expected outcomes of the workshop include further design and refinements of the recommended plan and completion of a cost and schedule risk assessment. Each of these outcomes was achieved. Attendees for all or part of the workshop included:

Kootenai Tribe of Idaho	Sue Ireland
USACE	Alan Coburn, Karl Erickson, Charyl Francois, Greg Hoffman, Kristen Kerns, Glenn Matlock, Kirk Frederick
IDFG	Vaughn Paragamian, Pete Rust
USFWS	Jason Flory
USGS	Gary Barton
BPA	Scott Bettin
Consultants	Paul Anders – Cramer Fish Sciences/University of Idaho Bill Fullerton, Patty Robinson, Merri Martz, Darlene Siegel, Matthew Merritt, Shannon Brattebo – Tetra Tech Alison Squier - Ziji Creative Resources

In addition to the workshops, project stakeholders were provided the opportunity to review and provide input on the DPR/EA during development of specific chapters as well as review of the overall document in November 2011.

7.1.2 PUBLIC INVOLVEMENT

[TO BE COMPLETED FOLLOWING PUBLIC REVIEW OF THE EA]

7.2 AGENCY AND PUBLIC COMMENTS AND RESPONSES

[TO BE COMPLETED FOLLOWING PUBLIC REVIEW OF THE EA]

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8 CONCLUSION

8.1 COST-SHARING AND IMPLEMENTATION CONSIDERATIONS

Preliminary total project costs include the feasibility phase as well as design and implementation and are presented in Table 8-1. The preliminary estimate of total feasibility costs is approximately $1.5 million. This figure will be refined based on review of work-in items which have been completed by the non-federal sponsor. The preliminary estimate of design and implementation costs is approximately $4.4 million. These costs will be refined in the design and implementation phase.

Table 8-1. Cost Share Summary (Q1FY12 Price Level)

	Total ($)	Federal Share ($1,000)	Non-Federal Share ($1,000)
Feasibility Costs[1]	1,535,000	767,000	767,000
Design and Implementation Costs	4,390,000	3,321,000	1,069,000
LERRD and non-federal LERRD Administrative	38,000	0	38,000
Totals	**5,963,000**	**4,088,000**	**1,874,000**

Notes: LERRD – land, easements, relocation, rights-of-way, and disposal areas
[1]Feasibility costs to be finalized pending determination of work in-kind services.

The non-federal sponsor is aware of their responsibilities. The non-federal sponsor shares 50 percent of feasibility costs and 25 percent of design and implementation costs under the Section 1135 program. Project costs exceeding the federal program limit will be the non-federal sponsor's responsibility. The non-federal sponsor is responsible for 100 percent of operation and maintenance, repair, replacement, and rehabilitation. The non-federal sponsor is responsible for providing all LERRD, the value of which will be applied towards their 25 percent of design and implementation costs. Up to 50 percent of the non-federal sponsor share can be provided as in-kind services. The remaining non-federal share is provided in cash after credit is applied for LERRD and in-kind services. Potential in-kind services will be outlined and agreed upon prior to signature of the Project Partnership Agreement.

8.2 AREAS OF CONTROVERSY

[TO BE COMPLETED FOLLOWING PUBLIC REVIEW OF THE EA]

8.3 RECOMMENDATIONS

It is recommended that the proposed work be authorized and a federal-funding allotment of $2,862,000 be made available to complete the recommended plan for the Shorty's Island/Meander Reach Ecosystem Restoration Project. The proposed work would improve habitat for KRWS in Meander Reach 1 of the Kootenai River as generally described in this report, with such modifications by the Chief of Engineers as may be advisable to meet provisions of Section 1135 of the Water Resources Development Act of 1986, as amended. Authorization is subject to cost-sharing and financing arrangements with the non-federal sponsor, the Kootenai Tribe of Idaho, and is based on the cost-sharing and financing requirements as contained in Public Law 104-303, as amended. Before carrying out any project under Section 1135, the non-federal sponsor will enter into a binding agreement to provide all lands easements, rights-of-way, and any relocations necessary to carry out the project; agree to pay 100 percent of the operation, maintenance, repair, replacement, and rehabilitation costs associated with the project; hold the U.S. government harmless from any claim or damage that may arise from carrying out the project, except any claim or damage that may arise from negligence of the federal government or a contractor of the federal government; and agree to operate and maintain the project after construction.

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Colonel Bruce A. Estok Date
U.S. Army Corps of Engineers
District Commander

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10 LIST OF PREPARERS AND SUPPORTERS

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Appendices

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