Fisheries Mitigation and Implementation Plan for Losses Attributable to the Construction and Operation of Libby Dam

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FISHERIES MITIGATION AND IMPLEMENTATION PLAN FOR LOSSES ATTRIBUTABLE TO THE CONSTRUCTION AND OPERATION OF LIBBY DAM

MONTANA DEPARTMENT OF FISH, WILDLIFE & PARKS

CONFEDERATED SALISH AND KOOTENAI TRIBES

KOOTENAI TRIBE OF IDAHO

1998

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EXECUTIVE SUMMARY

In this document we present fisheries losses, mitigation alternatives, and recommendations to protect, mitigate, and enhance resident fish and aquatic habitat affected by the construction and operation of Libby Dam. This plan addresses resident fish program measures in Section 10.3B of the existing Fish and Wildlife Program (NPPC 1995). This document represents a mitigation and implementation plan for consideration by the Northwest Power Planning Council (NPPC) process as called for in 10.3B.11. The work was funded the U.S. Army Corps of Engineers (ACOE) and Bonneville Power Administration (BPA).

Libby Dam, on the Kootenai River, near Libby, Montana, was completed in 1972, and filled for the first time in 1974. The dam was built for hydroelectric power production, flood control, and recreation. Libby Reservoir inundated 109 stream miles of the mainstem Kootenai River in the United States and Canada, and 40 miles of tributary streams in the U.S. that provided habitat for spawning, juvenile rearing, and migratory passage. Impoundment of the Kootenai River blocked the migrations of fish populations that once migrated freely between Kootenai Falls (29 miles below Libby Dam) and the headwaters in Canada. Historically, the fish residing downstream of Libby Dam could access quality spawning habitat upstream of Libby Dam in the United States and Canada.

Operations of Libby Dam cause large fluctuations in reservoir levels and rapid daily fluctuations in volume of water discharged to the Kootenai River. Seasonal flow patterns in the Kootenai River have changed dramatically, with higher flows during fall and winter, and lower flows during spring and early summer.

The complexities of the river-lake ecosystem (Kootenai River-Kootenay Lake) are not yet fully understood, but indications of the fragility of this unique ecosystem are evident with declining native white sturgeon recruitment and burbot populations, as well as kokanee and rainbow that reside in Kootenay Lake. Many of the losses have only recently become apparent (e.g. white sturgeon listing did not occur until 1994), though a gradual population declines have been evident for decades.

Construction of the dam blocked spawning migrations of westslope cutthroat trout, bull trout, and burbot residing above Kootenai Falls to spawning tributaries in the U.S. and Canada. The lack of fish passage facilities at Libby Dam assures that fish may not migrate upstream from below the dam. Downstream passage is possible through the dam turbines and outlet works (Skaar et al. 1996). It is difficult to ascertain the specific effect of this on the declining native fish species in the river. In this document, we group all of the perturbations associated with the construction and operation of Libby Dam, and assume that all changes in river function have contributed to the decline of native riverine fish populations residing below Libby Dam.

Reservoir operations that cause excessive drawdowns and refill failure are harmful to aquatic life in the reservoir. Jenkins (1967) found a negative correlation between standing crop of fish and yearly vertical water fluctuations in 70 reservoirs.

Problems occur for resident fish when Libby Reservoir is drawn down during late summer and fall, the most productive time of year. The reduced volume and surface area reduces the potential for providing thermally optimal water volume during the high growth period, and limits fall-hatching aquatic insects. Surface elevations continue to decline during winter, arriving at the lowest point in the annual cycle during April. Deep drafts reduce food production and concentrate young trout with predators like northern pikeminnow. Of greatest concern is the dewatering and desiccation of aquatic dipteran larvae in the bottom sediments. These insects are the primary spring food supply for westslope cutthroat, a species of special concern in Montana, and other important game and forage species. Deep drawdowns also increase the probability that the reservoirs will fail to refill. Refill failure negatively effects recreation and reduces biological production, which decreases fish survival and growth in the reservoir (Marotz et al. 1996, Chisholm et al. 1989). Furthermore, brief retention times flush nutrients out of the reservoir and downstream, thus making these nutrients unavailable to the reservoir biota. The continued nutrient loss to reservoir sediments has further contributed to declining nutrient loads throughout the Kootenai ecosystem. Investigations by Daley et al. (1981), Snyder and Minshall (1996), and Woods (1982) have documented the declining productivity of the Kootenai System and, specifically, reduced downstream transport of phosphorous and nitrogen by 63 percent and 25 percent, respectively.

Large daily fluctuations in river discharge and stage (4-6 feet per day) strand large numbers of sessile aquatic insects in the varial zone (Hauer 1996). The reduction in magnitude of spring flows has caused increased embeddedness of substrates, resulting in loss of interstitial spaces in cobble and gravel substrates, and in turn, loss of habitat for algal colonization and an overall reduction in species diversity and standing crop (Hauer 1996). Aquatic insects are affected by the reduction of microhabitat and food sources, as evidenced by the loss of species and total numbers since impoundment (Voelz and Ward 1991). Hauer (1996) found a significant reduction in insect production for nearly every species of insect during a 13-14 year interval in the Kootenai River. These losses can be directly attributed to hydropower operations. Benthic macroinvertebrate densities are one of the most important factors influencing growth and density of trout in the Kootenai River (May and Huston 1983).

Large gravel deltas have formed at the mouths of several tributaries of the Kootenai River (Quartz, O'Brien and Pipe Creeks) due to the loss of high spring flows. These deltas have reached proportions that are potential barriers to migrating fish such as bull trout, westslope cutthroat trout, burbot, and mountain whitefish at low river levels below Libby Dam (Graham et al. 1977, Marotz et al. 1988).

Libby Dam operations have caused a substantial decline in westslope cutthroat trout in Libby Reservoir, attributable to loss of habitat for native adfluvial salmonids (Dalbey et al. 1997). Since impoundment, fluctuating reservoir levels have impaired the establishment of shoreline vegetation in the varial zone, resulting in lack of habitat for juvenile fish when water levels rise. Reservoir-created barriers and degradation of existing habitat in reservoir tributaries have also contributed to declining westslope cutthroat trout populations.

Montana Fish, Wildlife & Parks (MFWP) began to assess and model the biological and physical effects of dam operation in 1982. One goal was to develop an operational plan to benefit fish and wildlife in the Kootenai System. The other goal was to assemble a set of non-operational mitigation actions (those measures that do not require changes in dam operations). This overall mitigation package assumes that operational measures will be implemented to meet approximately half of the mitigation goals and that the remainder will be met through non-operational measures. If operations change negatively, resulting in greater fisheries losses, the loss statement must be updated to reflect the new operating regime.

Dam operations were assessed during the Columbia Basin System Operation Review (SOR EIS 1994) and subsequent system-wide analyses (Wright et al. 1995). Integrated Rule Curves (IRC's) were designed by MFWP, in cooperation with the Confederated Salish and Kootenai Tribes (CSKT), to limit the duration and frequencies of deep drawdowns and reservoir refill failure (Marotz et al. 1996). Reduced drawdown protects aquatic insect larvae, assuring that a large percentage of insects will survive to emerge as pupae and adults providing an important springtime food supply for fish. Increased refill frequency maximizes biological production during the warm months. Refill provides an ample volume of thermally optimum water for fish growth and a large surface area for the deposition of terrestrial insects from the surrounding landscape. Proper refill timing also assures that passage into spawning and rearing habitats in tributaries is maintained for species of special concern, including westslope cutthroat trout and bull trout. These IRC's were adopted by the NPPC in 1994, but have not yet been implemented due to actions called for in the National Marine Fisheries Service (NMFS) 1995 biological opinion (95 BiOp).

MFWP initiated a study to quantify fish entrainment through Libby Dam in 1990. The completion of this investigation in 1996 revealed that an estimated 1.15 to 4.5 million kokanee salmon are entrained annually. A variety of other fish species were also entrained (including bull trout and burbot), although kokanee comprised 97.5 percent of total entrainment. No entrainment deterrent system currently exists on Libby Dam.

An instream flow incremental methodology (IFIM) study on the Kootenai River from Libby Dam to Kootenay Lake, BC, is nearly complete. This model quantifies fish habitat (juvenile and adult life stages of rainbow trout and mountain whitefish) under a variety of Libby Dam discharge scenarios. Further research is being conducted to include bull trout habitat requirements in the completed model. Ultimately, the IFIM, IRC's and the entrainment model from Libby Dam will be coupled to evaluate the biological tradeoffs under a variety of operational schemes between Libby reservoir and the Kootenai River.

INTRODUCTION

Background

The waters and the resources of the upper Columbia River region have always been fundamental to the Kutenai people. The river and all the lands it drained was their domain. In fact, the main thread that tied all the Kutenai bands together, both geographically and emotionally, was the Kootenai River. It was not unusual to see a flotilla of more than 300 hundred canoes moving up and down the river.

The waters of the Kootenai River, its tributaries, and the area lakes abounded with fish. Among the Kutenai, fish formed a dietary staple. They were expert in the construction and use of nets, traps, and weirs. Some individuals were expert divers. A fishing chief supervised the construction of the trap and weirs, the fishing activities themselves, and the eventual distribution of the fish among the tribal members. These collective efforts culminated into the annual Kutenai fish festival.

These people asked very little in life and gratefully accepted the natural wealth that the Kootenai River and the surrounding country provided. They fit into nature's scheme and never sought to upset her delicate balance. Unfortunately, European man began arriving and viewed the Kootenai country mainly in terms of the riches that could be removed from it, with one of those riches being hydropower production.

From 1933 to 1985, 23 federal dams were built on the Columbia River System. Construction and operation of these dams and others resulted in the sharp decline in anadromous salmon and steelhead *Oncorhynchus mykiss* populations, and resident fish populations in Montana, Idaho, Oregon and Washington. In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act (referred to as the Northwest Power Act). The Act specified three important points for fish and wildlife: 1) it created the NPPC, composed of two representatives from each of the four affected states; 2) it called for treating the Columbia River as a system; and 3) BPA, thus the electric ratepayer, was directed to fund the fish and wildlife protection, mitigation, and enhancement effort.

Murray Springs Fish Hatchery, located 7 miles northwest of Eureka, Montana on Sophie Bay (Lake Koocanusa), was constructed by the Seattle District ACOE, in cooperation with MFWP, to mitigate fishery losses attributed to the construction of Libby Dam. "Construction of the hatchery began in June 1978. Facilities include a hatchery building, head tank, pumphouse, a settling pond, a brood pond, eight rearing raceways, storage building, and three residences with garages. The original brood stock, consisting of 18,600 westslope cutthroat trout 2 to 5 years of age and nearly 600,000 eggs, were transferred into the facility from other Montana hatcheries in June 1979. However, water temperatures proved unsuitable for cutthroat brood (egg) development, so the broodstock were moved in 1988 to other hatcheries in a reciprocal arrangement whereby the other hatcheries would produce the cutthroat eggs in exchange for rearing of juvenile fish at Murray Springs. The hatchery is operated to provide fish for planting in Lake Koocanusa, the Kootenai River and adjacent waters. The hatchery was constructed and is currently operated with the $4,000,000 authorized in the Water Resource and Development Act of 1974 " (USACOE 1997).

The NPPC is a planning and policy-making body responsible for developing a program to protect, mitigate, and enhance fish and wildlife affected by hydropower development and operations in the Columbia River System. At the same time, the NPPC is directed to provide the region an adequate, efficient, economical, and reliable power system. The NPPC strives to rebuild and/or mitigate for fisheries and wildlife resources with maximum effectiveness and at a reasonable cost to ratepayers. To achieve these mutual goals, the NPPC promotes a regional approach to problem solving with involvement by all interested parties.

In reviewing recommendations for fisheries mitigation for losses caused by Libby Dam, the NPPC will consider whether the program is supported by: (a) documented or agreed upon resident fish losses attributable to the construction and operation of Libby Dam; (b) adaptive management principles defining anticipated results and appropriate monitoring; (c) evidence that the program will compliment other actions by state and tribal fisheries managers; (d) evidence that the program will result in significant biological results following sound objectives; (e) high cost-effectiveness; and (f) public involvement.

MFWP and CSKT have previously addressed some of these issues. Through the NPPC Fish and Wildlife Program, interim flow and reservoir drawdown and ramping rates have been established. MFWP has conducted studies in the Kootenai System to document losses, identify habitat requirements for important species, and develop mitigation options. Four public meetings were held in Libby and Eureka to introduce the concept of Libby mitigation and to solicit recommendations for project selection. This draft is the result of previous scoping and provides the basis for continued public review prior to submission to NPPC in 1998.

The Fish and Wildlife Program developed by the NPPC addresses all the hydropower projects in the Columbia Drainage in Montana. Montana Fish, Wildlife & Parks and the CSKT are addressing mitigation with the involvement of the Kootenai Tribe of Idaho (KTOI) and other appropriate entities for losses attributable to the construction and operation of Libby Dam.

Quantitative Reservoir Modeling

A FORTRAN simulation model was developed for Libby Reservoir (Marotz et al. 1997). The model simulates the physical operation of the dams including the water budget and downstream flood concerns, and predicts the resulting thermal structure of the reservoir and tailwater. Biological responses include primary production and washout, zooplankton production and washout, deposition of terrestrial insects on the reservoir surface, benthic dipteran production, and growth of the target game species, kokanee. Effects of other species can be inferred from lower trophic responses, and empirical measures of food selection. Input to the model is limited to annual flow forecasts, the annual inflow hydrograph, minimum and maximum outflow limits, and a proposal of either the annual surface elevation schedule or the annual schedule of dam discharges. The model user has the option to specify the depth at which water is withdrawn from the reservoir throughout the simulation or the model will automate depth selection to meet a pre-programmed temperature regime downstream. All other coefficients were fixed based on long-term source of empirical data (1983-1996). The model was designed to generate accurate, short-term predictions specific to Libby Reservoir and is not directly applicable to other waters. The modeling strategy, however, is portable to other reservoir systems where sufficient data are available.

Reservoir operation guidelines were developed to balance fisheries concerns in the headwaters with anadromous species recovery actions in the lower Columbia River. Fisheries operations were integrated with power production and flood control to reduce the economic impact of basin-wide fisheries recovery actions. These Integrated Rule Curves (IRC's) were critically reviewed in the Columbia Basin System Operation Review (SOR), the Northwest Power Planning Council's phase IV amendment process, by the Fisheries Research Institute (Dr. James Anderson), and by Applied Physics Laboratory (Dr. Gordie Swartzman), Seattle, Washington. Examination associated with ESA white sturgeon recovery actions for Columbia Basin fish species is ongoing.

The Models

The Libby Reservoir model (LRMOD) was empirically calibrated using field data from an extensive sampling program during 1983 through 1990. Field data from 1991 through 1995 were used to refine and correct uncertainties in the model and add a white sturgeon component (Marotz et al. 1996). The model was also expanded to include downstream hydrology and temperature effects. The physical models facilitate the assessment of power and flood control operations under varying water conditions, drought to flood. Biological model components were designed to compare one operational strategy to another, and assess their relative effects on the aquatic environment. The Libby model simulates the water balance in the Kootenai River, Kootenay Lake, Duncan Dam and Corra Linn Dam operations. Regional flood control strategies established using the models are being reviewed by the ACOE. Kootenai River flood control measures extend downstream to Corra Linn Dam at the outlet from Kootenay Lake. LRMOD calculates side flows to the Kootenai River (from inflowing water sources) between Libby Dam and

Bonners Ferry. Kootenai River flow targets are set at Bonners Ferry and elevation targets at Kootenay Lake to avoid flooding. Dynamic side flow estimates can also be added to Libby discharge to calculate the resultant flow at Bonners Ferry. Inflows to Kootenay Lake, flood control storage at Duncan Reservoir and lake stage/discharge relationships for Corra Linn Dam were incorporated in the model to mimic coordinated flood control measures stated in the International Joint Commission Treaty (Stanley et al. 1938).

The models were designed to be compatible with Columbia system hydroregulation models SAM, HYSSR and HYDROSIM. Although our model analyses were based on daily operations, subroutines enable the models to input and output monthly data (with April and August split into two half-month intervals) required by the system models. Thus, results from the Hungry Horse and Libby models could be readily input to the system models and vise versa. Multiple simulation with varying drawdown and reservoir refill schedules were used to assess the biological effects of operational alternatives. Results were used to estimate biological effects of historic operations and to develop a balanced operation (IRC's) to benefit fish in the reservoir and river downstream.

Relationship to Specific Fish and Wildlife Program Measures

- Specific Fish and Wildlife Program Measures (NPPC 1995) called for studies to identify losses attributable to Libby Dam, recommendations for mitigation, and related issues.

- Program Measure 10.1B defines priorities for resident fish programs. It directs managers to "accord highest priority to rebuilding to sustainable levels weak, but recoverable, native populations injured by the hydropower system, . . ."

- Measure 10.1C.1 directs managers to complete assessments of resident fish losses and gains, propose a crediting approach and incorporate a public review process.

- Measure 10.3B contains specific direction for Libby Dam resident fish mitigation.

- Measure 10.3B.2 directs the ACOE to implement the Integrated Rule Curves for Libby Dam operation approved by NPPC in 1994 (IRC's have not been implemented to date).

- Measure 10.3B.3 directs MFWP and CSKT to continue to refine the IRC's (IRC's have been amended to accommodate endangered Kootenai white sturgeon and Snake River salmon recovery [Marotz et al. 1996]).

- Measure 10.3B.5 directs BPA to "continue to fund studies to evaluate the effect of Libby Dam operating procedures on resident fish."

- Measure 10.3B.6 directs BPA to immediately fund the mitigation of fish losses caused by power operations in the event that IRC's are violated.

- Measure 10.3B.7 directs ACOE to immediately fund mitigation of fish losses caused by flood control operations in the event that IRC's are violated.

- Measure 10.3B.10 directs BPA to fund the removal of materials that have accumulated in Kootenai River tributary deltas below Libby Dam, where these materials interfere with fish migrations.

- Measure 10.3B.11 directs BPA to fund this mitigation program once it is approved by the NPPC.

Project Area

The Kootenai River, second largest tributary to the Columbia River, originates in Kootenay National Park near Banff, British Columbia. The river is 485 miles (780 km) long and drains approximately 19,300 mi^2 (50,000 km^2). It flows into Montana near Rexford, flows southward through the Purcell and Salish Mountains, and into the reservoir created by Libby Dam (Figure 2). Below Libby, Montana (17 miles below the dam), the river flows through a single, narrow channel and into a steep-sided canyon, over Kootenai Falls, and then into Kootenay Lake in British Columbia, 128 mile (206 km) downstream of the falls. It then flows southwest out of Kootenay Lake and enters the Columbia River at Castlegar, British Columbia. (Figure 1).

The Kootenai River has an average annual discharge of 868 m^3/s (30,650 cfs). The drainage basin is located within the Northern Rocky Mountain physiographic province, which is characterized by north to northwest trending mountain ranges separated by straight valleys parallel to the ranges (Woods and Falter 1982). As much as 90 percent of the Kootenai basin is coniferous forest; about 2 percent is agricultural land used mainly for pasture and forage production (Bonde and Bush 1982). The drainage is home to a unique native species assemblage (Table 1).

Construction of Libby Dam began in 1966 and was completed in 1972. Libby Reservoir reached full pool elevation (2,459 ft msl) in July, 1974. Libby Reservoir is a 145-km (90 miles) long storage reservoir with a surface area of 188 km^2 (46,500 acres) at full pool, and is operated by the ACOE. The primary benefits of the project are flood control (8.3 percent) and power production (91.5 percent), as well as navigation and other benefits (0.2 percent). Water passes through 16 downstream projects; Libby Dam must be regulated in concert with the complex network of electrical energy producing systems, water consumption needs and flood control requirements throughout the Columbia River Basin. Libby Dam is not currently equipped with fish passage facilities.

The surface elevation in Libby Reservoir ranges from 697.1 m (2,287 feet) to 749.5 m (2,459 feet, full pool). For water years 1974 through 1996, mean maximum reservoir drawdown averaged 112.44 feet. The deepest drafts occurred in 1991 (154 feet), 1988 (142 feet), and 1989 (138 feet). The 90-110 foot draft limit established in 1987 was exceeded in 1988, 1989, 1990, 1991 and 1993 (Table 2).

Typical operation schedule for Libby Dam and Libby Reservoir begins in July, when the reservoir fills to full pool. Drawdown begins in September and reaches minimum pool elevation in April. The reservoir stores water during spring runoff, and rises towards full pool through the summer. Historically, the ACOE operated Libby Reservoir to reach full pool in July and began drafting in September to reach a minimum pool elevation by April. Presently, operations are dictated by a combination of power production, flood control, recreation, and special operations for the recovery of endangered species, including Kootenai River white sturgeon and Snake River salmon.

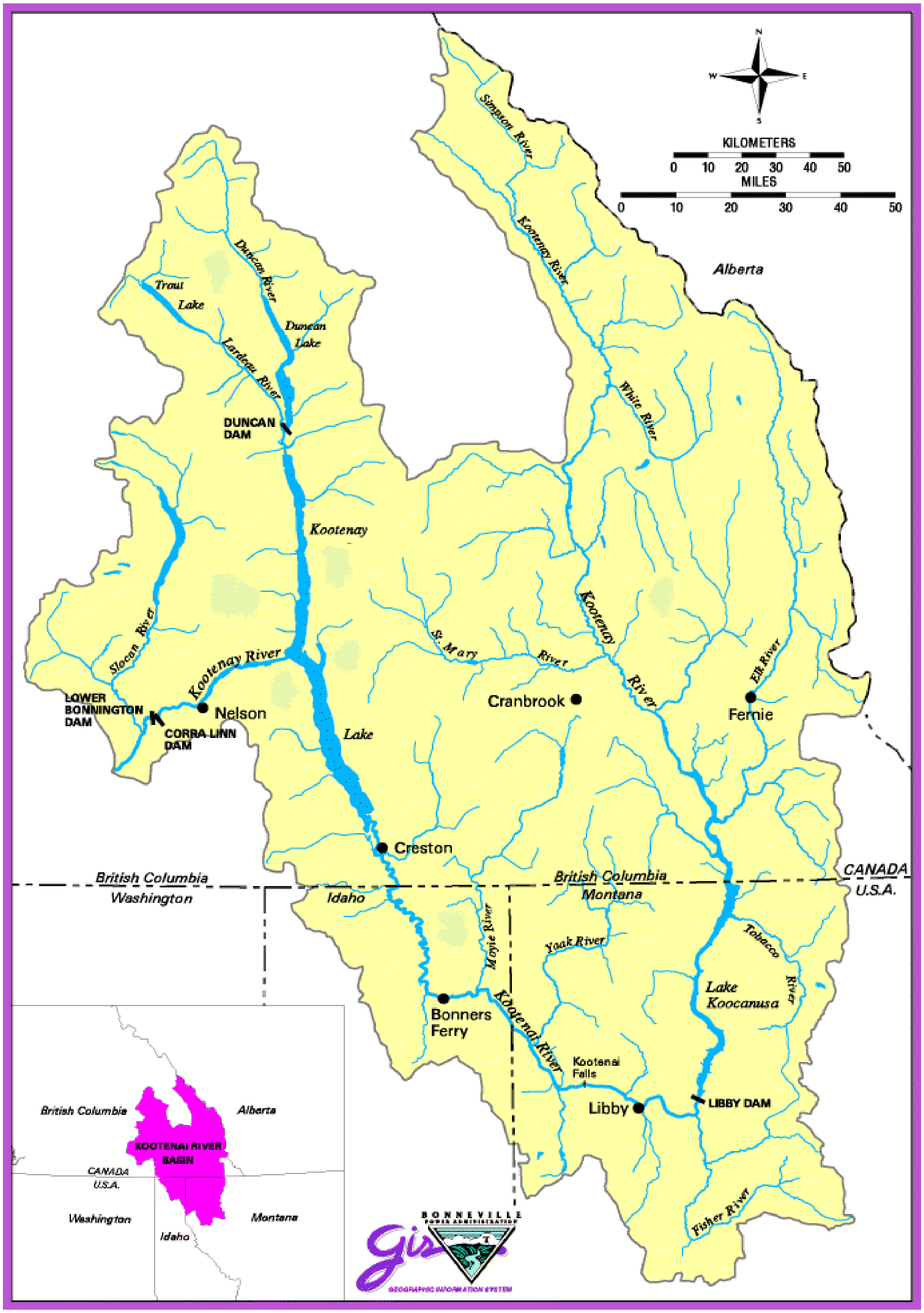


Figure 1. Map of the Kootenai River Basin, Montana.

Table 1. Fish species present in the Kootenai River Drainage.

FISH OF THE KOOTENAI RIVER DRAINAGE			
Common Name	**Genus species**	**Location**	**Native**
Westslope cutthroat trout	*Oncorhynchus clarki lewisi*	B	Yes
Rainbow trout	*Oncorhynchus mykiss*	B	Yes
Bull trout	*Salvelinus confluentus*	B	Yes
Brook trout	*Salvelinus fontinalis*	R	No
Kokanee salmon	*Oncorhynchus nerka*	B	Yes
Mountain whitefish	*Prosopium williamsoni*	B	Yes
Burbot	*Lota lota*	B	Yes
White sturgeon	*Acipenser transmontanus*	Ri	Yes
Yellow perch	*Perca flavescens*	R	No
Redside shiner	*Richardsonius balteatus*	B	Yes
Peamouth chub	*Mylocheilus caurinus*	B	Yes
Northern pikeminnow	*Ptychocheilus oregonensis*	B	Yes
Largescale sucker	*Catostomus macrocheilus*	B	Yes
Longnose sucker	*Catostomus catostomus*	B	Yes
Torrent sculpin	*Cottus rhotheus*	Ri	Yes
Slimy sculpin	*Cottus cognatus*	Ri	Yes
Longnose dace	*Rhinichthys cataractae*	Ri	Yes

R - Reservoir, **Ri** - River, **B** – Both

Table 2. Recommended fisheries and aquatic habitat mitigation actions for losses attributable to Libby Dam. The costs are estimates only. MFWP and Tribes propose to work with BPA to refine the estimates and accomplish mitigation as cost-effectively as possible.

Mitigation Action	Species Benefited	Quantifiable Habitat or Fisheries Benefit Goal	Cost Estimates
NON-OPERATIONAL			
Aquatic Habitat Improvement	Bull trout, burbot, Westslope cutthroat trout	20 acres / year, stream and reservoir	$320,000
Fisheries Easements	Bull trout, burbot, Westslope cutthroat trout	Based on state policy	Initially $250,000
Fish Passage Improvement	Bull trout, burbot, Westslope cutthroat trout	Equivalent of 2-7 miles of blocked stream reopened/year	$65,000
Off-Site Mitigation	Other target species and species presently in the region	Combination of the above fishery techniques at the level of funding requested	$65,000
Hatchery/Experimental Facility Upgrades/O&M	Conservation Aquaculture for burbot, interior redband rainbow; off-site put-grow-take imprint planting to restore runs	Develop wild captive brood stock for stocking. Provide genetic reserve and increase range. Develop burbot conservation aquaculture techniques.	$500,000 capital costs $500,000/year operations

The Kootenai River tributaries are primarily high gradient mountain streams with bed material consisting of various mixtures of sand, gravel, rubble, boulders and differing amounts of clay and silt, predominantly of glacio-lacustrine origin. Fine materials, due to their instability during periods of high stream discharge, are continually removed and redeposited as gravel bars, forming braided channels with alternating riffles and pools (May and Huston 1973). Environmental degradation of tributaries to the Kootenai River has been thoroughly documented (Northcote 1973, Cloern 1976, Daley et al. 1981 and Partridge 1983). Mining, logging, agriculture, road-building, and other human activities have contributed to the gradual decline in system health.

Proposed Plan of Action

To mitigate for losses of fisheries, aquatic insects, and aquatic habitat attributable to the construction and operation of Libby Dam, we recommend a combination of non-operational mitigation, operational mitigation and evaluation/monitoring. Murray Springs Fish Hatchery is considered non-operational mitigation.

A mix of mitigation techniques will be necessary to offset losses caused by dam construction and operation. Non-operational actions include aquatic habitat improvement, fish passage improvements, off-site mitigation, fisheries easements, and conservation aquaculture and hatchery products. Prior to public comment during the NPPC process, we estimated that approximately $540,000 per year (1997 dollars) would be required for these on-the-ground actions over a negotiated mitigation period. Fisheries easements to protect investments in habitat restoration will be purchased associated with site-specific evaluations. Initially we recommend that $250,000 be available to begin negotiating fisheries easements. Future easements should be evaluated on a site by site basis (Table 2). Costs given in this report represent working estimates; we plan to work with the public, BPA and NPPC to refine these figures.

Managers will begin a step-wise, adaptive management approach to correct limiting factors for bull trout, burbot, white sturgeon, and interior redband rainbow trout in the Kootenai Basin. Evaluation of pilot projects will continue to determine the most cost-effective methods of enhancing these diverse populations. Hatchery supplementation of these native species will be limited to state of the art techniques. Supplementation is a valuable, though controversial tool that has undergone increasing scientific scrutiny during the last two decades. Case histories of stocking large systems have shown limited success (e.g. direct stocking of kokanee in Flathead Lake). Hatchery stocking in small, closed-basin lakes has shown promising results (Knotek et al. 1997). Imprint stockings of fry or eyed eggs appear to be useful for reestablishing spawning runs, though in many ways restoration culture techniques have yet to be evaluated. Habitat enhancement and manipulation measures appear to hold the most promise for native fish stock recovery. All mitigation measures will be conducted with pre-treatment and intensive post-treatment monitoring to document project success.

Monitoring and evaluation are critical parts of any adaptive management plan. We recommend a monitoring/evaluation program of $135,000 per year (1997 dollars) for the mitigation period. This figure represents ≈25 percent of the annual costs for implementing mitigation. Many scientists have recommended a similar percentage of program dollars to be applied to monitoring, thereby emphasizing adaptive management. The evaluation and feedback process will increase the likelihood of achieving success in mitigation efforts and improve cost effectiveness.

Funding options for non-operational mitigation and monitoring include annual contracts with BPA through the regional prioritization process, with annual payments adjusted to 1997 dollars by the consumer price index, or a trust fund. We recommend pursuing a trust fund option because it meets the implementing agencies goals of annual investment in the resource and the principals of adaptive management, and it meets the goal of the utilities for establishing a spending cap. The trust fund should be designed to account for overhead rate and inflation to preserve the mitigation level recommended in 1997 dollars. MFWP and CSKT would negotiate annual contracts with BPA until the trust fund or multiple year authorization is established. Other funding sources and cost-sharing opportunities will be assessed on a case by case basis.

Success of this mitigation plan may be limited by shortcomings of present mitigation technologies, lack of suitable mitigation sites to completely replace lost habitat, and general uncertainty associated with ecological/social plans. In the implementation phase of this plan, managers must be flexible and continue to incorporate ideas from a broad range of citizen and scientific interests.

Based on our work and comments received from interested members of the public, we recommend a three-phase mitigation program. First, we ask for rapid implementation of operational mitigation measures, including Integrated Rule Curves (Marotz et al. 1996) and Army Corps of Engineers VARQ flood control, and tiered flow releases for white sturgeon and salmon recovery, as well as White Sturgeon Recovery Team experimental spawning enhancement flows. This work will balance dam operations to protect resident fish in the Kootenai system. Second, we ask for timely implementation of those mitigation strategies which do not require modification of dam operations, presented in this document. Thirdly, we ask for consideration of the installation of a gas supersaturation abatement structure below the spillway. This would allow for greater operational flexibility and reduce the risk of lethal levels of total dissolved gasses in the Kootenai River during spill events. We will work with BPA, ACOE, and others to examine alternatives.

FISHERIES LOSSES CAUSED BY THE CONSTRUCTION and OPERATION OF LIBBY DAM

Methods

Assessment of Fisheries Losses in Tributary Streams Located Upstream of Libby Dam

Estimation of tributary fishery losses *Oncorhynchus spp.* was conducted using the methods described by Zubik et al. (1987). Stream reaches were measured from USGS quadrangle maps using a digital planimeter. Loss estimates are most reliable for *Oncorhynchus spp.* in the tributaries. Fewer data were reported for other species, making accurate loss estimates difficult.

Fish population estimates conducted by Marotz et al. (1988) in the Kootenai River Drainage were used to estimate pre-dam fish densities in the flooded tributaries (Table 3). Estimates were made assuming that stream order and gradient categories are relatively accurate indices of fish density. The representative streams were divided into similar gradient and stream order with known mean fish density estimates. Tributary reaches that were inundated as the reservoir filled were categorized by gradient and stream order based on pre-impoundment topographical maps. The pre-impoundment fish population was calculated within each stream order and gradient category by multiplying the stream length by the associated density estimates from the representative streams. The following assumptions were made to conduct the estimate:

1) The representative streams were at carrying capacity when the population estimates were conducted.

2) Stream reaches with similar gradient and stream order classification supported similar densities of *Oncorhynchus spp.* (Tables 3 and 4).

3) Tributary fish densities are entirely density dependent.

Table 3. Estimated numbers of *Oncorhynchus spp*. above full pool / 100 meters of stream in the Lake Koocanusa Drainage, Montana, distinguished by gradient categories and stream order (Marotz et al. 1986, 1988, MFWP management files, Libby Field Station, Libby, MT).

Stream Order	Gradients (%)	Number of Reaches	Mean indiv./100m
2	0.4-2.8	3	96
2	3.5-4.0	2	123
2	6.5	1	18
3	0.6-1.9	6	90
3	2.0-2.6	3	77
3	3.1-4.4	3	68
3	6.5	1	71
4	0.3-0.6	2	16
4	2.0-2.0	2	140
TOTAL		23	

Table 4. Species composition of gamefish sampled from electrofishing in the Rexford and Cripple Horse Creek areas of the Kootenai River, 1969-1971 (Huston 1983). The number of fish caught is in parenthesis.

	Species		
Date	Cutthroat	Rainbow	Mountain Whitefish
Rexford Area (1969-1970)	2.2 (8)	0.3 (1)	96.7 (348)
Cripple Horse Area (1969-1971)	2.8 (18)	2.3 (15)	94.6 (611)

Main Stem Kootenai River Fish Loss Estimation Upstream of Libby Dam

Estimates of fishery losses in the main stem of the Kootenai River were conducted using the only available pre-impoundment fisheries information above Libby Dam as reported by Huston (1983; Table 4) and population estimates conducted in 1973 (Huston and May 1973) on the lower Kootenai River (Table 5). Loss estimates were based on the following assumptions:

1) The fish populations in the Kootenai River are entirely density dependent.

2) The 1969-1971 estimated composition in Cripple Horse and Rexford areas represents pre-impoundment Kootenai River fish assemblage above Libby Dam.

3) Population estimates conducted in the Flower/Pipe section of the lower Kootenai River are indicative of the number of fish that would have occupied the Kootenai River above Libby Dam.

Table 5. Fish population estimate conducted in the Flower-Pipe section of the Kootenai River in April 1973 (Huston and May 1973).

Species	Length Group (inches)	Number	Number/1,000 ft.	Species Composition (%)
Mountain Whitefish	6.0-14.0	8,934	421	61.4
Cutthroat Trout	9.0-21.2	433	21	3.0
Rainbow Trout	7.0-18.9	509	24	3.5

Fish species composition data from the Cripple Horse and Rexford area (Table 4) were used as an estimator of the fish assemblage lost from Libby Dam to the Canadian Border. The 1973 Flower/Pipe population estimate was used to represent how many fish were lost in the inundated Kootenai River. Estimates of loss were calculated by adjusting 1973 Flower/Pipe mark recapture estimates to reflect the mean species composition measured at the Rexford and Cripple Horse Creek areas of the Kootenai River.

Habitat Loss Assessment Upstream of Libby Dam

Losses of adfluvial *Oncorhynchus* fish habitat (Figure 2) in the Kootenai Drainage above Libby Dam were estimated using a digital planimeter. Total fluvial distribution was estimated as the sum of total inundated stream length in the main stem Kootenai River, the length of inundated tributaries to Lake Koocanusa, and the length of available habitat above full pool (Powers and Osborn, 1985).

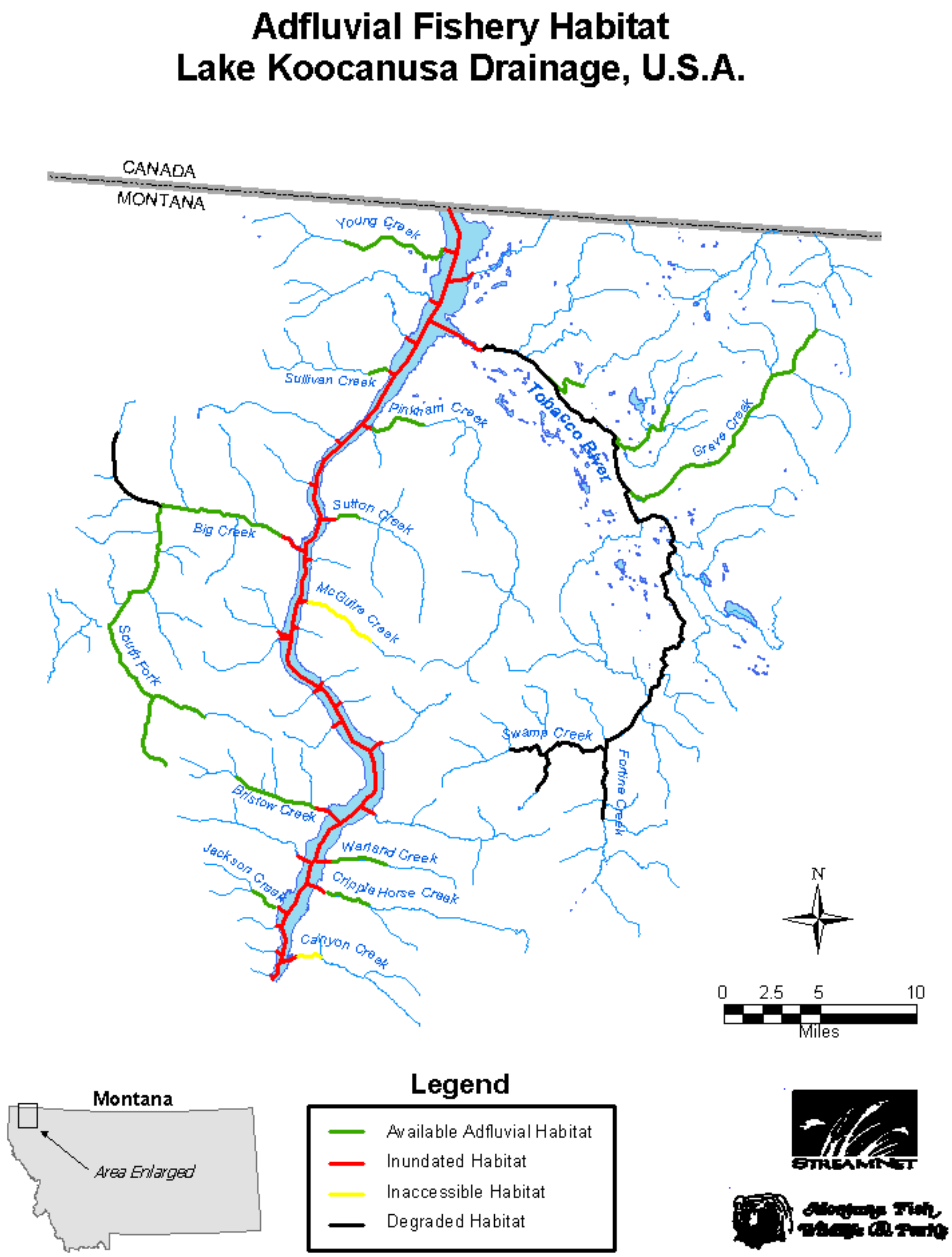


Figure 2. Adfluvial fish habitat, Libby Reservoir Drainage, U.S.A.

The distribution of fluvial migrants above full pool was conducted using historic MFWP redd count and fish habitat surveys. Where data were unavailable for specific stream reaches, USFS hydrologists and MFWP fish biologists were consulted to estimate the range of fluvial spawning based on known habitat and passage requirements of fluvial spawners.

The amount of habitat remaining today was estimated by subtracting all inundated, blocked, or degraded stream reaches. Habitat below full pool elevation was considered inundated and permanently lost. Several of the tributaries in the Kootenai Drainage have been degraded due to management practices conducted on private and federally owned land. Non-native fish species introduction (both illegal and MFWP sanctioned) has caused further decline of native fish populations due to competition. These affected stream reaches are no longer suitable for successful reproduction and rearing of adfluvial immigrants. Affected stream reaches were determined by analyzing USFS and MFWP habitat databases and assessing the potential for streams to support adfluvial fish. Indices used to classify degraded reaches include gravel embeddedness (fine sediment), instream cover, frequency of pools and riffles, channel stability indexes, and redd counts. A degraded classification was assigned to stream reaches where these indices showed unsuitable conditions for adfluvial spawning and/or rearing.

Location of Migration Barriers Caused by Road Construction - Above Libby Dam

To accommodate filling Libby Reservoir, the east highway (Highway 37) and the west highway (Forest Development Road) were constructed. Personnel assessed gradient, velocity, and blockages to determine if fish could physically pass suspected barriers (Powers and Osborn, 1985).

RESULTS AND DISCUSSION

Biological Effects of Dam Operation--Model Results

Dam operation has essentially reversed the natural hydrograph in the Kootenai River. The natural spring peak is now stored in the reservoir for release during the fall and winter period for flood control and power production (Figure 3). Flow fluctuation has been greatly increased by hydropower operations resulting in a wider, less productive varial zone. Reservoir operation has been variable from year to year, resulting in less biological production due to excessive drawdowns and refill failures (Figure 4).

Resident fish are adversely affected when reservoirs are drawn down in late summer or early fall. The reduced volume and surface area limits the fall food supply and volume of thermally optimal water during the critical trout growth period. Surface elevations continue to decline during winter, reaching the lowest point in the annual cycle during April. Deep drafts reduce food production and concentrate young trout with predators like northern pikeminnow. Of greatest concern is the dewatering and desiccation of aquatic dipteran larvae in the bottom sediments. These insects provide the primary spring food supply for westslope cutthroat, a species of special concern in Montana, and other important game and non-game species. Deep drawdowns also increase the probability that the reservoir will fail to refill (Figure 4). Refill failure adversely affects recreation, and reduces biological production, in turn decreasing fish survival and growth in the reservoir (Chisholm et al. 1989; May et al. 1988).

Integrated Rule Curves were designed to limit the duration and frequencies of deep drawdowns and reservoir refill failure (Figure 4). Reduced drawdown protects aquatic insect larvae, assuring that a large percentage of insects will survive to emerge as pupae and adults, which provide an important springtime food supply for fish. Increased refill frequency maximizes biological production during the warm months. Refill allows water to attain optimal temperature water for fish growth and a larger surface area for the deposition of terrestrial insects from the surrounding landscape. Refill timing also assures that passage into spawning and rearing habitats in tributaries is maintained for species of special concern, including westslope cutthroat trout and bull trout.

The IRC's incorporate incremental adjustments to allow for uncertainties in water availability (Marotz et al. 1996). The IRC's are a group of curves intended for uses similar to flood control rule curves. In real time, the dam operator would receive an inflow forecast in early January and operate the dam to achieve the correct elevation as dictated by the curve corresponding with that inflow forecast. Upon receipt of an updated forecast, the operator would adjust the elevation to the new curve corresponding with the updated inflow volume, and so on. The actual operation, then, is flexible and variable over time.

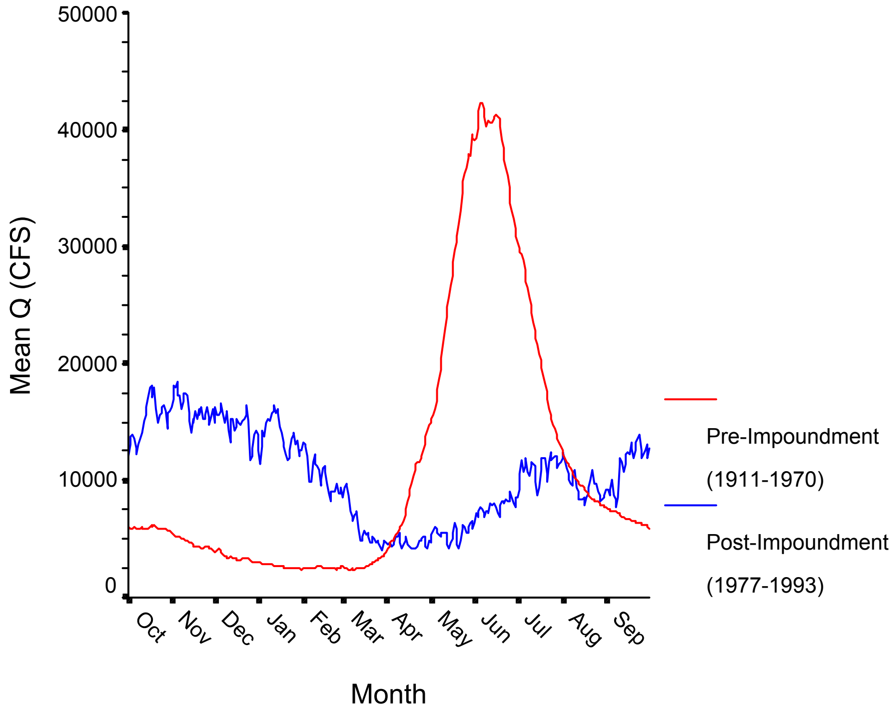


Figure 3. Kootenai River discharge pre-impoundment (1911-1970) and post-impoundment (1977-1993) in mean annual cubic feet per second (cfs) and cubic meters per second (cms).

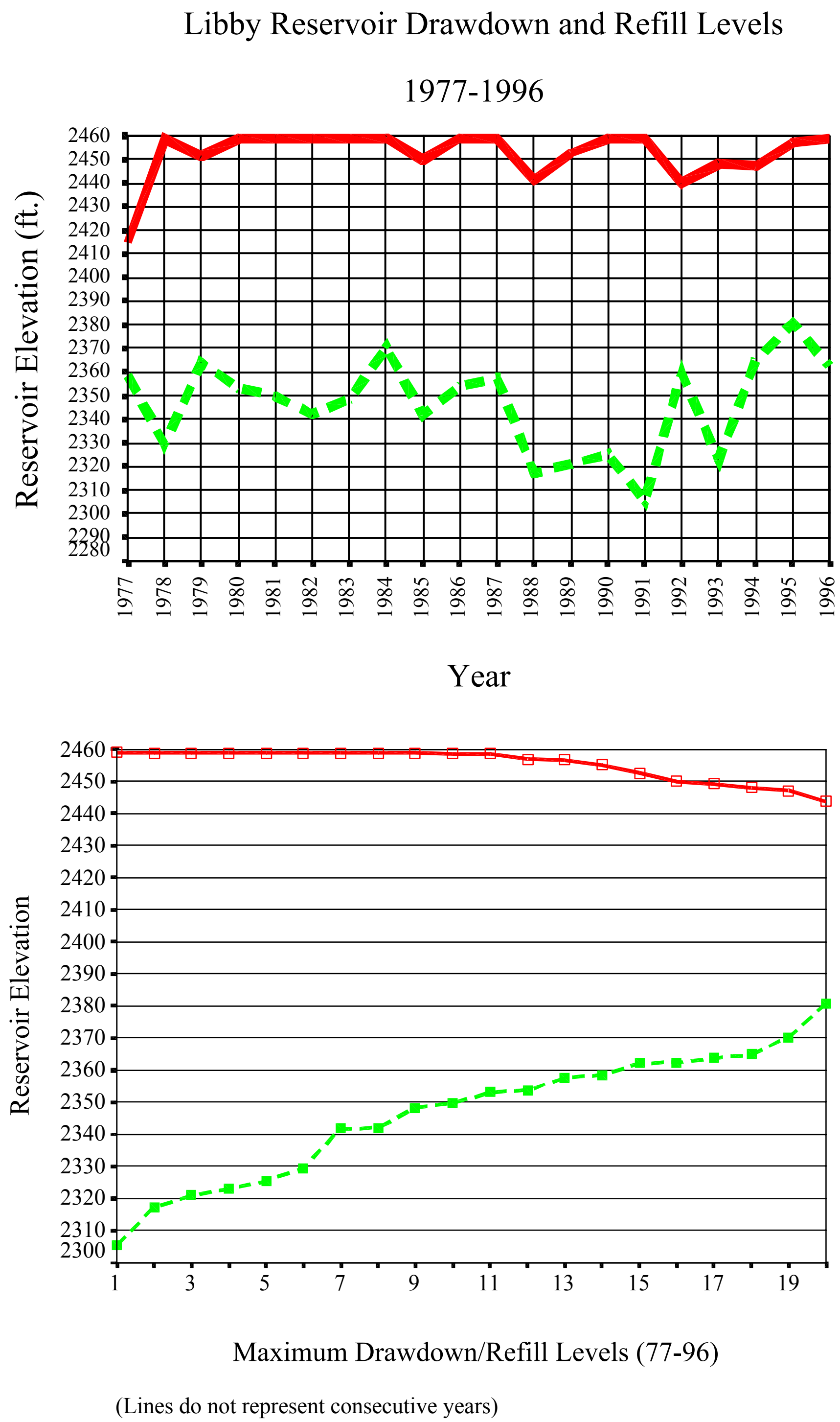


Figure 4. Libby Reservoir maximum drawdown and refill levels, 1977-1996.

The IRC's protect the fisheries resource from excessive drawdown and extreme reservoir refill failure. Modeling and field research indicate that reservoir productivity can, with time, rebound after infrequent deep drawdowns. However, even infrequent deep drafts have long lasting biological effects. These effects are especially evident in benthic insects, an important spring food supply for trout.

Power analyses conducted by BPA and NPPC showed that most effects on firm power generation occur in the fourth year of the critical period (extended drought). The probability of extreme drawdowns necessitating the adoption of the fourth critical year is low; drafts exceeding the IRC's would seldom be required even under current operating practices. Thus, the calculated effect to firm power would only occur under extreme conditions. During normal and high water years, the IRC's will cause only minor effects on firm power production. The most credible estimate of power costs associated with implementing the IRC's is $30-40 million annually (Northwest Power Planning Council 1994). More recent system modeling of the IRC's by Dittmer Control Center are less conservative for fish production (e.g. allow for greater flexibility in power operations) so the cost estimate should be reduced. Wise marketing practices can mitigate adverse effects to revenue. We feel the long-term biological benefits far exceed the value of foregone energy production.

The IRC strategy for flood abatement is to route water through the system so that large peaks in runoff are eliminated. The need for "system" flood control at Libby and storage reservoirs in general is reduced by the protracted water routing strategy which extends the spring runoff volume so that flows remain within flood stage limitations. Reregulation of runoff allows more water to be stored in the reservoirs prior to spring runoff. This water can be earmarked for later release to provide salmon passage flows, tiered flow augmentation for endangered white sturgeon recovery and power marketing. This strategy was developed independent of the Corps VARQ strategy and produces very similar results in system-wide simulations. The IRC's were modified in 1997 to be consistent with VARQ in the highest water years.

An understanding of flood control criteria at Bonners Ferry and Kootenay Lake was necessary to examine spring releases that enhance the river fisheries. Based on the currently available information, endangered white sturgeon in the Kootenai River require a high spring river discharge, a gradual ramp down from the peak, and favorable water temperatures to promote recruitment of juveniles. Spawning has been documented at lower flows but survival from mature egg to yearling stage appears to be related to flow and temperature. Research conducted by Idaho Fish and Game and Kootenai Tribe of Idaho revealed that few young white sturgeon have been recruited to the population since Libby Dam was installed. The failure to recruit juvenile sturgeon into the existing population has been linked to regulated flows below Libby Dam and changes in habitat in the river margins and backwater areas. Libby Dam has also been linked to habitat changes that have altered the species assemblage, which is dominated by omnivorous species such as northern pikeminnow and peamouth chub. These shifts may have resulted in increased predation on egg and larval white sturgeon. In September 1994, the

U.S. Fish and Wildlife Service formalized their decision to list the white sturgeon as endangered under the Endangered Species Act. A draft recovery plan is being finalized in 1999. The recovery team unanimously supports the IRC/tiered flow approach for sturgeon recovery. Power marketing strategies make it possible to store water during fall and winter explicitly for release during June to provide the necessary spawning stimulus without compromising reservoir refill probability. Water releases for white sturgeon then continue downstream to aid juvenile anadromous fish migration to the Pacific Ocean. Westslope cutthroat and rainbow trout also respond favorably to a spring discharge if timing of releases correspond with their life cycle requirements.

The ongoing salmon recovery program can cause important changes in storage reservoir operation. The National Marine Fisheries Service's 1995 Biological Opinion (95 BiOp) suggests that anadromous fish (ocean-run salmon and steelhead) require high water velocities in the Lower Columbia to aid in their downstream migrations. This requires releases from storage reservoirs during the May through August period. Historically, the reservoirs refilled from mid-April through early July and discharges were reduced to specified minimum limits. Thus, if the reservoirs are drawn down deeply in April, releases for anadromous fish can further reduce the probability of refilling the reservoirs. Refill failures effect the ability of the system to supply anadromous fish flows in subsequent years. Also, a lack of stored water could compromise the system's ability to maintain minimum flows required to maintain resident fish species in critical river reaches. Refill failures and reservoir drafts during summer adversely affect reservoir productivity (Marotz et al. 1996).

The IRC's were designed to balance the conflict between anadromous and resident fish requirements. This was accomplished by storing water during the fall through early spring period in the headwater reservoirs, for release during late May and June. Lag times in water movement enroute downstream and subsequent reregulation at downstream projects facilitates delivery of migration flows at the correct times to provide the greatest benefit. Deep drafts and refill failures can be minimized while serving the needs of anadromous species. Spawning stimulus for river species such as the endangered Kootenai white sturgeon and spring spawning trout are simultaneously provided. The adoption of the ACOE's VARQ flood control strategy and a tiered approach to Kootenai white sturgeon spawning flows are critical to this upstream/downstream balance.

The IRC concept is similar to the National Marine Fisheries Service's 1995 Biological Opinion (BiOp) for operations affecting the recovery of endangered salmon in the Snake River. The spring freshet produced by the IRC's is usually at or near the target flows specified in the BiOp (within flow measurement error). The IRC's do not support BiOp target flows in August, which call for a 20-foot draft from Hungry Horse and Libby Dams. The August release causes an unnatural second high flow period following the natural spring peak. This double peak is harmful to biological production in the river during the productive warm months. Although the IRC and BiOp differ substantially during the summer period, model results nonetheless show that August flows under the

IRC are higher than historic operations. Recently, the state of Montana offered a compromise to NMFS to draft Montana reservoirs 10 feet from full pool in August after the reservoirs refill, but reserved the right to shape the flow to a more natural runoff period with a gradual ramp down from the spring peak. This would split the difference between the IRC's and BiOp and initiate a program to evaluate results at a later date.

The IRC operational strategy was designed to improve conditions for all native fish species in the Columbia River System within the realities of flood control and power production. Flexible river flow and reservoir elevational targets allow for compromise among the often-competing uses within the basin. System models have shown that water velocity requirements for anadromous fish can be achieved, when hydrologically possible, without sacrificing native resident fish populations. Coordinated springtime releases from storage projects can achieve a protracted runoff, with peaks removed, to avoid flooding. The extended runoff aids salmon migrations in the lower Columbia and creates a marketing block for inter-regional power exports. Imported power during fall and winter allows headwater reservoirs to store water explicitly for release during spring. Resident fish benefit from higher reservoir elevations, decreased drawdowns and improved refill probability.

Fisheries Losses in the Flooded Kootenai River and Libby Reservoir Tributaries

Quantification of fisheries losses due to hydropower operations is often difficult. Historical data are limited, and in some instances only anecdotal information exists. We used a three-pronged approach to quantify riverine fish losses; 1) all available data were collected from agency reports, data files, newspaper reports and other historical accounts; 2) where pre-dam data were available, population estimates were repeated and compared to historic abundance estimates; and 3) losses in river and stream sections that no longer exist or are severely degraded were estimated using fisheries information from similar, representative streams. Losses are presented in an annual loss figure.

One hundred nine miles (175,355 m) of the Kootenai River and forty miles (63,628 m) of tributary stream habitat were lost because of the inundation of the Kootenai River in the U.S. and Canada (Figure 2). The inundated stream reaches encompassed a variety of essential stream habitat types for resident and adfluvial fish. These inundated habitat types provided fish species with spawning, juvenile rearing, migratory passage, and resident habitat (Table 6.)

A total of 57,183 tributary trout *Oncorhynchus spp*. were initially lost in 1972 in the U.S. and Canada due to the impoundment of the Kootenai River. Assuming populations are density dependent, a calculated 57,183 fish are lost on an annual basis (Table 7).

Table 6. Stream order, reach length and gradient of potential fish-bearing tributaries (U.S.) lost due to the impoundment of the Libby Dam, MT.

Stream Name	Order	Reach #	Length (m)	Gradient (%)
Young Creek	3	1	335.5	3.6
		2	227.2	5.4
		3	637.5	2.9
Tobacco River	4	1	1891.6	0.5
		2	1305.4	1.4
		3	4251.7	0.4
Murray Creek	2	1	1490.2	1.2
		2	814.4	3.7
Dodge Creek	3	1	1995.6	0.6
		2	337.0	12.7
Poverty Creek	2	1	659.4	3.7
Pinkham Creek+	3	1	829.9	1.5
		2	480.4	3.8
Cadette Creek*	2	1	79.3	15.4
Sullivan Creek	2	1	603.9	5.1
Boulder Creek*	2	1	793.0	4.6
Gold Creek	2	1	557.5	7.7
Sutton Creek	3	1	862.8	2.1
		2	761.3	3.2
Big Creek	4	1	2912.8	1.5
McGuire Creek*	2	1	1026.6	4.2
N.F. Parsnip Creek	2	1	1339.6	3.2
Parsnip Creek	3	1	1311.5	3.3
Geibler Creek	2	1	767.4	6.4
Bristow Creek	3	1	1647	1.1
		2	1320.7	2.3
Barron Creek*	2	1	1361.8	3.6
Ural Creek	2	1	1009.6	1.8
		2	477.3	6.4
Ten Mile Creek	3	1	2693.2	1.8
Five Mile Creek	3	1	1483.8	4.1
Cripple Horse Creek+	3	1	1993.8	0.9
		2	1550.0	2.8
Jackson Creek	2	1	1117.8	1.6
		2	402.6	9.1
Little Jackson Creek	2	1	487.4	11.3
Canyon Creek+	3	1	2316.5	2.4
Linklator Creek	2	1	2877.0	1.6
Gold Creek	3	1	2907.0	1.6
Elk Creek	4	1	6584.0	0.6
Kikomun Creek	3	1	1450.0	3.2
Sand Creek	3	1	2360.0	1.7
TOTAL			63,628.1	

(*) definite fish barrier , (+) probable fish barrier

Table 7. Estimated number of tributary *Oncorhynchus spp.* >75mm lost due to the installation of Libby Dam, Libby, Montana, using stream order classification and gradient categories as indices of fish population density.

Stream Order	Gradients (%)	Length (m)	Number of Reaches	Mean #/ 100 m	Total Lost
2	1.2-1.8	10,107.5	5	96	9,703
2	3.2-3.7	4,175.2	4	123	5,135
2	4.6-6.4	2,641.6	4	123	3,249
2	7.7-11.3	1,447.5	3	18	261
3	0.6-1.8	14,696.5	7	90	13,227
3	2.1-2.9	6,687.5	5	77	5,149
3	3.2-5.4	6,049.7	7	68	4,114
3	12.7-12.7	337.0	1	71	239
4	0.4-0.5	6,143.3	2	16	983
4	1.4-1.5	10,802.2	3	140	15,123
TOTAL		63,628.1	41		57,183

Loss estimates indicate 40 percent of the total loss was realized from third order streams (22,729 trout), 32 percent of the loss from second order streams (18,348 trout) and 28 percent of the loss from fourth order streams (16,106 trout).

Trout and Mountain Whitefish Losses in the Inundated Kootenai River

A total of 14,948 trout and 377,156 mountain whitefish were initially lost in 1972 due to the inundation of the Kootenai River in Canada and the U.S. Assuming these populations are entirely density dependent, 14,948 trout and 377,156 mountain whitefish are lost on an annual basis (Table 8), due to inundation of historic habitat.

Stream Habitat Losses

Prior to the impoundment of the Kootenai River, a total of 313,406 m (195 miles) of fluvial spawning and rearing habitat was available above Libby Dam, U.S. As a result of the dam construction, 134,141 m of the Kootenai River and tributaries were inundated (43 percent of the total potential habitat). In addition, 5,831 m of fluvial habitat was blocked due to road culverts. Thus, a total of 139,972 m of fluvial habitat (45 percent of the total potential) was lost due to the construction of Libby Dam (Table 9).

In addition to stream losses due to the inundation of the Kootenai River, tributary stream habitat above full pool has been severely degraded due to land management practices and the introduction of non-native species. A total of 90,824 m of degraded stream habitat is no longer available to adfluvial spawners. Consequently, a total of 230,797 m of fluvial habitat has been lost since 1972 (73 percent of the total potential habitat). Approximately 26 percent of the pre-dam fluvial distribution remains in the U.S. portion of the Kootenai Drainage above Libby Dam (Table 9).

Table 8. Estimated fish losses in the mainstem of the Kootenai River from 1972-1996.

Species	Annual Loss	Cumulative Loss Since Inundation (1972-1996)
Oncorhynchus trout (includes rainbow and westslope cutthroat trout) >7 inches	14,948	358,752
Mountain Whitefish >5.2 inches	377,156	9,051,744

Table 9. The total stream length of adfluvial habitat inundated by the construction of Libby Dam, existing adfluvial habitat above full pool, degraded adfluvial habitat, and adfluvial habitat blocked by culverts in the Kootenai River Drainage above Libby Dam, USA.

Stream Name	Stream Length Inundated (m)	Available Adfluvial Habitat above Full Pool (m)	Degraded Adfluvial Habitat above Full Pool (m)	Adfluvial Passage Blocked by Culverts (m)
Kootenai River (above Libby Dam)	86,961.6			
Canyon Creek	2,316.5	1,805.4		1,805.4
Cripple Horse Creek	1,993.8	4,026.0		
Jackson Creek	1,117.8	1,601.4		
Five Mile Creek	1,483.8	2,653.0	2,653.0	
Warland Creek	3,613.0	2,416.0		
Bristow Creek	1,647.0	8,760.0		
Big Creek:	2,912.8			
South Fork		30,514.0		
North Fork		4,842.0	4,842.0	
East Branch		4,800.0		
West Branch		4,000.0		
Sutton Creek	1,624.1	1,350.0		
Sullivan Creek	603.9	1,208.0		
Young Creek	1,200.2	6,215.0		
Pinkham Creek	1,310.3	4,035.0		
Tobacco River	7,448.7	24,478.0	24,478.0	
Fortine Creek	0.0	43,963.0	43.963.0	
Grave Creek	0.0	24,317.0		
Sinclair Creek	0.0	4,108.1	4,108.1	
Therriault Creek		5,390.0	5,390.0	
McGuire Creek	1,026.6			4,026.0
All other tributaries inundated (U.S.)	18,881.6			

Loss of Native Salmonid Habitat in Libby Reservoir Due to Increases of Non-Game Species

Westslope cutthroat trout and rainbow trout captured in annual gillnetting have declined from early post-impoundment levels of 10% and 14% to current levels 0.2% and 0.3% of the catch (Table 10, Figure 5). The reservoir was initially very productive following completion of Libby Dam, and supported strong populations of these two native salmonids (Chisholm et al. 1989). Reasons for the decline of both species include the change from river to lake environment, declining reservoir productivity, poor habitat quality in tributary streams, and declining trout prey populations, especially redside shiners (McMullin 1979). Competition for food with abundant non-native planktivores such as kokanee salmon has further limited native trout populations (Chisholm et al. 1989).

Table 10. Libby Reservoir gillnetting composition of catch, 1975-1996 (WCT = westslope cutthroat trout, RBT = rainbow trout, CRC = peamouth chub, NSQ = northern pikeminnow).

Year	% WCT	%RBT	% CRC	%NSQ
1975	10	14	0.5	4
1982	4	8	37	7
1987	2	2	60	8
1990	0.5	0.2	82	5
1996	0.2	0.3	57	9

Conversely, nongame species such as northern pikeminnow and peamouth chub (not abundant pre-impoundment) have increased in gill net catches to comprise up to 87 percent of the total catch in 1990 (Dalbey et al. 1997). This represents a two-fold increase from early post-impoundment levels. Reasons for this increase include the conversion from river to reservoir environment and the resultant creation of abundant mud and silt dominated substrates in the reservoir. Due to annual drafting of the reservoir, shoreline vegetation is not established in the varial zones.

Kokanee salmon were native to the Kootenai Drainage, but fish found below Kootenai Falls in Montana were likely migrating from Kootenay Lake, BC (Huston et al. 1984). Kokanee were inadvertently introduced to the new reservoir in the 1970s from the Kootenay Trout Hatchery in Wardner, British Columbia. Kokanee were first captured in the reservoir in 1979, and large numbers were netted in 1982. Had the reservoir environment not been present, the species could not have become self-sustaining. Since 1982, kokanee gillnet catches have oscillated between 1.5 percent in 1983 and 52.1 percent in 1995 (Dalbey et al. 1997, Chisholm et al. 1989).

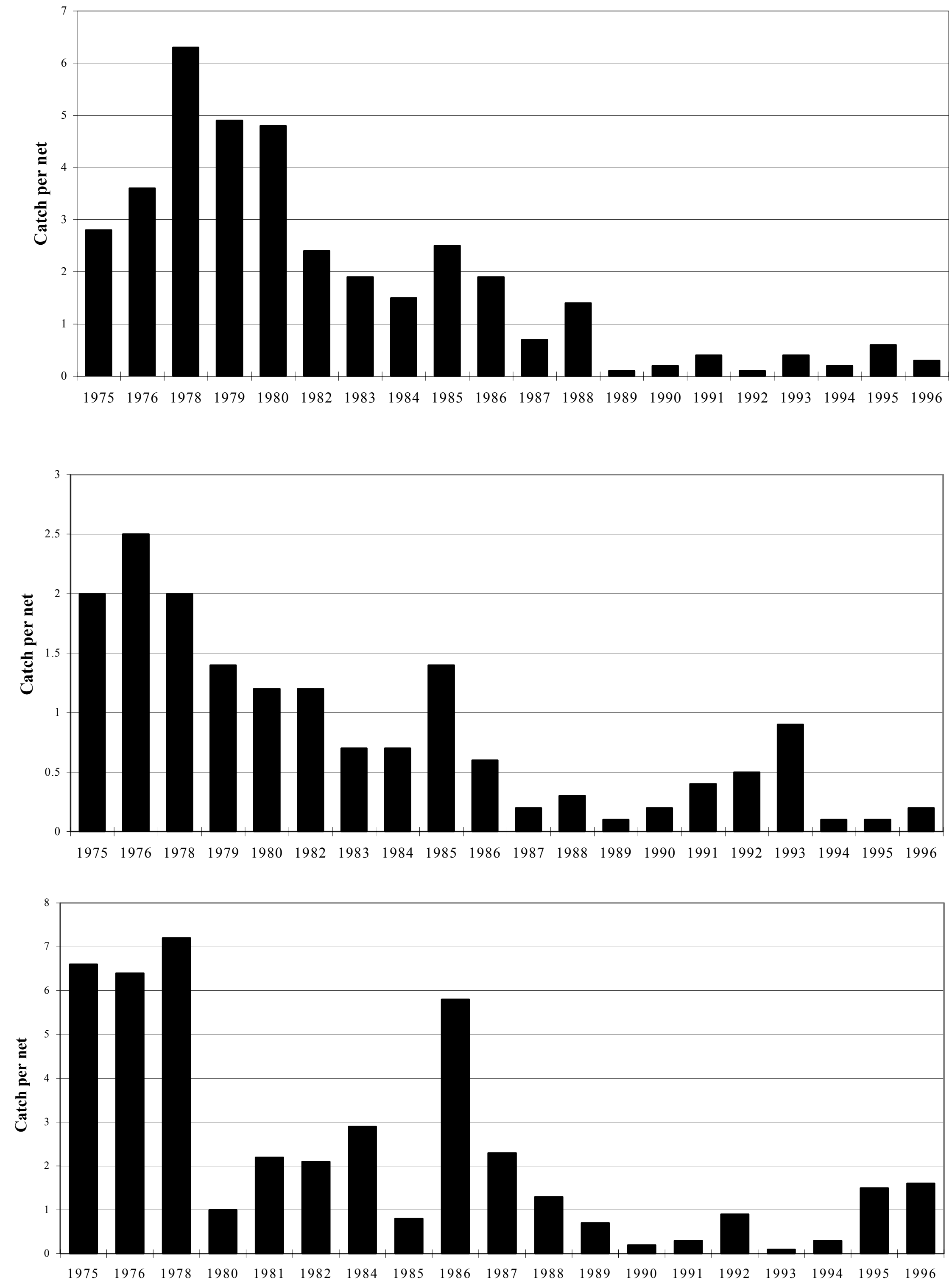


Figure 5. Catch per net of three native species: rainbow trout (top), westslope cutthroat trout (middle) and mountain whitefish (bottom) in gillnets in Libby Reservoir during 1975 through 1996.

Estimates of standing stock for cutthroat trout and rainbow trout in the reservoir have never been calculated. Therefore, it is difficult to quantify native species losses associated with the aforementioned ecosystem and trophic changes. Due to the lack of quantified data, these losses are not quantifiable.

Migration Barriers Caused by Road Construction

Canyon Creek (T59N, R28W, Sec1) provided a 1.1 mile (1.8 km) spawning reach for adfluvial cutthroat trout before impoundment of Lake Koocanusa. The Highway 37 road culvert has a 5 to 8 foot vertical drop at the outlet and a seasonal flow velocity barrier in the culvert during medium to high flows. The culvert is a deterrent to adfluvial spawning and may be a total barrier.

Eight miles (13 km) of potential adfluvial spawning habitat was lost in Boulder Creek (T63N, R28W, Sec22) due to a road culvert. The culvert is approximately 100 feet long and has a 12 percent gradient. This culvert is a barrier to historic fluvial trout spawning.

A road culvert on Highway 37 at McGuire Creek also becomes a total barrier to fish migration at approximately 50 feet of reservoir drawdown. Approximately 6.5 miles (10.5 km) of adfluvial habitat is no longer accessible to migrating fish. Bull trout and westslope cutthroat trout have been captured in the lower reaches of McGuire Creek above Highway 37. The importance of McGuire Creek to bull trout and other adfluvial trout has yet to be determined.

The estimated annual loss of production from the 15.6 miles (25.1 km) of inaccessible stream (Canyon, Boulder and McGuire Creeks.) is 5,990, resulting in a loss of 155,740 *Oncorhynchus spp*. between 1972 and 1997.

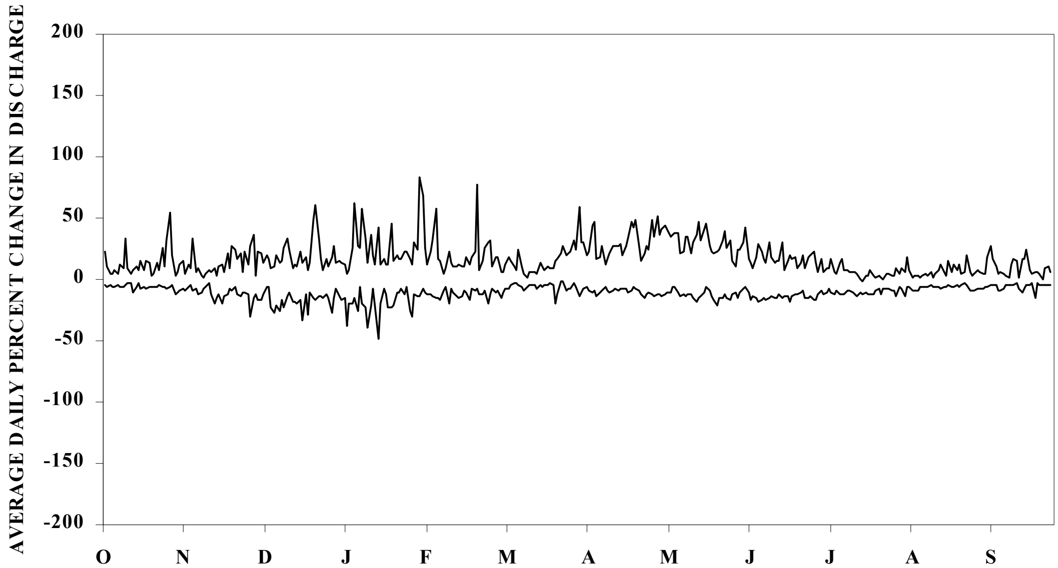
Fisheries Losses Caused by Operation of Libby Dam
Below Libby Dam

Migration Barriers Caused by Delta Formation

Tributaries to the Kootenai River annually deposit bedload materials (sand, gravel, and boulders) at their confluence with the river. Prior to construction of Libby Dam, the river contained sufficient hydraulic energy to remove these deltas annually. Deltas are potential barriers to fish migration - primarily fall-spawning bull trout when stream and Kootenai River flows are at their lowest point. Quartz and O'Brien creeks have been monitored biannually for delta growth since impoundment. These creeks support two of the three remaining substantial bull trout spawning migrations in the U.S. portion of the Kootenai Drainage. Several other tributaries currently support small bull trout spawning runs or had historical runs, including Libby Creek, Bobtail Creek, Pipe Creek, Star Creek, Callahan Creek and Cedar Creek. These creeks have not been monitored for delta barrier problems but should be surveyed in the future.

No pre-dam redd count data exist in any of the major spawning tributaries; therefore, we are unable to quantify losses (primarily bull trout) that may be associated with delta growth. The potential barriers to spawning bull trout during low water years must therefore be included with other factors in the decline of bull trout. As a result, no quantification of bull trout losses due to potential barriers below Libby Dam will be included in this mitigation document.

Fisheries habitat losses for a number of species occurred below Libby Dam as a result of its construction and operation. Physical alterations, such as delta formation, along with alterations in flow, temperature, and turbidity, have combined to reduce available habitat. Daily fluctuations in discharge (Figure 6) have led to diel losses of habitat, as well as a cumulative loss of habitat for important food items and vegetative cover in the varial zone.



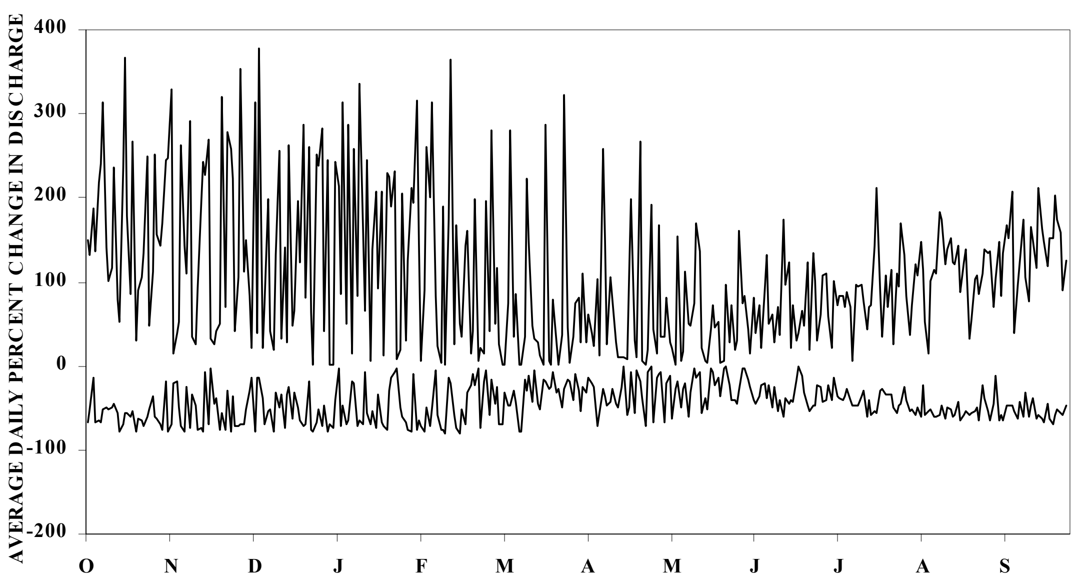


Figure 6. Range in daily change in discharge of the Kootenai River from water year 1952 through 1971 (top) and below Libby Dam from water years 1975 through 1995 (bottom) *in* Hauer 1996.

Burbot (Ling)

A popular winter burbot fishery existed in the river prior to construction of Libby Dam. Documentation of the decline of this fishery was conducted by B.C. Ministry of the Environment in Kootenay Lake (Andrusak and Crowley 1976). Hoopnetting conducted from 1979 through 1982 documented catch rates 94 percent lower than comparable efforts in 1957 and 1958 (Partridge 1983). In Montana, annual hoopnet catches below the dam continue to be low (0.002-0.168 fish/hoopnet hour). The collapse of burbot fisheries is a common phenomenon below tailwaters according to Dr. Don McPhail, of the University of British Columbia (personal communication), who has documented the decline of other burbot populations below impounded rivers (personal communication). Furthermore, it is likely that portions of the burbot that are captured annually below the dam in hoop nets are entrained from the reservoir. Twenty-four burbot were entrained between 29 January 1992 and 30 June 1994; burbot comprised 7.4 percent of non-kokanee fish entrained through Libby Dam (Skaar et al. 1996). The only population estimates that exist for burbot below Libby Dam are for 1993/1994 (56 ± 18) and 1995/1996 (759 ± 96). The variability between these two estimates may represent an increase in the population, but several factors must be considered. High flows that occurred during the 1995/1996 season likely resulted in an increase in burbot entrainment, which may have artificially inflated the population estimate below the dam. Libby Reservoir froze over in the winter of 1995/1996, resulting in lower than average river temperatures, which may have stimulated a strong spawning run, as indicated by high capture rates. The 1995/1996 spawning event was the first documented by MFWP in Montana portions of the Kootenai River since intensive trapping efforts were initiated in 1991.

Although difficult to quantify, current burbot abundance in the Kootenai River is approximately 10 percent of pre-impoundment abundance. This estimate is similar to those generated by IDFG, where the collapse in the burbot fishery closely parallels the losses in Montana. The estimated burbot population in the 29 mile (46 km) section of the Kootenai River from Libby Dam to Kootenai Falls is 408, or 14 burbot/mile. Assuming a 90 percent reduction in abundance, this represents a loss of 126 burbot/mile, or 9,135 burbot/year since impoundment.

Burbot losses below Kootenai Falls correspond strongly with declines in Kootenay Lake and Idaho portions of the Kootenai River (Vaughn Paragamian, IDFG, personal communication). Evidence suggests that this is a contiguous population, with small numbers of burbot using habitats in Montana. Tag returns and sonic telemetry data from IDFG show that burbot from Kootenay Lake travel into the Kootenai River (Vaughn Paragamian, IDFG, personal communication). Burbot were so abundant in this section that a commercial fishery existed during the 1960's. Assuming a similar linear loss relationship as burbot above Kootenai Falls exists, an estimated 66,150 burbot have been lost in the 21 miles (34 km) from Kootenai Falls to the Idaho border; therefore, an estimated 157,500 burbot have been lost in the Kootenai River between Libby Dam and the Idaho border since impoundment.

White Sturgeon

White sturgeon, the largest freshwater gamefish in North America, historically resided in the Kootenai River from Kootenai Falls downstream to Kootenay Lake. Some reports of white sturgeon above Kootenai Falls exist but cannot be validated. Due to dramatic declines in the Kootenai River population, this unique species was listed as endangered on September 6, 1994. Very few recruits have been documented since 1974. An approximated 27 percent reduction in the population occurred between 1982 and 1990, declining from 1,148 to 800 individuals (Apperson and Anders 1990, 1991). Graham (1981) reported that white sturgeon appeared to decline in the Kootenai River following impoundment. Partridge (1981) noted that a small population still existed in the lower river, but that few fish moved upstream into Montana.

White sturgeon provided a unique, though limited fishery in Montana; it was the only population of sturgeon west of the Continental Divide in Montana. Graham (1981) estimated the historical population of sub-adult sturgeon in the entire Kootenai system to be 4,000-6,000 fish. Reports of fish caught dating back to 1830 appeared regularly in community papers. The fishery was not restricted until 1973, when a slot-length limit of 40-72 in (102-183 cm) and a two sturgeon/year limit were imposed. Five to eighteen sturgeon were harvested annually until 1979, when the fishery was closed. The last reported sturgeon capture in Montana was in 1989 (Apperson and Anders 1991); IDFG personnel caught the same sturgeon twice with setlines during 1,487 hours of effort (0.001 sturgeon/hr).

White sturgeon have been lost from the Kootenai River in Montana since the construction of Libby Dam. A rare individual may swim into Montana, but since 1989, thousands of setline hours by MFWP and KTI have failed to catch any sturgeon (Anders 1993, MFWP data files). For all practical purposes, these fish are extinct in Montana. Assuming the historic 5-18 fish annually harvested in Montana represented a portion of the population during these years, a liberal estimate would place effective harvest at 50 percent of the population. From this, an estimated population of roughly 10-36 adult white sturgeon resided in Montana. This represents a complete loss of between 240-864 adult white sturgeon since Libby Dam was constructed, including loss of recruitment opportunities.

Westslope Cutthroat Trout

Westslope cutthroat trout represented an important pre-dam fishery in the Kootenai River, but because of their severe decline in numbers and distribution statewide, they are classified as a Class A species of special concern in Montana, and were petitioned for listing under the Endangered Species Act in June, 1997. Several factors have contributed to this decline in the Kootenai Drainage. Alteration of the hydrograph (Figure 3) resulted in a loss of mainstem spawning and rearing habitat, further complicated by reductions in insect diversity and production (Hauer 1996). Hybridization with rainbow trout and competition with non-native salmonids has negatively affected populations. The construction of Libby Dam created an impassable barrier for migrating fish, making important historic spawning and rearing streams above Libby Dam inaccessible.

Based on the 24 years of population estimates in the Flower Creek / Pipe Creek section of the Kootenai River immediately downstream from Libby, westslope cutthroat trout populations have been in decline. The 1973 and 1974 populations were 21 and 25 cutthroat trout/1,000 feet, respectively (44 percent of trout captured). Angler catch rates during the same period were 0.5 fish/hour, ranking the Kootenai River among other blue ribbon trout streams in Montana. The 1994 population estimate was approximately 9 westslope cutthroat trout/1,000 feet (less than 5 percent of the trout captured).

Assuming that current and historic westslope cutthroat trout densities were/are consistent throughout the 29 mi reach from Libby Dam to Kootenai Falls (1973-1973: 3,471 fish, 1993-1994: 1,358 fish), there has been a net annual reduction of 2,113 westslope cutthroat trout. This equates to a total loss of 50,712 westslope cutthroat trout in the Kootenai River from 1973 to 1997.

Developing Mitigation Options: Process and Timeline

Fishery studies on Libby Reservoir conducted by MFWP are nearing completion. We are now working with various computer models developed to refine recommendations for system operation. We are also conducting pilot mitigation projects to enhance native westslope cutthroat trout, inland redband rainbow trout, burbot, and bull trout in the Kootenai Watershed. The fisheries model we developed for the reservoir was used to calculate fishery losses caused by past operating strategies and define IRC's for reservoir water levels. An entrainment model assists in quantifying and predicting the entrainment of kokanee salmon and other species through the turbines during specific times of the year under various discharge scenarios. These models are being used to determine tradeoffs between river and reservoir operations, power generation, and flood control.

Based on our work in the Kootenai System, we have developed draft mitigation measures in cooperation with the CSKT and KTOI. All actions are influenced by Montana's fisheries mitigation guidelines (Attachment 1). Our draft mitigation recommendations (Attachment 2) are a set of opportunities addressing habitat and fish passage improvements, fisheries easements, hatchery production, and guidelines for dam operation. We have had technical input on this mitigation package through the Columbia Basin Fish and Wildlife Authority (CBFWA) Resident Fish Committee, scientific peer review, and agency meetings. Our fisheries management planning process in the Kootenai System provided public input and direction.

Now that we have prepared a list of mitigation opportunities, it is important to work together with our NPPC members, BPA, ACOE, representatives of utilities, conservation groups, and others to refine the recommendations. Our goal is to arrive at the best possible mitigation package for the Kootenai System.

This document contains our final recommendations to the NPPC (Attachment 3). After the NPPC public scoping process, we will append a response to comments.

Benefits and Tradeoffs Attributable to Libby Dam

Libby Dam has produced some resource benefits. During years of extremely low flow (e.g. 1988), water stored in Libby Reservoir augmented minimum flows in the Kootenai River. In winter, releases of warmer water from Libby Dam prevent heavy ice buildup, which caused physical damage to natural and man-made structures when it moved with currents, common before the construction of the dam.

Impoundment of the Kootenai River has been conducive to the production of rainbow trout and mountain whitefish below Libby Dam (May and Huston 1983). A portion of rainbow trout residing below Libby Dam eat entrained kokanee salmon. These trout grow to world record sizes; fish in the 10-20 lb. class are occasionally caught if river conditions are favorable, and a 33 lb. rainbow trout, a disputable world record, was landed by a local angler in August, 1997. This unique population is confined to the reach 4-5 miles (2.5-3.1 km) below Libby Dam.

The biological environment of Libby Reservoir has proven to benefit a number of different fish species. Columbia River (peamouth) chub numbers, based on annual gillnetting, have increased approximately 30,000 percent since early post-impoundment years. Northern pikeminnow caught in gillnets increased by roughly 400 percent between 1975 and 1996 (Dalbey et al. 1997). Kokanee salmon, illegally introduced into

Koocanusa in the late 1970s, provide the majority of angling opportunity in the reservoir. Since 1989, angler days have averaged approximately 28,000; kokanee comprised greater than 95 percent of the catch.

The creation of Libby Reservoir has provided a variety of natural resource-based recreation opportunities that did not exist prior to construction of Libby Dam. Angler guiding and outfitting has increased on the Kootenai River since impoundment. However, this would have occurred regardless; angling as a destination activity has increased on nearly all fishable waters. A seasonal fishery for kokanee salmon below Libby Dam is definitely a product of it's creation; kokanee were native only below Kootenai Falls, historically. Seasonal entrainment of kokanee through Libby dam provides angling opportunities during most years. However, the kokanee fishery has been nearly eliminated during years with high summer discharges for endangered Snake River salmon recovery (1995 and 1996)

The 90-mile long, 370 foot-deep reservoir stores water that would occasionally flood agricultural lands located in the historic Kootenai River floodplain. These benefits are best realized at Bonners Ferry, Idaho, where an estimated 3.4 million dollars of flood damage is prevented annually. Libby dam also produces nearly $19 million dollars in power generation annually.

Management Considerations

Installation of Libby Dam caused several biological, physical, and chemical alterations in the Kootenai River Drainage. These alterations in the aquatic environment have been estimated using the quantitative reservoir model LRMOD (Marotz et al. 1996). The determination of trout losses in the flooded tributaries and the mainstem of the Kootenai River will provide managers a partial estimate of losses. Recovery of pre-dam cutthroat and bull trout populations will require that mitigation efforts focus on stream rehabilitation, passage improvements, riparian fencing, and aggressive point and non-point source sediment abatement. Spawning habitat improvements and protection and reestablishment of natural reproduction are required to reestablish once outstanding fishing opportunities in the reservoir and river. Hatchery conservation stocking using state-of-the-art techniques will have limited applicability onsite. Direct supplementation of reservoir trout populations using hatchery fish has failed to produce an acceptable trout fishery in Lake Koocanusa. Stream imprinting of eyed-egg westslope cutthroat trout may show promise for recovering adfluvial-spawning runs in tributaries to Lake Koocanusa if spawning habitat can be improved and protected.

Fisheries Easements

Fisheries easements to protect investments in habitat restoration will be purchased associated with site-specific evaluations. Initially we recommend that $250,000 be available to begin negotiating fisheries easements. Future easements should be evaluated on a site by site basis (Table 2). Costs given in this report represent working estimates; we plan to work with the public, BPA and NPPC to refine these figures.

Opportunities to purchase fisheries easements in the Fisher and Thompson River drainages are increased by FWP's partnering with Rocky Mountain Elk Foundation and other private entities in the purchase of easements primarily for wildlife habitat. Joining fisheries dollars to these purchases may result in greater benefits for both fish and wildlife. The Fisher River is a corridor for migratory bull trout, and provides residential habitat for westslope cutthroat trout and rainbow trout. Tributaries to the Fisher River provide habitat for inland rainbow trout, primarily in headwater areas.

Fisheries easement opportunities in the upper Kootenai drainage exist primarily in the form of riparian management agreements with respect to livestock grazing, and to insure that the integrity of floodplains are not altered by further residential development. Similar opportunities exist in drainages in the lower Kootenai, primarily for insuring that residential development does not alter stream functionality.

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Attachment 1.

MONTANA'S FISHERIES MITIGATION GUIDELINES

In addition to our own management plans and those of other cooperators, the Fish and Wildlife program has been guided by the standards in the Northwest Power Planning Council's Fish and Wildlife program Measures (NPPC 1995).

As a result of these two influences, Montana's fisheries mitigation guidelines are to:

- Protect, mitigate, and enhance biological production in the affected waters;
- Emphasize natural fish production and habitat whenever possible;
- Mitigate with artificial propagation to enhance fish populations and provide recreation when full mitigation of natural production is not possible;
- Emphasize mitigation for designated endangered (white sturgeon) and species of special concern (westslope cutthroat, bull trout and interior redband rainbow trout), where appropriate;
- Mitigate in conjunction with the Confederated Salish and Kootenai Tribes, Idaho Department of Fish and Game, Kootenai Tribe of Idaho, and British Columbia Ministry of the Environment, as specified in the Fisheries Co-management Plan; and
- Emphasize cooperation with power/water management interests in determining reservoir operations and mitigation.

Attachment 2.

FISHERIES MITIGATION OPTIONS FOR LIBBY DAM

NON-OPERATIONAL OPTIONS WHICH DO NOT REQUIRE CHANGES IN TIMING OR VOLUME OF WATER RELEASED FROM THE DAM

- **Habitat Enhancement**

  Stream, river, reservoir, or lake habitat would be improved by adding instream fish cover (habitat structures), reestablishing natural meanders to channels while stabilizing mass wasting sediment sources, removing silt, fencing riparian zones, and adding spawning gravel.

- **Fish Passage Improvements**

  Streams which are presently blocked for fish migration would be reopened by improving culvert design, installing fish ladders, or removing deltas.

- **Off-Site Habitat Improvement / Stocking of Hatchery Fish**

  Fisheries in waters outside Libby Reservoir and the Kootenai River system would be improved to provide conservation genetics sources for species of special concern and more fishing opportunities.

- **Fisheries Easements**

  Fisheries easements to protect investments in habitat and passage enhancements will be pursued on a site by site basis. Conditions in negotiated easements will be designed to protect stream margins and watershed headwaters.

Attachment 3.

KOOTENAI RIVER
ECOSYSTEM MITIGATION PROCESS

1983-1996	INVESTIGATE SYSTEM FISHERIES IDENTIFY LOSSES
1995-1996	IDENTIFY MITIGATION OPTIONS
Sep-Dec 1996	CONSULT WITH GROUPS IMPLEMENT MITIGATION (ADVISORY GROUP)
1997	PRODUCE DRAFT MITIGATION PLAN

(DATES ARE TENTATIVE)

Oct 1997	RELEASE DRAFT PLAN FOR PUBLIC COMMENT
April 1998	SUBMIT DRAFT PLAN WITH PUBLIC INPUT TO NORTHWEST POWER PLANNING COUNCIL
1998	PRODUCE FINAL MITIGATION PLAN COUNCIL BEGINS PUBLIC REVIEW PROCESS
	FINAL COUNCIL RECOMMENDATIONS

Attachment 4.

Comment page for the initial consultation package for Libby Dam fisheries mitigation.

Name:

Organization:

Address and Phone #:

I have the following comments on fisheries losses, benefits, resource tradeoffs, mitigation options, issues, etc. (Please attach additional pages if necessary). It would be helpful for us if you would list mitigation options in your estimated order of importance (See Attachment 2).

____
____
____
____
____
____
____
____
____
____

____ I would like to receive more detailed technical information on fisheries losses and mitigation options.

____ I would like to schedule a consultation for my group.

____
(Contact person)

Please return to:

Montana Fish, Wildlife & Parks
Attn.: Greg Hoffman/Scott Snelson
475 Fish Hatchery Road
Libby, MT 59923

OR

Montana Fish, Wildlife, and Parks
Attn.: Brian Marotz
490 N. Meridian
Kalispell, MT 59901-3854

Thank you for commenting.

Attachment 5. Potential mitigation projects identified in the Kootenai Basin

Kootenai Basin Fisheries Mitigation Projects		
MITIGATION LOCATION	PROPOSED ACTIVITY	BENEFIT TO RESOURCE
Skinner Lake	Increase pool level by 20'.	Increase useable habitat area, allow access to spawning channel, and increase angler opportunities.
Lake Koocanusa	Introduce Fish Structures	Increase available habitat for several native species (burbot).
Kootenai Basin lakes with stunted perch populations	Introduce burbot from the LFS facility as predator on perch	Create genetic reserve for Kootenai River burbot stock, provide enhanced angler opportunities
Libby Field Station	Facility Upgrades	Improved facilities for experimental fish culture, Inland Rainbow brood stock opportunities and improved experimental activities
Libby Field Station	LFS Spring Creek channel rehabilitation (Brook Trout eradication :build barrier)	Establish an inland Rainbow Trout brood stock (egg source) for establishing basin brood lakes
Yaak River	Placement of large boulders in lower 1,500 feet of channel. Minor channel reconstruction.	Provide adult habitat, improved spawning habitat, and enhanced angler opportunities.
Star, Ruby, O'Brien, Quartz Creeks	Delta removal at Kootenai river confluence (10.3B.10)	Improve bull trout passage during spawning
O'Brien Creek	Beaver dam management	Decrease brook trout habitat and enhance bull trout spawning access.
O'Brien Creek	Brook Trout eradication	Decrease competition with native Bull Trout and enhance Cutthroat populations
O'Brien Creek	Mass wasting bank stabilization	Improve Bull Trout spawning and rearing habitat
Quartz Creek	Mass wasting bank stabilization	Improve Bull Trout spawning and rearing habitat
Deep Creek	Removal of barriers and channel reconstruction	Improve Bull Trout passage and enhance spawning habitat
Moran Lake	Purchase easement and rehabilitate lake	Improve angling opportunities
Summit Creek	Channel reconstruction	Enhance spawning habitat
Swamp and Lake Creeks	Riparian fencing	Bank stabilization and improved fish habitat

Kootenai Basin Fisheries Mitigation Projects		
Dunn Creek	Plug subsurface aquifer in creek channel	Create continuous flow for enhanced fish passage
Lake Creek	Channel reconstruction, barrier removal	Provide fish passage to upper portion of stream
Libby, Big Cherry and Granite Creeks	Channel reconstruction, bank stabilization	Decrease flooding risks, stabilize mine tailings (improve water quality) improve fish habitat for all life stages (Bull, Wct, Rbt Trout), improve fish passage, enhance Kootenai River fluvial / adfluvial populations.
Bobtail Creek	Bank stabilization, sediment source control, channel reconstruction	Improve Wct/Rbt spawning opportunities
Glen Lake	Rehabilitate and introduce Kokanee, Westslope Cutthroat and Kamloops Trout	Increase angling opportunity and return cutthroat to a historic lake.
Carpenter Lake	Rehabilitate and introduce Westslope Cutthroat and Kamloops Trout	Increase angling opportunity and return cutthroat to a historic lake.
Throops Lake	Purchase property (87 acres with closed basin lake an d Kootenai River access)	Provide permanent access to Kootenai River below Kootenai Falls for continued White Sturgeon Recovery efforts. Pond could be used as Inland Rainbow trout brood lake (genetic reserve).
Bootjack and Topless Lakes (Thompson Chain of Lakes)	Rehabilitate lakes and plant with historical species (Rainbow trout)	Enhance angling opportunities.
Hidden Lake Fortine Drainage	Rehabilitate the lake removing centrarchids and other non-natives and restock with grayling or cutthroat trout	Provide a fishable population of native fish
Sinclair Creek (Vredenberg's property)	Fence 300 yards of stream side	Increase bank stability, reduce input of fine sediment
Sinclair Creek (Downstream of Rick Vredenberg's property)	Create a flow regulated spawning channel downstream from Vredenberg's property	Increase fish passage to Sinclair Creek and increase the availability of spawning habitat
Sinclair Creek (Irrigation dam on Vredenberg's property below Hwy 93)	Construct a series of step pools at the outlet of the irrigation dam	Increase fish passage to Sinclair Creek
Sinclair Creek (Joe Purdy's property above Hwy 93 to Purdy Road)	Fence approximately 1 mile of stream and plant riparian vegetation	Increase bank stability, reduce the input of fine sediment, and provide fish habitat in the stream reach

Kootenai Basin Fisheries Mitigation Projects		
Grave Creek (Glen Lake Irrigation Diversion site)	Reconstruct stream channel above diversion, remove diversion dam and install a self-cleaning fish screen at the diversion site	Reduce bedload aggradation and bank cutting above dam Decrease loss of bull trout to the irrigation canal. Remove potential migration barrier.
Grave Creek (Glen Lake Irrigation Diversion site)	Install a infra-sonic fish barrier at the diversion site	Deter bull trout from accessing the irrigation canal, test application for other uses in the Kootenai Drainage
Therriault Creek- Headwater Fish Ponds	Reduce potential for pond failure and escapement of non-native fish into Therriault Creek	Decrease potential for non-native trout immigration into Therriault Creek
Therriault Creek (Dietzinger's property from Hwy 93 to the confluence with the Tobacco River)	Fence and plant riparian vegetation on approximately 1 mile of stream	Increase bank stability and provide cover for fish
Therriault Creek (Vredenberg's property approximately 2 mile from Hwy 93)	Reconstruct channelized portion of the stream, plant streamside vegetation and replace road culvert to eliminate channel down cutting. Assess potential for re-establishing bull trout spawning.	Increase bank stability, provide fish cover, and reduce gradient at the road culvert to prevent further channel downcutting, reducing sediment inputs into Therriault Creek, and Tobacco River. Potentially re-establish bull trout spawning.
Therriault Creek (Hanson Property below Hwy 93)	Fence and revegetate stream course.	Stabilize channel and reduce sediment input into Therriault Creek and the Tobacco River. Provide spawning and rearing habitat for westslope cutthroat trout.
Swamp Creek	Return channelized creek to historic stream course	Provide spawning and rearing habitat for resident and adfluvial cutthroat and reduce sediment loads in Fortine and Tobacco Drainages
Grave Creek - Lower reach	Channel reconstruction	Provide bull trout spawning and rearing habitat
Grave Creek-Headwater Tributaries: Blue Sky Creek Lewis Creek Stahl Creek Foundation Creek Clarence Creek Williams Creek	Non-point source sediment abatement	Decrease input of fine sediment into Grave Creek Drainage, a critical spawning and rearing drainage for bull trout and other salmonids
Deep Creek	Stream rehabilitation including fencing and sediment abatement	Enhance habitat for native species, reduce sediment loads
Fortine Creek- USFS	Stabilize channel below harvest sections with instream structures	Reduce risk of further channel degradation, reducing sediment inputs to Swamp Creek, Fortine Creek and Tobacco River. Provide spawning and rearing habitat for westslope cutthroat trout.

Kootenai Basin Fisheries Mitigation Projects		
Fortine Creek Drainage including Edna and Swamp Creek	Fence and revegetate 12 miles of stream	Decrease sediment input in primary spawning habitats.
Tobacco River-Eureka to mouth	Install fish habitat structure and channel reconstruction	Increase fish habitat for a recreational fishery and stabilize the stream channel
Frank Lake	Evaluate lake for opportunities to improve dissolved oxygen levels.	Provide necessary information to assess potential of creating a local trout fishery near the town of Eureka.]
Young Creek **Big Creek** **Sinclair Creek** **Therriault Creek** **Canyon Creek**	Construct artificial redds and imprint westslope cutthroat at the eyed egg stage	Increase strength of adfluvial and resident westslope cutthroat spawning runs and habitat in degraded tributaries, test application for use drainage wide, promote self-sustaining fish populations
Big Creek	Create a spawning side channel for native adfluvial and resident fisheries	Increase spawning habitat available for westslope cutthroat and potentially bull trout
Barron Creek	Eradicate existing population of eastern brook trout above a permanent barrier, re-establish native cutthroat population	Re-establish a fishable population of native species
Barron Creek	Non-point source sediment abatement	Reduce input of fine sediment to promote quality spawning habitat
Canyon Creek **McGuire Creek**	Improve fish passage through Hwy 37 culvert, improve access below culvert by creating a series of step pools	Increase fish passage for adfluvial spawners to Canyon Creek to spawning and rearing habitat
Arbo Creek	Eradicate existing hybrid *Oncorhynchus* fish population from the outlet of Wee Lake to the F.S. road # 2367 culvert, install a permanent barrier	Genetically isolate the pure population of inland redband trout inhabiting Wee Lake
Feeder Creek **(Kilbrennan Lake Inflow)**	Construct spawning channel	Provide spawning opportunity for pure strain Inland Redband Rainbow trout while excluding non-native species.
Kilbrennan Lake	Chemically eradicate black bullhead and perch populations and restock with native interior redband for use as a brood stock for recovery efforts	Provide a genetic reserve for interior redband trout and improve recreational fishery
Mt. Henry Lake - Basin Creek Drainage	Relocate redband trout from Basin Creek to barren lake. Construct a spawning channel from the upper lake to the lower lake	Create a self-propagating drainage specific genetic reserve in the Basin Creek Drainage
Wee Lake	Identify potential spawning site for use as an egg taking facility for interior redband trout	Use Wee Lake stock for recovery efforts and as an initial brood for Kilbrennan Lake

Kootenai Basin Fisheries Mitigation Projects		
Smith Lake - Idaho	Replace stocking of westslope cutthroat with inland redband trout	Reduce potential for inbreeding of westslope cutthroat and pure redband and
	from Callahan Creek. Assess potential for creating or improving spawning habitat for the redband trout from the lake.	provide a genetic reservoir for Callahan basin, inland redband stock.
Flower Creek	Reconstruct stream channel and reestablish westslope cutthroat trout spawning migrations.	Reclaim spawning and rearing habitat for westslope cutthroat trout and provide potential rearing for bull trout.
Dodge Creek	Sediment abatement and habitat improvement for native westslope cutthroat population.	Protect existing pure population of native westslope cutthroat trout
Kootenai Drainage	Identify seasonal habitat use of inland redband trout in the Kootenai Drainage	Provide fisheries managers with needed information to protect and enhance critical redband habitats
Kootenai Drainage [Montana, Idaho and British Columbia]	Identify population status of all redband populations in the Kootenai Drainage	Allow for protection and/or enhancement of redband populations
Kootenai Drainage	Evaluate current Hungry Horse westslope cutthroat strain to determine its effectiveness for establishing adfluvial spawning runs in reservoir tributaries	Determine need to establish alternative westslope cutthroat strains.
Kootenai Drainage [Montana, British Columbia]	Develop adfluvial westslope cutthroat trout brood stock using wild Kootenai Drainage genetics.	Have available an in-drainage supply of gametes for westslope trout re-introduction into reservoir tributaries to improve westslope cutthroat fishery in Lake Koocanusa.
Kootenai Drainage [Montana, Idaho and British Columbia]	Develop higher resolution population indices for Kootenai Drainage burbot populations	Effective monitoring of native burbot population trends
Deep Creek (ID)	Barrier removal	Provide fish passage to upper portion of stream
Kootenai Drainage (ID)	Develop burbot brood stock using wild Kootenai Drainage genetics	Have available an in-drainage supply of gametes for burbot re-introduction into the Kootenai Drainage below Kootenai Falls
Kootenai River (below Bonners Ferry)	Rip-rap of river banks	Stabilize banks and provide juvenile rearing habitat
Kootenai Drainage (Shorty's Island)	Purchase Island	Provide habitat and prevent future development. Protection of spawning site for White Sturgeon
Libby Ready Mix Handicap and childrens fishing pond	Seal the bottom of excavated gravel pit and provide a source of year- round water to maintain temperature and pool levels. Stock with native species to provide a put-take fishery and native species interpretive opportunity.	Promote youth fishing and provide fishing opportunities for handicap citizens that are limited with dam operations. Relieve fishing pressure on near town tributaries.

Kootenai Basin Fisheries Mitigation Projects		
Libby Armory Gravel Pit	Seal the bottom of already excavated gravel pit and provide a source of year- round water to maintain temperature and pool levels. Stock with native species to provide a put-take fishery and native species interpretive opportunity.	Promote youth fishing and provide fishing opportunities for handicap citizens that are limited with dam operations. Relieve fishing pressure on near town tributaries.
Long Canyon Creek	Plant riprap vegetation, channel reconstruction. Reintroduce Kokanee salmon	Improve spawning habitat and kokanee angling opportunities
Parker Creek	Water quality analysis. Replace bridge in downstream portion of creek.	Remove debris backing up channel
Parmenter Creek	Channel Reconstruction and streambank stabilization	Improve spawning and rearing habitat for westslope cutthroat trout and bull trout in the spawning limited middle Kootenai
Trout Creek (ID)	Channel reconstruction. Fence riparian area, create spawning channel, reintroduce native kokanee salmon	Increase bank stability. Improve spawning, rearing and adult habitat. Enhance angler opportunities.
Vredenberg Gravel Pit (Eureka-adjacent to Tobacco River)	Purchase property adjacent to the existing pond (from Sinclair Creek to the Tobacco River). Stock with native species.	Promote youth fishing and provide fishing opportunities for handicap citizens that are limited with dam operations. Relieve fishing pressure on near town tributaries.