FEDERAL COLUMBIA RIVER POWER SYSTEM
Project Operations

Biological Assessment for Effects of FCRPS Operations on Columbia Basin Bull Trout and Kootenai River White Sturgeon

US Army Corps of Engineers
US Bureau of Reclamation
Bonneville Power Administration

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1.0 Introduction

This Biological Assessment (BA) addresses the potential impacts of the coordinated operation of the Federal Columbia River Power System (FCRPS) from 1998 and future years on the continued existence of bull trout (*Salvelinus confluentus*) and in the Columbia and Snake River system, Montana, Idaho, Oregon and Washington, as well as the Kootenai River white sturgeon (*Acipenser transmontanus*) in Montana and Idaho. The BA is based on the operation of the FCRPS as contained the 1995 Biological Opinion (1995 Biological Opinion (BiOp) for Snake River sockeye salmon (*Oncorhynchus nerka*) and Snake River spring, summer, and fall chinook salmon (*O. tshawytscha*), prepared by the National Marine Fisheries Service (NMFS, 1995); as well as the 1995 BiOp on Kootenai River sturgeon and Snake River snails, US Fish and Wildlife Service (USFWS, 1995a), and encompasses the area and actions reviewed in the System Operation Review (Bonneville Power Administration et al., 1995), except as amended herein. This BA is prepared in compliance with the Endangered Species Act (ESA - 16 USC.1531 *et seq*., PL 93-205, as amended, 1973).

1.1 Project Action Area

The Columbia River is the largest river in the Pacific Northwest. It drains over 250,000 square miles in Washington, Oregon, Idaho, Montana, Wyoming, Utah, Nevada, and British Columbia. This BA covers the Federal Columbia River Power System (FCRPS), a collection of 14 large federal dams on the Columbia River and its tributaries (Figure 1.1-1 and Table 1.1-1). Twelve of these dams are operated by the US Army Corps of Engineers (USACE), and two are operated by the US Bureau of Reclamation (USBR). Project uses include flood control, hydroelectric energy generation, irrigation, navigation, fish and wildlife enhancement, recreation, low-flow augmentation, and both municipal and industrial water supply.

Figure 1.1-1. Map of the Columbia River Basin including the dams that make up the Federal Columbia River Power System (FCRPS).

Table 1.1-1. Dams that make up the Federal Columbia River Power System (FCRPS).

DAM	RIVER DRAINAGE	OPERATOR	TYPE OF RESERVOIR (acre-feet)	POWER CAPACITY[a] (megawatts)
Libby	Kootenai	Corps of Engineers	Storage (4,979,500)	604
Hungry Horse	South Fork Flathead	Bureau of Reclamation	Storage (3,161,000)	328
Albeni Falls	Pend Oreille	Corps of Engineers	Storage (1,042,000)	49
Dworshak	Clearwater	Corps of Engineers	Storage (2,015,800)	460
Grand Coulee	Columbia	Bureau of Reclamation	Storage (5,185,500)	7,416
Chief Joseph	Columbia	Corps of Engineers	Run-of-river	2,614
Lower Granite	Snake	Corps of Engineers	Run-of-river	932
Little Goose	Snake	Corps of Engineers	Run-of-river	932
Lower Monumental	Snake	Corps of Engineers	Run-of-river	930
Ice Harbor	Snake	Corps of Engineers	Run-of-river	693
McNary	Columbia	Corps of Engineers	Run-of-river	1,127
John Day	Columbia	Corps of Engineers	Storage (534,000)	2,485
The Dalles	Columbia	Corps of Engineers	Run-of-river	2,052
Bonneville	Columbia	Corps of Engineers	Run-of-river	1,093

[a] Overload capacity—equates to higher rpms than peak efficiency would dictate. Columbia and Snake River projects operate within 1% of peak efficiency, therefore generating less power than these capacities indicate.

1.2 Species Covered

This consultation deals with resident fish native to the Columbia drainage which are listed under the ESA, specifically bull trout (*Salvelinus confluentus*) and the Kootenai River population of white sturgeon (*Acipenser transmontanus*).

Bull trout were listed as threatened in the Columbia basin on June 10, 1998 by the US Fish and Wildlife Service (USFWS, 1998b). The Kootenai River population of white sturgeon (hereinafter referred to as "sturgeon") was listed as endangered on September 12, 1994 (USFWS, 1994b).

Previous consultation has occurred concerning sturgeon, starting with a Biological Opinion for operation of Libby Dam, dated March 1, 1995.

The USFWS convened a recovery team for the Kootenai River white sturgeon in 1994. On October 1, 1998, the team presented the draft recovery plan for the sturgeon to the regional director of the USFWS. It contained specific recommendations for actions to benefit Kootenai River white sturgeon, including flow provisions for spring and summer out of Libby Dam. The USFWS is currently reviewing this draft plan.

As of autumn 1998, no recovery team has yet been assembled for bull trout.

1.3 Areas Not Covered

There are some Federal projects in the Columbia Basin which do not fall under the Federal Columbia River Power System, and effects of their operations on bull trout will be addressed under separate Biological Assessments. They are as follows:

Yakima River Basin

The Yakima River Basin is located entirely within the state of Washington and drains the east side of the Cascade Mountain Range. The Yakima joins the Columbia River upstream from McNary Dam. USBR operates five reservoirs that provide about 1,000,000 acre-feet of irrigation water storage for basin farmlands and other uses. Bull trout are found in all five reservoirs and in associated stream reaches. With the recent ESA listing of bull trout, USBR has started to assemble biological information on the species and is currently in the informal stage of consultation. USBR plans to provide a biological assessment, evaluating the effects of its Yakima Project operations on bull trout, to the USFWS in early 1999.

Upper Snake Basin

The Bureau of Reclamation (USBR) completed a Biological Assessment in 1998, on the operations and maintenance of its dams and reservoirs in the Snake River Basin drainage above Lower Granite Reservoir. The geographical area covered by this consultation included southern Idaho and much of eastern Oregon. The Corps of Engineers' Lucky Peak Reservoir on the Boise River system was included in the consultation, since USBR administers its irrigation water service contracts. USBR wrote a biological assessment that initially considered 21 ESA listed, proposed and candidate species, including bull trout. As a result of the consultation, USBR determined that local bull trout populations in Arrowrock and Beulah Reservoirs were likely to be adversely affected by reservoir operations. Bull trout populations in the other USBR Snake Basin reservoirs (including Lucky Peak) were judged not likely to be adversely affected. In late 1998, the USFWS issued an incidental take statement in its biological opinion which directed USBR to carry out certain reasonable and prudent measures that were designed to reduce the level of bull trout take in Arrowrock and Beulah Reservoirs. These measures included conducting studies to identify possible fish passage improvements, implementation of operations to reduce fish entrainment, establishment of minimum reservoir pools, water quality assessments, and continued biological studies on bull trout populations.

Umatilla River Basin

The Umatilla River is located in northeastern Oregon and enters the Columbia River a few miles downstream of McNary Dam. There are two USBR storage reservoirs in the basin and several downstream irrigation diversion structures on the Umatilla River. Bull trout are found in some headwater stream sections, far above any USBR Umatilla Basin Project facilities. Previous NEPA evaluations have concluded that USBR project actions in the Umatilla Basin have no effect on bull trout. Accordingly, no ESA Section 7 consultation is contemplated at this time by USBR in the Umatilla Basin.

Willamette River Basin

Although composing part of the Columbia River Basin bull trout population, Willamette River bull trout will be addressed separately with the preparation of a Biological Assessment for the Corps of Engineers' Willamette Valley Projects. This separate biological assessment will be consistent in style and form with the on-going efforts for the FCRPS but address those issues and concerns unique and endemic to the Willamette River bull trout populations.

2.0 Status of Bull Trout in Project Areas

To develop an assessment of the potential impacts of the FCRPS on bull trout and on Kootenai River white sturgeon, background conditions must be understood. The following sections describe species life history, habitat requirements, stock status and environmental baseline conditions pertinent to the FCRPS operating projects and adjacent drainages.

2.1 Status of Stocks, and Bull Trout Life History

Bull trout are present in every FCRPS project operating area. General bull trout life history is in the succeeding paragraphs. A basin-specific summary of the past and present condition of bull trout stocks follows the basic life history information. The habitat requirements, stock status, and current environmental conditions of bull trout as they apply to each basin are indicated in those sections.

General History of Bull Trout

Taxonomy

Cavender (1978) identified bull trout *(Salvelinus confluentus)* as a distinct species of char, unique to western North America. Prior to the American Fisheries Society's acceptance of the description of *S. confluentus* in 1980, biologists considered bull trout and Dolly Varden, *S. malma*, to be of the same species.

The extent and structure of residual genetic variation provides important information in developing rational management plans necessary for preserving existing ecological and genetic diversity (Allendorf and Leary, 1988). Williams et al. (1997) separated bull trout populations in the American Northwest (excluding Puget Sound and Coastal Washington) into three distinct evolutionary groups: Klamath River (two populations), lower Columbia River (two populations), and upper Columbia River (13 populations). Based on analysis of mitochondrial DNA from Lake Pend Oreille populations, Williams et al. (1997) suggested that populations in the Upper Columbia River Basin and/or large lake systems in the region may contain populations that incorporate a substantial portion of the remaining natural genetic diversity in the species. This high genetic diversity in the Lake Pend Oreille population could have resulted from one of a variety of factors including 1) a high diversity of life history types—adfluvial, fluvial and resident; 2) the founding population was large enough to maintain diversity even with extirpation of local sub-populations; and 3) downstream migration from upper drainages such as the upper Clark and Flathead Rivers.

Fragmentation of the Clark Fork and Flathead Rivers through dam construction has probably further increased diversity in the Lake Pend Oreille population as juvenile bull trout are able to pass downstream during high peak flows but are unable to return to spawning tributaries as adults. Adult fish unable to migrate back to spawning are likely to seek secondary non-natal areas for spawning, thereby increasing diversity in local populations (Pratt and Huston, 1993; Williams et al., 1997).

Kanda et al. (1997) found substantial genetic divergence among populations from the North, Middle, and South Fork Flathead, Swan, and Stillwater drainages. They found little variation within drainages suggesting appreciable amounts of gene flow naturally occurs among them (stream-to-stream). Leary et al (1993) also noted substantial differences among populations and advocated that preservation of genetic diversity requires the continued existence of many populations throughout a region.

Distribution and Status

Migratory bull trout historically occurred in the Columbia River and its tributaries (Cavender 1978; Bond 1992). Donaldson and Cramer (1971) reported early fish wheels on the lower Columbia River near McCord Creek catching bull trout. Bull trout are estimated to have occupied 60% of the Columbia River Basin and presently occur in 45% of the estimated historical range (Quigley and Arbelbide, 1997). The Columbia River population segment is currently composed of 141 subpopulations. Bull trout distribution within the basin has four distinct geographical areas including 1) Upper Columbia River, 71 sub-populations (upstream from Chief Joseph Dam); 2) Mid-Columbia River, 17 sub-populations (Snake River confluence to Chief Joseph Dam); 3) Snake River and its tributaries, 34 sub-populations; and 4) Lower Columbia River, 20 sub-populations (downstream of the Snake River confluence). Table 2.1-1 provides a summary of the number of sub-populations, status, trends, and risk of stochastic extinction within each geographical area (from USFWS, 1998b and 1998c).

In a survey of bull trout populations in the northwestern U.S., Howell and Rieman (1997) stated that 60% of all populations have declined, while only 5% are considered secure or increasing. Buchanan et al. (1997) reported that 81 percent of Oregon's bull trout populations are considered to be at a "moderate risk of extinction," "high risk of extinction," or "probably extinct." The risk of sub-population extirpation varies by geographical area within the Columbia River Basin population segment with 1) 66% of Upper Columbia; 2) 26% of Snake River; 3) 63% of Mid-Columbia; and 4) 25% of Lower Columbia sub-populations at risk, respectively (Table 2.1-1).

Life History

Bull trout exhibit two distinct life history forms, resident and migratory. Resident populations spend their entire lives within small headwater streams. They typically exhibit slow growth and rarely exceed 300 mm in length (Goetz, 1989). Migratory bull trout, fluvial, adfluvial and anadromous, spawn and rear in tributary streams. Fluvial adults and juveniles migrate to larger mainstem rivers to overwinter and feed in spring and summer. Adfluvial fish reside in lakes except during their spawning migration. Anadromous fish have a juvenile stream rearing stage with an adult marine stage. In the contiguous United States, anadromous fish are found in the Puget Sound-Coastal Population Segment and were found in the extirpated California Bull Trout Population Segment. It is unclear if anadromy was present in the Lower Columbia River Population Segment.

Rieman and McIntyre (1993) indicate that diverse life-history strategies are important to the stability and persistence of populations of any species. Such diversity is thought to stabilize populations in highly variable environments or to refound segments of populations that have disappeared. Research on bull trout life history has focused on stocks, which migrate to lakes and reservoirs (especially Flathead Lake in Montana); less is known about stocks, which migrate to mainstem river systems or marine areas, or remain resident in streams. Table 2.1-2 (Knowles and Gumtow, 1996) provides a brief summary of the life history of bull trout.

Table 2.1-1. Bull trout status summary by sub-basin within the Columbia River Population Segment.

Columbia River Sub-Basin Watershed	Number of Subpopulations	Number of Sub-populations Extirpated	Status[1]	Trend[2]	Risk of Stochastic Extirpation
Upper Columbia					
Spokane River	1		D	D	N
Pend Oreille River	3	8 Lake tribs	D	D	N
		5 Below Albeni Falls			
Kootenai River	5		U	U	1Y&4N
Flathead River	24	3	7D&14U	7D&14U	6N&15Y
South Fork Flathead	3		1S&1U&1D	1S&2U	1N&2Y
Swan River	3		S	I	N
Clark Fork River	4	1	2D&2U	U	N
Bitterroot River	27		D	U	24Y&3N
Blackfoot River	1		D	U	N
Coeur d-Alene River	0	12			
St. Joe River	0	25			
		10 other tribs			
TOTAL	71	64	66% at Risk of Extirpation		
Middle Columbia					
Yakima River	8		7D&1S	6D&U&I	5Y&3N
Wenatchee River	3	1	2D&1S	2U&1S	2Y&1N
Entiat River	1		D	D	N
Methow River	4		D	U	2Y&2N
Napecqua River	1				
Lake Chelan	0	1			
Okanagon River	0	1			
Middle Columbia	0	1			
		6 other tributaries			
TOTAL	17	10	63% at Risk of Extirpation		
Snake River					

Below Hells Canyon Dam					
Tucannon River	2		U&D	U	N&Y
Clearwater River	3		U	U	2N&1Y
Asotin Creek	2	1	D	U	N&Y
Grande Ronde River	1	1	U	U	N
Imnaha River	4		2D&2U	U	3N&1Y
Salmon River	2		U&D	D	N
Above Hells Canyon Dam					
Pine Creek	4		D	U	U
Powder River	3	1	D	U	2N&1Y
Malheur River	2		D	U	N
Payette River	4		U	U	3N&1Y
Weiser River	2		D	U	N&Y
Boise River	2		U	U	N
Little Lost River	3		2D&1U	U	1N&2Y
TOTAL	34	3	26% at Risk of Extirpation		

Columbia River Sub-Basin Watershed	Number of Subpopulations	Number of Sub-populations Extirpated	Status[1]	Trend[2]	Risk of Stochastic Extirpation
Lewis River	2		D	U & S	N
Willamette River	3	3	D	U&I&D	2Y&1N
White Salmon River	1		D	U	U
Klickitat River	1		D	U	U
Hood River	2		D	U	Y&N
Deschutes River	3	2	S&D&U	2U&I	2N&Y
John Day River	3		D	U	N
Umatilla River	2		D	U	Y&N
Walla Walla River	3		D	U	N
TOTAL	20	5	25% at Risk of Extirpation		

1. D=depressed, S=strong, U=unknown; from U.S. Fish and Wildlife Service 1998. Numbers, e.g. “7D,” relate to specific number of sub-populations showing a population trend. If all sub-populations show the same trend in a category (D, S, or U) no number is given. Strong sub-populations have all life history forms that once occurred, abundance that is stable or increasing, and at least 5,000 total fish or 500 adult fish are present; depressed subpopulations either have a major life history form eliminated, abundance that is declining or half of historic, or less than 5,000 total fish or 500 adults are present.
2. D=decreasing, I=increasing, S=stable, and U=unknown.

Table 2.1-2. Bull trout life history summary.

Life Conditions	Criteria/Facts
Age at first reproduction	4-5 years
Number of eggs produced	1,300 to 9,000
Maximum size	Greater than 30 pounds and 36 inches
Life span	Up to 10 years
Food habits	Juveniles are insectivorous. Adults are piscivorous
Hatching success (percent)	Water temperature critical: 0-2^{o} C = 80-95% success 6^{o} C = 60-90% success 8-10^{o} C = 0-20% success Sediment size: 20% fines = 40% success 30% fines = 20% success 40% fines = 1% success
Migration strategies	Resident, adfluvial, fluvial, and anadromous
Closely related species	Dolly Varden, lake trout, and brook trout
Optimal and maximum water temperature	Juveniles = 4-9^{o} C and 15^{o} C Adults = 4-9^{o} C and 18^{o} C
Spawning season	September through November

Migratory Behavior

Juvenile emigration strategy varies by age class, seasonal timing, and final residence. Adfluvial bull trout fry migrate with spring freshets while older juveniles may migrate in all seasons but winter (McPhail and Murray, 1979; Goetz ,1989; Pratt, 1992; Connor et al., 1997). In upper Flathead River tributaries adfluvial juveniles (other than fry) migrated primarily at age 2 (49%), with smaller percentages emigrating at age 1 or 3 (18 and 32% respectively) (Pratt, 1985). Fry emigration in this system peaked in early May. Juvenile migrants probably move quickly downstream along the stream margin to the mainstem Flathead beginning as early as May and extending through the middle of July. Migration from the Flathead River mainstem to Flathead Lake occurs from August to September (Shepard et al., 1984). Flathead River tributaries in British Columbia have a primary or secondary migration peak in late September or early October (Aquatico, 1976). Most juvenile migration probably occurs at night (Riehle et al., 1997; Stelfox, 1997). Peak movements in a Metolius River tributary coincided with new moon phases.

In the Wigwam River system (Upper Kootenai River Basin) age 1 and 2 fish emigrated from their natal stream, Ram Creek, to the mainstem while age 2 and 3 juveniles emigrated downstream in the mainstem (Oliver, 1979). This researcher also speculated downstream movement may occur just prior to spring runoff. Fluvial bull trout in Rapid River emigrated in the fall, primarily at age 2 and 3, although younger fish may have outmigrated in the spring (Elle et al., 1994). Bull trout migrate to Lake Pend Oreille from tributary streams at age 2 (Mason 1985). In the Metolius River, juvenile migrants range from 25 to 261 mm in length and from age 0 to 4 (Riehle et al., 1997). The majorities of migrants was age 2 (54%) with age 3 and 4 fish representing 10%, age 1 19%, and age 0 10% of total outmigrants, respectively. Bull trout fry comprised 61% of all migrants in late April and 13% in May.

Spawning migrations by adult bull trout can last from days to months. Upstream migration by adult bull trout in the Blackfoot and Rapid Rivers appears to coincide with an increase in maximum daily water temperature and a falling hydrograph following peak runoff, usually May through early July (Elle et al., 1994; Swanberg, 1997). Conversely, McPhail and Murray (1979) found peak upstream movement in the Arrow Lakes to coincide with maximum water temperature and minimum flows. Bull trout leave Flathead Lake to begin their upstream migration in early spring, generally in April and May. Migrating bull trout remain in the Flathead River mainstem until mid-late August and then move into tributary streams to commence spawning (McDonnel and Fidler, 1985). Upstream movement of bull trout peaked by early August in the Wigwam River Drainage with an overall migration period of July to September (Oliver, 1979). Most adult bull trout migrate at night, covering 4-5 km per night (Stelfox, 1997; Swanberg, 1997).

Bull trout can home specifically to the same redd site year after year or they may shift among streams (Fraley et al., 1981; Pratt, 1985; Goetz, 1989). Tagging returns in the Wigwam Basin show bull trout were taken by anglers in streams other than the location of tagging, while the increasing size of repeat spawners in the Arrow Lakes results in shifts to new, larger spawning streams (McPhail and Murray, 1979; Oliver, 1979). Adults tend to migrate downstream to overwintering areas within 1-2 weeks of the completion of spawning (Oliver, 1979; Swanberg, 1997). Adults migrating downstream in the Flathead River often feed on spawning concentrations of mountain whitefish (Shepard et al., 1984). Figure 2.1-1 shows a male bull trout and an aggregate of adult bull trout during migration.

Figure 2.1-1. Left, male bull trout in spawning coloration. Right, bull trout staging during upstream migration with kokanee salmon (photo at left courtesy of Dimitri Vidergar, photo at right courtesy of Paul James, Central Washington University).

Migratory corridors provide access from over-wintering areas to spawning or foraging areas. Movement undoubtedly is important to the persistence and interaction of local populations within the metapopulation. Disruption of migratory corridors may reduce growth and survival, and possibly lead to the loss of the migratory life-history types. Resident stocks live upstream from natural barriers and an increasing number of barriers caused by human activities (U.S. Bureau of Reclamation, 1998). Because these stocks are sometimes isolated in marginal or extreme habitats, they will be at increased risk of extinction (Horowitz, 1978).

Juvenile and Adult Habitat Requirements

Bull trout appear to have more specific habitat requirements than other salmonids. Temperature, channel stability, winter high flows, summer low flows, substrate, cover, and the presence of migration corridors consistently appear to influence bull trout distribution or abundance (Oliver, 1979; Allan, 1980; Fraley and Graham, 1981; Leathe and Enk, 1985; Thurow, 1987; Ziller, 1992).

Temperature represents a critical habitat characteristic for all bull trout life stages. Temperatures above about 15^{o}C are thought to limit bull trout distribution and production (Oliver, 1979; Pratt, 1984; Fraley and Shepard, 1989; Ratliff, 1992; Rieman and McIntyre ,1993; Goetz, 1994). Increased temperature can limit the distribution of other char and likely will exacerbate fragmentation of bull trout populations (Meissner, 1990; Rieman and McIntyre, 1993). Bull trout in the Flathead Basin are not found in streams where maximum monthly water temperatures exceed 18^{o}C and are most abundant where water temperatures are 12^{o}C or less (Shepard et al., 1984). In the Lower Columbia River Basin, bull trout spawning and rearing areas are only found in spring-fed tributaries, usually at temperatures less than 12^{o} C (Goetz, 1994). Bull trout temperature requirements by life-stage are shown in Figure 2.1-2.

Increased water temperatures may affect the ability of bull trout to compete with other species. Pratt (1984) found allopatric bull trout in warmer water than in sympatry with westslope cutthroat trout. Shepard et al. (1984) proposed that increased temperatures could shift species composition to favor cutthroat trout over bull trout. Adams and Bjornn (1997) suggest that warmer water in the Weiser River basin may favor rainbow and brook trout over bull trout. Further increases in summer temperatures, from reduced riparian cover or decreased stream flow, could further reduce bull trout habitat and expand brook and rainbow trout.

Figure 2.1-2. Bull trout temperature requirements for each life history stage and time period, as reported in the general literature (from Buchanan and Gregory, 1997).

Juvenile Habitat

Shifts in habitat use occur depending on the time of day and season. Juvenile bull trout often conceal themselves in cover (substrate and woody debris) during the day and move on or above the substrate at night (Goetz, 1994, Jakober, 1995) (Figure 2.1-3). This pattern of daytime concealment is more pronounced as water temperatures decline below 7^{o}C (Schill, 1991; Jakober, 1995). During winter, activity and aggression are greatly reduced and survival depends on finding suitable shelter and minimizing energy costs (Cunjack and Power, 1987).

Figure 2.1-3. Bull trout holding above bottom substrate (Photo courtesy of Ernest Keeley, University of British Columbia).

Healthy riparian zones and relatively undisturbed stream channels are important components of stream reaches used by juvenile bull trout. Dambacher and Jones (1997) identified seven variables that are significant descriptors of juvenile bull trout habitat in Lower Columbia and Snake River streams: high levels of shade, undercut banks, large woody debris volume, large woody debris pieces, gravel in riffles, low levels of fine sediment in riffles, and low amounts of bank erosion. Cross and Everest (1997) related changes in quality and frequency of pool habitat, resulting from channel destabilitzation, as a negative influence on stream carrying capacity of westslope cutthroat trout and apparently on the distribution of spawning bull trout.

The presence of embryos, alevins and juvenile fish in the substrate during winter and spring indicates that highly variable stream flows, bedload movements, and channel instability negatively influence the survival of young bull trout (Weaver and White, 1985; Goetz, 1989). The redds of bull trout and other fall spawning fish are particularly vulnerable to flooding and scouring during winter and early spring (Seegrist and Gard, 1972; Goetz ,1994; Cross and Everest, 1997), and to low winter flows or freezing within the substrate. This association with substrate appears more important for bull trout than for other trout and char species (Pratt, 1984; Nakano et al., 1992).

After hatching, bull trout fry rear in low velocity water (McPhail and Murray, 1979). They find cover in substrate interstices, or within 0.03 meter (m) of the substrate and are associated with cobble and boulders or submerged fine debris where water velocity averages 0.09 meters per second (m/s) (Shepard et al., 1984). Juvenile bull trout prefer to be close to the substrate or some other cover, which creates visual isolation (Pratt, 1984).

Juveniles live close to in-channel wood, substrate, or undercut banks (Pratt, 1984, 1992; Goetz, 1994). Adult resident bull trout also closely associate with the substrate but appear to select large cobble and boulder substrates (Goetz, 1989; Jakober, 1995), as well as lateral scour and pocket pools (Hoelscher and Bjornn, 1989; Pratt, 1984) and areas with complex woody debris and undercut banks (Graham et al., 1981; Oliver 1979; Pratt, 1985; Shepard et al., 1984). Woody debris correlated significantly with densities of bull trout sampled in streams in the Bitterroot National Forest of Montana (Clancy, 1992). Jakober (1995) found that stream resident bull trout of all sizes conceal themselves in the interstices of large cobble and boulder substrate and large woody debris accumulations during the day.

Bull trout appear to seek large, deep pools with abundant cover in the autumn and winter (Jakober, 1995). No published information exists regarding juvenile overwinter habitat use in large rivers.

Although in-stream wood and substrate with clear interstitial spaces correlate with the distribution and abundance of bull trout, habitat complexity in any form can be important (Mullan et al., 1992). Strong bull trout populations will require high stream channel complexity.

The amount of cover needed to maintain a strong bull trout population cannot, however, be quantified.

Adult Habitat

Little information has been documented for bull trout habitat resident in the larger river systems of the Pacific Northwest. Most previous study has focused on describing adfluvial populations or spawning and rearing characteristics in tributary streams. Fluvial adult bull trout over-wintering in the Salmon and Clearwater Rivers used pool and run habitats with overhanging or instream cover (Elle et al., 1994; Rhem, 1997). Most over-wintering bull trout show high site fidelity after entering the main Salmon River. Individuals typically remain in the same habitat unit for a 6-month period after cessation of downstream movement (Schill et al., 1997). In the Athabasca River, after spawning, bull trout quickly return to over-wintering areas, typically moving less than 1 mile throughout the winter (McLeod and Clayton, 1997; Swanberg, 1997)

Adfluvial adult bull trout generally spend about one half of every year associated with a reservoir or lake (generally November-May). Bull trout in Flathead and Chester Morse Lakes have the most diverse habitat usage of any fish in the lake, and are found in both deep water and along the shoreline of the lake (Hanzel, 1985; Connor et al., 1997). Distribution in reservoirs and lakes may be related to water temperature and seasonal movement. Bull trout in Lake Koocanusa live in open water in the summer and near shore during the fall, usually occupying areas with temperatures of 8-14^{o} C (Shepard, 1985; Chisholm et al., 1989). In the same reservoir, kokanee are found in waters up to 15^{o} C and trout (*Oncorhynchus* spp.) at 18^{o} C. Bull trout occupy the lower portion of the thermocline at depths of 12.2 to 18.3 m in Priest Lake, where water temperatures are 7.2 to 12.8^{o} C and move to the surface when surface water temperatures drop to 12.8^{o} C or lower (Bjornn, 1961). In Flathead Lake during the fall, adults move into lower river reaches to feed on pygmy whitefish or shoreline areas to prey on spawning kokanee salmon (Hanzel, 1977; Shepard et al., 1984).

Reproduction

In the Columbia River Basin, bull trout generally become sexually mature between 5-7 years of age (Leathe and Enk, 1985; Fraley and Shepard, 1989; Goetz, 1989). Bull trout spawn in the late summer and fall, primarily September and October (Heimer, 1965; Leggett, 1969, Oliver, 1979; McPhail and Murray, 1979; Shepard et al., 1984). Bull trout exhibit two common reproductive strategies, repeat and alternate year spawning (Block, 1955; Pratt, 1985; Riehle et al., 1997). In any given year, approximately 38-69% (average 57%) of the adult bull trout in Flathead Lake migrate upstream to spawn (Fraley and Shepard, 1989). Male spawners show a wide variety of life history variations, including dominant male, jack male (>150 mm), and precocial parr (<150 mm). In most populations, dominant males are the predominant life history type, however if environmental or management conditions in lakes or rivers increase mortality of large males, then small males that mature early may be at a selective advantage (Kitano et al., 1994; James and Sexauer, 1997).

Migratory fish generally grow larger and have higher fecundity than do resident forms. Fluvial adult bull trout in the Rapid River drainage, grow an average of 54 millimeters (mm) during the 7 to 9 month over-wintering period and range from 290 to 540 mm in length (Elle et al., 1994; Elle, 1995). Limited radio-tracking data of Rapid River adults showed post-spawning mortality of up to 67 percent (Schill et al., 1997). In contrast, tagged bull trout spawners in Kananaskis Lake had an annual mortality (in absence of angler harvest) of less than 5% (Stelfox, 1997). Adfluvial bull trout spawners ranged from 300 to 875 mm in length and 4 to 9 years old in the Flathead and Pend Oreille Systems (Shepard et al., 1984; Pratt, 1985). Precocious males have been found in the Flathead and Pend Oreille drainages (Shepard et al., 1984; Pratt, 1984).

Variation in the timing of migration and in the timing and frequency of spawning also represents diversity in life history. It is possible that four or more year classes could compose any spawning population, with each year class including up to three outmigration strategies. This theory supports the idea that the multiple life-history strategies found in bull trout populations represent important diversity (both spatial and genetic) within populations (Bureau of Reclamation, 1998).

Decreasing water temperatures may influence the onset of spawning (Shepard et al. 1984, Weaver and White, 1985). Some bull trout spawn in streams with ground infiltration, particularly springs (Heimer, 1965; Allan, 1980; Shepard et al., 1984; Pratt, 1984) or groundwater upwelling (McDonald and Fidler, 1985). However, spawning sites in Rapid River and other central Idaho systems show no evidence of groundwater influence (Elle, 1995).

McPhail and Murray (1979) found egg survival was highest at temperatures of 2 to 4^{o} C. Egg mortality increased with increasing temperatures with only 0 to 20% survival in water 8 to 10^{o} C . Under stable conditions, forty to fifty percent of eggs survive in the wild (Allan, 1980). No specific work has been done on the oxygen requirements of bull trout eggs.

Spawning substrate is typically loosely compacted gravel and cobble (McPhail and Murray, 1979; Shepard et al., 1984). Spawning sites include runs or tails or pools with water 0.2 to 0.8 m deep. Eggs were buried 10 to 20 cm in the gravel, and water velocities associated with redds were 0.2 to 0.6 m/s (Shepard et al., 1984). Substrate size has been shown to influence survival in laboratory tests, with survival at 0% with more than 50% fines (less than 6.35 mm) to about 40% with no fines (Shepard et al., 1984). Groundwater or streambed recharge present may result in higher survival to emergence (Shepard et al., 1984).

Hatching is completed in 100 to 145 days, usually the end of January (Heimer, 1965; McPhail and Murray, 1979; Allan, 1980; Weaver and White, 1985). Yolk sac absorption requires 65 to 90 days (Shepard et al, 1984). Parr marks develop and feeding begins while fry are still in the gravel. Bull trout reach lengths of 25 to 28 mm before filling their air bladders and emerging from the streambed, approximately in April (Shepard et al., 1984).

Food Habits

Bull trout have voracious appetites and take full advantage of any and all food sources available to them. Fish are considered to be the major item in the diet of large bull trout. They feed primarily along the bottom and up to mid-water levels, consuming insects and other fish species such as suckers, sculpins, minnows, and trout. Mountain whitefish are one of the bull trout's preferred prey (Knowles and Gumtow, 1996).

In the Flathead basin, juvenile bull trout (less than 100 mm) were found feeding on macroinvertebrates (aquatic insects), with preference for mayflies (Ephemeroptera) and flies (Diptera) (Shepard et al., 1984). Mayflies, stoneflies (Plecoptera), caddisflies (Trichoptera) and beetles (Coleoptera) are the preferred food of juvenile bull trout in the Muskeg River system of Western Alberta (Boag, 1987). Adult bull trout are opportunistic fish eaters (piscivores). In Libby Reservoir, fish account for over 99% of the biomass consumed by bull trout (Chisholm et al., 1989).

Growth

Growth varies among the freshwater bull trout forms. McPhail and Murray (1979) found bull trout grew to larger sizes at lower temperature and grew largest at 4^{o}C. Bull trout rearing in streams are 100 to 150 mm by age 2 to 3 and growth increases once they enter lakes (McPhail and Murray, 1979). Generally, resident adults range from 150 to 300 mm in length (Goetz, 1989; Mullan et al., 1992) while migratory fish commonly exceed 600 mm in length (Shepard et al., 1984; Pratt, 1985; Goetz, 1989). The maximum period of growth appears to occur between the third and fourth years of age coinciding with a general switch in diet from insects to fish. Most adfluvial populations show an average annual increase of 90 mm. (Table 2.1-3).

Table 2.1-3. Bull trout growth in various Columbia River drainages (adapted from Leathe and Graham [1982] and Goetz [1989]).

	Total Length (mm) at Annulus								
Drainage	1	2	3	4	5	6	7	8	9
Flathead Basin									
Middle Fk Flathead	52	100	165	297	399	488	567	655	
North Fk Flathead	73	117	165	301	440	538	574		
Flathead Lake	68	129	204	291	384	472	566	658	731
Hungry Horse Reservoir	72	144	225	324	429	513	594	671	
Upper Kootenai Basin									
Ram Creek, Wigwam R	78	137	218	303					
Wigwam River	64	114	176	385	476	557	668		
Lake Koocanusa	67	123	212	309	482	518			
Pend Oreille Basin									
Lake Pend Oreille	91	164	272	403	497	578			
Priest Lake	71	114	183	310	424	516	605		
Deschutes Basin									
Metolius River[1]	72	111	191	299	459	652	820		
Willamette Basin									
Upper Willamette River	93	142	165			264	284	347	452

Riehle et al. (1997), Metolius River/Lake Billy Chinook system.

Factors Contributing to Species Decline

Impacts on bull trout generally occur from three areas of resource management: (1) land management practices; (2) water management practices, and (3) fisheries management practices. Current recognized threats to bull trout are discussed in the following sections.

Habitat Degradation

Bull trout have some of the most demanding habitat requirements of any native salmonid species. As an apex predator, bull trout fill an important ecological niche in rivers of the Pacific Northwest. Because of their special habitat requirements and ecological role, char, and in particular bull trout, are excellent “indicators” of ecosystem health and pristine conditions of cold-water ecosystems (Regier, 1980; Edwards et al., 1990; Goetz, 1994). Even though bull trout have been used as indicator species for National Forest Management Plans for two decades, Rieman and McIntyre (1993) believed that there is not enough information available to clearly define habitat condition thresholds that may control the abundance and distribution of bull trout. In an attempt to define broad factors that may be effecting the numbers and range of bull trout, the US Fish and Wildlife Service (1994a) surveyed fish biologists throughout the Pacific Northwest and summarized the types of impacts suppressing bull trout populations and their relative importance (Table 2.1-4.).

Table 2.1-4. Factors suppressing bull trout populations by state (USFWS 1994a). Figures for suppressing factors number of populations, rows are summed but columns are not since more than one factor suppressing most populations.

	Idaho	Montana	Nevada	Oregon	Washington	Total
Number of Populations	72	234	1	54	77	438
Land Management Impacts						
Forestry	38	126	1	44	40	249
Agriculture	10	59	0	24	11	104
Grazing	27	37	0	26	7	97
Mining	14	23	0	8	5	50
Water Management Impacts						
Hydropower	4	61	0	8	18	51
Passage Barriers	38	98	1	23	22	182
Fish Management Impacts						
Non-native Introductions	12	141	0	35	25	213
Poaching	10	98	1	2	26	137
Legal Harvest	27	49	1	6	2	85

Logging and grazing have led to an overall decline in riparian and stream habitat in bull trout watersheds with loss of riparian vegetation and instream woody debris, collapse of stream banks, sediment input and loss of pool area and volume. Reduced riparian cover results in increased stream temperatures and bank instability (Ziller, 1992; Rieman and McIntyre, 1993). Mining activities have effected bull trout populations by dewatering streams and discharging toxic sediments from poor mining operations and failed tailings ponds. The Clark Fork River has been severely impacted by leaching of heavy metals with resultant fish kills following heavy rains (Thomas, 1992).

Water Management

Impacts on bull trout from water management practices fall into four general categories: 1) passage barriers and stream diversions; 2) inundation of spawning and rearing habitat; 3) modification of stream flow and temperature regime; and 4) dewatering of varial zone and reduction of reservoir productivity

Passage Barriers and Stream Diversions. Construction of water storage structures appears to have been a significant factor in the reduction of bull trout range and distribution. At least 39 major impoundments are located within the range of the bull trout. An undetermined number of dams were constructed without adequate fish passage and are now barriers to migratory bull trout, precluding access to former spawning rearing and migration habitats (USFWS, 1995b). As described by Rieman and McIntyre (1993), if the isolation increases between several sub-populations, through mechanisms such as habitat destruction or migratory barriers, dispersal among these groups ceases, some go extinct, and the entire metapopulation moves incrementally closer to extinction. Many migratory bull trout populations associated with main stem river systems have been extirpated due to construction of dams, including elimination of the California Bull Trout after completion of McCloud Dam (Rode, 1990; Brown, 1992; Goetz, 1994).

Elimination of upstream and downstream migratory corridors has resulted in increasing isolation of residual populations with increasing risks of extinction (Fraley et al., 1989; Thomas, 1992; Pratt and Huston, 1993). In the Upper Columbia River Basin, Bigrock and Hungry Horse Dams restrict interchange of bull trout sub-populations in the Flathead Basin. Dams on the Clark Fork River restrict movement between the Flatlhead and Pend Oreille system. Dams at Albeni Falls, Noxon Rapids, and Cabinet Gorge have contributed to the fragmentation and decline of fluvial and adfluvial bull trout.

Barrier location relative to sub-population spawning and rearing habitat may be important. Dams built with no upstream passage that are found immediately downstream of a spawning area may have a higher impact on a population than a dam with a fish ladder located much further downstream (Ratliff and Howell, 1992).

Habitat Inundation. A direct impact of water storage structures on bull trout populations is seasonal or permanent inundation of spawning and rearing habitat. In the Upper Columbia River, construction of Hungry Horse and Libby Dams resulted in inundation of tens of miles of mainstem and tributary habitat used by numerous sub-populations.

Modification of Stream Flow and Temperature Regime. Irrigation diversions may negatively effect stream flows in waters occupied by bull trout by reducing flows below the diversion point and by returning warmer, sediment laden water. In the Columbia River Basin, water control structures have altered the natural flow regime below most impoundments changing the timing, duration, frequency and magnitude of peak and low flows, water quality characteristics (dissolved gases, temperature, and turbidity, and sediment transport). The impact of these flow regime changes on bull trout is largely unknown. The instream flow and habitat requirements of *Oncorhynchus* species have been extensively studied with numerous instream flow models available to simulate the effects of altered stream flows on trout and salmon. In comparison, western charr -- Dolly Varden and bull trout -- have been little studied with virtually no supporting information available on their instream flow (water quantity) requirements. For example, instream flow negotiations in the Klamath and Athabasca drainages have relied on Delphi process to identify major habitat requirements of migratory and resident bull trout. Instream flow studies using radio-tagged bull trout are just beginning in the Kootenai River below Libby Dam, results from that research will not be available for this BA.

Accepted ramping rates for bull trout are not available for most river systems, but since juvenile bull trout extensively use nearshore, low-velocity habitats, it would be prudent to apply rates equal to or possibly exceeding accepted rates for other salmonids. In addition, as low water temperatures appear to reduce the activity levels of bull trout and other resident salmonids (westslope cutthroat trout), resulting in long periods of inactivity under nearshore substrate, fall and winter ramping rates may need to be even more stringent.

Given that bull trout are highly sensitive to changes in temperature and instream cover, it would not be unusual to expect that even minor flow regime changes could have a negative impact on juvenile and adult bull trout. When coupled with changes in water quality (increased temperature, changes in dissolved gasses, turbidity) and sediment transport that typically accompany changes in flow regime, water management practices may have a large impact on bull trout populations found below dams. For example, in the South Fork of the McKenzie River below Cougar Dam, as conservation storage is drawn down in late summer a remnant bull trout population is exposed to rising stream temperatures, 10-14^{o} C, at a time when adults would normally be spawning at temperatures of less than 9^{o} C. In conjunction with these elevated stream temperatures, Cougar Dam has also altered the sediment transport regime, resulting in down cutting of the riverbed, which isolates important juvenile off-channel rearing habitat.

The effect of gas supersaturation on bull trout has not been studied. In 1997, elevated levels of dissolved gas (up to 158%) were documented as a result of spill from Cabinet Gorge Dam at a time bull trout were undergoing their spawning migration up the Clark Fork River (Parametrix, Inc., 1997). No direct observations of gas bubble disease were made for bull trout although a single individual was collected and released. To the extent that spill has occurred in the past, it is possible that bull trout have been directly affected. Kokanee (a major bull trout prey species) were also collected, though none exhibited symptoms of gas bubble disease. These fish may have compensated by swimming deeper to avoid high total dissolved gas.

<u>Dewatering of Varial Zone, and Reduction of Reservoir Productivity</u>. Reservoirs experience substantial drawdowns during drought years. Reduced reservoir volume directly impacts the amount of aquatic environment for all organisms in the food web. Production of phytoplankton, zooplankton, and aquatic insects are all reduced when drawdowns are extreme. Reduction in the food base may reduce the prey available for predator species like bull trout; although some forage fish populations may be more concentrated and more available as prey. In Libby Reservoir, fish made up 99% of the diet of reservoir rearing bull trout (Chisholm, 1989). When reservoir volume is greatly reduced, bull trout and other fish species may be forced into recently exposed and heavily degraded riverine habitats. In addition, as water levels fall, upstream migrants may be blocked from entering their spawning tributaries either by perched road culverts or possibly by delta formation at the tributary/reservoir confluence (Capurso, 1997; Hansen and DosSantos, 1997; Reiser et al., 1997). Conversely, downstream migrants may be blocked by tributary delta formation and could become vulnerable to terrestrial predators.

Ecological Change—Introduction of Non-native Species

The Montana Department of Fish and Wildlife and Parks (MDFWP) attributes the dramatic decline of bull trout sub-populations in the Flathead Lake subbasin to recent ecological changes in Flathead Lake (Weaver 1997). Since the MDFWP began monitoring index redd areas in the Flathead Lake sub-basin (1980-1994), monitoring counts have declined dramatically, reaching the lowest observed levels in 1992 and 1993. The annual rate of decline is estimated at over 16 redds per year (annual average count of 340). The decline in redd counts has occurred concurrently with observed ecological changes in Flathead Lake that began in the mid-1980's, when densities of non-native opossum shrimp (*Mysis relicta*) peaked, other zooplanktors declined, and the kokanee salmon (*O. nerka*) population collapsed. Data analysis of redd trend counts since this time, 1988 and later, indicates a highly significant decline with an estimated annual loss of over 60 redds. This recent decline (7-year) is significantly greater than the long-term rate (15-year).

The introduction of non-native salmonids within the historic range of Columbia River bull trout can be a limiting factor for many sub-populations. Brook trout are found throughout the Columbia River subbasin and have been implicated as a factor in the decline of selected bull trout subpopulations (Markle, 1992; Ratliff and Howell, 1992; Leary et al., 1991 and 1993). Brook trout are reported as present in 35 of the 69 sub-populations listed in the state of Oregon (Buchanan et al., 1997). Brook trout directly compete with juvenile bull trout for food and they may also mate with bull trout to produce hybrids (some hybrids are fertile) (Figure 2.1-4). Lake trout have displaced and eliminated native adfluvial bull trout (Donald and Alger, 1992). Brown trout have also been identified as a potential competitor and predator of bull trout (Moyle, 1976; Bond, 1992). Habitat degradation may exacerbate the adverse effects of non-native species on bull trout (Rieman and McIntyre, 1993).

Figure 2.1-4. Comparison of native bull trout and introduced brook trout (Photo courtesy of Oregon Department of Fish and Wildlife).

Reduced Populations from Overfishing or Eradication Efforts

From early in the 20^{th} century to recent times, bull trout were viewed as a trash fish by many anglers and most state fish and wildlife agencies. They were characterized as a heavy predator of juvenile salmon and other game fish so they were considered undesirable. Many natural resource agencies mounted active campaigns to eliminate bull trout. For example, during 1913 and 1914 in Montana, large-scale commercial net fishing was permitted in an attempt to eradicate bull trout (Brown, 1971). In a few regions bull trout were valued as game fish. In most of these regions, bull trout have been overfished, sometimes to the point of extirpation. Every state with remaining bull trout sub-populations has adopted protective management strategies that include severe statewide angling restrictions. However, most of these restrictions were generally not implemented until after 1990 and many rely on the ability of fishermen to properly identify and handle bull trout for effective survival after release. One of the best examples of overfishing as a limiting factor is the Metolius River Basin. Prior to 1980, there was a 10 fish per day limit on bull trout; since 1988 all tributaries are closed during spawning season and the limit in Lake Billy Chinook is one fish. Following adoption of these fishing restrictions, redd counts have increased from 27 redds in 1986 to 330 redds in 1994 (Ratliff, 1992; Ratliff et al., 1996).

Even after active elimination programs have ceased and overfishing has been reduced, bull trout populations have continued to decline (particularly isolated groups), due to impacts related to other human activities. Some populations of bull trout have not recovered from (or were eliminated by) overfishing or deliberate efforts to eradicate them. These populations probably suffer from a loss of genetic diversity and may not be able to sustain themselves.

Catastrophic Events

Knowles and Gumtow (1996) identified five catastrophic events—introduced disease, catastrophic fire, salvage timber sales, drought, and climate change—that can occur within the range of bull trout, and which could have a high probability of extirpating small isolated populations and contribute to further declines in the number and range of bull trout. Disease has not been documented as a problem affecting bull trout, but whirling disease is a possible threat to fragmented populations in the Columbia River basin. For example, rainbow trout populations have been reduced as much as 90% in less than four years along 50 miles of the Madison River. Catastrophic fire events can drastically alter water quality, water temperature, woody debris, bank vegetation, and stream flow characteristics. Wildfire has been documented as impacting bull trout populations (Burton, 1997.). Salvage timber sales have a high potential to impact bull trout populations from logging and construction of new or additional roads into isolated watersheds. Drought results in reduced summer stream flows (and reduced reservoir elevations) and increased water temperature, and will predictably reduce spawning success and survival of bull trout. Climate change as a result of global warming could reduce bull trout spawning success, particularly in low elevation watersheds. Environmental stochasticity, or the effect of a catastrophic event (such as deep reservoir drawdowns for flood control or during drought conditions) influences the probability of bull trout extinction when population size is small (Rieman and McIntyre, 1993).

2.1.1 Kootenai Basin

General

Habitat Requirements.

Bull trout in the Kootenai Basin of Montana are mostly confined to small, isolated, resident populations (Thomas, 1992). However, the Kootenai River still supports a population of fluvial bull trout which spawn in a limited number of tributaries. The ability of migratory bull trout to use a variety of habitats makes them the life history strategy least susceptible to extinction (Rieman and McIntyre, 1993).

Bull trout spawning in Montana generally takes place during September and October (Thomas, 1992). Initiation of spawning is correlated with declining water temperatures. The threshold temperature appears to be 9^{o}C (Thomas, 1992). When the daily maximum temperature drops below this level, spawning takes place (Fraley and Shepard 1989, McPhail and Murray 1979).

Adfluvial bull trout generally mature for two or three years in lakes or reservoirs before undertaking spawning migrations (Goetz 1989). In Flathead Lake, bull trout begin their spawning migration into the river system as early as April, with the peak of migration occurring during the high flows of May and June. Spawning migrations in the Flathead range from 88-250 km in length. Adult bull trout hold in the tributaries for up to a month or more in deep holes or in debris cover before spawning. (Fraley and Shepard, 1989). Adults quickly move downstream after spawning (Willamette National Forest, 1989).

Population Status—Past and Present

Bull trout were one of six native salmonid species distributed throughout the Kootenai River drainage. Bull trout are generally distributed in a North-South belt along the Rocky Mountains. Bull trout can be found on both sides of the continental divide between latitude 50 and 60 degrees N, but primarily west of the continental divide to the south of this zone (Thomas, 1992). In addition to the their distribution west of the continental divide, bull trout are also native to the St. Marys River drainage (Saskatchewan River drainage), east of the continental divide (Brown, 1971). Figure 2.1.1-1 shows current bull trout distribution in the US portion of the Kootenai drainage.

Figure 2.1.1-1. Current bull trout distribution in the US part of the Kootenai River drainage.

Upper Kootenai River

Habitat Requirements

The upper Kootenai River population segment includes those areas of present bull trout range above Libby Dam, including Lake Koocanusa and its immediate tributary system, as well as the Kootenay River drainage in British Columbia. (MBTSG, 1996d). Migratory bull trout are the only known life history type to exist in the upper Kootenai River drainage. Adults reach maturity in Lake Koocanusa or the upper Kootenay River. Spawning and rearing areas are located in the Grave Creek and the Wigwam River drainages (MBTSG, 1996d). There is also a disjunct population in Sophie Lake (MBTSG, 1996d). Sophie Lake bull trout spawn and rear in Phillips Creek.

<u>Pre-Dam Distribution</u>. There is some question as to whether Kootenai Falls was an upstream migration barrier to fish construction of Libby Dam. High spring flows may have allowed seasonal passage by some fish species. If this was the case, the bull trout population likely included migratory fish from Kootenay Lake in British Columbia as well as Kootenai River fish which may have moved freely throughout the drainage (MBTSG, 1996d). Resident bull trout may have been present, but this life history has not been confirmed. If upstream passage did not occur over Kootenai Falls, the bull trout population in the Kootenai Drainage upstream was isolated at this point. Genetic interaction with downstream populations would have occurred only if fish passed over Kootenai Falls.

<u>Current Distribution- Migratory (Fluvial and Adfluvial) Populations</u>. Construction of Libby Dam in 1972 resulted in a barrier to upstream fish movement and formed a 90-mile long reservoir. Habitat fragmentation may have also occurred with the construction of a dam on the Elk River in British Columbia (MBTSG, 1996d). Bull trout in Lake Koocanusa migrate into tributary drainages to spawn. Juvenile fish rear for several years before moving back downstream to the river or reservoir. Sub-adults remain in the river or reservoir for several more years prior to maturity. The Kootenay River upstream of the reservoir in British Columbia likely supports migratory fish as well. The only known spawning and rearing area in the United States is located in the Grave Creek drainage. The Ram River and Wigwam River drainages in British Columbia support the majority of the known spawning and rearing area for this population. Most of the upper Kootenai River bull trout range is in British Columbia.

Current Distribution- Disjunct Populations. Sophie Lake contains a disjunct bull trout population. The mature fish of Sophie Lake spawn and rear in Phillips Creek. No information on abundance or distribution is available. Bull trout are also present in Glen Lake, but they are not reproducing in the system. The fish access Glen Lake as juveniles out-migrating from Grave Creek via the Glen Lake Ditch. It is thought that bull trout occurrence in Glen Lake has resulted from either an illegal introduction or from construction of the ditch. Once bull trout mature in Glen Lake there is no way for them to return to Grave Creek for spawning due to a migration barrier in the ditch.

Population Status- Past and Present

Historic Bull Trout Status. Bull trout surveys were initiated in the Wigwam River drainage in British Columbia around 1978. Efforts to assess population status in the United States didn't start until 1983. Historic trend and population estimations before that time are unavailable.

Present Bull Trout Status. Additional survey work is required to adequately describe current population trends in the upper Kootenai River drainage. But, recent spawning site surveys in the Grave Creek drainage have resulted in a similar number of bull trout redds to what was recorded during the first surveys (Table 2.1.1-1). Gill netting in Lake Koocanusa suggests the bull trout population may be stable. However, the existing knowledge of the current population is inadequate (MBTSG, 1996d).

Table 2.1.1-1. Bull trout redd counts- upper Kootenai River system.

Location	1983	1984	1985	1993	1994	1995
Grave Ck.	31	21	24	123	57	11
Clarence Ck.	31	12	3	8	13	4
Blue Sky Ck.	2	2	0	5	1	0

Current Environmental Conditions

The upper Kootenai River bull trout populations are at low risk of decline due to the relative stability of their environment. The upper Kootenai bull trout are not as susceptible to damaging floods as populations downstream of Libby Dam. Drought is not seen as much of a problem as streams are snow fed during warmer periods. The risk of fire is present but not high. The large geographic area available to this population reduces the impact of localized catastrophic events. Brook trout and other introduced species occur in area and have been shown to hybridize with bull trout. Deep drafts in several years have added to impacts on benthic organism production and insect deposition. Entrainment of fish through the dam may be increased because of a lack of thermocline formation due to selective withdrawal. Forestry practices have impacted some spawning tributaries such as Grave Creek and the Wigwam drainage.

Middle Kootenai River

Habitat Requirements

The middle Kootenai River bull trout population includes the Kootenai River and all tributary habitats between Libby dam and Kootenai Falls. A fluvial population of bull trout exists in the Middle Kootenai River drainage. Resident populations also exist in some streams including Libby Creek.

Pre-Dam Distribution. The Montana Bull Trout Scientific Group (1996c) found references of early sampling to collect bull trout age and growth data in O'Brien Creek in 1950, Graves Creek in 1952 and Flower Creek in 1959. They also found reference to bull trout found in Pipe Creek and Flower Creek in 1959 and Flower Creek in 1960, 1961, and 1962.

Present Distribution. In the 29-mile reach of the Kootenai River, a fluvial and resident population of bull trout exist with the resident population found in the tributaries of the middle Kootenai River. One high-quality spawning tributary, Quartz creek and several lesser quality spawning tributaries are available to these populations. One way gene flow may still occur downstream as bull trout pass over Kootenai Falls.

Bull trout migration into Libby Creek and the Fisher River takes place later in the season (September- October) than migration into Quartz Creek (May-July). This is speculated to be temperature related since Libby Creek and Fisher River experience elevated temperatures during mid-summer.

Population Status- Past and Present

Historic Bull Trout Status- Detailed quantitative bull trout surveys were not initiated prior to 1985. Little qualitative information exists regarding historic bull trout abundance or population status.

Present Bull Trout Status. According to the Montana Bull Trout Scientific Group, bull trout have been recorded in Midas Creek, Dunn Creek, Fisher Creek, Granite Creek, Pipe Creek, Poorman Creek, and Ramsey Creek. Resident bull trout are also found in the upper reaches of Flower and Libby Creeks. The most important spawning and rearing area is Quartz Creek where an estimated 250 fish use the tributary.

Table 2.1.1-2. Bull trout redd counts- middle Kootenai River system.

Location	1985	1987	1990	1991	1992	1993	1994	1995
Quartz Ck.	-	6	32	22	4	34	37	26
WF Quartz Ck.	16[a]	14	44	54	13	55	27	40
Pipe Ck.	-	-	-	5	11	6	7	5
Fisher River				-	2	12[b]		3

[a] Includes Quartz Ck. [b] possible brook trout redds

Forest practices are the dominant land use of the middle Kootenai River. The river is most influenced by Libby Dam that can produce large variations in flow and during infrequent spills, high dissolved gas supersaturation levels. The dam also acts as a physical barrier to upstream migration. Illegal harvest is also a concern due to the limited and well known spawning locations of bull trout. Brook trout inhabit all major drainages within the middle Kootenai River and are considered a threat due to likelihood of hybridization (MBTSG, 1996c).

Lower Kootenai River

Habitat Requirements

The lower Kootenai River bull trout population includes the Kootenai River and its tributary drainages from Kootenai Falls downstream to the Montana-Idaho border. Fluvial bull trout are the only known life history form in the lower Kootenai drainage. Resident life history forms have not been documented.

Pre-Dam Distribution. Historic bull trout population in the river below Kootenai Falls likely included adfluvial fish from Kootenai Lake in British Columbia as well as fish that may have moved freely between Idaho and Montana. Resident bull trout may have been present at one time.

Present Distribution—Migratory (Fluvial and Adfluvial) Populations. Adfluvial bull trout are distributed from Kootenai Falls to Kootenai Lake in British Columbia. Spawning and rearing by adfluvial adults likely occurs in tributaries draining portions of British Columbia, Idaho, and Montana. These fish spend their adult lives in Kootenay Lake while the fluvial population lives in the Kootenai River. Fluvial bull trout exist in the Kootenai River between Idaho and Montana and use suitable tributaries for spawning. Based on adult capture studies, O'Brien creek appears to be the most important rearing area for this population segment (MBTSG, 1996b).

In 1992, MDFWP conducted redd counts in several other tributaries to the Kootenai River below the falls, including Callahan Creek, Ruby Creek, Star Creek, and the Yaak River downstream from Yaak falls. Redds counts in Callahan Creek and the Yaak River were not successful but small bull trout were found in these creeks while electroshocking. Redds were not located in Ruby Creek although one bull trout was found in the creek in 1995 during a snorkeling effort. Bull trout spawning in the mainstem Kootenai River has not been documented.

Present Distribution—Disjunct Populations. Bull Lake, a natural lake in the headwater of the Lake Creek drainage, supports a disjunct bull trout population. The Troy Dam was constructed on Lake Creek in 1917 about 15 miles downstream from Bull Lake. It is not known whether migration was possible prior to this dam but it is currently an upstream passage barrier. The Bull Lake bull trout population exhibits an unusual downstream spawning migration into Lake Creek, accessing spawning areas in Keeler and Stanley Creeks.

Population Status—Past and Present

Historic Bull Trout Status. Little qualitative information exists regarding historic bull trout abundance downstream from Kootenai Falls in Montana.

Present Bull Trout Status. The current bull trout population is estimated at several hundred fish or less. The number of migratory bull trout utilizing O'Brien Creek appears to be small and they may be part of a separate, larger population.

Current Environmental Conditions

The lower Kootenai River tributaries are prone to floods creating the potential for egg scour and unsuitable flows. Callahan Creek and Keeler Creek can also suffer loss of surface flow during summer months. Past stocking practices have established several reproducing populations of brook trout, coastal rainbow trout, and other fish species into the lower Kootenai River. Introduced brook trout are also established in O'Brien Creek and suspected to hybridize with bull trout. Additional fish introductions may increase the potential for harm to bull trout through competition and increased fishing pressure. One exception is the introduction of kokanee which are thought to be a food source for bull trout and therefore, generally beneficial.

Lake Creek below the outlet of Bull Lake is a known thermal barrier as higher water temperatures occur naturally between the outlet and confluence of Stanley Creek. Libby Dam discharges have influenced migration patterns by creating a year-round barrier at Kootenai Falls although sturgeon restoration flows may act to remedy this problem by providing higher flow. Flow regimes altered by Libby Dam have also altered downstream discharge patterns impacting bull trout by reducing insect, periphyton and fish populations. Logging operations and logging roads are present in areas occupied by this population segment. Past and current silvicultural practices have damaged Keeler Creek, O'Brien Creek and Lake Creek.

2.1.2 Flathead River Basin and Flathead Lake

The Flathead River basin is located in northwestern Montana with a segment of the North Fork draining from the Canadian province of British Columbia. The basin contains about 3,500 miles of flowing streams, some 450 lakes and reservoirs and covers an area of about 8,450 square miles. Flathead Lake itself is the largest freshwater lake in the western United States with a surface area of 122,500 acres. The basin discharges an annual average of about 8.5 million acre-feet of water to the Clark Fork River (Montana Dept. of Natural Resources and Conservation, 1976). The North and Middle forks form the western boundary of Glacier National Park and much of the South Fork is located in the Bob Marshall Wilderness. Other principal tributaries include the Stillwater, Whitefish, Swan, Little Bitterroot and Jocko Rivers.

Hungry Horse Reservoir is a USBR storage project in the Flathead Basin. In consideration of the influence that Hungry Horse operations may have on bull trout resources, the coverage of the Flathead Basin in this document is divided into three subbasin areas. Those areas are (1) Hungry Horse Reservoir/South Fork Flathead River, (2) the North and Middle Forks Flathead River, Flathead Lake, Stillwater and Whitefish River, and (3) the Flathead River downstream of Kerr Dam.

Hungry Horse Reservoir/South Fork Flathead River

Hungry Horse Dam is located on the South Fork Flathead River about five miles upstream from its confluence with the mainstem Flathead River. The dam was completed in 1953. At full pool, Hungry Horse Reservoir extends for 32-miles, has a surface area of 23,800 acres and contains up to 2,982,000 acre-feet in active storage (USBR, 1994). The average annual runoff of the South Fork at Hungry Horse Dam is 2.6 million acre-feet from a drainage area of 1,663 mi^2. This represents about 30 percent of the total water yield from the entire Flathead River Basin. The South Fork basin is in the Flathead National Forest and the upper two-thirds of the drainage is within the Bob Marshall Wilderness Area.

Habitat Requirements

The basin above Hungry Horse Reservoir is considered by MDFWP to contain one of the strongest meta-populations of bull trout in Montana, due in large part to the substantial amount of pristine and undisturbed habitat found there (Marotz, 1998). Figure 2.1.2-1 illustrates the distribution of bull trout in the basin. Within the watershed, there are many intact core drainages that contain stable populations of bull trout. These populations are connected by nodal habitats, such as the South Fork, which provide key migratory corridors for adfluvial bull trout. There are likely some resident and fluvial type populations, but most bull trout in the South Fork Flathead watershed exhibit the adfluvial life history pattern—the adult fish migrate from Hungry Horse Reservoir to spawn in reservoir tributaries and into upstream river tributaries. Spawners begin to move up the South Fork and into reservoir tributaries in June, reaching streams in July and August where they hold until September spawning (B. Marotz, MDFWP, pers. comm.). There is a high incidence of alternate year spawning in the adult fish (Zubik and Fraley, 1986). Bull trout spawners select stream channel locations with loose gravel substrates and at sites that are typically subject to groundwater inflow or upwelling. Spawning can be very concentrated. Fraley and Shepard (1989) reported an average of 5,482 eggs per female in Flathead drainages. The eggs incubate and overwinter in the redds, hatching within 100 - 145 days. Embryo survival is best at water temperatures from 2 - 4^{o} C. Past studies in Montana have shown that fry emergence takes place in April to early May and within 219 - 225 days after spawning (Weaver in Thomas, 1992). Juvenile fish rear in the streams for one to four years before migrating downstream to reside and grow to sexual maturity in the reservoir (Montana Bull Trout Scientific Group, 1995a).

Figure 2.1.2-1. Current bull trout distribution in the Flathead River basin.

Juvenile bull trout rearing in tributaries feed primarily on aquatic and terrestrial insects. When the young fish emigrate from their natal streams, insects continue to comprise an important part of their diet. As the juveniles reach the reservoir environment, they start shifting from insects to fish prey. Past MDFWP food habits studies have confirmed, however, that young bull trout continue to feed on both benthic and terrestrial insects and zooplankton during their first year of residence in Hungry Horse Reservoir as they transition more to a fish diet (raw data, B. Marotz, MDFWP, pers. comm.). As the fish increase in size, they become almost fully piscivorous. At this stage, other fish such as northern squawfish, longnose and largescale suckers and mountain whitefish compose their diet (Marotz et al., 1996).

There are also some bull trout in headwater areas of the South Fork that are considered to be "disjunct" populations. These fish are considered to be functionally isolated and are found in Big Salmon and Doctor lakes in the backcounty wilderness area. Adult fish live in these lakes and spawn in nearby tributaries (Montana Bull Trout Scientific Group, 1995b). Downstream emigration is possible, but adult return migration is thought to be prevented by summertime warm water temperatures in outlet streams. These isolated bull trout populations are not influenced by Hungry Horse Reservoir and therefore, will not be addressed further in this assessment.

Population Status—Past and Present

The MDFWP has conducted gill net sampling in Hungry Horse Reservoir since 1958 in an effort to monitor fish population trends. Beginning in 1992, springtime netting was discontinued due to the incidence of large catches of mature westslope cutthroat taken near spawning streams. Only fall gill netting is now conducted. Tables 2.1.2-1 and 2.1.2-2 show catch results for bull trout and other target species from fall floating and sinking gill net sets, respectively, through the years (MDFWP, 1998, unpublished data). Weaver (1998a) pointed out that gill net sets in recent years have recorded some of the highest captures in the 38-year sampling period, suggesting a relatively stable adfluvial bull trout population in the Hungry Horse Reservoir - South Fork Flathead basin.

Table 2.1.2-1. Species composition and relative abundance for fall gill netting in Hungry Horse Reservoir, 1988-1997 (L. Knotek, MDFWP, personal communication).

Fish Per Net (Percent Composition)
Floating Nets

Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Mean
WCT	3.0(52.6)	2(47.6)	3.3(63.5)	2.1(60.5)	0.8(42.1)	0.9(56.3)	2.2(57.3)	2.5(81.2)	2.0(77.8)	3.2(69.7)	2.2(60.8)
DV	1(17.5)	0.6(14.3)	0.7(13.5)	0.6(17.1)	0.6(31.6)	0.4(25.0)	0.8(20.8)	0.4(13.0)	0.2(6.3)	0.8(16.5)	0.6(17.6)
MWF	1.4(24.6)	1.3(31.0)	1(19.2)	0.6(17.1)	0.5(26.3)	0.2(12.5)	0.7(18.2)	0.1(3.2)	0.4(14.3)	0.5(11.9)	0.7(17.8)
NSQ	0.1(1.8)	0.2(4.8)	0.1(1.9)	0(0.0)	0(0.0)	0(0.0)	0.04(1.0)	0.04(1.3)	0.04(1.6)	0.04(0.9)	0.06(1.3)
CSU	0.2(3.5)	0.1(2.4)	0.1(1.9)	0.1(2.9)	0(0.0)	0.1(6.3)	0.1(2.6)	0(0.0)	0(0.0)	0(0.0)	0.07(2.0)
LNSU	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
PWF	0(0.0)	0(0.0)	0(0.0)	0.1(2.9)	0(0.0)	0(0.0)	0(0.0)	0.04(1.3)	0(0.0)	0.04(0.9)	0.02(0.5)

WCT - Westslope Cutthroat
DV - Bull Trout
MWF - Mountain Whitefish
NSQ - Northern Squawfish
CSU - Largescale Sucker
LNSU - Longnose Sucker
PWF - Pygmy Whitefish

Table 2.1.2-2. Catch (fish/net) for fall sinking gill nets in Hungry Horse Reservoir, 1958-1997 (L. Knotek, MDFWP, pers. comm.).

Fish Per Sinking Net

YEAR	WCT	DV	MWF	NSQ	CSU	LNSU	PWF
1958	2.4	6.9	14.6	3.3	2.0	2.5	0.0
1961	0.8	4.6	15.3	2.1	1.2	0.8	0.0
1966	0.6	2.2	11.3	12.2	1.7	0.2	0.0
1968	0.8	2.3	6.8	1.1	1.4	0.0	0.0
1970	2.1	6.1	20.9	3.9	1.4	0.7	0.0
1972	1.0	4.6	17.9	5.0	2.6	0.2	0.0
1974	0.8	5.2	17.5	1.8	2.5	0.0	0.0
1976	1.2	3.7	11.4	0.9	1.2	0.1	0.4
1978	1.9	2.8	12.7	0.8	2.3	0.0	0.0
1980	0.8	4.3	14.1	0.9	1.3	0.0	0.0
1983	0.7	1.9	8.2	1.7	0.6	0.1	0.0
1984	0.3	4.6	23.5	4.7	0.9	0.3	0.0
1985	0.2	3.3	6.8	2.3	1.0	0.3	0.0
1986	0.4	4.9	12.8	2.1	1.2	0.1	1.2
1988	0.9	7.0	13.5	3.7	2.5	1.8	0.0
1989	0.8	5.4	11.4	1.8	1.4	0.5	0.2
1990	1.9	5.5	16.8	4.1	2.2	0.1	0.0
1991	0.7	4.2	9.9	2.1	3.0	0.1	0.1
1992[a]	0.2	6.5	8.8	0.8	2.2	0.3	0.8
1993	0.3	5.4	6.1	0.9	1.9	0.1	0.1
1994	0.3	7.3	15.7	1.7	2.2	0.4	0.2
1995	0.1	6.9	16.8	0.8	2.2	0.3	0.0
1996	0.2	7.2	15.3	0.7	0.4	0.0	1.0
1997	0.9	7.0	13.9	0.2	1.2	0.7	0.2
Mean	0.85	4.99	13.38	2.45	1.69	0.40	0.18
Std. Dev	0.64	1.68	4.38	2.49	0.68	0.60	0.34

[a] Sullivan area not set
WCT - Westslope Cutthroat
DV - Bull Trout
MWF - Mountain Whitefish
NSQ - Northern Squawfish
CSU - Largescale Sucker
LNSU - Longnose Sucker
PWF - Pygmy Whitefish

In 1993 for the first time, MDFWP conducted an extensive spawning redd inventory throughout the South Fork basin to collect baseline information and to identify important spawning streams for future trend monitoring (Weaver, 1998a). In total, six reservoir tributaries and 28 upper basin streams were surveyed where adfluvial type spawning populations were suspected. During the survey, 64 redds were counted in streams directly entering Hungry Horse Reservoir and 210 redds were observed in streams tributary to the South Fork above the reservoir. Field crews documented spawning in a total of 13 streams, with an absence of redds in 21 of the streams evaluated. Based on these findings, MDFWP designated four reservoir tributaries (Wounded Buck, Wheeler, Sullivan, and Quintonkin creeks) and four upper basin tributaries (Little Salmon, Gordon, Youngs creeks and the White River) as index streams. These eight selected index streams accounted for 85 percent of the 274 total bull trout redds counted in the 1993 survey (Table 2.1.2-3).

Each subsequent year through 1997, MDFWP conducted follow up redd counts in the eight reservoir/South Fork bull trout index streams. In 1998, MDFWP decided to discontinue counts in the four upper basin streams, but to maintain annual surveys in the four index streams entering Hungry Horse Reservoir (L. Knotek, MDFWP, 1998, pers. comm.). As of this writing, the 1998 redd count data for the reservoir tributaries had just been completed. The results of these spawning site inventories on the index streams are summarized in Table 2.1.2-4 (Weaver, 1998a). Annual reservoir tributary redd counts from1993 through 1998 have ranged from 42 to 100, while upper river redd numbers for the period from 1993 - 1997 ranged from 168 to 353. Weaver (1997) concluded that based on the MDFWP spawning ground survey results, there appears to be greater annual fluctuation in redd numbers in the reservoir index streams than in the upper basin.

Using methodology described in an April 30, 1998 MDFWP memorandum, Weaver (1998a) estimated that the Hungry Horse bull trout spawner escapement ranged from about 1,000 to 1,700 fish and that the total reservoir adult population was probably double this amount. This estimate was based, in part, on redd count results from the index streams surveyed between 1993 and 1997, a factor applied for average number of spawners per redd, and the expected proportion of adults spawning in any given year. Weaver cautioned however, that, “the numbers generated are not to be considered as statistically valid population estimates; no confidence intervals are provided.”

Current Environmental Conditions

As previously discussed, bull trout habitat conditions in the South Fork Flathead may be some of the best found anywhere. This is due largely to the fact that most of the drainage is in a designated wilderness. Some other basin forested lands outside the wilderness have been logged and roaded which have degraded stream habitats. Fishery habitat restoration projects are pending on some of these streams.

Table 2.1.2-3. Number of bull trout redds observed during basin-wide spawning site inventories in the South Fork of the Flathead River during fall 1993 (Weaver, 1998).

Reservoir Tributaries

Doris	0	Clark	0
Wounded Buck	22	Sullivan	25
Wheeler	12	Quintonkin	5

Total = 64

Upper Basin Tributaries

Spotted Bear	13	Otter	0
Bunker	2	Cabin	0
Harrison	0	Marshall	0
Mid	0	Babcock	4
Black Bear	0	Jenny	0
Little Salmon	56	Danaher	9
Holbrook	0	Camp	0
Burnt	0	Basin	0
Barlett	0	Foolhen	0
White River	39	Rapid	12
South Fork White	0	Spring	0
Gordon	35	Calf	0
Youngs	40	Bar	0
Hahn	0	Limestone	0

Total = 210
BASIN-WIDE TOTAL = 274

Table 2.1.2-4. Number of bull trout redds observed in South Fork Flathead Basin monitoring areas (index streams) during 1993 - 1998) (Weaver, 1998).

Reservoir Tributaries							Upper River Tributaries					
	1993	1994	1995	1996	1997	1998		1993	1994	1995	1996	1997
Wounded Buck	22	29	34	41	14	5	Youngs	40	24	34	74	43
Wheeler	12	10	1	3	1	4	Gordon	35	44	46	58	30
Sullivan	25	8	- -	52	50	54	White River	39	60	45	86	31
Quintonkin	5	3	7	4	0	11	Little Salmon	56	47	43	134	100
Totals	64	50	42	100	65	74	Totals	170	175	168	353	204

When construction was finished in 1953, Hungry Horse Dam blocked off an estimated 38 percent of the historic bull trout spawning and rearing area available to adfluvial Flathead Lake fish (Zubik and Fraley, 1987). In 1993, the Northwest Power Planning Council (NPPC) formally adopted the Hungry Horse Dam and Fisheries Mitigation Implementation Plan (IP) to mitigate for the dam's construction and operation (Hungry Horse Implementation Group, 1994).

This plan provided BPA Fish and Wildlife Program funding for fish habitat restoration, fish passage improvements (culvert replacements in reservoir tributary streams), off site mitigation, hatchery production, and continued research and monitoring. Major culvert replacements (cost share funding provided from BPA, U.S. Forest Service, the Flathead Basin Commission, USBR, and the National Fish and Wildlife Foundation) at five Road 38 stream crossings along the east side of Hungry Horse Reservoir have resulted in bull trout spawning for the first time in 1998 in upstream sections not previously accessible to the fish (Marotz, MDFWP, 1998, pers. comm.). Another significant project was the construction of a selective withdrawal system at Hungry Horse Dam. The system was completed and became operational in August 1995. Its intended purpose is to allow release of warmer water from the reservoir during summer and fall periods to mimic natural pre dam temperature conditions in the river below. With selective withdrawal, the MDFWP has projected significant improvement in cutthroat growth rates and a decline in the presence of predatory lake trout in the mainstem Flathead River due to warmer water temperatures. Studies are underway to monitor changes in the aquatic invertebrate community, fish growth, and food habits (Marotz, Knotek and Malta, MDFWP, 1998, pers. comm.).

Another resident fish protection initiative resulted from the language in the NPPC Columbia Basin Fish and Wildlife Program (Measures 903 (a) and (b), and 903 (b)(1)(D)) which stated that if Hungry Horse Reservoir drawdowns exceeded an 85-foot draft for hydropower purposes, BPA would fund mitigation of fishery losses. These program measures resulted in retroactive and ongoing mitigation tied to deep drawdowns that have occurred since 1987 in the years of 1988 (-178.1 ft draft), 1989 (-137.7 ft), 1991 (-99.3 ft), 1993(-188 ft), and 1994 (-173.8 ft) (Malta et al., 1997). Mitigation tied to this program include funding fishery investigations to monitor performance of the selective withdrawal system at Hungry Horse Dam, food habitats and migrational studies in the Flathead River, and additional habitat improvement projects on Hungry Horse Reservoir tributaries that have been impacted by forest practices (Marotz, MDFWP, 1998 pers. comm.).

The frequency of Hungry Horse Reservoir deep drawdowns has been reduced based on implementation of the operational guidelines contained in the 1995 (salmon) and 1998 supplemental (steelhead) Federal Columbia River Power System biological opinions (BiOp). The 1995 BiOp's Reasonable and Prudent Alternatives related to salmon flow provisions required that Hungry Horse Reservoir be operated through the fall and winter to achieve a 75 percent confidence of reaching April 20 flood control elevation (Bureau of Reclamation ROD 1995). The 1998 supplemental BiOp moved this operational requirement back to April 10 (NMFS 1998 BiOp). These operations criteria have reduced the likelihood of deep drafting and improves spring/summer refill chances and will result in maintaining Hungry Horse Reservoir from one year to next at higher pool levels. As a result, there should be some biological benefits to reservoir resident fish populations, including bull trout.

In 1997, a bull trout conservation agreement initiated by the MDFWP was signed by the Flathead National Forest; the Confederated Salish and Kootenai Tribes; Bonneville Power Administration; the Bureau of Reclamation; and the U.S. Fish and Wildlife Service. This agreement assures that bull trout protection and conservation will be considered in Flathead River Basin resource management decisions.

Marotz (1998) identifies the threat of illegal fish introductions as the greatest potential threat to South Fork bull trout populations. Competition with both legally and illegally introduced fish species has developed to be a significant detriment to bull trout in other locations. In one respect, the presence of the dam has precluded the upstream movement of non-native species into the basin (Marotz et al., 1996) and helped secure the native fish assemblage. Other bull trout concerns are related to forestry practices and associated stream habitat degradation in non-wilderness areas, the uncertain affects of the 20-foot summertime draft of Hungry Horse Reservoir for salmon flow augmentation, and poaching of spawners in back country streams.

North and Middle Forks Flathead River, Flathead Lake, Stillwater and Whitefish River (Adfluvial Flathead Lake Population)

The river subbasins addressed in this section, including Flathead Lake, cover a drainage area of about 4,762 square miles (Montana Dept. of Natural Resources and Conservation, 1976). A discussion of bull trout resources for this area is specifically covered in the Flathead River Drainage Bull Trout Status Report (Montana Bull Trout Scientific Group, 1995a). Most land in the watershed is Federally owned and managed (Flathead National Forest and Glacier National Park) or within the Flathead Indian Reservation. Some 427 square miles of the North Fork Flathead watershed are located in the southeastern corner of British Columbia. There are no major dams in these river drainages except for Kerr Dam located at the outlet of Flathead Lake. There are, however, numerous natural lakes, many of which contain disjunct populations of bull trout.

Habitat Requirements

The adfluvial (migratory) bull trout life history form is dominant. Adfluvial bull trout utilize Flathead Lake and the upstream river and tributary systems throughout their life cycle. Nodal habitats in the basin consist of the Flathead Lake, the mainstem corridor of the Flathead River, and the North and Middle forks. Core habitats are found in the headwater streams where spawning and juvenile rearing take place. Adult fish live much of their life in Flathead Lake, growing to maturity and preying on other fish. Past MDFWP studies (Fraley and Shepard, 1989 in Montana Bull Trout Scientific Group, 1998) have estimated that about 57 percent of the adult bull trout population in Flathead Lake leave each year to spawn. In the spring, mature spawners begin migrating up the Flathead River (Fraley and Shepard, 1989 in Montana Bull Trout Scientific Group, 1998) with most of the fish destined for tributaries to the North and Middle Fork rivers. The streams that drain from the west side of the North Fork support adfluvial bull trout, while the eastside lakes and their tributaries in Glacier National Park contain disjunct populations. About 25 percent of the spawning in the North Fork basin occurs across the border in British Columbia. Adfluvial bull trout spawn throughout much of the Middle Fork subbasin which contain many pristine, undisturbed streams in Glacier National Park and in the Great Bear Wilderness. Due to degraded habitat, little adfluvial spawning is now documented in the lower elevation Stillwater and Whitefish rivers (Montana Bull Trout Scientific Group 1995a). Stream habitat requirements for spawning and rearing are similar for those conditions described for the South Fork Flathead above Hungry Horse Reservoir.

With the finish of spawning in early fall, the adult fish return to Flathead Lake. Young bull trout rear in their natal tributaries for one to three years and then begin to emigrate to Flathead Lake following subsidence of the spring freshet. The migrational and rearing behavior of these fish as they reside in the larger mainstem river is not completely understood. Some fish seem to migrate to the lake fairly quickly while others exhibit a more prolonged, delayed movement through the mainstem. Subadults feed and grow through the summer and fall months as they stay in the mainstem and/or move towards the lake. Some fish apparently choose to overwinter in mainstem reaches before entering Flathead Lake. Young bull trout are not typically found in main current areas of the river and are believed to prefer slower velocity shoreline and off channel locations (T. Weaver, MDFWP, 1998, pers. comm.). Studies have shown that juvenile trout require shallow riffle habitat where they feed and rest. They are subject to stress and mortality in these shallow areas if flows drop or fluctuate in rapid fashion (Stanford and Hauer, 1991). Stanford and Hauer (1991) reported that in the past, some hydropower operations at Hungry Horse Dam tended to strand insects and fish in the mainstem Flathead varial zone (i.e., that portion of the river bottom that is alternately flooded and dewatered by flow fluctuations associated with drafting and with daily variations due to load following by the power system) where they froze or were desiccated depending on the season. These shallow, close to shore habitats are colonized by insects and juvenile fish when water is at higher stage for extended periods. Marotz reported in the Northwest Salmon Recovery Report (1998) that the second peak flow in the mainstem Flathead created by summertime Hungry Horse salmon water releases represents a departure from the natural hydrograph and, has in the past, disrupted riverine habitats, stranding insects, zooplankton and fish and eggs.

There have also been concerns that large predator species such as lake trout may be foraging on young bull trout in the Flathead River. Recent ongoing predator/prey studies by MDFWP have found very few young bull trout in the stomachs of river sampled predator species (lake trout, northern pike). However, this could be resulting from the relative small numbers of bull trout actually available. For the last four years, MDFWP (Malta, MDFWP, 1998, pers. comm.) biologists have also been conducting research that included migrational studies on the assemblage of Flathead River fish species using tagging and radio-telemetry technologies to track fish movement. Capturing subadult bull trout for these investigations and monitoring their movement in the Flathead has been problematic given the large size of the river and the small numbers of fish that are apparently available (Malta, 1997). During 1998, only 7 or 8 subadult bull trout were caught and implanted with transmitters (Malta, MDFWP, 1998, pers. comm.). Observations from tracking these fish have not, as yet, lead to clear conclusions regarding their migrational or seasonal movements in the riverine environment.

Flathead basin adfluvial bull trout reach sexual maturity in Flathead Lake. In the lake, they continue to exhibit their opportunistic piscivorous feeding behavior, foraging on such species as lake whitefish, mountain whitefish and yellow perch. At one time, kokanee salmon represented an important prey species when abundant in Flathead Lake (Leathe and Graham, 1982 in Montana Bull Trout Scientific Group, 1998). In the mid-1980's, opossum shrimp (*Mysis relicta*) became inadvertently established in Flathead Lake from introductions in upstream lakes. The presence and ultimate proliferation of *Mysis* resulted in trophic changes in

Flathead Lake. *Mysis*, a zooplankton feeder, competes with juvenile kokanee and is believed to be a factor in the collapse of the kokanee population in Flathead Lake. At the same time, the abundant *Mysis* was available to and fed on by lake whitefish and young lake trout. In time, lake whitefish and lake trout populations dramatically increased. and native bull trout and westslope cutthroat trout stocks have declined. Lake trout were documented to prey on young bull trout and cutthroat (Montana Bull Trout Scientific Group, 1995a) and the greater numbers of lake whitefish and lake trout residing in Flathead Lake are now believed to be a major reason for the decrease in basinwide bull trout numbers. A panel of fishery experts that convened in November 1997, concluded that the present lake trout population would need to be reduced by 70 - 90 percent in order for the basin's adfluvial bull trout numbers to recover to historic 1980's levels (McIntyre, 1998).

The Flathead River drainages originating in Glacier National Park contain numerous lake/tributary stream complexes that have disjunct populations of bull trout. This circumstance is also found in the headwaters of the Stillwater and Whitefish river basins (Montana Bull Trout Scientific Group, 1998). These basins could possibly contribute bull trout genetic material with some fish emigrating downstream to Flathead Lake, but return spawning is generally not considered likely due to seasonal stream thermal (warm water) blockages below the lakes (Weaver, 1998b). As with disjunct bull trout populations found in the South Fork basin, these populations are considered to be functionally isolated and genetic testing has shown them to be distinct from adfluvial Flathead Lake stocks. These disjunct populations are unlikely to be influenced by Hungry Horse Reservoir operations and, therefore, will not be addressed further in this assessment.

Population Status - Past and Present

Prior to the turn of this century, bull trout were widely distributed throughout the Flathead River system with fish that probably migrated from Idaho's Lake Pend Oreille upstream in the Clark Fork River into the Flathead River and past Flathead Lake. This "interconnectedness" among river and lake basins began to be disrupted when Bigfork Dam was constructed in 1902 on the Swan River, followed by completion in 1938 of Kerr Dam at the outlet of Flathead Lake and closure of Hungry Horse Dam on the South Fork Flathead in 1953 (Montana Bull Trout Scientific Group, 1995b). Kerr Dam is presently owned and operated by Montana Power Company. Three additional dams (Thompson Falls, Cabinet Gorge and Noxon Rapids) were constructed by private utilities on the mainstem Clark Fork River below the confluence of the Flathead in 1917, 1952, and 1959 (US Army Corps of Engineers, 1989). Construction of all these dams substantially impacted the range of bull trout spawning migration in the Flathead River basin.

More data have been collected on bull trout in the North and Middle Fork drainages than anywhere else in Montana (Montana Bull Trout Scientific Group, 1995a). The MDFWP has been monitoring the amount of adfluvial bull trout spawning on selected high quality index stream sections in these drainages for the past 20 years. Redd count surveys have been conducted every year on eight index stream sections during this period, four in the North Fork (on Big, Coal, Whale, and Trail creeks) and four in the Middle Fork (on Morrison, Granite, Lodgepole, and Ole creeks) watersheds. Since 1980, there have also been seven years when basin-wide surveys (including streams in British Columbia) were carried out on all 30 of the basin's streams considered suitable for bull trout spawners. On average, about 17 percent of North Fork bull trout spawning occurs in seven Canadian streams. Basin-wide redd counts are found in Table 2.1.2-5, while Table 2.1.2-6 covers the annual index stream survey results (Weaver, 1998c). As can be observed from this information, there was a noticeable decline in redds counted starting in 1992. From 1980 through 1991, index stream redd counts averaged 372, ranging between 243 (1992) and 600 (1982). From 1992 through 1997, redd counts averaged 120 with a range between 83 (1996) and 161 (1995). This represents nearly a 70 percent reduction from the 12-year period of 1980-1991. The lower redd counts since 1991 support conclusions that the establishment of *Mysis* and the resultant increase in predatory lake trout in Flathead Lake has significantly impacted the North and Middle Fork bull trout spawning runs. Improvement was observed in the just completed 1998 survey when the index stream redd count rose to 187. Hopefully this is reflective of the positive effects (on bull trout) of *Mysis* shrimp reaching stability at lower population densities in Flathead Lake.

Based on the MDFWP 20-year basin redd surveys and methodology described in an April 29, 1998, Interoffice Memorandum (1998 redd count data not included), Weaver (1998c) tried to estimate the total population of adult bull trout residing in Flathead Lake. His methodology included assumptions regarding number of spawners/redd; the incidence of unaccounted for spawning; past angler harvest estimates; and the proportion of adults that spawn in a given year.

In Weaver's memorandum, he cautioned, "The numbers generated are not to be considered as statistically valid population estimates; no confidence intervals are provided." He later went on to explain that, "They should by no means be interpreted as defensible estimates. The specific calculations are gross over-simplifications of complex and unquantified interactions....[they] are intended to give an idea of how bull trout status has changed during our period of record."

To illustrate how bull trout numbers have declined over the last two decades and for comparative purposes between the best and worst year, Weaver estimated the1982 adult population in Flathead Lake (pre-Mysis, highest redd numbers observed) to be 12,980 fish, while the 1996 population to be 916 fish (lowest redd count year). With an improved spawner escapement in1997, he estimated the lake's bull trout adult population at 1,662 fish.

Table2.1.2-5. Summary of basin-wide bull trout spawning site inventories for tributaries to the North and Middle Forks of the Flathead River. All stream sections known to be utilized by Flathead Lake spawners are included (Weaver, 1998).

	1980	1981	1982	1986	1991	1992	1997
North Fork							
Big	20	24	45	12	32	16	13
Hallowat	8	14	31	3	27	2	0
Coal	48	30	95	35	42	7	5
South Coal	2	24	9	4	8	5	4
Mathias	10	10	17	10	8	4	0
Red Meadow	6	19	10	8	15	0	3
Whale	47	101	236	90	61	12	17
Shorty	4	17	56	35	6	3	2
Trail	31	82	101	69	27	26	9
Cauldrey	15	24	18	7	- -	9	5
Cabin	2	2	3	0	- -	3	2
Howell	47	72	103	22	- -	31	7
Starvation	1	1	- -	- -	- -	- -	0
Sage	6	5	4	5	- -	- -	2
Kishenehn	16	13	23	18	- -	12	10
N. Fork River	10	34	17	12	- -	14	19
TOTAL	273	472	768	330	334[1]	144	98
Middle Fork							
Nyack	14	14	23	27	22	12	9
Park	- -	13	0	87	19	1	2
Ole	19	23	51	36	23	16	14
Bear	9	12	23	21	23	9	2
Long	8	- -	- -	- -	12	1	15
Granite	34	14	34	37	20	16	12
Morrison	75	32	86	52	45	17	39
Lodgepole	14	18	23	42	9	13	5
Schafer	10	12	17	30	12	12	5
Dolly Varden	21	31	36	42	23	13	9
Clack	10	7	7	16	11	6	1
Bowl	29	10	19	36	14	8	8
Strawberry	17	21	39	41	20	14	13
Trail	31	26	30	53	37	9	6
TOTAL	291	233	388	520	290	147	138
BASIN TOTAL	**564**	**705**	**1,156**	**850**	**624[a]**	**291**	**236**

[a] Total redd numbers for 1991 have been adjusted based on averages during other years when complete Canadian counts were made.

Table 2.1.2-6. Summary of Flathead Basin bull trout spawning site inventories from 1979-1998 in the stream sections monitored annually (MDFWP 1998 Press Release).

Drainage: Stream	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
North Fork:																				
Big	10	20	18	41	22	9	9	12	22	19	24	25	24	16	2	11	14	6	13	30
Coal	38	34	23	60	61	53	40	13	48	52	50	29	34	7	10	6	13	3	5	14
Whale	35	45	98	211	141	33	94	90	143	136	119	109	61	12	46	32	28	35	17	40
Trail	34[a]	31[a]	78	94	56	32	25	69	64	62	51	65	27	26	13	15	28	8	9	17
Total	117	130	217	406	280	227	168[b]	184	277	269	224	228	146	61	71	64	83	52	44	101
Middle Fork:																				
Morrison	25[a]	75	32[a]	86	67	38	99	52	49	50	63	24	45	17	14	21	28	9	39	35
Granite	14	34	14[a]	34	31	47	24	37	34	32	31	21	20	16	9	18	25	4	12	22
Lodgepole	32	14	18	23	23	23	20	42	21	19	43	12	9	13	9	6	9	8	5	7
Ole	- -[a]	19	19	51	35	26	30	36	45	59	21	20	23	16	19	6	16	10	14	22
Total	71	142	83	194	156	134	173[b]	167	149	160	158	77	97	62	51	51	78	31	70	86
Flathead Drainage Monitoring Count	**188[a]**	**272[a]**	**300[a]**	**600**	**436**	**361**	**341[b]**	**351**	**426**	**429**	**402**	**305**	**243**	**123**	**122**	**115**	**161**	**83**	**114**	**187**

[a]Counts may be low due to incomplete survey.
[b]High flows may have obliterated some redds.

Current Environmental Conditions

As discussed above, there as been a significant decline since the 1980's in numbers of bull trout spawners in North and Middle Fork Flathead drainages. The principal reason is felt to be the expanded lake trout population which are believed to prey on young bull trout (documented to some extent) in the mainstem river and lake system. Much of the basin's spawning and rearing habitat is preserved in wilderness within the boundaries of Glacier National Park and the Great Bear Wilderness. Some bull trout streams that drain from the west into the North Fork have degraded habitat stemming from logging and related road building. Some of these streams are receiving habitat treatments under offsite Hungry Horse mitigation initiatives, and overall, habitat conditions are not likely to be substantially limiting. Present land use activities in the British Columbia portion of North Fork's watershed does not pose a significant threat to bull trout, but future coal mine development could (Moy, MDNR, 1998, pers. comm.).

The operation of the selective withdrawal system at Hungry Horse Dam began in August of 1995 allows summer and fall water temperature in the mainstem Flathead River to return to more natural pre-project (warmer) conditions (Cavigli et al., 1998). Indications are that resultant warmer temperatures derived from selective withdrawal operations are reducing lake trout presence in the river and that survival of subadult bull trout and westslope cutthroat are expected to improve (Knotek and Marotz, MDFWP, 1998, pers. comm.). Studies are underway to document the riverine biological and fish community responses since the temperature control system began operating in 1995.

The basin's low redd counts since 1992 may reflect a declining bull trout population trend that has finally bottomed out. The 1998 redd counts in the eight North and Middle Fork index streams increased by 36 percent over the previous six-year average. *Mysis* have stabilized at significantly lower density levels in Flathead Lake, and lake trout growth rates have slowed (B. Marotz, MDFWP, 1998, pers. comm.). The goal as identified in the Flathead River Drainage Bull Trout Status Report is to restore bull trout spawner escapement to the average redd count levels during the 1980's and to maintain that level for 15 years (Montana Bull Trout Scientific Group, 1995a). This represents a significant improvement over present day conditions. Given the current understanding regarding bull trout biology and the impact that the *Mysis*/lake trout relationship has had, it does not appear at this time that the goal is achievable.

The Flathead River Drainage Bull Trout Status Report (Montana Bull Trout Scientific Group, 1995a) identifies a range of threats to the species. The expanded lake trout population in Flathead Lake is considered to represent the greatest treat to restoring bull trout. Another threat is mortality associated with the incidental catch (and release) of bull trout in sport fisheries open to other species. Illegal poaching of adult fish in backcountry headwater spawning streams has and may continue to be a notable threat to bull trout. Timber harvest in some basin streams have resulted in increased erosion/sedimentation and is identified as a significant potential problem in the future (Montana Bull Trout Scientific Group 1995a). Lesser risk may be related to rural residential development adjacent to stream reaches utilized by bull trout. Finally, certain Hungry Horse Dam hydropower and salmon flow operations may cause undesirable consequences from repeated flooding and dewatering of the varial zone. These near shore and shallow river margins are occupied by young bull trout during their migrational and rearing phases through the mainstem Flathead River. The actual quantification of those impacts are problematic and has not been definitatively documented to date.

Flathead River Downstream of Kerr Dam

The lower Flathead River is one of Montana's largest rivers, with an annual average discharge of 11,700 cfs. Downstream of Kerr Dam, the river flows south and west for 72 miles, to the confluence with the Clark Fork of the Columbia River near Paradise, Montana. DosSantos (1988) indicated that the lower river cuts through highly erosive lacustrine and alluvial sediments deposited during the life span of glacial lake Missoula. The river is a low gradient river draining a watershed area if about 8.5 million acres. The majority of the river is smooth flowing and shallow. The lower 19.5 miles widens to an average of 656 feet and has slower velocities than upstream reaches. This lower reach is characterized by having braided channels, numerous islands, and backwater areas and sloughs.

Habitat Requirements

While the lower Flathead River is one of Montana's largest rivers, trout abundance in the lower river averaged only 30 fish per mile during a study conducted by DosSantos et al. (1988), the lowest abundance of trout for a river of this size in Montana. They are most likely found in the upper reaches of lower Flathead River tributaries.

From 1983 through 1986, DosSantos (1988) captured 17 bull trout in the lower Flathead ranging in size from 8 to 34 inches. Bull trout that were captured in the lower reaches of the lower Flathead were much larger than those captured upstream towards Kerr Dam (DosSantos et al. 1988). Population estimates were not possible due to the limited numbers of bull trout captured. These bull trout were most likely upstream migrants from the Clark Fork River, were successful in passing through or over Kerr Dam, or were from the upper reaches of Lower Flathead River tributaries.

DosSantos (1988), in the same study, documented a small resident population of bull trout in the South Fork of the Jocko River, which is tributary to the lower Flathead River. This population appears to be limited to the upper reaches of the South Fork where upstream barriers (irrigation diversion dams) limit fish movement.

Population Status—Past and Present

Historically, bull trout from Lake Pend Oreille had access to the Clark Fork up to the confluence with the lower Flathead River (Everman, 1892). Bull trout from Flathead Lake may have also moved downstream out of Flathead Lake into the lower Flathead River.

Presently, Kerr Dam blocks upstream fish passage between the lower Flathead/Clark Fork River system and Flathead Lake. The impacts of this dam on fish populations have not been determined. According to the Montana Bull Trout Scientific Group (1996e), there was a natural cascade at the outlet of Flathead Lake prior to dam construction that had an unknown impact on upstream fish passage between Flathead Lake and the lower Flathead River.

The Flathead Agency Irrigation Division (FAID) project, which was constructed beginning about 1910, broke the connection between many of the tributary streams and the lower

Flathead River. Cross and DosSantos (1988) reported that irrigation diversions, canals, and dams on the tributaries eliminated access to more than 62 miles of spawning and rearing habitat for bull trout.

The FAID created three disjunct populations of bull trout when they created irrigation reservoirs out of natural lakes (Montana Bull Trout Scientific Group, 1996e). Although there is still out-migration from these lakes, the construction of these dams has totally eliminated upstream passage, thereby isolating these populations from the lower Flathead and Clark Fork river systems.

Current Environmental Conditions

Historical hydropower operations of Kerr Dam resulted in rapidly varying discharge in the river below, which subsequently resulted in recurring impacts to the aquatic ecosystem, particularly the aquatic biota (DosSantos et al., 1988). Impacts included lack of spawning success of lower Flathead River trout, behavioral changes, dewatering of juvenile fish habitat, and poor over-winter survival. Studies elsewhere have shown that fish in a system such as the lower Flathead cannot overcome the stress of moving into and out of a regulated varial zone and are either vulnerable to predation or starvation (Stanford et al., 1991).

Water temperatures in the lower Flathead appeared to be negatively influenced by Kerr Dam operations combined with the majority of the river being shallow, resulting in summer temperatures in the main river near 68^{o} F. Mainstem water temperatures were as much as 10^{o} F. warmer than any lower river tributary inflow (DosSantos et al., 1988). Further research is needed to determine the specific causes of thermal problems and the resultant impact on bull trout in the lower Flathead River.

The annual hydrograph for historical releases from Kerr Dam showed a reduction in peak flows and an increase in winter flows from the preimpoundment hydrograph. High pre-dam runoff flows have been diminished and winter flows increased. The major physical change in the lower river apparently relates to the timing and volume of flows from Kerr Dam. Rapid fluctuations in flow releases have occurred hourly due peaking operations of Kerr Dam. Water level fluctuations of 2 to 8 feet within 3 hours have been recorded at Polson (Mack et al., 1990).

In 1990, the Montana Power Company (MPC) applied to the Federal Energy Regulatory Commission for relicensing of Kerr Dam. This relicensing application included protection, mitigation and enhancement for the lower Flathead River. In October of 1997, the Federal Energy Regulatory Commission (FERC) issued the Final Environmental Impact Statement (FERC, 1997) for the MPC's FERC license for the Kerr project which had the following requirements (Table 2.1.2-7) that would be more protective of fish and wildlife resources in the lower Flathead River.

Table 2.1.2-7. FERC relicensing flow and ramping requirements at Kerr Dam as measured at the U.S. Geological Survey Polson gage (Project S-021, FERC Relicense Articles).

Minimum Flow Requirements

Dates	Minimum flows
August 1 to April 15	Continuous at 3,200 cfs
April 16 to April 30	Increased from 3,200 cfs to 5,000 cfs at 120 cfs per day
May 1 to May 15	Increased from 5,000 cfs to 12,700 cfs at 510 cfs per day
May 16 to June 30	Continuous at 12,700 cfs
July 1 to July 15	Reduced from 12,700 cfs to 6,400 cfs at 420 cfs per day
July 16 to July 31	Reduced from 6,400 cfs to 3,200 cfs at 200 cfs per day

Maximum Between-Day Flow Changes

Mean Flow (cfs, 24-hour average)	Maximum Change in Flow (cfs)
Less than 5,000	500
Between 5,000 and 10,000	1,000
Between 10,000 and 20,000	2,500
Between 20,000 and 40,000	5,000
Between 40,000 and 60,000	10,000

Maximum Allowable Ramping Rates

Mean Flow (cfs, 24-hour average)	Ramping Rate
Between 3,200 and 7,500	250 cfs/hour
7,500 or greater	1,000 cfs/hour

Followup studies by the MPC and the Confederated Salish and Kootenai Tribes will assess the effectiveness of the recommended flows and ramping rates in improving habitat conditions and fish population responses.

Most streams tributary to the lower Flathead River have experienced habitat degradation as a result of sedimentation. The majority of tributaries also have diversions and impoundments for irrigation resulting often times in poor water quality and quantity, caused primarily by irrigation return flows, agricultural dewatering, and erosion of fragile soils as a result of livestock overgrazing (DosSantos et al., 1988). The poor condition of the tributaries eventually effects fish populations (including bull trout) in the lower Flathead River.

Brook trout and brown trout introductions into the lower Flathead River drainage are believed to be the greatest risks to bull trout. Hansen and DosSantos (1993) have reported that brook trout are known to be hybridized with bull trout in several tributaries of the lower Flathead.

Limited information indicates that migratory bull trout are declining at the present time. However, insufficient information is available to determine short and long term population trends.

2.1.3 Pend Oreille Basin

General Habitat Requirements

Bull trout are generally adfluvial in the Lake Pend Oreille basin (Irving, 1986; Pratt and Huston, 1993). They use several different drainages as spawning habitat, though they are no longer present in all drainages they historically used (Pratt and Huston, 1993; USFWS, 1998c). Little mainstem use apparently occurs in the Pend Oreille River between Lake Pend Oreille and Albeni Falls Dam; apparently a fluvial life history is prevalent there, but bull trout in that reach of the Pend Oreille seem to be currently restricted to the Priest River drainage (Bennett and DuPont, 1993). A few tributaries are used below Albeni Falls Dam, in the Box Canyon Reservoir reach of the Pend Oreille (Kalispel Natural Resource Dept, and Washington Dept. of Fish and Wildlife, 1997).

In the Lake Pend Oreille drainage, spawning occurs from August through November, with a peak in October (Pratt, 1985), though spawning migrations begin during spring snowmelt. Huston (1993) reported on historical accounts in the Thompson Falls, Montana, area that provided evidence of movement of “char” into spawning tributaries of the Clark Fork in July and August. There is no lakeshore spawning by bull trout, as there is with kokanee (Jeppson, 1955).

After hatching and emerging from the gravel in spring, the juveniles rear in the colder mid and upper reaches of tributaries to Lake Pend Oreille and the Clark Fork River, though they may be found in lower reaches of some tributaries. Saffel (1994) found juvenile bull trout in Granite, North Gold, Gold, and Trestle creeks at elevations of 628-1158 m (2072-3821 ft), at gradients of 1.9-8.3%. Lake Pend Oreille surface elevation varies most of the time between 621.5 and 625 m (2,051 and 2,062.5 ft, respectively). Maximum summer temperature and number of pools per unit stream length were the main determinants of juvenile bull trout density. They preferred maximum temperatures in the 50-57^{o} F (10-14^{o} C) range, and the relationship of density to number of pools was positive.

Bull trout apparently emigrate to Lake Pend Oreille in the summer or fall of the second or third growing season (Shepard et al., 1984). Once in the lake, they grow more rapidly than in many other locations (Jeppson, 1961). Three-year-olds captured in Lake Pend Oreille by Pratt (1985) were about 10.7 inches (27 cm) in length. She stated that growth slows to about 3 inches per year after spawning. Adults in Lake Pend Oreille historically averaged 20 inches (500 mm) in size (Suckley, 1860). Some fish in the historic harvest in Lake Pend Oreille and Priest Lake reached over 30 pounds (Burton et al, 1995; Irving, 1986).

Bull trout may spawn more than once, starting at age 4, 5 or 6, but an individual will not necessarily spawn each year (Jeppson, 1955; Pratt, 1984, 1985).

Population Status—Past and Present

Redd counts exhibit a statistical decline, according to Rieman and Myers (1997). Distribution has declined since the 1800s, a factor attributable in major part to human activities. Figure 2.1.3-1 and Table 2.1.3-1 show bull trout distribution in the 1990s. Pratt (1985) noted that bull trout spawning was confined to about 25 miles (40 km) of stream; this represented about 23% of the accessible stream habitat. In 1983, Trestle and South Gold creeks, and tributaries to Lightning Creek, were where 90% of the observed redds occurred. The following season, those areas had only 62% of the spawning, while spawning increased where temporary barriers had previously existed. Observations of the Clark Fork mainstem revealed no redds between the mouth of Lightning Creek and Cabinet Gorge Dam, nor were any seen in a previously-used spawning channel below the dam.

Figure 2.1.3-1. Map showing current distribution of bull trout in the Pend Oreille/lower Clark Fork drainages. Dams are named in capital letters.

Table 2.1.3-1. Present distribution of bull trout in the Lake Pend Oreille drainage from Albeni Falls Dam to the lower Clark Fork River, below Cabinet Gorge (information from Pratt and Huston [1993] except as noted).

Clark Fork (Idaho)			**Northern Shore**	
Mainstem	present		Trestle	present
Johnson	present		Pack River	present
Lightning	present		Trout	absent
Spring	present		Rapid Lightning	absent
Cascade	absent		Gold	absent
Morris	absent		Grouse	present
East Fork	present		Plank	unknown
Savage	unknown[a]		North Fork Grouse	present
Char	present		South Fork Grouse	present
Porcupine	present		Sand	absent
Wellington	present		Berry	absent
Rattle	present		Colburn	absent
Source to Quartz	absent		Caribou	absent
Mosquito	absent		Hellroaring	unknown[b]
Twin	present		Jeru	absent
Eastern Shore			Youngs	absent
Granite	present		McCormick	absent
Sullivan Springs	present		Sand	absent
Falls	absent		Spring	absent
Cedar	absent		Schweitzer	absent
North Gold	present		Little Sand	absent
(South) Gold	present		**Pend Oreille R. to Albeni Falls**	present
West Gold	absent			

[a]Davis et al. (1996)—no redds counted in 1995 or 1996
[b]Davis et al. (1996)—no redds counted in 1995

Pratt (1985) also stated that rearing bull trout were less widely distributed, and less abundant, than juvenile cutthroat or rainbow trout, and inhabited only 42% of tributary streams. Bull trout appeared to prefer high-gradient creeks with partial to full canopy and large substrate materials.

Stream habitat used for spawning in South Gold and lower Twin creeks included about 42% fines, resulting in low estimates of egg-to-fry survival (Pratt, 1985).

As illustrated in Table 2.1.3-2 and Table 2.1.3-3, counts of redds and spawners for the Lake Pend Oreille adfluvial population have been in the low thousands (N. Horner, IDFG, pers. comm.; Pratt and Huston, 1993), in contrast to the historical estimate (Huston, 1993) of about 10,000 spawners. Harvest of bull trout and trophy bull trout declined between 1950 and 1980 (Ellis and Bowler, 1981). Trestle, South Gold, and Lightning Creek drainages appear to support most of the spawning, based on redd counts, at least through the 1980s. Redd count variations in Lightning Creek may be related to bedload movement (Rieman and McIntyre, 1993). Counts in Trestle and South Gold creeks appear to be more stable (Pratt and Huston, 1993).

Table 2.1.3-2. Bull trout total redd counts and estimates 1983-1997 in the Pend Oreille basin from Albeni Falls Dam to the lower Clark Fork River, below Cabinet Gorge (N. Horner, IDFG, pers. comm.). Only index streams were sampled during the period 1988-1991.

STREAM	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Clark Fork River										2	8	17	18	3	7	8
Lightning Creek	28	9	46	14	4					11	2	5	0	6	0	3
East Fork	110	24	132	8	59					32	27	28	3	49	22	64
Savage Creek	36	12	29		0	79	100	29		1	6	6	0	0	0	0
Char Creek	18	9	11	0	2					9	37	13	2	14	1	16
Porcupine Creek	37	52	32	1	9					4	6	1	2	0	0	0
Wellington Creek	21	18	15	7	2					9	4	9	1	5	2	1
Rattle Creek	51	32	21	10	35					10	8	0	1	10	2	15
Johnson Creek	13	33	23	36	10					16	23	3	4	5	27	17
Twin Creek	7	25	5	28	0					3	4	0	5	16	6	10
Subbasin total	321	214	314	104	121	79	100	29	0	97	125	82	36	108	67	134
N. Shore Pend Oreille																
Trestle Creek	298	272	298	147	230	236	217	274	220	134	304	276	140	243	221	330
Pack River	34	37	49	25	14					65	21	22	0	6	4	17
Grouse Creek	2	108	55	13	56	24	50	48	33	17	23	18	0	50	8	44
Subbasin total	334	417	402	185	300	260	267	322	253	216	348	316	140	299	233	391
E. Shore Pend Oreille																
Granite Creek	3	81	37	37	30					0	7	11	9	47	90	49
Sullivan Creek	9	8	14		6					0	24	31	9	15	42	10
N. Fk. Gold Creek	16	37	52	8	36	24	37	35	41	41	32	27	31	39	19	22
Gold Creek	131	124	11	78	62	111	122	84	104	93	120	164	95	100	76	120
Subbasin total	159	250	114	123	134	135	159	119	145	134	183	233	144	201	227	201
Total	814	881	830	412	555	474	526	470	398	447	656	631	320	608	527	726

Table 2.1.3-3. Pend Oreille basin (Albeni Falls Dam to Cabinet Gorge) bull trout spawner counts, 1983-1997, estimated by multiplying redd count values in Table 2.1.3-2 by 3.2 (factor from Pratt and Huston, 1993). This factor is currently being reexamined and may or may not change (N. Horner, IDFG, pers. comm.). Only index streams were sampled during the period 1988-1991.

STREAM	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Clark Fork River										6	26	54	58	10	22	26
Lightning Creek	90	29	147	45	13					35	6	16	0	19	0	10
East Fork	352	77	422	26	189					102	86	90	10	157	70	205
Savage Creek	115	38	93		0	253	320	93	0	3	19	19	0	0	0	0
Char Creek	58	29	35	0	6					29	118	42	6	45	3	51
Porcupine Creek	118	166	102	3	29					13	19	3	6	0	0	0
Wellington Creek	67	58	48	22	6					29	13	29	3	16	6	3
Rattle Creek	163	102	67	32	112					32	26	0	3	32	6	48
Johnson Creek	42	106	74	115	32					51	74	10	13	16	86	54
Twin Creek	22	80	16	90	0					10	13	0	16	51	19	32
Subbasin total	1027	685	1005	333	387	253	320	93	0	310	400	262	115	346	214	429
N. Shore Pend Oreille																
Trestle Creek	954	870	954	470	736	755	694	877	704	429	973	883	448	778	707	1056
Pack River	109	118	157	80	45					208	67	70	0	19	13	54
Grouse Creek	6	346	176	42	179	77	160	154	106	54	74	58	0	160	26	141
Subbasin total	1069	1334	1286	592	960	832	854	1030	810	691	1114	1011	448	957	746	1251
E. Shore Pend Oreille																
Granite Creek	10	259	118	118	96					0	22	35	29	150	288	157
Sullivan Creek	29	26	45		19					0	77	99	29	48	134	32
N. Fk. Gold Creek	51	118	166	26	115	77	118	112	131	131	102	86	99	125	61	70
Gold Creek	419	397	35	250	198	355	390	269	333	298	384	525	304	320	243	384
Subbasin total	509	800	365	394	429	432	509	381	464	429	586	746	461	643	726	643
Total	2605	2819	2656	1318	1776	1517	1683	1504	1274	1430	2099	2019	1024	1946	1686	2323

Lower Clark Fork River

According to the USFWS (1953), about 88% of the Pend Oreille basin is in the Clark Fork drainage. About 10 miles (16 km) of the lower Clark Fork lies below Cabinet Gorge Dam, which was constructed in 1952 and is a barrier to fish passage.

Habitat Requirements

There are fluvial bull trout populations that inhabit the Clark Fork River upstream of Thompson Falls in Montana. They are isolated from Lake Pend Oreille by the existence of three nonfederal hydropower dams on the Clark Fork. Otherwise, use of the lower Clark Fork is adfluvial, which was generally the historical condition (Pratt and Huston, 1993).

Population Status—Past and Present

Historically, as many as 2,000 adfluvial spawners might have used the lower Clark Fork system, to the present site of Thompson Falls (Huston, 1993), though this number is apparently difficult to confirm. Bull trout from Lake Pend Oreille historically had access to the entire Clark Fork basin (Pratt and Huston, 1993). It appears unlikely that the mainstem Clark Fork was a bull trout spawning area, but several tributaries were among the possibilities (Huston, 1993). Thomas (1992) assumed that bull trout used all available areas, but Huston (1993) differed and thought that bull trout existed in many, but not all, of the drainages. Lightning Creek in Idaho is the only one below the present site of Cabinet Gorge that he felt likely to have supported bull trout. The others are in Montana, and range to the Clark Fork's headwaters near Butte, Montana. The Flathead is also a historic bull trout area, both above and below Flathead Lake, to its confluence with the Clark Fork.

The Mosquito and Lightning Creek drainages are now key watershed components to bull trout habitat in the lower Clark Fork drainage (Burton et al., 1995; Irving, 1986; Jeppson, 1955). The Clark Fork upstream of Lake Pend Oreille is also apparently important overwintering habitat. Irizarry (1974a) documented the Clark Fork as a source of trophy "Dolly Varden" for anglers over the period March 1973 to February 1974, though the source of these fish was not clear, nor was it certain how many were Dolly Varden and how many in fact were bull trout.

Current Environmental Conditions

There were four major events impacting bull trout populations in the Clark Fork drainage (Huston, 1993). They included construction of a dam on the Clark Fork near Milltown, Montana, between 1906 and 1913; construction of Thompson Falls Dam on the Clark Fork in 1913; the forest fire of 1910 in northern Idaho and western Montana; and the construction of Cabinet Gorge Dam on the Clark Fork in Idaho in 1951. The latter event created a barrier to migration of bull trout upstream to the Thompson Falls area. In 1958, Noxon Rapids Dam was built near Noxon, Montana, intermediate between Thompson Falls and Cabinet Gorge. Prior to dam construction, there were no major barriers to bull trout migration in the drainage. Thus, although there may have been individual populations, they were free to mix, recolonize after disasters, and maintain genetic diversity (Pratt and Huston, 1993).

Other land-use related impacts occurred beginning in the 1800s, including mining and ore processing, timber harvest and sawmilling, and grazing (Pratt and Huston, 1993). Discharge of suspended sediments from ore processing in the upper Clark Fork was recognized as a problem as it was occurring (Evermann, 1893). Sawdust from sawmills also created impacts, though perhaps not as severe to bull trout as to other species (Pratt and Huston, 1993). Fires, particularly the major 1910 event, caused some perennnial streams to become intermittent, and resulted in large amounts of ash entering surface waters and killing fish. Timber practices caused soil erosion into creeks.

In 1997, elevated levels of dissolved gas were documented as a result of spill from Cabinet Gorge Dam (Parametrix, Inc., 1997). Saturation levels up to 158% were measured in the lower Clark Fork River, and levels up to 126% were observed in Lake Pend Oreille near Sandpoint. Effects on bull trout are not fully understood, but the spill occurred coincident with their spawning migration season. Thus, it is possible that impacts may have occurred to adult migrants attempting to reach Clark Fork tributaries. To the extent that spill has occurred in the past, it is possible that bull trout have been directly affected. No direct observations of gas bubble disease (GBD) were made for bull trout. Only one bull trout was collected, and unfortunately, it was released without observation. Kokanee, a prey item for bull trout were collected, but exhibited no symptoms of GBD. Samples consisted mainly of fry and larger juveniles (all 200 mm or less). These fish may have compensated by swimming deeper to avoid high TDG. No samples of pre-swimup kokanee were collected in spawning areas, but if high TDG was present in redds, the fry would have been vulnerable. IDFG has examined egg-to-fall-fry survival in kokanee for correlations with lower Clark Fork flows. Turbine capacity at Cabinet Gorge Dam is 37,500 cfs, and higher flows are spilled, resulting in elevated TDG. There were negative correlations between survival and number of days of flows above 40,000 cfs, and between survival and number of days of flows above 50,000 cfs. However, coefficients were not strong, and r^2 values for the correlations were .55 and .48, respectively. Similarly, there was a negative correlation between survival and Clark Fork maximum runoff ($r^2 = .51$). There was no apparent correlation between days exceeding 50,000 cfs and survival of kokanee from age 0 to 1. Other possible factors affecting kokanee fry survival identified by IDFG include entrainment at Albeni Falls Dam, and low food availability. So, while kokanee survival may be related to Clark Fork discharges, more investigation is needed.

Lake Pend Oreille, Upper Pend Oreille River, and Tributaries

Habitat Requirements

An adfluvial habitat use pattern appears to be the rule for bull trout in tributaries draining into Lake Pend Oreille.

Population Status—Past and Present

There are several tributaries to Lake Pend Oreille which support spawning and rearing of bull trout (Table 2.1.3-1). Pratt and Huston (1993) stated that the bull trout populations in these tributaries seem unstable, and some streams that historically hosted bull trout no longer do so. Approximately 40% of the tributary streams are in use (Pratt, 1985), but nursery area is declining (Pratt and Huston, 1993).

The upper Pend Oreille River was apparently used historically by bull trout, but seems rarely used at present (Evermann, 1893; Bennett and DuPont, 1993), though they did appear in littoral areas in May and June in Bennett and DuPont’s (1993) study. The impounded Pend Oreille River is warm in the summer, with surface temperatures exceeding 70° F (21° C) for extended periods. It is not considered a favorable environment for bull trout.

The Priest River is the only tributary to the Pend Oreille River above Albeni Falls Dam currently known to support bull trout (Horner et al., 1987). Bull trout use in many of its tributaries is uncertain. They are documented in Quartz Creek, Big Creek, the Happy Fork of Big Creek, and East Branch, Tarlac and Uleda creeks. Lake trout have apparently displaced bull trout from Priest Lake (Mauser et al., 1988).

Annual mortality in Lake Pend Oreille is about 47% for 4-5-year-olds, and about 82% for fish aged 5-6 years. Annual historical harvests of 5,000 fish have been known for Priest and Pend Oreille lakes, including some fish over 30 pounds (Burton et al., 1995). There has been no legal harvest in Lake Pend Oreille since 1996, though anglers may catch them as long as they are immediately released. Fishing is closed in Trestle and Gold Creek drainages. For about 20 years up to 1991, creel censuses documented about 500 to 1,500 bull trout harvested per year (N. Horner, IDFG, pers. comm.).

Gilbert and Evermann (1895) documented Albeni (Albany) Falls as no apparent barrier to salmon, characterizing it as "scarcely more than pretty steep rapids" which dropped about 10 feet during their visit in August and perhaps more at lower water. Thus, presumably, it was traversable by bull trout as well, and thus, Albeni Falls Dam would constitute a migration barrier (at least for fish moving upstream).

Current Environmental Conditions

Bull trout in the Pend Oreille/Clark Fork drainage are subject to some stresses due to human influences and competition with other fish. General risks to bull trout in the basin include poaching, which has been a serious problem in the past and continues today (Pratt and Huston, 1993). Timber practices have in the past created erosion and contributed to risk of fire. Fire in the Pack River drainage in 1919 resulted in ash deposition to the river and killed fish. Inconsistent nursery habitat results from intermittency caused by fires, logging and gravel mining. It is not necessarily irreversible when it occurs, however. Sedimentation results from erosion and reduces egg survival.

Hybridization with other char, such as brook trout (a nonnative), as well as competition with brook trout, are threats. Lake trout, another char, compete with bull trout. Brown trout, another nonnative, use similar habitats as bull trout, and since brown trout spawn after bull trout, some disturbance of bull trout redds may occur (Pratt and Huston, 1993). Interactions with rainbow trout (native to the region but not to the Pend Oreille/Clark Fork drainage), may not be intensive, since rainbows use lower reaches and bull trout upper reaches of the streams they use in common. Disease appears to be of concern, but is not well-documented for bull trout.

Fish are the main staple for adult bull trout. In Lake Pend Oreille, they feed primarily on kokanee. They compete with Gerrard-strain rainbow trout (not native to the Pend Oreille drainage), which themselves may range well above 20 pounds (9.1 kg) in size, and northern pikeminnow, a native. Other nonnatives—brown trout, lake trout, northern pike, smallmouth bass, and largemouth bass—also are present and may compete with bull trout for forage fish.

The Idaho Dept. of Fish and Game (IDFG) has contended that kokanee harvest has declined as a result of drafting Lake Pend Oreille in winter for power, making shoreline spawning gravels inaccessible (Maiolie and Elam, 1993a, 1993b). At the request of the Northwest Power Planning Council (1995) and IDFG (1996), the Corps of Engineers has instituted a three-year test in which the winter lake level is being held 4 feet higher than in recent years. There may be other factors affecting kokanee populations; for instance, outplants from Cabinet Gorge hatchery have not been fully successful. Although kokanee are not native to Lake Pend Oreille, they appear to be important prey for bull trout at this time, especially when competition with other large predators is considered.

The high levels of total dissolved gas (TDG) resulting from spill in 1997 at Cabinet Gorge Dam extended into the north end of Lake Pend Oreille. Direct impacts to fish are not well-documented, but are possible. It is possible, though perhaps unlikely, that adult bull trout and kokanee were affected. Juvenile kokanee may have been more likely to be impacted, especially if they remained near shore.

Pend Oreille River Below Albeni Falls Dam

Habitat Requirements

Bull trout in this reach of the Pend Oreille are apparently adfluvial, and use the mainstem for migration to tributaries for spawning (University of Idaho, 1998).

Population Status—Past and Present

Tributaries in the Box Canyon reach supporting bull trout include Cedar, Whiteman, Mineral, and Mill Creeks (Streamnet, 1998), as well as Cee Cee Ah, Flume, and Le Clerc creeks (University of Idaho, 1998). However, densities appear to be extremely low (Kalispel Natural Resource Dept. and Washington Dept. of Wildlife, 1997), and little other information is available specific to bull trout use of these streams.

Current Environmental Conditions

In tributaries below Albeni Falls Dam, embeddedness of spawning substrate has been observed, along with low habitat diversity (Kalispel Natural Resource Dept., and Washington Dept. of Wildlife, 1997). In addition, nonnative salmonids (mainly brook trout, but also brown and rainbow trout) were much more abundant than native species, including bull trout, in four streams studied.

The Pend Oreille mainstem is impounded by Box Canyon Dam, which creates a reservoir 90 km long to Albeni Falls Dam (Kalispel Natural Resource Dept., and Washington Dept. of Wildlife, 1997).

2.1.4 Upper Columbia Basin

Grand Coulee Dam was constructed without a fish ladder. Bull trout, if present, could migrate downstream through the dam but are unable to return.

Population Status - Past and Present

Little qualitative information exists regarding historic bull trout abundance prior to construction of Grand Coulee Dam. Historically, bull trout were migratory throughout the mid-Columbia. Bull trout movement and migration were most likely altered on the mid-Columbia River following the construction of Grand Coulee. Additional alterations in movement and migration most likely occurred as other dams were completed throughout the Columbia River basin. Dam construction and operation and the resultant ecosystem changes from free-flowing rivers to reservoirs changed, altered, or eliminated bull trout migration patterns throughout the mid-Columbia River and its tributaries.

Tributaries which historically supported bull trout (and to a limited extent, support bull trout today) has been greatly impacted by man. Impacts include overfishing, introduction of competitive species such as brook trout, dams, migration obstructions such as culverts, and any type of water flow diversion. These impacts prevent some populations of bull trout from migrating to more productive habitat, prevent movement of bull trout, and restrict overall distribution.

There is very limited information on Lake Roosevelt bull trout populations. Electrofishing surveys conducted by the Spokane Tribe (T. Cichosz, 1998, pers. comm.) in Lake Roosevelt near the Spokane River, Hawk Creek (near the Seven Bays area), Nez Perce Creek (near Hunters area), and near the mouth of the Sanpoil River produced 4 bull trout between 1989 and 1995. Primary impacts to this species may be juvenile growth potential reduction related since benthic or other food items may be exposed and killed by drawdowns. Additional limiting factors are similar to those described in the section for Chief Joseph Dam and Lake Rufus Woods. Some question exists as to whether bull trout are present in the reservoir today (Fickeisen et al., 1993).

According to the Washington Department of Fish and Wildlife (K. Vale, 1998, pers. comm.), there have been individual bull trout sightings in Boulder Creek (a tributary of the Kettle River) and Onion Creek (tributary to Lake Roosevelt). However, subsequent surveys resulted in no additional bull trout observed either upstream or downstream from these sightings. Figure 2.1.4-1 depicts currently known distribution.

Figure 2.1.4-1. Currently known bull trout distribution in the upper US portion of the Columbia mainstem drainage.

2.1.5 Mid-Columbia Basin Including Chief Joseph Dam

The following concerns bull trout from the mid-Columbia and tributaries as influenced by Chief Joseph Dam. It does not include the 5 public utility district projects, nor the Yakima River.

Habitat Requirements

The majority of bull trout in this reach of the Columbia River and its tributaries are resident fish. Through the development of dams and water diversion structures, along with natural barriers (i.e., falls), the opportunity for the bull trout to migrate has diminished. Another natural barrier is stream width. Apparently bull trout require a wider stream than brook or cutthroat trout as their populations terminated in headwater reaches not blocked by barriers. In that brook and bull trout occupy the same habitat and hybridize extensively, this could lead to the extirpation of bull trout if they are not able to migrate. This could have happened on Eightmile and Boulder creeks in the Methow River, especially considering bull trout require 6-9 years to mature sexually and 2-4 years for brook trout.

Temperature preference for bull trout is outlined in Sec. 2.0. Mullan et. al. (1992) predict that if stream temperatures rise the projected 4-5^{o} C by the mid 21st century, due to global warming, cutthroat and bull trout in the Methow River will be replaced by rainbow trout, except for populations above the falls. An example of this is Lake Chelan, where bull trout existed until recent years following introduction of kokanee and rainbow trout in 1917.

Population Status—Past and Present

Figures 2.1.4-1 and 2.1.5-1 show bull trout distribution below Chief Joseph Dam in the mid-Columbia and tributaries. Of all the tributaries of the mid-Columbia River, only the Wenatchee, Entiat, and Methow Rivers have bull trout populations that could migrate into the mainstem of the Columbia River. However, these populations of bull trout are separated by dams located on the mainstem of the Columbia River. This suggests that various populations of bull trout are separate from each other with no chance of genetic variation. Table 2.1.5-1 depicts the potential of stochastic extirpation for these populations of bull trout.

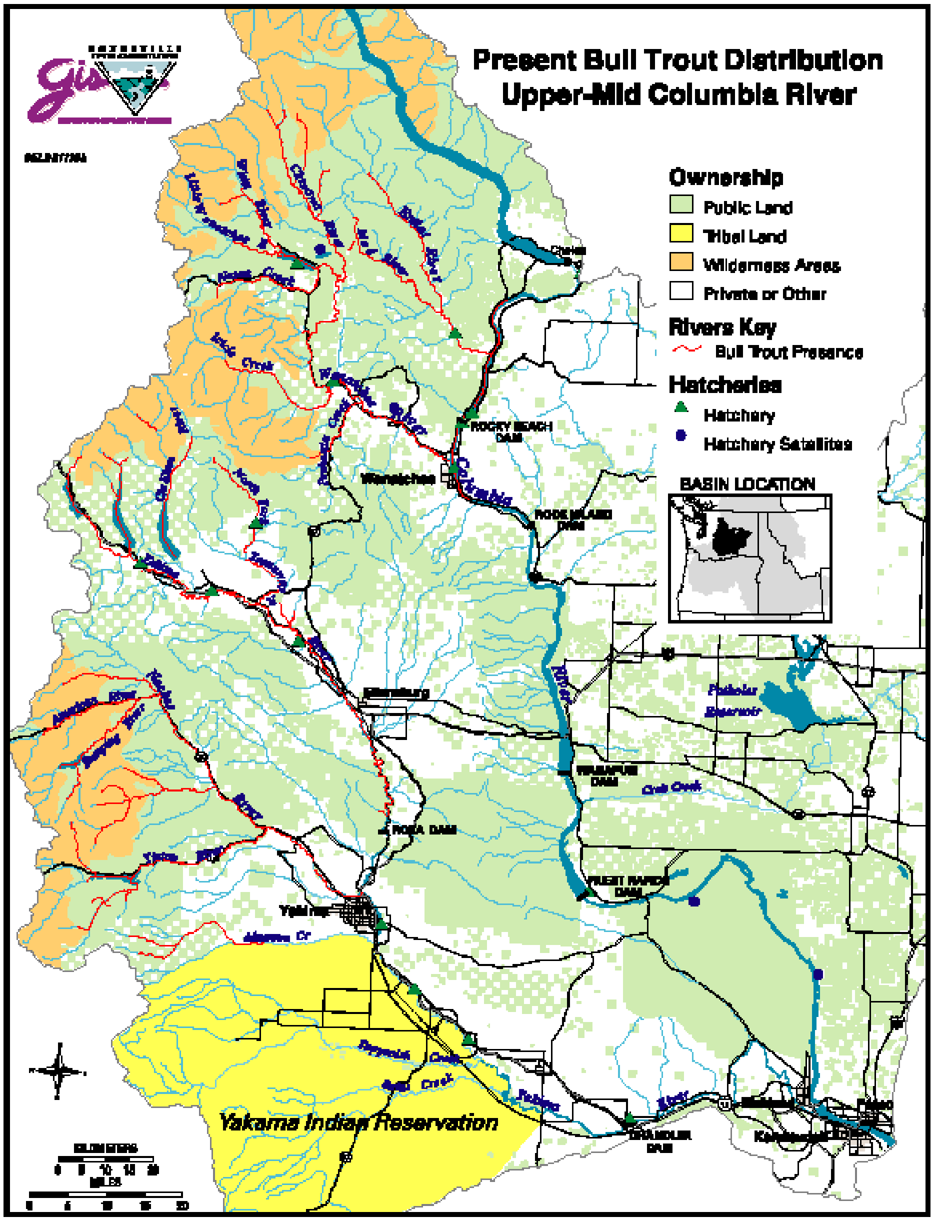

Figure 2.1.5-1. Mid-Columbia River basin, showing present bull trout distribution.

Table 2.1.5-1. Mid Columbia River bull trout population segments.

Basin	Subpopulation	Single Spawning area	Refound. Unlikely	Life Hist. Forms	Number	Data type descriptor; years	Status and Trend	Risk of stochastic extirpation
Yakima River	Ahtanum Creek	Y	Y	R	8.5	R,A,4	D,D	Y
	Naches River	N	N	M,R	64	R,T,1	D,U	N
	Rimrock Lake	N	Y	M	311	R,A,4	S,I	N
	Bumping Lake	Y	Y	M	61	R,A,6	D,D	Y
	N.F. Teanaway River	Y	Y	R	28	T,T,7	D,D	Y
	Cle Elum Lake	Y	Y	M	20	T,T,7	D,D	Y
	Kachess Lake	Y	Y	M	4.5	R,A,13	D,D	Y
	Keechelus Lake	Y	Y	M	14	R,A,13	D,D	Y
Wenatchee River	Lake Wenatchee	N	Y	M	>275	R,A,7	S,S	N
	Icicle Creek	Y	Y	R	11	T,T,2	D,U	Y
	Ingalls Creek	Y	Y	R	8	T,T,1	D,U	Y
Entiat River	Entiat River	N	Y	M	18	R,A,9	D,D	N
Methow River	Methow River	N	N	M,R	63	R,A,2	D,U	N
	Lost River	N	Y	M,R	1092	T,T,1	D,U	N
	Goat Creek	Y	Y	R	U	T	D,U	Y
	Upper Early Winters Creek	Y	Y	R	U	T	D,U	Y

Life History Forms: M-migratory, R-resident; A-adults, J-juvenile, R-redds, S-spawners, T-total
Descriptor: A-average, D-density, T-total count; years-number of years of record.
Status and Trend: D-depressed, S-strong, U-unknown (modified after Rieman et al. [in press])(i.e. strong subpopulations have all life history forms that once occurred, abundance that is stable or increasing, and at least 5,000 total fish or 500 adult fish are present; depressed subpopulations have either a major life history form eliminated, abundance that is declining or half of historic or less than 5,000 total fish or 500 adults are present.). D-decreasing, I-increasing, S-stable, U-unknown. (U.S. Fish and Wildlife Service, 1998c)

Bull trout occur in 16 subpopulations in the mid-Columbia. The Yakima River has 8 isolated subpopulations, Wenatchee River has 3 subpopulations, Entiat River has one subpopulation, and the Methow River has 4 subpopulations. There are 10 streams in this area where the bull trout are believed to be extirpated, including:

1. Status Creek
2. Nile Creek
3. Orr Creek
4. Little Wenatchee River
5. Nopecqua River
6. Lake Chelan
7. Okanogan River
8. Eightmile Creek
9. South Fork Beaver Creek
10. Hanford Reach of the Columbia River

The active subpopulations are addressed here except for the Yakima River and that will be addressed in detail in another document. Apparently there are no known bull trout populations remaining in the mainstem of the Yakima River, therefore, no migration would occur into the mainstem of the Columbia River. Bull trout are likely extirpated from the Hanford Reach (WDFW, 1997).

A. Wenatchee River
   1. Lake Wenatchee has the highest population of bull trout of the three and is also the beginning of the Wenatchee River.
   2. The Icicle Creek population is isolated above Leavenworth National Fish Hatchery dam; only 11 bull trout were observed in 1994 and 1995 (Ringel, 1997).
   3. The Ingalls population has just resident fish with only 8 observed in 1995. Ingalls may no longer support migrating fish (Ringel, 1997).

B. Entiat River
   1. The Entiat River begins as meltwater from glaciers and perennial snow fields that are approximately 52 miles from the Columbia River. Spawning is confined to a 12.3 km (7.7 miles) reach of the Mad River, a tributary of the Entiat River (WDFW 1997). From 1989-1996 redd counts ranged from 10 to 23 (K. Williams, WDFW, in lit. 1996).

C. Methow River
   1. The Methow River basin is south of the Canadian border between the crest of the Cascade Mountains and the paralleling Okanogan River basin. The Methow River has migratory fish that could spawn in 7 tributaries (Gold, Wolf, lower Early Winters, Twisp, West Fork Methow, Lower Lost, and Chewach River (WDFW 1997)). The number of redds observed in the tributaries combined was 0 to 27 (K.Williams, WDFW, in lit. 1996). The
   2. The Lost River is a stronghold for bull trout. They are isolated in the upper portion of the watershed, with an estimated 1000 resident and migratory fish in 1993 (K. Williams, WDFW, in lit. 1996).
   3. Goat Creek has low numbers of resident bull trout that are isolated upstream by a culvert 10.9 km (6.8 miles) from the confluence and a seasonal barrier in dry years.
   4. The Early Winters Creek population is isolated by a waterfall 12.6 km (7.9 miles) from the confluence. Resident bull trout in 1986 and 1989 numbered from 2 to 7 fish per 100 square meters.

Current Environmental Conditions

Few data exist on bull trout migration within the mainstem Columbia River. Various other species of salmonids have been studied relative to migration impediments caused by dams constructed on the Columbia River. However, since bull trout are historically migratory fish, one might apply some of the implications for salmon to bull trout located in the mainstem Columbia River. Where dams are barriers, bull trout genetic diversity is impacted. Fishing, changes in habitat, or both have changed the mid-Columbia River fish community to many small to medium sized trophic generalists (e.g., redside shiner) and fewer large piscivores (e.g., bull trout) (Mullan et al., 1992).

Nature-induced impacts to the bull trout could include fire and landslides, but the greatest impacts are man induced (Mullan et al., 1992). Those impacts could be overfishing, introducing competitive species, dams, culverts, and any type of water flow diversion. These impacts prevent some populations of bull trout from migrating to a more productive, anadromous or adfluvial-inducing habitat. This could result in more competition with other species of trout like the cutthroat and brook and possibly lead to extirpation of the bull trout at various locations. Brook and bull trout may occupy the same habitat and hybridize extensively, leading to extirpation of bull trout (Mullan et al., 1992). This may have occurred on Eightmile and Boulder Creek in the Methow River, especially considering that bull trout require 6-9 years to reach sexual maturity versus 2-4 years for brook trout (Mullan et al., 1992).

Bull trout migrants from tributaries would be similarly restricted by dams on the mainstem Columbia River. These movement restrictions could lead to overfishing of bull trout (particularly by a fishery selective to larger fish) and a reduced reproductive potential. Mullan and Martin (1992) compared a 300mm resident bull trout that had less than 200 eggs to an adfluvial 600 mm bull trout that had over 3,000 eggs. This suggests that a restricted migration could result in a reduced population of bull trout in a specific location. With natural barriers and the added man-induced barriers, the potential of hybridizing, reduced genetic variability, and reduced reproduction, could accelerate extirpation of bull trout at various locations.

2.1.6 Clearwater River Basin

Population Status—Past and Present

Historic data are not available that would allow an estimate of the number of bull trout in the basin as a whole or within any sub-watershed of the North Fork of the Clearwater River. The only studies done on bull trout in the Dworshak Reservoir include creel surveys done 1988 through 1992 (Maiolie and Elam, 1993). During 1988, when it was thought that there may have been more bull trout than the years to follow, only 142 bull trout were caught (0.6% of the total catch for 1988). Thirty-four were caught in March, 63 in April, 35 in May and 10 in December.

Figure 2.1.6-1 shows current bull trout distribution in the Clearwater basin. Adfluvial-type populations have been found in the upper tributaries and the North Fork of the Clearwater inlet of Dworshak Reservoir. The combined efforts of IDFG and the Nez Perce Tribe (Maiolie, et al. 1992) report creel survey data where 151 bull trout were caught in 1990 from 149,592 angling hours and 0 bull trout caught in 1991 from 1632 angling hours. IDFG and NPT's own gillnetting samples yielded only 1 bull trout caught in the Little North Fork out of 340 fish captured in 1988 (2 August to 23 December sampling dates), 1 bull trout caught in Reed's Creek Arm out of 230 fish captured in 1989 (27 April to 16 August sampling dates), and no bull trout out of 185 fish captured in 1990 (26 June to 5 September sampling dates).

Reservoir filling resulted in creating a functional passage barrier that has been implicated in modifying bull trout life history patterns from fluvial to adfluvial in the North Fork of the

Clearwater River populations. For example, bull trout historically occupying the North Fork of the Clearwater River were fluvial, but following the filling of Dworshak Reservoir the descendents of these fish are now adfluvial. It cannot be determined whether this lifestyle modification has any effects on fitness to the individual fish or population. The general trend observed in physical size distribution of life history segment is that the adfluvial or anadromous life histories produce larger fish in length and weight over fluvial life histories. Phusical size is smallest for resident life histories. The observed plasticity in bull trout life history traits throughout its range indicates any effects to the fitness of a healthy viable population attributable to fluvial versus adfluvial is likely low as long as adequate forage fish is available.

It is believed that Dworshak Reservoir does not currently support spawning or early rearing habitat for bull trout, but the North Fork of the Clearwater River and its tributaries upstream of Dworshak are believed to be important spawning, rearing, and possibly overwintering habitat segments for adults, sub-adults, and juveniles. The reservoir near full pool may provide overwintering habitat for adults and subadults. The data on the bull trout populations that migrate from the North Fork of the Clearwater River into Dworshak reservoir appear to indicate remnant, isolated subpopulations that may reach a threshold at which the probability of local extinction from genetic inbreeding, demographic, or an environmental stochastic event could increase rapidly.

Figure 2.1.6-1. Clearwater River basin showing present bull trout distribution.

2.1.7 Lower Snake River and McNary Projects

Habitat Use

Water temperature is a critical habitat characteristic for bull trout. Temperatures above 59 degrees F are thought to limit bull trout distribution (Allen et al. in Batt, 1996). Optimum water temperatures for rearing are thought to be 45- 46 degrees F. Researchers recognized water temperature more consistently than any other factor influencing bull trout distribution. However, it is poorly understood whether the influence of temperature is consistent throughout life or whether a particular stage is especially sensitive. Bull trout have voracious appetites and take full advantage of any and all food sources available to them. Fish are considered to be the major item in the diet of large bull trout. They feed primarily along the bottom and up to mid-water levels, consuming insects and other fish species such as suckers, sculpins, minnows, and trout. Mountain whitefish are one of the bull trout's preferred prey (Knowles and Gumtow, 1996). Adult bull trout that are adfluvial generally spend about one half of every year associated with a reservoir (generally November-May). These fish most likely forage in shallow areas where the majority of prey exist. Depending on water conditions, bull trout will occupy deeper areas of the reservoir where water temperatures are cooler (45-54 degrees F) and move to the surface when surface water temperatures drop to or below 54 degrees F.

The adfluvial life history modification scenario is probably true for bull trout in the Columbia and Snake Rivers, although these populations may be considered functionally extinct as a consequence of increased water temperature, spawning and rearing habitat modification with fine sediment accumulation, and historic overfishing under predator control philosophies. The upper reservoir of Lower Granite may be a candidate for containing a remnant population of Snake and Clearwater River bull trout, although University of Idaho sampling since 1983 has not captured any individuals in the reservoir proper below River Mile 138 (about one-half mile upstream of Red Wolf Bridge, pers. comm. Tom Dresser, University of Idaho, October 1993).

Population Status—Past and Present

Bull trout were likely widely dispersed throughout the Snake River drainage, limited only by natural passage and thermal barriers. Bull trout were present in all of the Snake River basin (except the eastern section of Idaho). In the Snake River basin, their historical range approximates that of spring, summer, and fall chinook salmon (Thurow, 1987; Rieman and McIntyre, 1993) and other Snake River tributaries upstream as far as Salmon Falls Creek.

The distribution of bull trout may parallel the distribution of potential prey such as whitefish and sculpins. In several river basins where bull trout evolved with populations of juvenile salmon, bull trout abundance declined when juvenile salmon prey declined or were eliminated (Ratliff, 1992). Biologists have known of the bull trout's decline for at least two decades, but until recently, management agencies have done little to reverse the process. Until recently, state fish and wildlife agencies have focused their management efforts on salmon or introduced trout.

Current distribution is primarily in tributaries to the main stem Snake River upstream to and including the Clearwater River (Figure 2.1.7-1). Bull trout exhibit two distinct life history forms in the Snake River basin–migrant and resident. Migrant fish emigrate from the small streams where the juveniles rear to larger rivers (fluvial) or lakes (adfluvial). Resident fish remain in the rearing streams. Bull trout can live up to 10 years and are sexually mature after 4 years. They spawn during September through November, in cold, flowing groundwater-fed streams that are clean and free of sediment. Migrant bull trout usually emigrate from their rearing streams at 2-3 years of age when they are 6-8 inches long; however, younger fish may occasionally outmigrate earlier (Elle et al., 1994). Adfluvial mature bull trout associated with Reclamation projects further upriver in the basin appear to reside in reservoirs for about 6 months in the period from November to June. During this period, when water temperatures range from 45 to 54 degrees F, adult adfluvial bull trout live near shallower areas depending on food supply (Flatter, 1997). It appears that most bull trout, even those not ready to spawn, migrate upstream beginning in May-June and return in November-December. This migration may be in part to avoid high summertime water temperatures in some areas or insufficient flows or water levels.

Figure 2.1.7-1. Current distribution of bull trout in the lower Snake River drainage.

Fluvial type populations also inhabit the Tucannon River and tributaries of the Walla Walla River. These populations were heavily fished with little regulation by the local public during the time that steelhead numbers were low in these rivers (1960s and 1970s). Bull trout may be adfluvial in the lower reaches of the Tucannon River where it joins Lower Monumental Reservoir, but this has not been verified (Martin et al., 1992). The 1991 Annual Report of Martin et al. (1992) provides the most complete and informative document on bull trout in southeastern Washington tributaries to the Snake River. The Project Final Report will be available in January 1994. The findings of the first year of a two year study focused at identifying species interactions between bull trout, spring chinook, and steelhead in various levels of supplemented streams (Mill Creek, Tucannon River, Asotin Creek, and the Wolf Fork of the Touchet River which flows into the Walla Walla River). Bull trout populations were highest in the Tucannon River, followed by upper Mill Creek. Adult bull trout were difficult to capture in order to determine migratory habits. Young of the year and juvenile bull trout prefer the same habitat as spring chinook and steelhead in the absence or presence of these putative competitors. Spawning habits of bull trout and spring chinook are also similar, but spatially differentiated with little overlap. Bull trout spawn in geographically higher reaches of the river than spring chinook.

Current Environmental Conditions

Contributing Factors as Predator/Competitor to More Desirable Species. Bull trout were formerly viewed as a "trash fish" by anglers. They consume juvenile salmon and other game fish so they were considered undesirable predators. Many fish and wildlife agencies mounted active campaigns to eliminate bull trout. Even after active efforts to eliminate bull trout ceased, populations continued to decline due to impacts of other human activities. The causes of this decline of bull trout are many and varied and have worked in concert to cumulatively impact this and other native salmonids species. Impacts on bull trout generally occur from three areas of resource management: (1) land management practices; (2) water management practices, and (3) fisheries management practices. Current recognized threats to bull trout are discussed in the following sections.

Passage Barriers and Stream Diversions. Dams, irrigation diversions, and other alterations of waterways have interrupted the migration of bull trout. Numerous dams without adequate fish passage have caused some populations with migratory life histories to switch to resident life histories. Where once the migratory bull trout linked resident bull trout to much of the species' gene pool, today, the resident populations are isolated, vulnerable to habitat degradation and may suffer a loss of genetic diversity. If a barrier is high in a drainage, the isolated population may be too small to sustain itself.

On tributary streams where there are irrigation diversions, at least four potential problems may affect bull trout production. Irrigation diversions reduce instream flows; the water returned to streams tends to be warmer than the water diverted; sediment is added to streams; and unscreened diversions entrain migrating juvenile bull trout to conveyance systems and fields where they die. Construction of water storage structures appears to have been a significant factor in the reduction of bull trout range and distribution. Construction and operation of these facilities have modified streamflows, changed stream temperature regimen, blocked migration routes, entrained bull trout, and affected bull trout forage bases. Reservoirs experience substantial drawdowns during drought years and flow augmentation for ESA-listed chinook salmon migration. Reduced reservoir volume directly impacts the amount of aquatic environment for all organisms in the food web. Production of phytoplankton, zooplankton, and aquatic insects are all reduced when drawdowns are extreme. Reduction in the food base may reduce the prey available for predator species like bull trout; although some forage fish populations may be more concentrated and more available as prey. When reservoir volume is greatly reduced, bull trout and other fish species may be forced into riverine habitats.

Catastrophic Events. Drought results in reduced summer stream flows (and reduced reservoir elevations) and increased water temperature and will predictably reduce spawning success and survival of bull trout (Knowles and Gumtow, 1996). Environmental stochasticity, or the effect of a catastrophic event (such as deep reservoir drawdowns for flood control or during drought conditions) influences the probability of bull trout extinction when population size is small (Rieman and McIntyre, 1993).

2.1.8 Lower Columbia River and Tributaries

The lower Columbia River and tributaries encompass portions of the Portland and Walla Walla Districts. Bull trout populations have been mostly extirpated from the mainstem Columbia River including The Dalles, John Day, and McNary pools (USFWS, 1994). A small, remnant fluvial population from the Hood River in Oregon migrates to the Bonneville pool for rearing. Most remaining populations are isolated in tributary headwaters or lakes. In Washington, remnant populations remain in the Lewis, White Salmon, and Klickitat rivers. In Oregon, bull trout populations occur in the Willamette, Hood, Deschutes, John Day, and Umatilla rivers. Figures 2.1.8-1 and 2.1.8-2 depict current bull trout distribution in the lower Columbia drainage.

Figure 2.1.8-1. Current bull trout distribution in the lower Columbia drainage below Bonneville Dam.

Figure 2.1.8-2. Current bull trout distribution in the lower Columbia River drainage above Bonneville Dam.

Lower Columbia Mainstem

Habitat Requirements

In the lower Columbia River basin, bull trout generally reside in restricted habitat primarily in the upper reaches of major tributaries to the Columbia River. In the lower Columbia River basin, bull trout exhibit three life history patterns represented by resident, fluvial, and adfluvial fish.

Bull trout are stenothermal, requiring a narrow range of cold water temperature conditions to reproduce and rear (Buchanan and Gregory, 1997). Water temperatures in excess of about 15° C are thought to limit bull trout distribution. Rieman and McIntyre (1993) stated that bull trout seem to have more specific habitat requirements than other salmonids. Channel stability, substrate composition, cover, temperature, and migratory corridors all influence bull trout distribution and abundance.

The Columbia River probably provided important historical rearing habitat for migratory bull trout from the Hood River system (Buchanan et al., 1997). A small remnant, fluvial population migrates from the Hood River in Oregon and rears in the Bonneville pool (Buchanan et al., 1997).

Population Status—Past and Present

Historically, bull trout were widely distributed in the mainstem Columbia River and its many tributaries in Oregon, Washington, Idaho, and Montana. George Suckley first collected the holotype specimen for bull trout on the lower Columbia River near The Dalles, Oregon, in 1854 (Cavender, 1978). Prior to the construction of a large number of storage and hydropower projects in the basin, bull trout populations had access to hundreds of miles of mainstem and tributary spawning, rearing, foraging, and migration habitat.

Of the lower Columbia River mainstem reservoirs, the Bonneville pool appears to be the only mainstem habitat that still supports bull trout. Limited current and historic information indicates that the mainstem Columbia River provided important rearing and migration habitat for bull trout from the Hood River in Oregon. One bull trout marked at the Powerdale Dam trap on the Hood River in 1994 was recaptured in 1995 in the Columbia River approximately 11 km downstream from the mouth of the Hood River. Records indicate that an untagged bull trout was captured in the Columbia River immediately below Bonneville Dam in 1991. The few documented sightings of adult bull trout observed in the lower White Salmon, Little White Salmon (Drano Lake), and Wind rivers in Washington are believed to be fluvial fish from the Hood River system (WDFW, 1998). The two captures of bull trout in the lower Columbia River and the large size of some of the fluvial bull trout suggest that the lower Columbia River is still important habitat for Hood River bull trout (Buchanan et al., 1997).

Current Environmental Conditions

The only known bull trout population that uses the lower Columbia River mainstem migrates to and from the Hood River and uses the Columbia River for rearing. The Bonneville pool has fish passage facilities for adult and juvenile salmonids and provides an available food source in the form of salmon and steelhead smolts.

Ratliff and Howell (1992) identified this Hood River population as having a *high risk* of extinction. In the recent assessment by Buchanan et al. (1997), the population status remained at *high risk*.

Lewis River

Habitat Requirements

The Lewis River joins the Columbia River at approximately RK 140 or approximately 95 km (60 miles) downstream of Bonneville Dam. Prior to the construction of three hydropower projects on the Lewis River, access to the mainstem Columbia River was available throughout the Lewis River basin. Private and public utility companies operate the hydropower projects. None of the hydropower projects have upstream fish passage facilities. Some fish move downstream when water is spilled

Population Status—Past and Present

It is believed that prior to dam construction, the Lewis River contained anadromous and fluvial bull trout populations (WDFW, 1998). However, the remaining bull trout populations in Merwin, Yale and Swift reservoirs are adfluvial and isolated from each other as well as mainstem rearing, foraging, and migration habitat in the lower Lewis and Columbia rivers. These remnant populations are very small and have little available spawning habitat.

The Lewis River bull trout stock status is considered depressed due to chronically low abundance (WDFW, 1998).

Current Environmental Conditions

The North Fork Lewis River contains three mainstem power dams that restrict movement of bull trout in the watershed. The volcanic eruption of Mt. St. Helens in 1980 devastated some streams in the watershed such as Pine Creek. Pine Creek is slowly recovering with clean gravels and revegetated riparian zones. Other activities such as logging, road building, and development are occurring above Merwin Dam (WDFW, 1998).

Three hatcheries are located on the North Fork Lewis River. Hatchery coho salmon fingerlings are planted annually in Merwin Reservoir as part of a mitigation program. Hatchery rainbow trout fingerlings are annually stocked in Swift Reservoir. Kokanee were introduced into the upper reservoirs in the 1950s and now spawn in tributaries to Merwin and Yale reservoirs. Brook trout have been stocked in the upper Lewis River watershed. Interactions between hatchery-origin salmonids and bull trout have not been examined in the Lewis River basin (WDFW, 1998).

Extremely small population sizes, limited spawning habitat, and isolation indicates status is precarious and could decline dramatically in response to environmental perturbations and poaching (USFWS, 1994).

White Salmon River

Habitat Requirements

The White Salmon River is a tributary that enters the Columbia River (Bonneville pool) from the state of Washington. The Condit Project is located on the lower White Salmon River at approximately RK 5.3. This hydropower project has no upstream fish passage facilities. It is owned and operated by the Pacific Power and Light Company.

Spawn timing and locations for bull trout in the White Salmon River are unknown. Stock status is unknown because there is insufficient information to make an assessment (WDFW, 1998).

Population Status—Past and Present

Bull trout historically occupied the White Salmon and Klickitat rivers and the Columbia River between them. Isolated populations remain in the White Salmon River. Only very small numbers persist in the White Salmon. Reported sightings of bull trout in the White Salmon River are rare. Washington Department of Fish and Wildlife (WDFW) biologists have reported two sightings above Condit Dam. Bull trout observed below Condit Dam are not believed to reproduce in the White Salmon River. No juvenile bull trout have been recorded in electrofishing sampling projects in the lower river. WDFW biologists believe that the few adult bull trout seen in the lower White Salmon River are fluvial fish from the Hood River in Oregon (WDFW, 1998). It is questionable whether viable populations remain in the White Salmon River (USFWS, 1994).

Current Environmental Conditions

The White Salmon River contains potential bull trout spawning habitat in the upper reaches above Trout Lake. However, water temperature is a critical limiting factor. Many upper river tributaries, such as Trout Lake Creek, contain suitable spawning gravels, but the water is too warm for bull trout.

Condit Dam has been a fish passage barrier on the White Salmon River for most of this century. The dam has blocked both adult and juvenile passage. Fish have been injured or killed by passage through turbines or spillways. Increases in water temperature and changes in plant communities attributed to the Condit Dam and reservoir have made much of the White Salmon River mainstem unsuitable for bull trout (WDFW, 1998).

There are no hatcheries in the White Salmon River drainage. Spring chinook and coho are released in the White Salmon River below Condit Dam but interactions with bull trout are unlikely. Hatchery rainbow trout fingerlings are stocked annually in Northwestern Reservoir and may serve as a food source for bull trout. However, interactions between hatchery salmonids and bull trout have not been examined in this drainage (WDFW, 1998).

Klickitat River

Habitat Requirements

The Klickitat River is a tributary that enters the Columbia River (Bonneville pool) from the state of Washington. There area no passage barriers that prevent bull trout migration to and from the Klickitat River basin.

Spawn timing and location, age at maturity, sex ratio and fecundity, timing of fry emergence, and survival rates are unknown. Stock status is unknown because there is insufficient information available to make an assessment. However, it appears that there are few bull trout in the lower to middle Klickitat River basin. Bull trout appear to be rare but more abundant in the upper drainage where habitat conditions are more favorable than in the lower drainage (WDFW, 1998).

Population Status—Past and Present

Very little is known about bull trout populations in the Klickitat River other than they are known to occur there (WDFW, 1998). Isolated bull trout populations remain in the Klickitat River. Only very small numbers persist in the White Salmon and Klickitat rivers, and it is questionable whether viable populations remain. The lower Klickitat River tributaries may have historically been too warm to support bull trout (USFWS, 1994).

Current Environmental Conditions

Warm water temperatures due to natural low flows are a concern for both adult bull trout that may spawn in the mainstem or in the lower reaches of tributaries and for juveniles that may rear in the area. Irrigation water withdrawals from the Little Klickitat River and other lower river tributaries exacerbate the natural low river flows and warm water temperatures. Bank protection (riprap) along the lower river has eliminated riparian vegetation and contributed to higher water temperatures. Turbid water conditions and sedimentation during peak discharge periods from natural sources as well as grazing, logging, and roads impair fish health and impede fish growth and development. Development within the floodplain and in riparian areas has reduced bank protection and overhead cover, elevated water temperatures, and increased sediment loads. Areas in the upper watershed where development has not occurred appear to be in excellent condition (WDFW, 1998).

Historically, bull trout were included in a daily limit of two trout. Restrictive harvest regulations have been implemented. Beginning is 1992, fishing for bull trout has been prohibited in the Klickitat drainage. Although angling and harvest impacts are unknown, they may have been significant prior to the implementation of restrictive angling regulations (WDFW, 1998).

Hatchery rainbow trout have been stocked in the Little Klickitat River and tributaries since at least the late 1960s. Brown trout were also stocked in the Little Klickitat River in 1984-85. Hatchery salmon and steelhead have been stocked and colonized the mainstem Klickitat River. Hatchery impacts on bull trout are usually manifested in the form of competition of food and space, predation of juvenile bull trout, and increased angler harvest rates of trout (including increased incidental catch of bull trout). It is unknown what impacts hatchery stocking programs may have had on bull trout in the Klickitat River basin (WDFW, 1998).

Hood River

Habitat Requirements

The Hood River Basin is located in north central Oregon and consists of the mainstem Hood River, West Fork, East Fork, and Middle Fork. The East and Middle forks originate from permanent glaciers on the northern and eastern slopes of Mount Hood. The Hood River enters the Columbia River at approximately RK 272 (Bonneville pool).

The Hood River system most likely contains resident, fluvial, and adfluvial bull trout populations. The adfluvial life history is the result of historically fluvial fish being trapped in Laurance Lake by the construction of the Clear Branch Dam. It is unknown whether separate genetic or life history differences exist (Buchanan et al., 1997).

Population Status—Past and Present

Recorded historical information of bull trout in the Hood River basin is very limited. Construction of the Hines Lumber Company Dam on the mainstem Hood River at Dee (RK 21) in the early 1900’s probably interrupted upstream migration. This dam was removed in the early

1960s. Bull trout were captured at the upstream ladder and trap at the Powerdale Dam from 1962 to 1971, indicating that a small migratory or fluvial population has existed in the mainstem for many years (Buchanan et al., 1997).

A single bull trout was captured in the lower part of the West Fork Hood River in 1963 at Punchbowl Falls. No bull trout have been observed in the West Fork since this single observation (Buchanan et al., 1997).

Prior to 1994, known bull trout distribution in the upper basin was comprised of a small population in Laurance Lake and the Clear Branch system above Clear Branch Dam. A single bull trout was observed downstream of Clear Branch Dam in Bear Creek near the confluence with the Middle Fork in 1990, but actual distribution in Bear Creek has not been substantiated. Some fluvial bull trout were captured and tagged at Powerdale Dam on the lower Hood River. Tag recaptures document instream movement from Powerdale Dam to immediately below Clear Branch Dam. One bull trout tagged at the Powerdale Dam trap was recaptured in the mainstem Columbia River near RK 261 or about 11 km downstream of the mouth of the Hood River. An unmarked bull trout was captured in the Columbia River immediately below Bonneville Dam near Ives Island in 1991. The two Columbia River captures and the large size of some fluvial bull trout captured at Powerdale Dam suggest that the lower Columbia River is still an important habitat for Hood River bull trout (Buchanan et al., 1997).

Spawning ground surveys in Clear Branch Creek upstream from Laurance Lake began in 1991. Bull trout redds were found to be very difficult to identify. Redds were only apparent when spawning adults were actively using them and only visible for a few days after construction. It has been estimated that the total adult population may be less than 300 hundred individuals (Buchanan et al., 1997).

Ratliff and Howell (1992) first assessed the status of bull trout in the Hood River basin. They listed a Clear Branch population as having a *high risk* of extinction and a West Fork Hood River population as *probably extinct*. The status remains the same in the most recent status report compiled by the Oregon Department of Fish and Wildlife. However, a possible new population in the Compass/Coe Branch watershed has been rated at *high risk* of extinction (Buchanan et al., 1997).

Current Environmental Conditions

Passage barriers are a major limiting factor for bull trout in the Hood River basin. Two large dams impede or block upstream passage of migratory fish in the Hood River system. Powerdale Dam, located on the lower mainstem Hood River, is owned and operated by PacifiCorp. Powerdale Dam has adequate upstream passage for bull trout except during brief periods of high flows. Juvenile fish are screened from the Powerdale Diversion, but the efficiency of these screens is inadequate. Clear Branch Dam is located on Clear Branch Creek, a tributary of the Middle Fork. This dam was built for irrigation storage and later modified for power production (Buchanan et al., 1997). It is located immediately downstream of prime spawning and rearing habitat. No upstream fish passage facilities were present until a migrant trap was completed in 1996. There are no downstream fish passage facilities other than the potential for juveniles to migrate out of the reservoir by limited surface spill. Surface spill is not an annual event. Survival of bull trout passing out of Laurance Lake is unknown (Buchanan et al., 1997).

Laurance Lake creates a heat sump that significantly warms the upper basin below the dam. Monitoring during the summer and fall of 1995 indicated increases in water temperature caused by the reservoir. These temperature increases occur during the critical summer rearing and fall spawning times. It has been hypothesized that adult bull trout unable to pass above Clear Branch Dam would not spawn successfully immediately below the dam due to elevated water temperatures (Buchanan et al., 1997).

Bull trout spawning habitat is limited in the basin. Glacial sand and silt occur in Coe Branch Creek and are carried into the Middle Fork Hood River beyond the confluence. The sand and silt flows peak near the bull trout spawning time. Adult bull trout must migrate through the sand and silt flows to reach spawning areas. Spawning success is unknown under these conditions. The Clear Branch watershed was heavily logged prior to dam construction in 1969 resulting in a lack of large woody debris and a reduction of riparian corridors. The Clear Branch Dam halts downstream movement of gravel resulting in limited spawning gravel immediately below the dam (Buchanan et al., 1997).

No non-native trout are presently found in parts of the Hood River basin where bull trout occur. However, brook trout have been widely stocked in other parts of the basin but not in the Middle Fork subbasin (Buchanan et al., 1997).

Because the total adult population of bull trout is believed to be less than 300 individuals, there is a high risk of extinction. This population is highly susceptible to random processes such as increase natural death rates or catastrophic environmental events such as droughts, fires, or volcanic activities. Further loss of genetic diversity could also reduce fitness (Buchanan et al., 1997).

Deschutes River

Habitat Requirements

The Deschutes River flows north through central Oregon and is a major tributary to the Columbia River entering at about RK 327 (The Dalles pool). The Deschutes Basin drains an area approximately 27,195 sq km in size. The mainstem Deschutes River begins at its source at Little Lava Lake and travels approximately 405 km to its confluence with the Columbia River. Major tributaries include the White River, Warm Springs River, Trout Creek, Metolius River, Crooked River, and Little Deschutes River.

Lands in the Deschutes River basin that support bull trout habitat are owned or managed by the US Forest Service, Bureau of Land Management, Confederated Tribes of the Warm Springs Reservation, and private timber companies and individuals.

Some excellent life history information is available for bull trout in the Metolius River and Lake Billy Chinook subbasin developed by multi-agency, tribal, and private industry biologists. Most bull trout in the Metolius River and tributaries spawn between mid-August and early October. It appears that the extremely cold tributaries provide the critical spawning and juvenile rearing habitats that support the Metolius River bull trout population. These rearing tributaries for juvenile bull trout are dominated by riffle and run habitats. Pools make up less than 12% of the habitat in bull trout streams. Cover, mostly as undercut banks and overhanging and aquatic vegetation, comprises up to 10% of the habitat. Summer water temperature in the streams used by bull trout for spawning and rearing was strongly influenced by cold springs.

Since 1986, the number of bull trout redds counted in the Metolius River basin has generally increased from a low of 27 to a high of 330 in 1994. The number of bull trout counted in the Metolius River basin suggest that the population is fit and robust enough to prevent excessive inbreeding (Buchanan et al., 1997).

Population Status—Past and Present

Bull trout were historically found throughout most of the Deschutes River basin (Ratliff et al., 1996). A major Native American and pioneer fishery occurred in the upper Deschutes River at Pringle Falls. Bull trout populations upstream of Big Falls (RK 212) were apparently isolated from populations in the lower river. Historical, adfluvial populations were also present in the Blue/Suttle lake complex, Crescent Lake, and Davis Lake. The last bull trout were observed in Crane Prairie Reservoir in 1955, in Wickiup Reservoir in 1957, and in Crescent Lake in 1959. The last bull trout in the Deschutes River above Bend were observed in 1954. There may have been separate populations in Fall River and Tumalo Creek, but spawning was not documented in these systems, and bull trout can no longer be found in either stream (Buchanan et al., 1997).

Dam constructions have further isolated bull trout populations in the lower Deschutes River basin. Round Butte Dam, built in 1964, isolated the Metolius River populations from those in Shitike Creek and the Warm Springs River. Bull trout are no longer found in Trout Creek.

The Blue Lake-Link Creek-Suttle Lake bull trout group (Metolius subbasin) has been extirpated probably by overharvest.

By the 1950s, the Crooked River basin had been degraded due to severe water withdrawal and radically altered riparian areas. Wandering subadult and adult bull trout, likely from the Metolius system, were occasionally caught in the Crooked River as far up as the city of Prineville (RK 77) through the early 1980s. The enlargement of the Opal Springs Diversion Dam in 1983 on the lower Crooked River created an upstream barrier to bull trout and other fish species (Buchanan et al., 1997).

Current bull trout distribution in the Deschutes River basin includes an adfluvial population isolated in Odell Lake in the upper basin. Bull trout inhabit most riverine habitats in the Metolius subbasin except Lake Creek, Link Creek, and Suttle and Blue lakes. The Metolius River, Lake Billy Chinook Reservoir (LBC), the Deschutes River above LBC upstream to Steelhead Falls, and the lower part of the Crooked River up to Opal Springs Dam also support bull trout. In the lower Deschutes River, bull trout are found above Sherars Falls, Shitike Creek, and the Warm Springs River. In 19 years of operation of a steeppass trap at Sherars Falls, no bull trout have been captured (Buchanan et al., 1997) indicating that bull trout have been extirpated from the lower Deschutes River downstream of Sherars Falls.

Ratliff and Howell (1992) first reported the status of bull trout in the Deschutes River basin. They listed six populations with the upper Deschutes River and Crescent Lake populations as *probably extinct*. The Odell Lake population was listed as *high risk* of extinction and the Warm Springs River was listed as having a *moderate risk*. The Metolius River and Shitike Creek populations were listed as having only a *low risk* of extinction. Buchanan et al. (1997) identified the same six populations for the basin with no status change for the Upper Deschutes River, Crescent Lake, Odell Lake, Warm Springs River, and the Metolius River. However, Shitike Creek has been downgraded to a *moderate risk* because recent surveys found brook trout in the system, and the bull trout redd counts are low.

Current Environmental Conditions

Isolation of upper basin bull trout populations probably occurred upon completion of the irrigation storage dams including Crane Prairie Dam (1922), Crescent Lake (1928), and Wickiup Dam (1947). All of these dams were without fish passage facilities and blocked access for adult bull trout migrating to the upper Deschutes River spawning areas (Buchanan et al., 1997). Hydropower dams constructed and operated by private companies have further isolated populations of bull trout in the lower Deschutes River basin. Round Butte Dam, constructed in 1964, and the subsequent abandonment of downstream passage facilities in 1968, isolated the Metolius River bull trout populations from those downstream populations in Shitike Creek and the Warm Springs River.

Increased water temperatures, altered stream flows, inundation of rearing areas, blockage of adult spawning areas, competition with non-native trout, and overharvest eliminated remnant bull trout populations in the Deschutes River above Big Falls during the 1950s.

John Day River

Habitat Requirements

The John Day River, situated in northeast Oregon, drains nearly 13,033 sq km of an extensive interior plateau lying between the Cascade Range and the Blue Mountains. It is the fourth largest river basin in Oregon. The John Day River is the largest Columbia River tributary that has no major dams or reservoirs that block fish migration. Elevations range from about 61 m at the confluence of the John Day River with the Columbia River (John Day pool) up to 2,745 m in the Strawberry Range (OWRD, 1986).

Coniferous forests and meadows are prevalent above 1,220 m. Some irrigated agriculture takes place in the canyon bottoms, but dryland farming and livestock grazing are the most prevalent agricultural activities in the basin.

Population Status—Past and Present

Bull trout were historically found throughout much of the upper John Day River basin. Local anglers caught bull trout in the Middle Fork John Day River and tributaries from Indian, Butte, Vinegar, Big Boulder creeks and the Middle Fork itself from Big Creek to Phipps Meadow. Old-time anglers report larger bull trout up to a meter long caught throughout the North Fork John Day. Water diversion trap records indicated bull trout were captured in Pine, Dixie, Dad's, Beech, and Laycock creeks in the late 1950s and throughout the 1960s.

The limited data collected to date suggests that populations of bull trout in the John Day River basin are fragmented with extremely low numbers. Small bull trout populations are currently found in the upper mainstem John Day and in Indian, Deardorff, Reynolds, Rail, Roberts, and Call creeks. In the Middle Fork John Day subbasin, small populations of bull trout have been found scattered in upper Clear Creek, Big Creek, and Granite Boulder Creek. Bull trout migration from these headwater streams into the lower Middle Fork John Day River during the summer months is unlikely due to serious temperature increases, poor habitat conditions, and irrigation withdrawals. Bull trout distribution in the North Fork John Day River include the mainstem above Gutridge, Clear, Crane, Desolation, South Fork Desolation, Baldy, Trail, Crayfish, Cunningham, Onion, and Boulder creeks.

Ratliff and Howell (1992) first reported the status of bull trout in the John Day River basin. They rated the upper mainstem John Day River population as having a *moderate risk of extinction*. This status has not changed (Buchanan et al., 1997). They rated the Middle Fork subbasin as *probably extinct* for the upper Middle Fork John Day and *high risk* for Granite Boulder Creek and Big Creek. These assessments remain unchanged but a new *high risk* population has recently been found in Clear Creek (Buchanan et al., 1997). The North Fork John Day River populations have been downgraded from *of special concern* to a *moderate risk* of extinction. This status downgrade for the North Fork John Day River population is due to recent biological surveys and documentation of interactions and hybridization between non-native brook trout and native bull trout.

Current Environmental Conditions

Basins in eastern Oregon like the John Day basin naturally experience relatively higher stream temperatures as a result of the arid climate and clear sunny days. Changes in riparian vegetation, channel widening, or channel shallowing as a result of land and water use activities increase water temperatures.

Loss of riparian habitat and the resulting high water temperatures in much of the mainstem and larger tributaries act as thermal passage barriers during most of the summer and early fall months (Buchanan et al., 1997).

Land use activities commonly practiced in the John Day River basin include livestock grazing on private and public lands, logging, mining, and farming. These activities have reduced riparian vegetation and bank stability, increased sediment, and raised water temperatures in all three of the main subbasins within the John Day River basin (Buchanan et al., 1997).

Umatilla River

Habitat Requirements

The Umatilla River, situated in northeast Oregon, is a tributary to the Columbia River (John Day pool) entering at about RK 440. It drains an area approximately 6,592 sq km. Major tributaries include the North and South Forks, Meacham Creek, Birch Creek, Butter Creek, McKay Creek, and Wildhorse Creek. The Umatilla River originates in the Blue Mountains at elevations up to 1,289 m and descends to an elevation of about 82 m at the confluence with the Columbia River.

Generally, bull trout are restricted to the mainstem Umatilla River and tributaries found in the upper watersheds of the basin. The North Fork Umatilla River wilderness area is the primary area where bull trout spawn and rear.

Population Status—Past and Present

Earliest known documentation of bull trout in the Umatilla River basin is from ODFW creel reports from 1963. Bull trout were still being caught occasionally near Pendleton as late as 1988. Bull trout likely existed in Woodward, Bear, Bobsled, and Squaw creeks, as well as the McKay and Birch creek drainages. This has been hypothesized based on the presence of available habitat at suitable elevations in these drainages, compared to areas where bull trout are currently found (Buchanan et al., 1997).

Currently, bull trout are found in the mainstem Umatilla River and several tributaries upstream from Thorn Hollow (RK 110) at elevations above 500 m. Spawning and rearing occurs in the North and South forks of the Umatilla River, and in the North Fork Meacham Creek. Rearing and migration activities occur in Squaw Creek, Ryan Creek, North Fork Umatilla River, Coyote Creek, Shimmiehorn Creek, and Meacham Creek. A single bull trout was captured at the adult fish trapping facility at Three Mile Falls Diversion Dam on the lower Umatilla River (RK 6) on June 26, 1996. This was the first recorded capture of a bull trout at that facility since at least 1973. Sightings of bull trout in this area prior to 1973 have not been documented. A population estimate for the Umatilla River bull trout is not available at this time (Buchanan et al., 1997).

Ratliff and Howell (1992) first reported the status of bull trout in the Umatilla River basin and recognized two populations (North Fork and South Fork). At that time, the North Fork population was rated at *low risk of extinction* based on the available data. The South Fork Umatilla River bull trout population was rated *of special concern* due to habitat degradation. Buchanan et al. (1997) downgraded the North Fork Umatilla River population to *of special concern* and downgraded the South Fork Umatilla River population to *high risk* based upon additional field studies. The Meacham Creek population has been added and rated at *high risk* based on available data.

Current Environmental Conditions

Agriculture activities dominate the landuse pattern in the basin including timber harvest, dryland and irrigated farming, and livestock grazing. Irrigation and hydroelectric development and overharvest have been cited in the decline of anadromous fish populations in the Umatilla

River (OWRD, 1988). Three Mile Falls Diversion Dam constructed in 1914 and McKay Creek Dam constructed in 1927 are barriers to bull trout as well as to the anadromous species.

The mainstem Umatilla River is artificially confined for much of its length between high terraces constructed for roads, railroads, and dikes (Contor et al., 1995). The Umatilla River below Meacham Creek and the lower 16 km of Meacham Creek were chemically treated to control non-game fish during the summer of 1967 (Smith, 1973). No bull trout were observed during this treatment and it is most likely that the habitat was inhospitable for bull trout prior to the treatment projects (Buchanan et al., 1997).

Historic land uses affecting bull trout habitat in the Umatilla River include timber harvest, grazing, and irrigated agriculture. Channels have been modified for flood control purposes. Overharvest and competition with stocked hatchery rainbows have also affected bull trout populations. Loss of habitat from water withdrawal, increased water temperatures, lack of large wood, and sedimentation continue to impact aquatic resources in the Umatilla basin (Buchanan et al., 1997).

2.2 Kootenai River White Sturgeon

A Biological Assessment was prepared under previous consultation for the Kootenai River white sturgeon in 1995. The operating agencies have operated the FCRPS, especially Libby Dam, according to the subsequent 1995 Biological Opinion on effects of operation of the FCRPS on Kootenai River white sturgeon (Dwyer, 1995).

The Kootenai River white sturgeon is genetically distinct (Setter and Brannon, 1990) from other white sturgeon. It is not anadromous, as lower Columbia River white sturgeon are. It has been isolated from other populations above Bonnington Falls in what is now British Columbia, for the last 10,000 years, since the last glacial age (Northcote, 1973).

It was listed as endangered in 1994 because of evidence of lack of recruitment of juveniles to the population (USFWS, 1994b). A healthy population of fish will exhibit an age class distribution skewed toward juveniles, and tapering off as mortality claims older individuals over time. Apperson and Anders (1991) compared the Kootenai population of white sturgeon with that of the lower Columbia, and contrasted their age distributions, showing that a gap existed for the Kootenai population where the Columbia population showed a healthy juvenile distribution.

The final rule to list Kootenai River white sturgeon as endangered (USFWS, 1994b) includes a comprehensive set of information on habitat use, population status and current environmental conditions for the sturgeon, and is incorporated by reference. The following provides clarification or additions to that information, however.

Habitat Requirements and Biology

The Kootenai River population of white sturgeon lives in Kootenay Lake in British Columbia, and in the Kootenai River, in Idaho and Montana. Spawning migrations up the

Kootenai into the area near Bonners Ferry, Idaho, occur in the spring as snowmelt at lower elevations raises flows in the Kootenai. Spawning takes place in May and June as water temperatures rise above 7-8^{o} C (45-46^{o} F), and also is associated with peaks in the hydrograph (V. Paragamian, IDFG, pers. comm.). Although evidence has indicated spawning upstream of Bonners Ferry in the Kootenai canyon, recent observations have documented spawning in the meandering reach below Bonners Ferry. The canyon is characterized by rocky substrate, whereas the meandering reach has mostly sand and silt substrate. This raises concerns about the egg hatching success, because of the fact that the adhesive eggs become coated with sand when they are released in the meandering reach (see discussion of Kootenay Lake level below).

Population Status—Past and Present

The USFWS (1994b) characterized information on the population status of Kootenai River white sturgeon as follows:

> "Based on a comparison of population estimates made in 1982 and 1990, Kootenai River white sturgeon declined from an estimated 1,194 fish (range of 907 to 1,503) (Partridge 1983) to approximately 880 fish (range of 638 to 1,211) (Apperson and Anders 1991). The Bonneville Power Administration (BPA) (1993), commenting on the proposed rule, believes that the population has further declined in 1993 to an estimated 785 individuals (range 569 to 1,080) based on recent estimates of annual mortality and no natural recruitment since 1990."

A more recent population estimate (V. Paragamian, IDFG, 1998, pers. comm.) was 1,468 adults (95% confidence interval 740-2,197), and 87 wild juveniles. Thus it is not clear that the population has declined since Partridge's (1983) estimate, but the evidence for lack of juvenile recruitment is of concern.

According to the USFWS (1994b):

> "The population is reproductively mature, with few of the remaining white sturgeon younger than 20 years old (Apperson 1992). The Idaho Department of Fish and Game (IDFG) estimates that 7 percent of the female, and 30 percent of the male white sturgeon in the Kootenai River are reproductive each year (Apperson 1992). Based on a 1:1 sex ratio, this translated into 22 to 42 females and 96 to 182 males available to spawn in 1990. The actual number of available spawners is dependent upon size at maturity and spawning frequency. It is not certain at what age reproductive senescence occurs in white sturgeon, although most sturgeon species reproduce in the age brackets of 10 to 20 years for males and 15 to 25 years for females (Doroshov 1993)."

However, Paragamian et al. (1997) estimated the male:female ratio at 1.7:1 for Kootenai River sturgeon adults. Numbers of spawners by gender would also be affected by updated population estimates. If the adult population is 1,468, then 544 would be females and 924 would be males. Male spawners in a given year would number 277, and female spawners would number 38.

Little recruitment has occurred since 1974, and it was intermittent since the 1960s (Partridge, 1983; Apperson and Anders, 1991). Partridge (1983) attributed this in part to loss of rearing habitat and an increase in contaminants which might have impacted reproductive success.

Current Environmental Conditions

The USFWS (1994b) identified several significant factors affecting the survival of Kootenai River white sturgeon. Primary among those is the modification of the hydrograph, especially in spring and summer, by Libby Dam, as a result of refill operations. This is believed to affect reproductive success. For this reason, experimental flow enhancements above normal refill releases have been provided experimentally since 1992, and spawning has been documented each year. There were also higher flows provided in 1990 and 1991, though 1990 high flows were a result of higher-than-average snowpack. High runoff also occurred in 1997. However, little documented recruitment of juveniles beyond age 1 has occurred, and there has been almost no success in sampling age 0 fish (only 2 larvae have been captured).

The USFWS believes load-factoring (power peaking) adversely affects sturgeon reproductive behavior, and may also reduce success by dewatering habitat important to early life-history stages (primarily shallower habitat where eggs may deposit or fry may be found).

Another factor identified by the USFWS is loss of side-channel habitat as a result of diking and bank protection to protect of agricultural land. Partridge (1983) considered these side-channel areas important for sturgeon juveniles and their food organisms.

It has also been suggested (R. Lauzier, Canada Dept. of Fisheries and Oceans, pers. comm.) that Kootenay Lake levels may be at least partially responsible for lack of reproductive success. Since 1972, the annual peak elevation of Kootenay Lake has been held to levels about 2 m lower than prior, under the operation of Corra Linn Dam. The lake backs up in the Pend Oreille River to about Bonners Ferry, Idaho, when full. Sturgeon have been spawning there instead of upriver in the Kootenai River canyon. A hypothesis to explain this fact is that at reduced peak pool elevations, velocities below Bonners Ferry increase to a point sufficient to induce sturgeon to spawn. The disadvantage in use of the reach below Bonners Ferry is that the substrate there consists of sand and silt, which coats the adhesive surface of the sturgeon eggs when they settle to the bottom. This is thought to hinder their survival and hatching success. Furthermore, the fine substrate materials afford no shelter to the larvae and early fry. If sturgeon spawned in the canyon, the eggs would be released over rock and gravel substrate, to which they would adhere, and among which the larvae could take refuge from predators or other adverse conditions. Property owners around Kootenay Lake have built structures at lower elevations; they would be damaged if the lake level were allowed to be raised to test the hypothesis, so lake regulators have not yet aquiesced to any experimentally changed operation (G. Ennis, Canada Dept. of Fisheries and Oceans, pers. comm.)

Although any harvest of Kootenai River white sturgeon is currently illegal in British Columbia, Idaho and Montana, there may still be poaching occurring (USFWS, 1994b). For instance, a setline was observed in the Kootenai upstream of Bonners Ferry after harvest was outlawed (J. Laufle, USACE, pers. obs.). The effect of this is unknown. In addition, sanctioned harvest of adult sturgeon occurs for broodstocking the Kootenai Tribe of Idaho’s Kootenai River hatchery, where supplementation aquaculture is taking place. This is permitted under an extensively reviewed program by the USFWS and is not felt to be a risk to the population (USACE, 1994b, 1996).

Disease is potentially a factor but is felt by the USFWS (1994b) as probably not applicable. The possibility does exist for a disease outbreak at the Kootenai River hatchery, and discussions of a backup ("failsafe") rearing hatchery have included extensive consideration of disease potential.

Predation is felt to be a possibility as a significant factor in early recruitment success (C. Walters, Univ. of British Columbia, 1997, pers. comm.). It may explain lack of evidence of hatching or of age-0 fish. It also may be a factor if high flows help enhance year-classes of sturgeon; the hypothesis is that if predators have more water volume to search, then the likelihood of heavy losses is reduced. More research is needed to support or refute this idea, however.

Other than the ESA listing, regulatory mechanisms which are currently in place include a State of Idaho classification of the Kootenai River white sturgeon as endangered, and Montana's classification of the sturgeon as a Species of Special Concern. However, these mechanisms do little other than restrict harvest (USFWS, 1994b). The Corps operates Libby Dam under its authority, the Flood Control Act of 1950 (Public Law 81-516), and may also treat fish and wildlife as a project purpose. This, as well as the Biological Opinion for sturgeon (USFWS, 1995a), has resulted in enhanced spring flows for sturgeon spawning.

Daley et al. (1981) documented loss of nutrients from the Kootenai River and Kootenay Lake as a result of trapping in Lake Koocanusa. The USFWS (1994b) listed potential effects on the sturgeon including decreased food organism availability, decreased condition factor (possibly affecting fecundity and reproduction, and possible reduction in overall carrying capacity of the Kootenai system. The British Columbia Ministry of Environment, Lands and Parks has been conducting experimental nutrient releases in Kootenay Lake to attempt to boost productivity (Ashley and Thompson, 1993), and studies have been conducted in the Kootenai River (Snyder and Minshall,).

Contaminants (organochlorines, metals including copper and zinc) have been identified as a possible source of concern relating to spawning and hatching success (Apperson, 1992), but no conclusions have yet been reached implicating them as a problem.

Since 1992, the USACE, in cooperation with BPA, the USFWS, and other interested state and tribal entities, has provided experimentally elevated flows from Libby Dam in springtime in order to provide cues for the sturgeon to stage and spawn. The results have been documented each year since then (Apperson, 1992; Apperson and Wakkinen, 1993; Anders, 1994; Marcuson, 1994; Marcuson et al., 1995; Paragamian et al., 1995; USFWS, 1997). Figure 2.2-1 depicts an example operation, from 1995, showing the flow provisions and water temperatures. Spawning has occurred during these operations, as evidenced by eggs on sampling mats. Other methods have not been fruitful as they have in the Columbia, nor have the sampling mats shown the same rates of capture as in the Columbia. Environmental factors may be responsible, but it is also evidence that eggs are not as dense in the Kootenai as in the lower Columbia (Fredericks and Fleck, 1995). Since the Kootenai is a smaller river, this is of concern. Furthermore, very little evidence of age 0 fish has emerged from sampling. A handful of wild fish age 2 or older have been captured in gillnets, but the overall evidence so far points to some limitation at the egg or age-0 life stage which is not being addressed by experimental flows (at least as so far provided).

Figure 2.2-1. Kootenai River flows and temperatures in 1995. Sturgeon spawning dates are shown as diamonds on the horizontal axis.

3.0 Current Operation of the FCRPS

Every year the regulation of the Federal Columbia River Power system is unique in the details but similar in seasonal characteristics. The storage projects (Libby, Dworshak, Hungry Horse, Grand Coulee, and Albeni Falls) draft in the winter and make space available to capture spring runoff so that flooding is minimized. The run-of-river projects (Chief Joseph, McNary, The Dalles, Bonneville, Lower Granite, Lower Monumental, Little Goose, and Ice Harbor) operate within a small elevation range by essentially passing inflow. John Day is somewhat of a hybrid, storing water when necessary to limit flooding on the lower Columbia River, but mostly operating within a limited elevation range like a run-of-river project. Winter snow begins to melt in April, and storage reservoirs begin to refill while attempting to meet downstream flow objectives established through consultation under the Endangered Species Act. The Biological Opinions on Snake River salmon (NMFS, 1995, 1998), Kootenai River white sturgeon (Dwyer, 1995), and Columbia/Snake River steelhead (NMFS,1998) have outlined various flow regimes and operational guidelines necessary to avoid jeopardy to the various endangered species. Reservoir operations are guided by recommendations of the Technical Management Team (TMT) consisting of representatives from the federal operating agencies as well as federal, state, and tribal fisheries experts. By mid-summer the storage reservoirs fill to their highest elevations. The storage reservoirs are then drafted again in July and August to meet summer fisheries objectives in the Snake and lower Columbia Rivers. By September, endangered species operations have generally finished. The storage reservoirs begin their seasonal drafts and prepare for the next flood season.

The following sections describe the proposed operation of the FCRPS in more detail.

3.1 Proposed Operation of the FCRPS

The operations described below are proposed for the bull trout and sturgeon. These operations also support recovery of ESA-listed species as outlined in the NMFS' and USFWS' 1995 Biological Opinions and the 1998 Supplemental Biological Opinion. Further, they are consistent with the Juvenile Fish Transportation Program contained in the Section 10 permit issued to the Corps for that activity by NMFS.

Flow Objectives

The FCRPS will be operated in an attempt to meet flow objectives identified for Snake River salmon stocks, Snake and Columbia River steelhead stocks, and the Kootenai River white sturgeon. At this time, no specific flow objectives have been identified for bull trout.

Salmon and Steelhead

For the Snake River salmon and steelhead, the seasonal average flow objectives range from 85 to 100 kcfs from April 3 to June 20 and 50 to 55 kcfs from June 21 to August 31 in the lower Snake River, measured at Lower Granite, and 220 to 260 kcfs from April 20 to June 30 and 200 kcfs from July 1 to August 31 in the lower Columbia River measured at McNary. The flow objective in any year would be determined using a sliding scale based on forecasted runoff as specified in the 1995 Biological Opinion.

For the Upper Columbia steelhead, the seasonal average flow objective is 135 kcfs from April 10 to June 30 measured at Priest Rapids.

Sturgeon

Since the issuance of the Biological Opinion for the Kootenai River white sturgeon in 1995, flow objectives for sturgeon have been modified through annual written requests from USFWS. The proposed action for sturgeon reflects the Action Agencies' understanding of the sturgeon flow objectives from the latest version of the 1996 draft recovery plan (Table 3.1-1). The table has a sliding scale based on runoff forecasts. Through adaptive management, releases from Libby would be shaped based on water temperature, sturgeon movement and water availability similar to the guidelines USFWS provides each year. Since 1995, USFWS has requested flows be shaped to provide temperature-triggered minimum flows (meaning generally 15 kcfs) at Bonners Ferry starting in April, followed by up to three peak releases dependent upon river temperatures, and then an incubation flow at Bonners Ferry.

Table 3.1-1. Expected minimum Kootenai River flow objectives (kcfs) at Bonners Ferry based on Kootenai Integrated Rule Curve/Tiered Flow Approach.

	0≤ FC<4.80 Maf	**4.80≤ FC <6.00 Maf**	**6.00≤ FC <6.70 Maf**	**6.70≤ FC <8.10 Maf**	**8.10≤ FC <8.90 Maf**	**8.90< FC Maf**
1-May *	4.00	4.00	4.00	4.00	4.00	4.00
15-May	4.00	7.61	9.42	13.48	20.26	24.77
1-June	4.00	12.00	16.00	25.00	40.00	50.00
30-June	4.00	12.00	16.00	25.00	40.00	50.00
15-July	4.00	8.13	10.19	14.84	22.58	27.74
31-July *	4.00	4.00	4.00	4.00	4.00	4.00
The number of years, out of 61, which the observed volume falls within each category.						
Apr-Aug	12	13	12	16	6	2

FC = April – August Volume Forecast at Libby

* = Release from Libby which may be increased in May if required for flood control and July for salmon.

For purposes of this Biological Assessment, the results of hydroregulation modeling assumed that the flow objectives were for the dates specified. For periods between the dates, flows were estimated assuming a linear relationship as illustrated in the 1996 draft Recovery Plan Figure 10. For example, for the first runoff period of less than 4.80 MAF, flow objectives were increased 0.13 kcfs per day from May 1st to May 15th. The Action Agencies have also modeled the proposed flow objectives assuming the flow objectives remained unchanged for the periods in between the dates. In this case, flow objectives would remain 4 kcfs from May 1 to May 14. Further refinement of the assumptions of the table will be accomplished during consultation. Revisions in the hydroregulation modeling may be required to reflect final selection of a proposed operation for sturgeon.

Project Operations

Specific project operations to support the above flow objectives are described below.

Libby

Per the 1995 Salmon BiOp and the 1998 Supplemental BiOp, Libby Reservoir begins fall drawdown near its August 31 interim draft limit of elevation 2,439', 20' from full. Libby will be drafted from September to December to be on or near the end of December flood control elevation 2,411. Starting in January, Libby will be on minimum releases except for flood control, IJC at Kootenay Lake or power emergencies in an attempt to achieve a 75% confidence of being on upper flood control rule curve by April 10th. In April to July, Libby will be operated in an attempt to meet sturgeon flow requests consistent with existing treaties/laws. If at the conclusion of sturgeon operation, Lake Koocanusa is above elevation 2,439, flows may be provided to meet salmon flow objectives, without spilling, down to a reservoir elevation of 2,439 by August 31. Since no other Federal project can provide the requested sturgeon flows, the priority at Libby will be to operate to attempt to meet sturgeon flow objectives first and then salmon flow objectives.

In an effort to minimize flow fluctuations for the benefit of bull trout after the sturgeon operation due to releases for salmon, the estimated volume of water down to elevation 2,439 would be released in a constant amount from the start of the incubation flows until August 31. This release would be in addition to inflow.

General Ramping Rate Guidelines. Changes in ramping rates for Libby between April and August are proposed. The project would be operated in an attempt to meet the ramping rates except for flood control, or power and project emergencies.

The proposed guidelines were developed to minimize the adverse biologic impacts of power operations in the Kootenai River downstream during April through August months. Rapid dewatering of the river channel can strand juvenile fish and aquatic insects. The amount of fish and insect habitat dramatically decreases at flows below 10,000 cfs. River operations that routinely water and dewater the zone below 10,000 cfs should be avoided. Evidence suggests that after 10 days, aquatic insects have begun to colonize newly wetted areas; therefore it is important to bring the river down slowly after it has been high for long periods. A consequential benefit of these guidelines will be a decrease in river bank sloughing and an increase in levee stability downstream.

The following describes the proposed guidelines.

Flow Increases. During April, tailwater increases are limited to no more than 1 foot an hour and 6 feet per 24 hours. From May to August, tailwater increases are limited to no more than is 1 foot per hour and 4 feet per 24 hours.

Flow Decreases. During the April to August months, if the lowest instantaneous discharge from Libby Dam during the previous 10 days was 15,000 cfs or more, then discharges may be decreased by up to 5,000 cfs/day or to 12,000 cfs, which ever provides the lesser reduction in discharge. For example, if the discharges are 18,000 cfs, then flows could be reduced to 13,000 cfs, a reduction of 5,000 cfs. For flows of 16,000 cfs, flow could be reduced to only 12,000 cfs, a reduction of 4,000 cfs.

If the lowest instantaneous discharge from Libby Dam during the previous 10 days was between 15,000 cfs and 10,000 cfs, then the discharge may be reduced by up to 3,000 cfs per day, or to 9,000 cfs, which ever provides the lesser reduction in discharge.

After the instantaneous discharge drops below the 10,000 cfs threshold, the discharge may be reduced by no more than 1,000 cfs per day.

All flow decreases (i.e. 5,000 cfs, 3,000 cfs and 1,000 cfs) reductions are objectives and will be dependent upon head and safe unit loadings. In addition, once the decision is to drop flows over consecutive days, then the flow decreases will be based on the previous day, and not the previous 10 days. For example, if the lowest instantaneous discharge was 17,000 cfs during the previous 10 days, then flows could be reduced to 12,000 cfs, then to 9,000 on the second day and 8,000 cfs on the third day.

As a general rule, decreases in discharge shall be limited to no more than 1 foot per hour. Whenever practical, tailwater decreases should be less than 1 foot per hour and be spread throughout the day to minimize stranding impacts and riverbank sloughing downstream.

Power Peaking Guidelines. During the April to August months, no daily power peaking will be allowed. Weekly power peaking is permitted above a minimum discharge of 10,000 cfs, except during the period specifically set aside for white sturgeon spawning and incubation.

Exceptions. Ramping rates can be modified at the discretion of the Corps of Engineers during flood events, power emergencies, and in the interest of public safety.

Revised Flood Control Operations. A revised flood control operation called VARQ is currently being evaluated. Additional work is being done to evaluate the effects on system flood control and Grand Coulee operations as well as hydropower production, fish and wildlife resources and other factors. At this time, the Action Agencies do not propose to include VARQ as part of the proposed action, but will continue their evaluation of VARQ.

Additional Flow Capacity. The USFWS has requested in the 1995 Sturgeon BiOp that the Action Agencies explore means to provide more flows at Libby for sturgeon operations. Additional flow capacity at Libby could be achieved by installing flow deflectors and/or completing installation of one or more additional units in the skeleton bays 6-8. At this time, there are no Corps funds to study or implement such a measure at Libby, and therefore additional flow capacity is not part of the proposed action.

Hungry Horse

Per the 1995 BiOp and the 1998 Supplemental BiOp, Hungry Horse Reservoir begins fall drawdown near its August 31 interim draft limit of elevation 3,540', 20' from full. It is operated in the fall and winter to maintain a 75% confidence of being at its April 10 flood control elevation. Reclamation determined that the reservoir needs to be above elevation 3521' on December 31 to have the 75% confidence to be at flood control on April 10. Flood control criteria for Hungry Horse are established by the Corps of Engineers. The reservoir is required to not exceed elevation 3,555.7 feet from October 31 through December 31. The requirements for flood control storage from January through June are based on water supply forecasts of the reservoir's inflow. Storage and outflows are managed to attempt to keep flows from exceeding the 14' flood stage at Columbia Falls, about 52,000 cfs. In June, Hungry Horse will be operated to attempt to refill by June 30. From April 10 to August 31, releases will be made to augment flows for anadromous fish. The reservoir will be drafted up to 20' from full by August 31 for this purpose per recommendations of the Technical Management Team.

Hungry Horse releases are made to meet a minimum flow of 145 cfs below the dam and 3,500 cfs at Columbia Falls. There is no formal limit on hourly or daily rates of change in outflow. Informally the project tries to make hourly changes at about 60 MW/hr (approx 1,700 cfs) in the summer per discussions with Montana Fish Wildlife and Parks. Under power emergency conditions the project will increase at rates up to 25MW/min/unit (about 2,800 cfs/minute). Spills are generally avoided unless needed for flood control

Albeni Falls

Albeni Falls will be operated during fall and winter in an attempt to meet a 90 percent level of confidence of being at the April 10 flood control elevation while meeting the project minimum flow and flood control requirements. The Corps intends to operate Albeni Falls so that Lake Pend Oreille is at or above elevation 2,055' during the winter for a three year test (fall 1996 through spring 1999) to evaluate potential reservoir level improvements for kokanee spawning and production consistent with the terms of a stipulation filed in Lake Pend Oreille Idaho Club v. US Army Corps of Engineers. Summer operation would be within the normal summer operating range above elevation 2,062' at Lake Pend Oreille.

The recommendation of the Northwest Power Planning Council's Independent Scientific Review Panel's "Review of the Columbia River Basin Fish and Wildlife Program" dated June 18, 1998, is that the three-year test should be extended for a longer period. Based on the annual review and recommendations from the NPPC, USFWS, state and Tribes, the winter pool elevation of 2,055' may be extended on a yearly basis.

Grand Coulee

Per the 1995 Salmon BiOp and the 1998 Supplemental BiOp, FDR Reservoir will usually be near elevation 1,280' following Labor Day weekend. It is usually refilled to elevation 1,283' or higher by the end of September for resident fish. Fall draft is limited to elevation 1,265' by December 31. The operation from January through April 10 is to ensure an 85% confidence of refill to flood control on April 10 per the Supplemental BiOp and to be consistent with historical operations and studies conducted during ESA consultations. FDR flood control criteria are established by the Corps of Engineers. A minimum space of 500,000 acre feet (about elevation 1,283') may be required starting in January. Additional draft is required based on water supply forecasts for The Dalles with adjustments made for flood space provided upstream of Grand Coulee. The winter draft is generally limited to elevation 1,260', 1,250', and 1,240' in January, February and March, respectively, unless needed for flood control or power emergencies. The Gifford-Inchelium Ferry will need an elevation of 1,225' feet to operate after proposed repairs are completed in 1999. The flood control operation is managed to store in April, May, and June while reducing flooding downstream and refilling by June 30. From April 10 to August 31, releases will be made to augment flows for anadromous fish. The reservoir will be drafted to as low as elevation 1,280' by August 31 for this purpose per the recommendations of the Technical Management Team.

There are daily draft limits at FDR for purposes of reservoir bank stability. The limit between elevation 1,260 and 1,290 feet is 1.5 feet per day, between 1,240 and 1,260 feet is 1.3 feet per day, and below 1,240 is 1 foot per day.

Grand Coulee has a minimum flow requirement of about 30,000 cfs or larger as needed to meet the minimum flows at Priest Rapids Dam. The Priest Rapids minimum flow is the higher of 36,000 cfs or the Vernita Bar flow requirements during the December through May period. The Grand Coulee minimum flow is an average daily flow requirement; instantaneous flows may be less. Grand Coulee also has limits to the hourly rates of change for discharge.

Chief Joseph

Normal reservoir operation throughout the year will be from elevation 950 feet to 956 feet. The only time that this may change is from October 16 through February 14 when the minimum allowable reservoir operating level of 930 feet may be used. This operation will be only for a short duration and only after advance consultation with appropriate entities. From February 15 through October 15 the lower limit will remain 950 feet in order to protect goose nesting, cultural resource sites, irrigation pump intakes, and boat docks, and to avoid creating boating hazards.

Dworshak

Per the 1995 BiOp and the 1998 Supplemental BiOp, Dworshak Reservoir begins fall operation near its August 31 interim draft limit of elevation 1,520', 80' from full. Dworshak will be operated at a minimum discharge of 1.3 kcfs once the reservoir is evacuated to the interim draft level for salmon, or from September through April 3 to enhance the probability of being on the flood control rule curve by April 3 (planning date for flow augmentation), unless higher discharges are required to stay on the flood control rule curve or for emergencies. Dworshak Reservoir will be operated to be no higher than a 1,558-foot maximum elevation on December

15 (winter flood control maximum elevation). From April 3 to August 31, releases will be made to augment flows for anadromous fish. Dworshak may be drafted as low as elevation 1,520' by August 31 to meet salmon flow objectives per the recommendations of the Technical Management Team.

Lower Granite, Little Goose, Lower Monumental, Ice Harbor

Lower Granite, Little Goose, Lower Monumental and Ice Harbor will be operated to be within a one-foot range above MOP from April 3 until adult fall chinook salmon begin entering the lower Snake River as determined by the TMT. Lower Granite would be filled after November 15, or when juvenile fish passage falls off and all four lower Snake projects would be operated within their normal operating range for the remainder of the water year.

Spill and transport will be provided per the 98 BiOp and Corps Record of Consultation and Summary of Decision.

McNary, John Day, The Dalles, Bonneville

During the spring and summer, Bonneville, The Dalles and McNary Reservoirs will be operated in their normal operating range. John Day will be operated within a one-and-a-half foot range above elevation 262.5 without adversely affecting irrigation, from April 20 to September 30 each year, unless additional space is needed for flood control. The pool will be raised if irrigation pumping problems occur. During fall and winter, all four lower Columbia River projects will be operated within their normal operating range, with the exception of temporary flood control at John Day.

Spill and transport will be provided per the 98 BiOp and Corps Record of Consultation and Summary of Decision.

Adaptive Management

The proposed operation would adopt the adaptive management approach. Under this approach, operations may be modified in-season and/or year-to-year based upon new scientific information or to support studies for long-term configuration changes through the RPA 26 framework process of the 1995 Salmon BiOp. The regional forum provides for discussions and procedures to assist in decisions on modifications of measures. A Technical Management Team will make in-season recommendations to the Action Agencies based on runoff conditions, fish migration and other factors. There are also various regional groups within the forum, such as the Implementation Team, where system operations are discussed. The Action Agencies will continue to coordinate through the regional forum with NMFS, USFWS, NPPC, states, and Tribes on different proposed reservoir operations in the regional forum TMT process, and will consider TMT recommendations in making final decisions on the operation of the FCRPS projects. Operations may be modified on a case-by-case basis if recommended by the TMT or Implementation Team. In making adjustments to the operations, the Action Agencies will rely upon existing authority, the information in the NEPA documents, and the evaluation of such new operations.

3.2 Project Descriptions

The following summaries describe the 14 FCRPS operating projects and their general operating criteria.

3.2.1 Libby Dam

General
- Sub-basin: Upper Columbia
- Stream: Kootenai River
- Location: Libby, Montana
- Owner: Corps of Engineers
- Type of Project: Storage
- Authorized Purposes: Flood Control, Power, Recreation
- Other Uses: Fish and Wildlife (USACE, 1984)

Powerhouse
- Number of units.................................5
- Nameplate capacity...........................525 MW
- Overload capacity..............................604 MW
- Normal minimum flow……………..4,000 cfs
- Hydraulic capacity (full pool)…….24,100 cfs
- Rate of change at tailwater:
  1 May-30 Sep….….1 ft/hr…4 ft/24 hrs
  1 Oct-30 Apr….1 ft/1/2 hr…6 ft/24 hrs

Hydrologic Data
- Drainage area = 8,985 sq mi
- Maximum historical peak inflow = 130,000 cfs (1894)
- Lake Elevation
  Maximum pool = 2,459.0 ft
  Minimum pool = 2,287.0 ft
- Usable Storage (2,287.0 to 2,459.0) = 4,979,500 AF

Libby Dam on the Kootenai River in northwest Montana is authorized primarily for flood control and power production, and operated by the US Army Corps of Engineers. Reservoir releases are greatly influenced by endangered species concerns. Operating guidelines for endangered fish populations are specified in the 1995 Biological Opinion for Kootenai River White Sturgeon (Dwyer, 1995), the 1995 Biological Opinion for Snake River Salmon (NMFS,1995), the 1998 Biological Opinion for Columbia/Snake River Steelhead (NMFS, 1998), and annual guidelines from the US Fish and Wildlife Service.

The year begins with the reservoir level near elevation 2411 feet (48 feet from full) on January 1. The elevation for Lake Koocanusa (aka Libby Reservoir) is guided by its flood control storage reservation diagram (Figure 3.2.1-1), and constrained by the International Joint Commission (IJC) 1938 Order on Kootenay Lake. Libby Dam is operated during the winter months to maximize power revenues while the reservoir is being drafted to provide space for spring runoff. Daily and weekly power peaking operations are common.

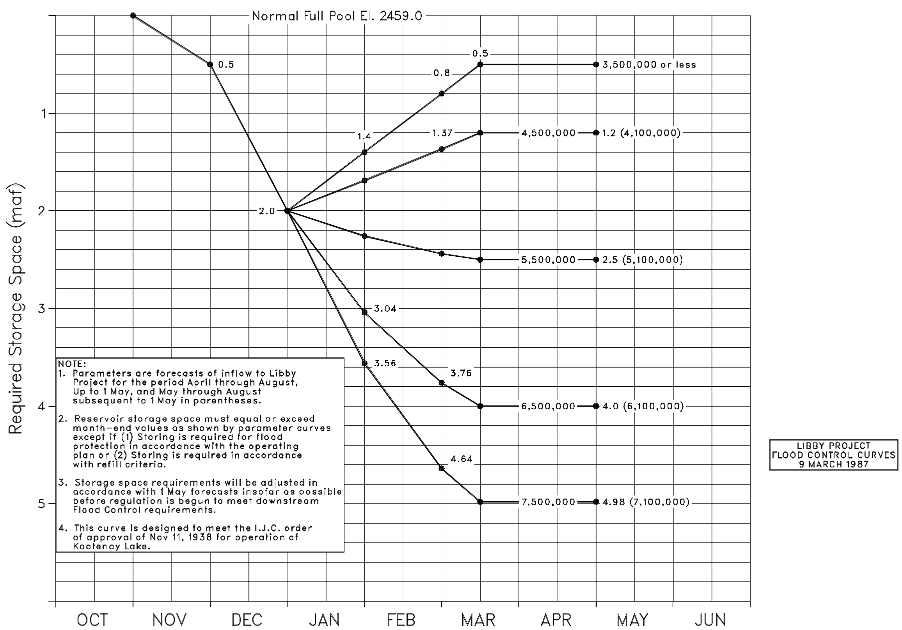

Figure 3.2.1-1. The current storage reservation diagram for Libby Dam (USACE,1991)

Reservoir regulators attempt to draft Lake Koocanusa to its lowest annual elevation by March 15 in anticipation of spring runoff. From April until July, the Corps strives to merge the sometimes conflicting objectives of flood control, and flow augmentation for endangered Kootenai River white sturgeon. Flood control operations take precedence over sturgeon operations, and are focussed on providing system flood control as well as 200 year flood protection from river stages in excess of elevation 1770 feet at Bonners Ferry, Idaho (McGrane, 1996). The Corps has attempted to limit the river elevation at Bonners Ferry to the flood stage of 1764 feet when sufficient space is available in the reservoir, while at the same time allowing the river to rise near flood stage for the benefit of white sturgeon. This has been a difficult balancing act. Libby Dam also provides system flood control benefits to the lower Columbia River.

While the primary guidance for white sturgeon recovery is found in the 1995 Biological Opinion for Kootenai River white sturgeon (sturgeon BiOp) (Dwyer, 1995), the US Fish and Wildlife Service has submitted additional guidelines for Libby Dam operation in 1996, 1997 and 1998. The current white sturgeon operation is a hybrid between that described in the 1995 sturgeon BiOp (ie. flow targets of 35,000 cfs at Bonners Ferry for 42 days followed by 21 days of incubation flows of 11,000 cfs), and the tiered flow regimen (Table 3.2.1-1) described in the 1996 Kootenai River White Sturgeon Draft Recovery Plan (USFWS, 1996).

Table 3.2.1-1. The tiered flow regimen for white sturgeon spawning described in the 1996 Kootenai River White Sturgeon Draft Recovery Plan (USFWS, 1996).

	Runoff Forecast for April-September (million acre-feet)					
	>=9.5	9.49-8.5	8.49-7.08	7.07-6.40	6.39-5.05	<5.04
Date	*Expected Minimum Flows at Bonners Ferry, Idaho (in kcfs)*					
1-Apr	4.00	4.00	4.00	4.00	4.00	4.00
15-May	24.77	20.26	13.48	9.42	7.61	5.81
1-Jun	50.00	40.00	25.00	16.00	12.00	8.00
30-Jun	50.00	40.00	25.00	16.00	12.00	8.00
1-Jul	27.74	22.58	14.84	10.19	8.13	6.06
31-Jul	4.00	4.00	4.00	4.00	4.00	4.00

In general, the current sturgeon flow regimen features at least one “pulse” of maximum powerhouse discharge from Libby Dam for a minimum duration of three days coincident with the peak of the lowland runoff, and targeting water temperatures at Bonners Ferry above 10° C. The pulse (or pulses) is followed by a period of incubation flow in the 11,000 to 25,000 cfs range at Bonners Ferry. The number, magnitude, and duration of the pulses and incubation flows is dependent on water availability, sturgeon movement, and other pending in-season flow requests. The current sturgeon operation represents a form of adaptive management. Due to the uncertain nature of the sturgeon operation from year to year, it was decided to use the tiered flow regimen in the 1996 Kootenai River White Sturgeon Draft Recovery Plan (USFWS, 1996) as the basis of computer simulations for this Biological Assessment.

After the flood threat has passed and the sturgeon operation is completed (usually in early July), an attempt is made to fill Lake Koocanusa to the peak elevation of 2459 feet. This has often meant dropping flows to near the minimum, 4,000 cfs. Computer modeling has shown that operating to the current storage reservation diagrams and the 1995 Biological Opinion would result in an average refill shortfall of 28 feet (McGrane, 1998). Operating to the current storage reservation diagrams and the 1996 Kootenai River White Sturgeon Draft Recovery Plan (USFWS, 1996) would result in an average refill shortfall of nine feet. Either way, the reservoir is within five feet of its highest elevation for only a few weeks before it begins to draft in early August.

Lake Koocanusa is drafted in August to elevation 2439 (20 feet from full pool) to provide flow augmentation for salmon in the Columbia River downstream as stipulated in the 1995 Biological Opinion. This has meant releasing flows in excess of 20,000 cfs at times resulting in a “double peak” in the river down stream. In 1996, 1997, and 1998, water swaps with BC Hydro have allowed Lake Koocanusa to remain higher than elevation 2439 feet in August because an equivalent amount of water was delivered to the confluence of the Kootenay and Columbia Rivers from Arrow Reservoir instead of Lake Koocanusa. This arrangement, known as the “Libby/Arrow swap” has been done strictly at the discretion of BC Hydro, and is not to be considered permanent. Upon completion of the August draft, Libby Dam is again operated to maximize power production, and is drafted back down to the December 31 flood control elevation of 2411 feet. The cycle is then repeated. Figure 3.2.1-2 shows the operation of Libby Dam in 1997, and illustrates the various flood control, power, and fisheries operations.

Figure 3.2.1-2. Libby Dam operation in 1997, illustrating flood control, power, and fish operations.

3.2.2 Hungry Horse Dam

General
- Sub-basin: Upper Columbia
- Stream: South Fork of Flathead River
- Location: Hungry Horse, Montana
- Owner: US Bureau Of Reclamation
- Type of Project: Storage

Powerhouse
- Number of units...................4
- Nameplate capacity...........428,000 kW
- Overload capacity.............none
- Normal minimum flow........ 145 cfs
- Hydraulic capacity (full pool)...11,200 cfs

Hydrologic Data
- Drainage area = 1,654 sq mi
- Maximum historic peak inflow = 68,300 cfs
- Lake Elevation
  - Maximum pool = 3565 ft
  - Full pool = 3560 ft
  - Minimum pool = 3336 ft
- Usable Storage (3336 to 3560) = 2,982,000 AF
- Authorized Purpose: Flood Control, Power
- Other Uses: Fishery, Recreation

Hungry Horse Dam is located on the South Fork Flathead River in northwestern Montana and is authorized primarily for flood control and power production. The project is operated by the US Bureau of Reclamation (USBR). Hungry Horse Reservoir operations are also influenced by downstream ESA species concerns. Operating guidelines for ESA listed Snake River salmon stocks are specified in the 1995 Salmon BiOp on FCRPS operations (NMFS, 1995) and in the 1998 FCRPS supplemental BiOp for ESA listed Columbia/Snake River steelhead runs (NMFS, 1998).

In accordance with the 1995 Salmon BiOp and the 1998 supplemental BiOp, Hungry Horse Reservoir begins fall drawdown near its August 31 interim draft limit of elevation 3540 feet, 20 feet down from full pool. The reservoir is operated in the fall and winter to maintain at least a 75% confidence of being at its flood control rule curve elevation on the planning date of April 10. USBR has determined that the reservoir needs to be above elevation 3521 feet on December 31 to have the 75% confidence to be at flood control on April 20 (NMFS, 1995).

Flood control criteria for Hungry Horse Reservoir are established by the Corps of Engineers (USACE, 1992). The reservoir is required to not exceed elevation 3555.7 feet from October 31 through December 31. The requirements for flood control storage from January through June are based on water supply forecasts of the reservoir's inflow and the flood control rule curve (Figure 3.2.2-1). Storage and outflows are managed to attempt to keep flows from exceeding the 14 foot stage at Columbia Falls, which is about 52,000 cfs. Flood control criteria allow the reservoir to refill some time in June or July depending on the runoff volume forecast.

Figure 3.2.2-1. Flood control rule curve drafting requirements for Hungry Horse Reservoir.

Summer drafts, for Columbia River salmon flow augmentation, are limited to a 20 foot drawdown (3540 feet). The salmon water is released by the end of August. USBR considers recommendations of the TMT (Technical Management Team), Bonneville Power Administration, and the state of Montana in scheduling releases for this draft.

Reservoir releases are made to meet a minimum flow of 145 cfs in the South Fork Flathead below the dam (USBR, 1987). However, releases from the dam must also be sufficient to meet a year round flow of at least 3,500 cfs at Columbia Falls for resident fish needs. There is no formal limit on hourly or daily rates of change in outflow. Informally the project tries to make hourly changes at about 60 MW/hr (approx. 1,700 cfs) in the summer, typically from June 1 to September 30 based on discussions with Montana Fish Wildlife and Parks (USBR, 1992). Outside the summer season the rates of change are limited to the turbine manufacturer's recommended ramping rate of 3 MW/min/unit (about 90 cfs/min/unit, or 360 cfs/min total if all 4 units are available). Under power emergency conditions (as declared by the Bonneville Power Administration) the project can increase at rates up to 25 MW/min/unit (about 750 cfs/min/unit, or 2,800 cfs/minute total if all 4 units are available). Spill is generally avoided unless needed for flood control as releases from the outlet works have been shown to exceed state dissolved gas standards (110%).

A selective withdrawal system was installed to help meet temperature targets in the Flathead River during the summer and fall months. Due to hydraulic constraints, the selective withdrawal system's control gates cannot be stationed closer than 20 feet from the reservoir's water surface. Montana Fish, Wildlife and Parks (Cavigli et al., 1998) has prepared temperature profile recommendations for June 1 through the end of October. The Hungry Horse project operates the selective withdrawal system in an attempt to mimic natural water temperature conditions that result from the unregulated North and Middle forks. An attempt is made to operate to keep water release temperatures between recommended maximum and minimum temperature targets. Figure 3.2.2-2 shows target temperatures and the temperature regimes that were actually achieved in 1996 and 1997 during selective withdrawal operations.

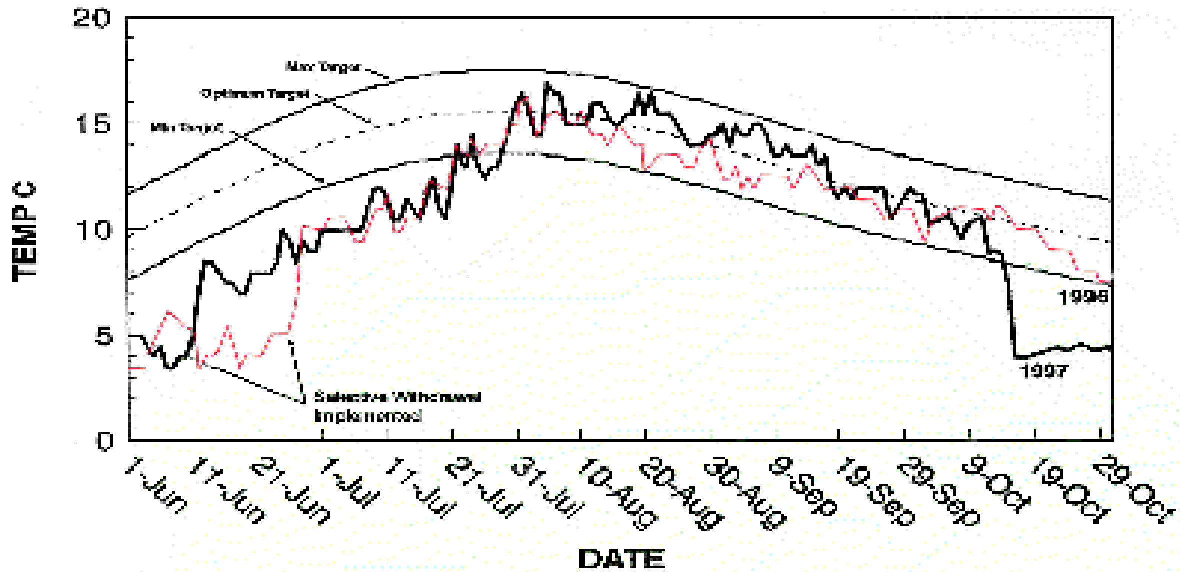

Figure 3.2.2-2. Hungry Horse release water temperature targets and actual outflow temperatures for 1996 and 1997. Targets were not met until July because of high reservoir inflow and delayed stratification.

Although USBR generally does not coordinate operations with Kerr Dam, they do advise Montana Power Company of operational changes at Hungry Horse since they may impact Flathead Lake and Kerr Dam operations. Montana Power Company does occasionally make requests as to the operations of Hungry Horse Dam, and USBR will provide assistance if possible (R. Carter, USBR, 1998, pers. comm.).

3.2.3 Albeni Falls Dam

Project Description

- Sub-basin: Upper Columbia
- Stream: Pend Oreille River
- Location: Newport, Washington
- Owner: Corps of Engineers
- Type of Project: Storage
- Authorized Purposes: Flood Control, Power, Navigation, Recreation

Powerhouse

- Number of generating units....................3
- Nameplate rating................................... 42.0 MW
- Continuous overload..............................48.9 MW
- Short time overload............................... 54.3 MW
- Hydraulic capacity.................................33,000 cfs

Hydrologic Data

- TMT Historical Data Plot
- Drainage area = 24,400 sq mi
- Maximum historical peak discharge = 200,000 cfs (1894)
- Lake Elevation (at Hope)
  Maximum pool = 2,067.5 ft (limit of flowage right-of-way)
  Normal full pool = 2,062.5 ft
  Normal minimum pool = 2,051 ft
- Usable Storage (2,051.0 to 2,062.5) = 1,042,000 AF

Albeni Falls Dam on Lake Pend Oreille in northern Idaho is owned and operated by the US Army Corps of Engineers and is authorized primarily for flood control, power production, and navigation. Lake Pend Oreille is the largest natural lake in Idaho covering 86,000 acres with depths to 1,200 feet. Before the construction of Albeni Falls Dam, the average elevation of Lake Pend Oreille fluctuated between elevation 2,047 feet through the fall and winter to approximately elevation 2,060 feet during the peak of spring runoff. Before the dam, the duration of high summer lake levels was relatively short allowing water tolerant grasses and brush to thrive along the lake shore. The dam raised the elevation of the lake on a year round basis as shown in Figure 3.2.3-1. Albeni Falls Dam stabilized the lake level during the summer months which drowned much of the perennial shoreline vegetation, but generally improved conditions for real estate development and recreation.

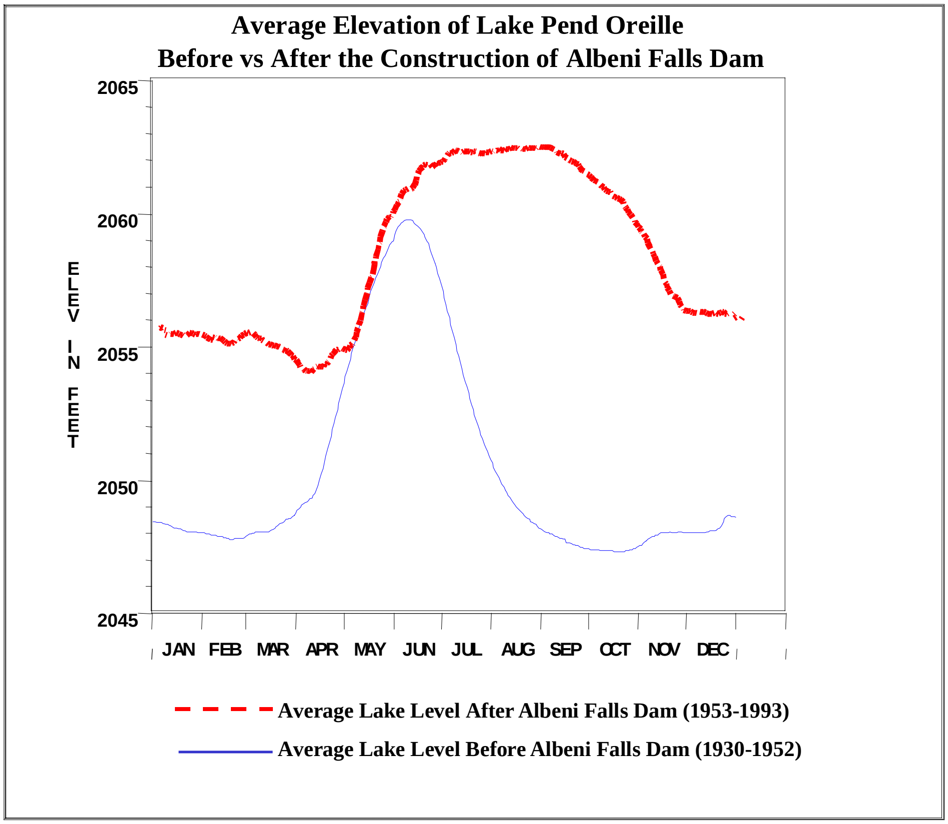

Figure 3.2.3-1. Average lake Levels for Lake Pend Oreille before and after Albeni Falls Dam completion.

Albeni Falls Dam has had little affect on water quality in Lake Pend Oreille. Water temperature in the lake has not significantly changed since the dam was constructed. (USACE, 1998) No substantial changes have been detected in water quality variables such as pH, alkalinity, dissolved oxygen, percent saturation, nutrients, and trophic state (NWPPC, 1996). In 1997, total dissolved gas (TDG) levels were found to be quite high (>130%) in Lake Pend Oreille as the result of spilling from dams on the Clark Fork River during a period of unusually high runoff.(Parametrix, 1997). The effect of these high gas levels is not known. The dam is not a significant source for dissolved gases in the lower river. Eurasian milfoil in the Pend Oreille River downstream of the dam may become a water quality concern as a result of biochemical oxygen demand as a result of decay of dead plants if it expands to a large area. The annual lake drawdown by Albeni Falls Dam has helped minimize the milfoil problem in Lake Pend Oreille.

Albeni Falls Dam is an annual storage project that is refilled during the spring primarily by snowmelt runoff and is drafted each fall to provide water supply for electric generation at downstream hydroelectric projects. The lake's usable storage (1,042,000 acre-feet) is generally filled and evacuated according to the seasonal guidance curve (Figure 3.2.3-2). The lake elevations reflected in the guidance curves show the maximum and minimum allowable lake elevations for each seasonal period. Actual elevations normally range between these two limits during the year.

Figure 3.2.3-2. Seasonal guidance curves for Albeni Falls project (USACE,1998).

Fall Storage Drawdown Period: September-November 20

Beginning immediately after Labor Day, the lake is normally drafted from the summer level (elev. 2,062.0-2,062.5 ft) to within 1.5 ft of the normal minimum pool (elev. 2,05l ft) by November 20th or earlier if possible. In the last few years, additional effort has focused on kokanee spawning conditions, and the drawdown has been scheduled for completion by November 15th whenever possible (streamflows permitting) to provide additional time to stabilize the lake for kokanee spawning in December.

Lake Stabilization Period: November 20-November 30

The lake drawdown is essentially completed by November 20th. The period from November 20th to November 30th is provided to stabilize the lake prior to the kokanee spawning in December. This stabilization period provides time for the kokanee to acclimate to the shoreline spawning habitat, and is part of the mandatory control criteria developed for the kokanee spawning. By controlling the kokanee spawning to a narrow vertical range, damage to kokanee redds due to lake drawdown is limited. A final drawdown no greater than one foot is permitted between November 20th and November 30th, provided the lake is not drafted below elev. 2051 ft at any time.

December Operating Range

The December minimum control elevation for protection of kokanee spawning is no lower than 0.5 ft below the November 30th elevation, and no lower than the minimum lake elev. 2,051 ft. An operating range 0.5 ft above the minimum control elevation is permitted for normal project operation. If unexpected conditions cause the lake to fill above the established operating range during December, a new operating range must be set which is no more than 0.5 ft below the highest level observed. The minimum operating range is observed until the spring runoff occurs.

Winter-Spring Holding Period: January 1-March 31

The lake is operated at or above the December minimum operating range from December until the beginning of the spring runoff. Lake storage above the minimum control level may be used for occasional flood control or unscheduled hydropower operations without resetting the control elevation, provided storage above the maximum rule curve is evacuated by April 1.

April-June Flood Season

Spring snowmelt runoff in the Clark Fork-Pend Oreille basin generally begins in early April with melting of the low elevation snowpack in the valleys and lower foothills. Runoff normally continues to rise during April and May with the peak discharge into the lake occurring during May or June. It is during this period that the lake refills and occasional flood control operations occur at Albeni Falls Dam. About every ten years on the average, floods have filled the lake above maximum regulated lake (elev. 2,062.5 ft) because of the large runoff volume and limited outlet capacity. During large floods that are likely to fill the lake above elev. 2,062.5 ft, the spillway gates are raised and freeflow conditions established to maximize project discharge. As soon as it is determined that the danger of flooding has passed and the lake is nearly full, outflow is controlled to stabilize the lake at the summer level.

Summer Conservation and Recreation Holding Period

Following the annual spring runoff, the lake is maintained between elev. 2,062.0 ft and elev. 2,062.5 ft for optimum recreation.

Operations to Benefit Kokanee Spawning

In fall of 1996, the Corps of Engineers raised the minimum lake operating level for Lake Pend Oreille from elevation 2,051 feet to elevation 2,055 feet to accommodate a study of kokanee spawning habitat by the Idaho Department of Fish and Game. This study was endorsed by the Northwest Power Planning Council (NPPC, 1996). The “higher winter pool” operation is scheduled for three winter seasons, and will be completed in the spring of 1999. It may be extended for a fourth winter in 1999-2000.

3.2.4 Grand Coulee Dam

General
- Sub-basin: Upper Columbia
- Stream: Columbia River
- Location: On Columbia River, 28 miles northeast of Coulee City, Washington
- Owner: US Bureau Of Reclamation
- Type of Project: Storage

Powerhouse (Consisting of Left, Right, Third, and pump generating plant)
- Number of units...................21
- Nameplate capacity...........6,809,000 kW
- Overload capacity.............7,830,000 kW
- Normal minimum flow........ 30,000 cfs or larger as needed to meet minimum requirement at Priest Rapids
- Hydraulic capacity (full pool)...260 kcfs
- Minimum Tailbay elevation is the higher of a, b, or c as defined below:

  a. The average tailbay elevation for the previous 24 hour period minus 11 feet (10 feet if the average exceeds elevation 966 for 5 consecutive days).

  b. The average tailbay elevation for the previous 5 day period minus 11 feet (10 feet if the average exceeds elevation 966 for 5 consecutive days).

  c. Elevation 951 feet.
- Tailbay hourly drawdown limit:

Above 962’	5 ft/hour
962’-957’	4 ft/hour
957’-953’	3 ft/hour
953’-951’	2 ft/hour

Hydrologic Data
- Drainage area = 74,100 sq mi
- Maximum historic peak inflow = 1,230,000 cfs
- Lake Elevation

  Maximum pool = 1290.0 ft

  Full pool = 1290.0 ft

  Minimum pool = 1208.0 ft
- Usable Storage (1208.0 to 1290.0) = 5,185,400 AF
- Authorized Purpose: Flood Control, Power, Irrigation
- Other Uses: Fishery, Recreation

Grand Coulee Dam is located on the mainstem Columbia River in northeast Washington. The project is authorized for flood control, power production and irrigation and is operated by the US Bureau of Reclamation (USBR). Reservoir (Franklin Delano Roosevelt, or FDR, Reservoir) releases are also influenced by downstream ESA listed salmon and steelhead runs. Operating guidelines relating to the listed Snake River salmon runs are specified in the 1995 Salmon BiOp on the Federal Columbia River Power System (FCRPS) operations (NMFS, 1995) and in the 1998 supplemental FCRPS BiOp covering listed Columbia/Snake River steelhead stocks (NMFS, 1998).

In accordance with the 1995 Salmon BiOp (NMFS, 1995) and the 1998 supplemental BiOp (NMFS, 1998), FDR Reservoir will be near elevation 1280 feet following Labor Day weekend. It is usually refilled to elevation 1283 feet or higher by the end of September for resident fish. Fall draft is limited to elevation 1265 feet by December 31 to ensure an 85% confidence of refill to the flood control rule curve on the planning date of April 10 per the supplemental BiOp and to be consistent with previous operations and studies conducted during ESA consultations. FDR flood control criteria are established by the Corps of Engineers (Figure 3.2.4-1). A minimum space of 500,000 AF (about elevation 1283 feet) is required starting in January. Additional draft is required based on water supply forecasts for The Dalles with adjustments made for flood space provided by storage projects upstream of Grand Coulee Dam. The winter draft is generally limited to elevation 1260, 1250 and 1240 in January, February and March respectively unless more is needed for flood control or power emergencies. The Gifford-Inchelium Ferry needs elevation 1225 feet or higher to operate (C. Sprankle, USBR, 1998, pers. comm.).

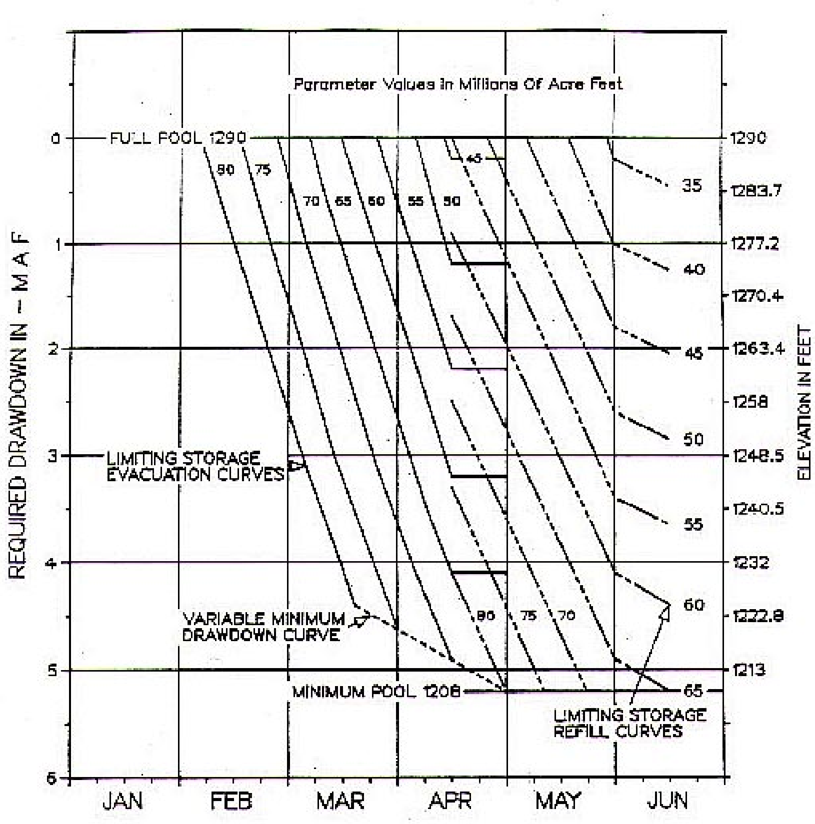

Figure 3.2.4-1. Grand Coulee flood control rule curve drafting requirements.

The reservoir is managed to refill in April, May, and June while reducing flooding downstream. Complete refill is targeted for June 30. FDR Reservoir will generally be drafted in

July and August to as low as elevation 1280 feet for salmon flow augmentation per recommendations of the Technical Management Team and the FCRPS BiOp requirements.

There are daily draft limits at FDR Reservoir for purposes of reservoir bank stability (USBR, 1993). The limit between elevation 1260 and 1290 feet is 1.5 feet per day, between 1240 and 1260 feet is 1.3 feet per day, and below 1240 feet is 1 foot per day. During power emergencies, as declared by Bonneville Power Administration (BPA), draft rates can be as high as 2 feet per day, but only after BPA has clearly demonstrated that all other reasonable actions have been taken to meet the emergency. Aerial inspection of the FDR shoreline is required in these situations.

Grand Coulee Dam has a minimum flow requirement of about 30,000 cfs or larger as needed to meet the minimum flows at Priest Rapids Dam. The Priest Rapids minimum flow is the higher of 36,000 cfs or the Vernita Bar flow requirements. Grand Coulee Dam minimum flow is an average daily flow requirement; instantaneous flows may be less.

Grand Coulee also has limits to the minimum tailbay elevation and hourly tailbay drawdown limits for maintaining stability in the river banks downstream of the dam (USBR, 1995). The allowable minimum tailbay elevation is the higher of a) the average tailbay elevation for the previous 24 hours minus 11 feet; b) the average tailbay elevation for the previous 5 days minus 11 feet; or c) elevation 951 feet. If either the 24 hour average for the 5 day average exceed elevation 966 for 5 consecutive days then 10 feet will be subtracted rather than 11 feet. The tailbay hourly drawdown limit is as follows: 5 ft/hour above 962', 4 ft/hour between 957' and 962', 3 ft/hour between 953' and 957', and 2 ft/hour between 951' and 953'.

Although there are no flow restrictions at Grand Coulee to reduce gas levels, there are priorities of how the water is released. First priority is to generate. If no power is needed then second priority is to operate units speed-no-load. If releases are in excess of the power plant capacity, then the water is released in the following order:

1. Spillway gates - the water is to be released evenly across eleven gates.

2. Outlets - this is the last choice. If water is to be released through the outlets then there are to be releases evenly through upper and lower gates. If only two gates are required then an upper gate and the lower gate immediately below will be used rather than side by side.

3.2.5 Chief Joseph Dam

Project Description

- Sub-basin: Middle Columbia
- Stream: Columbia River
- Location: Bridgeport, Washington
- Owner: Corps of Engineers
- Type of Project: Run-of-river
- Authorized Purposes: Power, Recreation
- Other Uses: Irrigation, Water Quality

Powerhouse

- Number of main units....................27
- Nameplate capacity........................2,069 MW
- Overload capacity..........................2,614 MW
- Hydraulic capacity........................219,000 cfs

Hydrologic Data

- Drainage area = 75,000 sq mi
- Maximum historical peak discharge = 725,000 cfs (1894)
- Maximum rate of change = No limit
- Lake Elevation
  Maximum pool = 958.8 ft
  Full pool = 956.0 ft
  Minimum pool = 930.0 ft
- Reservoir gross capacity (Elev. 946.0) = 518,000 AF

Chief Joseph Dam on the Columbia River near Bridgeport, Washington is operated by the US Army Corps of Engineers. The dam is authorized primarily for power production and irrigation. Chief Joseph Dam is 52 miles downstream of Grand Coulee Dam, and operates as a run-of-river hydropower project, fluctuating less than six feet in elevation over a normal year. Chief Joseph Dam has no fish ladder. Releases from Chief Joseph Dam are generally coordinated with those of Grand Coulee Dam to optimize power revenues.

The elevation of Rufus Woods Reservoir (the reservoir behind Chief Joseph Dam) fluctuates very little throughout the year. The normal operating range is between elevation 950 feet and 956 feet (Figure 3.2.5-1). Although the project was authorized to fluctuate between elevation 930 feet and 956 feet, a plethora of constraints make that nearly impossible. A pool elevation below 950 feet will have adverse consequences because irrigation pump intakes will be dewatered (irrigation season extends primarily between 16 May and 15 October), boat docks will become unusable, boat ramps will require clean-up, and obstructions in the river will cause boating hazards. During the goose nesting season, from 15 February through 15 May, elevation 950 feet at Chief Joseph takes on added importance due to the formation of land bridges to nesting sites. These bridges result in increased predation on young birds. Salmon net pens in Rufus Woods Lake may also need to be relocated if the reservoir is drawn down far below the

normal minimum elevation. Channel bank instability occurs when the Chief Joseph forebay drops below elevation 950 feet. The most acute bank instability takes place in the Elmer City area below Grand Coulee Dam. The U.S. Bureau of Reclamation has standing orders to keep the tailwater elevation below Grand Coulee Dam at or above elevation 951 feet to prevent bank sloughing. The Chief Joseph forebay elevation directly influences the Grand Coulee tailwater gage. Various combinations of Chief Joseph pool elevations and Grand Coulee discharges can produce such a condition where Grand Coulee tailwater drops below 951ft. For these reasons, elevation 950 feet should be considered the year-round normal minimum forebay elevation for Chief Joseph project.
Figure 3.2.5-1. The total discharge and spill from Chief Joseph Dam, and the elevation of Rufus Woods Reservoir in water year 1997 is illustrated.

The greatest water quality concern related to Chief Joseph Dam is total dissolved gas (TDG) levels in both Rufus Woods Reservoir and the Columbia River below the dam. Due to the height of the spillway and the configuration of the stilling basin, TDG levels can top the Washington state water quality standard of 110%. This problem is most acute during the spring and summer when both Grand Coulee and Chief Joseph Dams are spilling water due to high runoff, and insufficient power demand does not allow all inflow to pass through the generating units. To address this issue the Corps of Engineers and the US Bureau of Reclamation are currently investigation ways to minimize TDG production at both dams through structural and operational modifications.

3.2.6 Dworshak Dam

<u>General</u>

- Sub-basin: North Fork Clearwater River
- Stream: North Fork Clearwater River
- Location: Ahsaka, Idaho
- Owner: Corps of Engineers
- Type of project: Storage

<u>Powerhouse</u>

- Number of units: 3
- Nameplate capacity: 400 MW
- Overload capacity: 460 MW
- Normal Minimum Flow: 1,000 cfs
- Hydraulic capacity (full pool): 10,500 cfs
- Rate of change at tailwater: The maximum cfs per hour change results in 1 foot per hour (Peck Gaging Station). During normal operations outflow changes are not to exceed 0.5 ft/half-hour at Peck. Variations occur for flood control, recreation, fish wildlife, and public safety.

<u>Hydrologic</u>

- Drainage area: 2,440 sq mi
- Maximum historical peak inflow: 150,000 cfs
- Lake elevation
  - Maximum pool: 1,604.7 ft
  - Full pool: 1,600.0 ft
  - Minimum pool: 1,445.0 ft
- Usable storage (1,600.0 to 1,445.0): 2,015,800 AF
- Authorized purposes: flood control, power, recreation, navigation, fish and wildlife
- Other uses: water quality

Dworshak Dam is authorized primarily for flood control and power production. The project is operated for fishery, wildlife, water quality, and recreation uses also. Dworshak was constructed by and is operated by the US Army Corps of Engineers, Walla Walla District. Construction of Dworshak Dam began in 1966 and was completed in 1971. The reservoir attained full pool for the first time on July 3, 1973. The dam is 717 feet high. The reservoir is 54 miles long and 2 miles across at full pool. The water surface area is 9,050 acres at minimum pool and 17,090 acres at full pool. When the reservoir is full, it contains 3,468,000 acre-feet of water. Dworshak Dam is located on the North Fork Clearwater River in northwest Idaho.

Dam Operation

There is a multi-level outlet facility which is provided to select the temperature of water discharging through the turbines. The initial operating objectives were to match the temperature of the water in the Clearwater River just above the North Fork and maintain acceptable levels of dissolved oxygen. This type of operation during the initial operation of the project released water that was too warm for Dworshak National Fish Hatchery downstream of the Dam and too warm to cool the powerhouse generators. Therefore, an interim plan was developed in 1974 to provide cooler water for the generators and hatchery. This plan requires 53° F releases whenever possible. The 53° F temperature usually cannot be achieved until early June. However; the selector gates are set for use in May. The gates are used to provide as warm a temperature as possible in November when the reservoir becomes too cool to maintain 53° F.

Figure 3.2.6-1 depicts flow augmentation and water temperature releases from Dworshak Dam from 1997-1998. This graph reflects the approximate output at Dworshak Dam during a typical year (not unusually wet or dry, depending on snow melt). The increased output from late May through July correlates to the flow augmentation period in which additional flow is provided to aid juvenile salmonids as they migrate. In this example year, the increased output in August correlates to the temperature release period in which cooler water from Dworshak Reservoir is released. This additional flow of cooler water lowers the water temperature in the Snake River to improve conditions for salmonids.

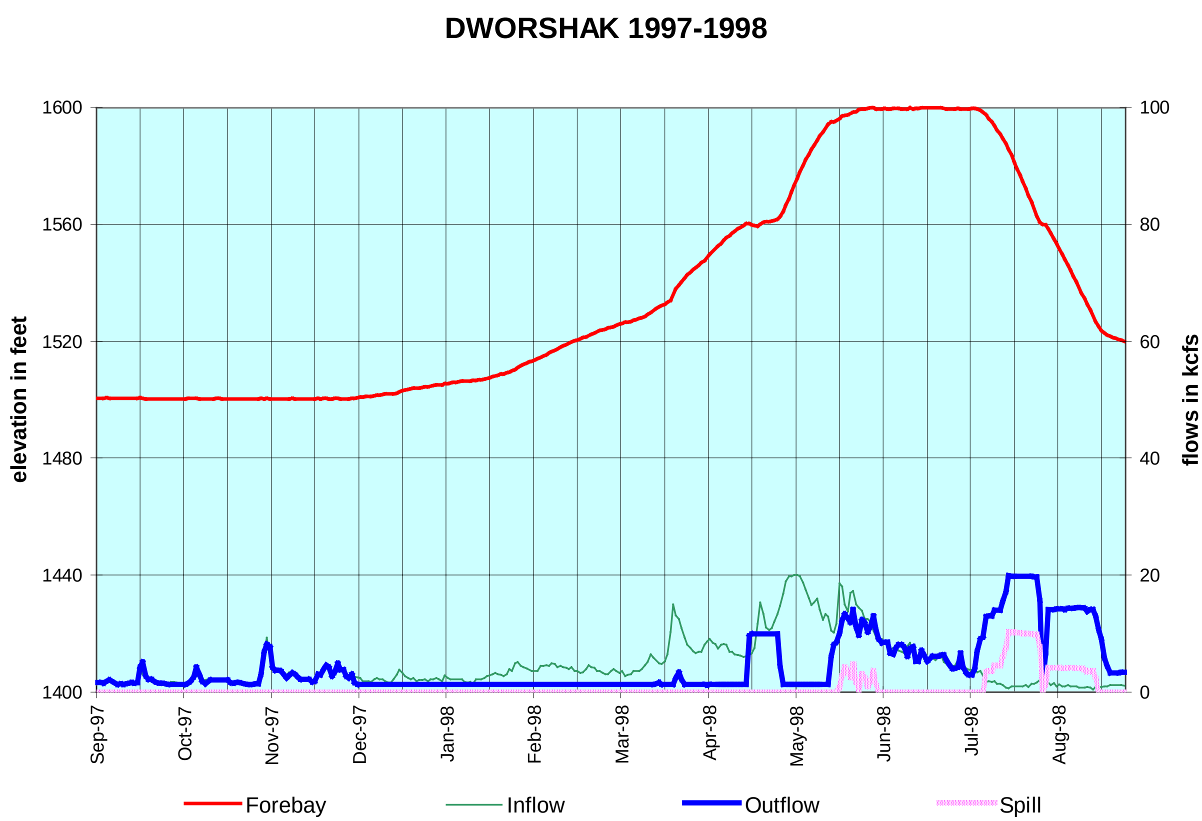

Figure 3.2.6-1. Operation of Dworshak Dam in 1997-1998, showing flow augmentation for salmon outmigration (May-July), and release of cooler temperatures for fish temperature requirements.

It is desirable to draw water only from the top 50 feet of the reservoir from January to April to prevent kokanee loss through the turbines. When reservoir elevations fluctuate between 1600 and 1500 feet it is possible to withdraw water from over the top of the selector gates. Water must be drawn from underneath the gates when the elevation is between 1500 and 1445 feet.

Reservoir releases are greatly influenced by endangered species concerns. Operating guidelines for endangered fish populations are specified in the 1995 Biological Opinion for Snake River Salmon (NMFS,1995), and the 1998 Biological Opinion for Columbia/Snake River Steelhead (NMFS, 1998).

Dworshak will be operated on 1.3 kcfs minimum discharge once the reservoir is evacuated to the interim draft level for salmon, or from September through April to enhance the probability of being on the flood control rule curve by April, unless higher discharges are required to stay on the flood control rule curve or for emergencies. Dworshak Reservoir will be operated to be no higher than a 1,558-foot maximum elevation on December 15 (winter flood control maximum elevation). Dworshak may be drafted as low as elevation 1520 by August 31 to meet salmon flow objectives.

3.2.7 Lower Snake River Dams and Reservoirs, and McNary Dam and Reservoir

Lower Granite Dam and Reservoir

General
- Sub-basin: Lower Snake River
- Stream: Lower Snake River
- Location: RM 107.5 upriver from confluence of Columbia River
- Owner: Corps of Engineers, Walla Walla District
- Type of Project: Run-of-River

Powerhouse
- Number of units.................................6
- Nameplate capacity...........................135 MW
- Overload capacity.............................810 MW
- Normal minimum flow…………….11,500 cfs
- Hydraulic capacity (full pool)…….130,000 cfs
- Rate of change at tailwater………...max 1 ft/hr based on max discharge change

Hydrologic Data
- Drainage area = 103,200 sq mi
- Maximum historical peak inflow = 369,000 cfs (1948)
- Lake Elevation (Lower Granite Lake)
  Maximum pool = 746.5 ft
  Full pool = 738.0 ft
  Minimum pool = 733.0 ft
- Usable Storage = n/a
- Authorized Purposes: Power, nland navigation, recreation, fish and wildlife, irrigation

Little Goose Dam and Reservoir

General

- Sub-basin: Lower Snake River
- Stream: Lower Snake River
- Location: RM 70.3 upriver from confluence with Columbia River
- Owner: Corps of Engineers, Walla Walla District
- Type of Project: Run-of-River

Powerhouse

- Number of units…..............................6
- Nameplate capacity….........................135 MW
- Overload capacity…..........................810 MW
- Normal minimum flow…………….11,500 cfs
- Hydraulic capacity (full pool)…….130,000 cfs
- Rate of change at tailwater………...max 1 ft/hr based on max discharge change

Hydrologic Data

- Drainage area = 103,200 sq mi
- Maximum historical peak inflow = 369,000 cfs (1948)
- Lake Elevation (Lake Bryan)
  Maximum pool = 646.5 ft
  Full pool = 638.0 ft
  Minimum pool = 633.0 ft
- Usable Storage = na
- Authorized Purposes: Power, inland navigation, recreation, fish and wildlife, irrigation

Lower Monumental Dam and Reservoir

General
- Sub-basin: Lower Snake River
- Stream: Lower Snake River
- Location: RM 31.9 upriver of confluence with the Columbia River
- Owner: Corps of Engineers, Walla Walla District
- Type of Project: Run-of-River

Powerhouse
- Number of units.................................3
- Nameplate capacity...........................135 MW
- Overload capacity.............................810 MW
- Normal minimum flow…………….11,500 cfs
- Hydraulic capacity (full pool)…….130,000 cfs
- Rate of change at tailwater:
- The maximum cfs per hour change results in 1 foot per hour change of stage.

Hydrologic Data
- Drainage area = 103,200 sq mi
- Maximum historical peak inflow = 369,000 cfs (1948)
- Lake Elevation (Lake Herbert G. West)
  Maximum pool = 548.0 ft
  Full pool = 540.0 ft
  Minimum pool = 537.0 ft
- Usable Storage = na
- Authorized Purposes: Power, inland navigation, recreation, fish and wildlife, irrigation

Ice Harbor Dam and Reservoir

General

- Sub-basin: Lower Snake River
- Stream: Lower Snake River
- Location: RM 9.7 upriver of confluence with the Columbia River
- Owner: Corps of Engineers, Walla Walla District
- Type of Project: Run-of-River

Powerhouse

- Number of units.................................6
- Nameplate capacity...........................90-111 MW
- Overload capacity............................. 603 MW
- Normal minimum flow…………….11,500 cfs
- Hydraulic capacity (full pool)…….106,000 cfs
- Rate of change at tailwater………...max 1 ft/hr based on max discharge change

Hydrologic Data

- Drainage area = 103,200 sq mi
- Maximum historical peak inflow = 369,000 cfs (1948)
- Lake Elevation (Lake Sacajawea)
  Maximum pool = 446.4 ft
  Full pool = 440.0 ft
  Minimum pool = 437.0 ft
- Usable Storage = N/A
- Authorized Purposes: Power, inland navigation, recreation, fish and wildlife, irrigation

McNary Dam and Reservoir

General
- Sub-basin: Columbia River
- River: Columbia River, RM 292.0
- Location: Umatilla, Oregon; RM 292.0
- Owner: Corps of Engineers, Walla Walla District
- Type of Project: Run-of-River

Powerhouse
- Number of units.................................14
- Nameplate capacity........................... 70 MW
- Overload capacity............................. 14 units @ 80.5 MW = 1,127 MW
- Normal minimum flow……………. 68,400 cfs
- Hydraulic capacity (full pool)……. 230,000 cfs
- Rate of change at tailwater………...max 1 ft/hr based on max discharge change

Hydrologic Data
- Drainage area = 214,000 sq mi
- Maximum historical peak inflow = 1,240,000 cfs (1894)
- Lake Elevation (Lake Wallula)
  Maximum pool = 356.5 ft
  Full pool = 340.0 ft
  Minimum pool = 335.0 ft
- Usable Storage = na
- Authorized Purposes: Power, inland navigation, recreation, fish and wildlife, irrigation
- Other Uses: Water quality

Operation

Lower Granite, Little Goose, Lower Monumental, Ice Harbor

Lower Granite, Little Goose, Lower Monumental and Ice Harbor will be operated to be within a one-foot range above MOP from April 3 until adult fall chinook salmon begin entering the lower Snake River as determined by the TMT. Lower Granite would be filled after November 15 and all four lower Snake projects would be operated within their normal operating range for the remainder of the water year. Spill and transport will be provided per the 98 BiOp and Record of Consultation and Summary of Decision.

McNary

During the spring and summer, McNary Reservoir will be operated in the normal operating range. During fall and winter, all four lower Columbia River projects will be operated within their normal operating range. Spill and transport will be provided per the 98 BiOp and Record of Consultation and Summary of Decision.

3.2.8 Lower Columbia River Projects

John Day Lock and Dam

General

- Subbasin: Lower Columbia
- Stream: Columbia River (R.M. 215.6)
- Location: Rufus, Oregon
- Owner: Corps of Engineers, Portland District
- Type of Project: Storage
- Project Authorization: PL 81-516, 1950

Powerhouse

- Number of units 16
- Nameplate capacity 2160 MW
- Overload capacity 2485 MW
- Hydraulic capacity 322,000 cfs
- TW rate of change 3 feet per hour

Hydrologic Data

- Drainage Area ~226,000 square miles
- Maximum historical peak inflow 1,230,000 cfs (1894) [588,000 cfs (1974 fully regulated)]
- Lake Elevations

Maximum pool	276.5 feet, NGVD		
Full pool	268.0 feet, NGVD		
Minimum pool	257.0 feet, NGVD		
Normal Operating Range	Season	Upper	Lower
	01 July – 01 October	268.0	265.0
	01 November – 01 June	265.0	260.0[1]

- Usable Storage (257.0 - 268.0) 534,000 Acre Feet
- Authorized Purposes Flood control, power, navigation, fish and wildlife, recreation, irrigation, water quality

General

John Day Lock and Dam is located on the Columbia River at river mile 215.6. The project provides approximately 77 miles of slack water to McNary dam (RM 292.0). Lake Umatilla is the second longest of all the lakes on the Columbia River. The project was authorized in 1950 under Public Law 81-516 with the authorized purposes of flood control, power, and navigation. Other uses include fish and wildlife, recreation, irrigation, and water quality. John Day dam began operations in 1968, with the last generator and turbine being added to the powerhouse in 1971. The power house currently has 16 turbine/generator units. Twenty units were authorized but installation of four was deferred. Lands adjacent to the reservoir are

[1] Normal minimum elevation in the spring is 262.0 for protection of geese during nesting period of 1 March through 15 May (land bridges form below this elevation).

used to grow grain and other crops, all of which are irrigated. Recent studies have identified 24 pumping plants along Lake Umatilla that irrigate about 138,850 acres. Navigation is also an important consideration for the project. Commodities moving downriver through the John Day pool are grain, petroleum, basic chemical and machinery. John Day is normally operated as a run-of-river project. The project is operated to provide optimum conditions for navigation and hydroelectric power without creating “unnecessary” detriment to fish passage, irrigation, recreation, fish and wildlife, and water quality. The vast majority of the time John Day Dam is *not* operated for flood control. Operating as a run-of-river project, the primary concern is for hydropower production and navigation and in most years is not operated for flood control at all. Typically, this is due to a mild winter with no sustained storms in the Pacific Northwest and a lower than average snowpack during the spring in the upper Columbia Basin.

Historically, John Day pool has been operated between 265 and 268 feet in the summer (01 July – 01 October), and between 260 and 265 feet in the winter (01 November – 01 June). Due to the implementation of Reasonable and Prudent Alternative Number 5 (RPA-5) from the 1995 Salmon Biological Opinion (NMFS, 1995), the Corps now operates John Day pool between 262.5 and 264 feet from 20 April through 30 September, and between 262.5 and 265 feet from 01 October through 19 April. The operating elevation range may be changed slightly to accommodate the needs of John Day irrigators as long as the 1.5-foot operating range indicated in RPA-5 is met from 20 April through 30 September.

John Day is operated for various special operations, as requested, which further restrict its operating range. Special operations are not implemented if they interfere with authorized project operation. In the spring, John Day pool is operated to encourage upland goose nesting by being in the top foot at least once every four days during daylight hours. In the fall, John Day pool is operated to enhance waterfowl hunting by being in the top foot Wednesdays, weekends and holidays during daylight hours. Also, John Day participates in the spill program assisting downstream migrant fish from 20 April through 30 June as recommended in the1995 Biological Opinion, RPA-2. Additional special operations are implemented in order to facilitate the needs of the project and the many river users affected by John Day.

Operations for Flood Control

John Day Dam is the only project on the lower Columbia River that has flood control as an authorized project function. When compared to other Columbia River flood control projects, however, John Day is considered to have only a minor amount of flood control storage and is used primarily to modify the flood peaks and make final adjustments to flows on the Lower Columbia River. Primary flood control operations take place at other upstream reservoirs (e.g. Mica, Arrow Lakes, Libby, Grand Coulee, and Dworshak). Flood control operations at John Day are unique in that the lake is only lowered for additional storage when flood stages are *forecast* for Vancouver, Washington. Flood control storage requirements are based on the following data (Table 3.2.8-1):

Table 3.2.8-1. Flood forecast and storage requirements for John Day Dam.

Forecast stage Vancouver, Washington (Feet, NGVD)	John Day pool elevation required for flood storage	Flow at The Dalles(cfs)	Reference term at Portland/Vancouver
12	265.0		
14	262.8		
16	260.5	~ 450,000	Bankfull
18	258.2	-	
19	257.0	-	
22.5		600,000	Minor damage
26		750,000	Major damage
30		950,000	Levee overtopping

Because of the two types of flooding possible at Portland/Vancouver, John Day Project must be available to provide flood control on short notice. The two types of floods are (1) snowmelt floods which occur generally in spring and early summer, and (2) rainfall induced floods during the winter months. In addition, a combination of the two types may occasionally occur. A heavy sustained baseflow from the upper Columbia combined with fast rising Cascade streams (Deschutes, Willamette, Sandy, etc.) is a potentially dangerous situation. The preceding discussion notwithstanding, John Day Project can, with judicious use, provide significant stage reduction possibilities in the Portland/Vancouver area. The 500,000 acre-feet of flood control available on demand at John Day is sufficient to reduce downstream flows by 75,000 cfs for three days. This may be sufficient to reduce stages near Portland/Vancouver by as much as two feet.

John Day dam has a very small operating range. This narrow range of pool elevations has created ideal conditions for hydropower generation, recreational development, irrigation withdrawals, and habitat for fish and wildlife. With the exception of infrequent special operations, pool levels are considered to be very stable. The major exception is during flood control operation. The amount of flood control storage required at John Day is based on anticipated runoff and projected flood stages at the Vancouver, Washington. The drawdown period to evacuate for flood storage and refill can be as short as only a few days, if appropriate. At Vancouver, a discharge of about 450,000 cfs (measured at The Dalles) is classified as bankfull condition. This is considered to be the lower Columbia River flood regulation goal for all of the flood control reservoirs in the Columbia and Snake River system. The associated stage for this discharge is currently estimated to be 16 feet at Vancouver. It has approximately a 50 percent chance of being equaled or exceeded in any given year (~2-year flood).

Operations for Navigation

Operation for navigation, a major project function, consists of making the necessary lockages and observing pondage and release limitations. The lock facilities are operable for a full range of flow conditions. At the minimum operational pool of 257 feet, NGVD, the upstream sill of the navigation lock will have 15 feet of water depth. The project was originally designed for barges with 9 feet of draft but currently some of the larger barges have up to 14 feet of draft.

The authorized federal navigation channel through John Day reservoir is 14 feet deep by 250 feet wide. Emergency dredging operations in 1992 removed areas of rock (at about elevation 242') in and adjacent to the navigation channel in the upstream portions of the reservoir. These rock outcrops caused a major concern for navigation if the forebay of John Day dropped below elevation 261.0', in combination with low releases from McNary dam.

John Day reservoir has numerous local port and dock facilities. Most of these facilities require local access channels and were originally designed and dredged by local sponsors. These channels are not considered to be a part of the "federal channel" and are normally not within the authority the Corps to be maintained. Currently, all local access channels are operable at the minimum pool of 257 feet, NGVD.

Operations for Hydropower

To the degree practicable, power units at John Day are operated to provide the greatest overall project efficiency. The powerhouse is equipped with 16 generators of 135,000 kilowatts each, having a total generating capacity of 2,160,000 kilowatts. Each unit while in operation is operated within 1% of maximum efficiency to ensure optimum power generation and to provide the safest passage for downstream migrating fingerlings. Load factoring is accomplished by making use of the 150,000 acre-feet of storage between elevation 262 feet and 265 feet when inflows to the project are less than power plant hydraulic capacity. Pool fluctuations are generally on the order of about $1^{1}/_{2}$ feet or less on a daily basis.

Irrigation and Water Supply Considerations

John Day has no specific storage for water supply or irrigation, although the presence of a stable pool between the elevations of about 262 to 265 feet, NGVD, serves to support water users along the reservoir. Withdrawal of irrigation, municipal, and industrial water from the John Day pool is common practice, with water users entitled to the natural water rights as governed by state law. The largest water withdrawals are for irrigation needs. Along the reservoir and tributary shore line, there are pumping facilities serving 29 separate entities. The primary reason for these pumping facilities is to supply water for large irrigation systems that are needed in the area. As most of the area has less than 15 inches rainfall per year, irrigation water is needed to support crop growth. Typically, crops are irrigated from about the beginning of April through the end of September, but often can be irrigated into October or November. The City of Boardman municipal and industrial water supply is taken from the John Day pool via a Ranney Well system. Fish hatcheries at Umatilla and Irrigon depend upon the John Day pool as a reliable water source. Both of these hatcheries are considered to be vital assets for fishery needs in this reach of the Columbia River and the Snake River.

Wildlife Management Considerations

Two principal areas of wildlife management affect the reservoir regulation of the John Day project. They are (1) the waterfowl nesting, and (2) the waterfowl hunting programs in the Umatilla National Wildlife Refuge. The programs are operated in conjunction with the U. S. Fish and Wildlife Service and Umatilla National Wildlife Refuge. The refuge has about 22,000 acres located on both sides of the river starting at river mile 262. As an important goose nesting area, pool elevations will be maintained between the elevations of 263.0 and 265.0 feet, NGVD, during the nesting period 1 March through 15 May. Part of the operating plan is to raise the pool to elevation 265.0', every three days. This results in discouraging geese nesting at lower elevations which are more susceptible to flooding. For the waterfowl hunting program, USFWS would prefer pool levels between the elevations of 263.5 and 265.0 feet, NGVD, during the weekends and on Wednesdays of each week from 11 October through 26 January. An exception is made during the month of October when a pool level of 266.0' is acceptable. These special operations have been formulated to enhance hunting on Lake Umatilla and are maintained as long as they do not conflict with other authorized project functions.

Recreation Considerations

To support high levels of recreational use that occurs at the John Day project about 17 recreational areas/facilities (federal and local) are located along Lake Umatilla. Presently there are 13 boat ramps with 26 launch lanes, 160 picnic sites, and 242 individual camp sites. For the period 1987-1991 the average number of visitors per year to the recreational sites along the John Day pool was 2,272 000. August is the peak month for visitation to the project, with about 350,000 visitors. The plan of operation at John Day does not specifically provide for special regulation of the reservoir in the interest of recreation, but the stable pool levels enhance the popularity of these recreational sites. The Corps of Engineers cooperates with Oregon and Washington state park departments and a variety of local entities such as counties, cities, and port districts, to build and manage a system of water related recreational facilities.

The Dalles Lock and Dam

General

• Sub-basin:	Lower Columbia
• Stream:	Columbia River (R.M. 191.5)
• Location:	The Dalles, Oregon
• Owner:	Corps of Engineers, Portland District
• Type of Project:	Run-of-River
• Project Authorization:	House Document 531, 1950

Powerhouse

• Number of units	22
• Nameplate capacity	1696 MW
• Overload capacity	2052 MW
• Hydraulic capacity	375,000 cfs
• TW rate of change	3 feet per hour

Hydrologic Data

- Drainage Area ~237,000 square miles
- Maximum historical peak inflow 1,230,000 cfs (1894) [588,000 cfs (1974 fully regulated)]
  Measured at the USGS gaging station at The Dalles, Oregon
- Lake Elevations
  - Maximum pool 182.3feet, NGVD
  - Full pool 160.0 feet, NGVD
  - Minimum pool 155.0 feet, NGVD
- Usable Storage (155.0 - 160.0) 51,500 Acre Feet [2]
- Authorized Purposes Power, navigation, fish and wildlife, recreation, irrigation, water Quality

The Dalles Lock and Dam is located on the Columbia River at river mile 191.5, forming Lake Celilo. The project provides approximately 24 miles of slack water to John Day dam (RM 215.6). The project was authorized under House Document 531 in 1950 with the authorized purposes of power and navigation. Other uses include: fisheries, recreation, irrigation, and water quality. The initial project at The Dalles began operations in 1960, with the completion of the first 14 generating units. The additional 8 units were completed in 1973. The project was not designed for flood control.

The Dalles is a run of river project. Other uses are fishery, recreation, irrigation, and water quality. The normal year-round operating range is between elevations 157' and 160'. Spill for juvenile fish passage is required annually between April 20 and August 31 in accordance with the 1995 Biological Opinion for Snake River Salmon.

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[2] Based on 100,000 cfs. From Water Control Manual, December 1960.

Bonneville Lock and Dam

General

• Sub-basin	Lower Columbia
• Stream	Columbia River (R.M. 146.1)
• Location	Bonneville, Oregon
• Owner	Corps of Engineers, Portland District
• Type of Project	Run-of-River
• Project Authorization	1935 Rivers and Harbors Act

First Powerhouse

• Number of units	10
• Nameplate capacity	518 MW
• Overload capacity	574 MW
• Hydraulic capacity	136,000 cfs

Second Powerhouse

• Number of units	8
• Nameplate capacity	532 MW
• Overload capacity	612 MW
• Hydraulic capacity	152,000 cfs

Hydrologic Data

- Drainage Area ~240,000 square miles
- Maximum historical peak inflow 1,230,000 cfs (1894) [588,000 cfs (1974 fully regulated)]
  Measured at the USGS gaging station at The Dalles, Oregon
- Lake Elevations
  - Maximum pool 82.5 feet, NGVD
  - Full pool 77.0 feet, NGVD
  - Minimum pool 70.0 feet, NGVD
- Usable Storage (70.0 – 77.0) 148,000 Acre Feet [3]
- Authorized Purposes Power, navigation, fish and wildlife, recreation, water quality

Bonneville Lock and Dam is located on the Columbia River at river mile 146.1, forming Lake Bonneville. The lake is approximately 45 miles in length to The Dalles dam (RM 191.5). The project was authorized under the 1935 Rivers and Harbors Act with the authorized purposes of power and navigation. Other uses include: fisheries, recreation, and water quality. The first powerhouse at Bonneville began operations in 1938, with the completion of the first 10 generating units. Construction on the second powerhouse consisting of 8 additional units and two fishway units began in 1974 and was completed in 1982. The project was not designed for flood control.

[3] Capacity difference above elevation 45 feet, with level pool, from Discharge and Capacity Curves for Bonneville Power Plant, 06 January 1942.

Bonneville is a run-of-river project. Other uses are fishery, recreation, and water quality. Its year-round operating range is 70.5' – 76.5'. When inflows are forecast to exceed 376,000 cfs, the maximum forebay is 75.5' until the project is on free flow (1,170,000 cubic feet per second). Spill for juvenile fish passage is required annually between April 20 and August 31 in accordance with the 1995 Biological Opinion for Snake River Salmon. Special operations during the year include high forebay elevations for stranded boats, high forebay elevations for gillnet fishing, and low tailwater elevations for construction work.

3.3 International and Tribal Coordination

The Army Corps of Engineers, Bureau of Reclamation, and BPA operate the Federal Columbia River Power System consistent with existing treaties and laws. Real time reservoir operations are coordinated with tribal representatives through the Technical Management Team. Coordination with Canada is done through the Columbia Treaty Operation Committee, the Columbia River Treaty Hydrometeorological Committee, the Permanent Engineering Board, and the U.S. Department of State.

3.3.1 Columbia River Treaty

The Columbia River Treaty allowed the construction of Duncan, Mica, and Keenleyside Dams in Canada, and Libby Dam in the United States. The Columbia River Treaty set up a process in which three entities (the Corps of Engineers, Bonneville Power Administration, and BC Hydro) could coordinated flood control and hydropower operations and address common problems. The Corps and BPA coordinate reservoir operations regularly with BC Hydro through the Columbia River Treaty Operation Committee.

3.3.2 International Joint Commission

The International Joint Commission (IJC) was created under the Boundary Waters Treaty of 1909 between the U.S. and Canada. Its principal function is rendering decisions on the use of boundary waters, investigating important problems arising along the common frontier not necessarily connected with waterways, and making recommendations on any question referred to it by either government. The IJC has appointed three local Boards of Control that affect the FCRPS. These are the Kootenay Lake Board of Control, the International Columbia River Board of Control, and the Osoyoos Lake Board of Control to insure compliance with IJC Orders and keep the IJC informed. The most applicable Order affecting the FCRPS is the 1938 Order on Kootenay Lake. The 1938 Order acts to constrain the operation of Libby Dam because releases from Libby Dam can force the level of Kootenay Lake (140 miles downstream in Canada) above elevations specified in the Order. The 1938 Order sometimes prevents the Corps of Engineers from drafting Lake Koocanusa to its flood control rule curve in years of high winter runoff. The Corps coordinates Libby Dam operation with BC Hydro and West Kootenay Power to assure compliance with the 1938 IJC Order.

3.3.3 Regional Forum

The NMFS 1995 Biological Opinion on hydropower operations and salmon provides for adaptive management in applying the measures in the opinion. To accomplish this a Regional Forum has been established with teams of representatives from federal, state, and tribal entities at three administrative levels. This allows for a coordinated management of the Federal Columbia

River Power System guided by the NMFS and USFWS biological opinions for listed species in the Columbia and Snake rivers.

The first level of the Forum is the Executive Committee, comprising executive level members who set overall policy and strategic direction for addressing Columbia/Snake River listed species issues.

The Implementation Team (IT) includes senior managers who carry out policy direction and consider disputes raised in the technical teams. IT forwards its recommendations to the action agencies—the Corps, BPA, and/or USBR.

The third tier consists of five technical teams. The Technical Management Team (TMT) is an interagency technical group which meets weekly during the salmon migration season to advise the operating agencies on dam and reservoir operations to improve passage conditions for juvenile and adult salmon. TMT also provides pre-season planning and post-season review. The System Configuration Team (SCT) advises the Corps on prioritization of construction and study efforts under the Columbia River Fish Mitigation project. The Dissolved Gas Team (DGT) is responsible for the Total Dissolved Gas Management Plan and Dissolved Gas Monitoring Plan to guide system operations to minimize dissolved gas problems during fish migrations. The PATH, or Plan for Analyzing and Testing Hypotheses, team of scientists provides analysis of computer model outputs of expected biological outcomes given various scenarios of dam operation, fish passage options and dam configuration. The Independent Scientific Review Group is called upon by NMFS and others to provide independent scientific review of the biological merit of proposed or ongoing activities for fish.

4.0 Effects of Operations on Bull Trout and Kootenai River White Sturgeon

Effects on bull trout and sturgeon from current and proposed FCRPS operations are variable and dependent on the individual project. They may have a cumulative effect when other impacts such as from land use are accounted for. Reservoir operations may result in trophic effects through mechanisms concerning the prey base or competitors; they may also result in barriers to migration into tributaries. Reservoir effects may also include thermal changes affecting suitability of adfluvial habitat. Downstream effects may include trophic effects from flow fluctuation and dewatering of organisms, or migration barriers at tributary mouths due to delta formation. Dams also may divide up metapopulations by creating barriers to migration in the mainstems of rivers.

Operational effects on Kootenai River white sturgeon include impacts to spawning due to changes in spring migrational flows, and potential effects on juvenile habitat use as a result of flow fluctuations. Trophic effects on prey species may also occur from seasonal flow manipulation.

4.1 Bull Trout

The following sections describe effects to bull trout anticipated from operation of the FCRPS.

4.1.1 Kootenai River Basin

Bull trout were historically found on both sides of the continental divide between latitude 50 and 60 degrees N and distributed in a north-south belt along the Rocky Mountains. South of this zone, bull trout were found primarily west of the continental divide. Kootenai Falls were thought passable by bull trout at high flows, allowing two-way gene flow throughout the basin. Resident and migratory populations existed in all reaches of the Kootenai River with the exception of the upper Kootenai River where only the migratory life history is thought to exist. Resident populations also exist in a few isolated lakes in the Kootenai River basin. The Kutenai Indians historically fished for char, trout and whitefish in the tributaries of the lower Kootenai River.

Bull trout movement and migration were altered on the Kootenai River with the construction of Libby Dam in 1972. Passage barriers or the elimination of migration corridors is a major limiting factor for some populations of bull trout. Passage barriers serve to isolate populations and prevent the exchange of genetic information (Buchanan et al., 1997). Dam construction and reservoir operation changed the Kootenai River from a free flowing river to a regulated river and undoubtedly altered or eliminated bull trout migration patterns in the Kootenai River and its tributaries.

Effects of Construction and Current Operation

The creation of Lake Koocanusa inundated 90 miles of stream habitat that was usable by bull trout. Lake Koocanusa covers 224 miles of shoreline in which reservoir fluctuations, specifically the fall drawdown, can reduce the habitat available for bull trout. Drawdown limits are in place to protect fisheries resources but have been exceeded on numerous occasions (Montana Bull Trout Scientific Group, 1996d). Excessive drawdowns have negative consequences on benthic and terrestrial prey production as well as reducing available nearshore habitat for bull trout. In addition, the mouths of streams can become impassable as the reservoir elevation lowers. During low flows, tributary surface flows at the mouth can become shallow and impassable. Surface water temperatures are higher in the reservoir than under riverine conditions.

Libby Dam isolated the current population of bull trout downstream from the upper reaches of the Kootenai River and decreased the possibility of repopulation after a catastrophic event. Colonization of the bull trout population below Libby Dam is limited to areas between the dam and Kootenai Falls (river mile 192) which prevents upstream passage of bull trout from below. The falls are believed to be a permanent migration barrier to bull trout as a result of reduced peak flows from Libby Dam for flood control. Peak discharge rates are currently regulated between 4,000 and 10,000 cfs in the summer and 15,000 to 24,500 cfs in the winter. Peak discharges prior to dam construction reached as high as 64,000 cfs. Power peaking of daily or weekly flows has increased flow variations compared to pre-Libby dam conditions, which can have a negative effect on benthic and terrestrial prey production (Hauer and Stanford, 1997). Daily winter flow fluctuations from 4,000 to 10,000 cfs have occurred within a 24-hr period. Fluctuations within this "varial zone" below 10,000 cfs are thought to have the most effect on wetted perimeter of the Kootenai River (B. Marotz, MDFWP, 1998, pers. comm.). Gas supersaturation is also a possibility when spill conditions occur, creating the potential for the formation of gas bubble disease in fish. Lastly, the formation of deltas at the mouths of downstream tributaries can preclude bull trout passage if the formation is severe and flows are low. Tributary mouth delta formation is thought to develop in the absence of high flood flows within the reach.

Cumulative Effects

In addition to Libby Dam and reservoir operations acting as direct potential sources of bull trout decline, other limiting factors affect the bull trout populations of the Kootenai River Basin. Creation of Lake Koocanusa has increased angling pressure on native fish which can affect bull trout due to the trout's aggressive behavior and high susceptibility to angling methods. To curtail the potential for overharvest, anglers are prohibited from removing bull trout from Lake Koocanusa. Brook trout (*Salvelinus fontinalis*) and other introduced fishes represent a potential impact to bull trout in the mainstem and tributaries downstream of Libby Dam. Brook trout represent a specific problem because of their high reproduction rate and ability to hybridize with bull trout. Human habitation around Lake Koocanusa is still sparse but has increased since the construction of Libby Dam and is evidenced by the development of homes, marinas and resorts.

Flood control provided by Libby Dam supports additional human encroachment near the Kootenai River and its tributaries. While the mainstem has remained relatively undisturbed, many of the river's tributaries have experienced increased temperatures and a decline in water quality. Increased human encroachment has also increased the need for timber resources. Logging currently occurs in Canada and the U.S. in the Wigwam River drainage and other important spawning reaches.

Salmon and white sturgeon flow releases from Libby Dam as a requirement under the Endangered species Act could affect bull trout. In the fall, the National Marine Fisheries Service (NMFS) requests a water release from behind Libby Dam to provide additional flow for juvenile salmon in the lower Columbia River. This release causes drawdown to occur early (August) and may reduce the reservoir elevation as much as 20 feet. This reduction in reservoir elevation during the most productive summer months may have an effect on prey production and habitat availability for reservoir populations of bull trout. This release also causes an artificial increase in downstream water stage which may increase the potential for stranding as flows subside. In the spring, the USFWS may request high flows from Libby Dam as a requirement under the white sturgeon recovery effort. The request generates a peak flow of 25,000 cfs or higher, which may increase the level of bull trout entrainment through Lake Koocanusa.

Current Operational Effects

As described previously, Libby Dam and Lake Koocanusa have contributed to the alteration of the Kootenai River from its historical hydrologic and physical character. The effect this has had on bull trout populations is difficult to quantify; however, studies performed by various agencies point to several issues. Issues related to Libby Dam and its operation appear to be generally negative and are described below.

<u>Upstream</u>

The 90 miles of Kootenai River inundated by Lake Koocanusa has resulted in the loss of spawning habitat in the lower reaches of streams that enter the reservoir. Prior to the creation of the reservoir, the lower reaches of approximately 20 streams, including the Tobacco River, were accessible to bull trout for spawning and rearing. Other major spawning regions such as the Wigwam River drainage and others in Canada are not significantly affected by the reservoir. For those tributaries that are affected, Libby Dam currently compensates the fishery resource for this inundation impact through artificial propagation. The Murray Springs Fish hatchery located in Eureka, Montana, is operated by the Montana Dept. of Fish, Wildlife and Parks and recent changes to hatchery operating protocols include provisions for the rearing of bull trout and other ESA listed fishes. The effect of tributary inundation will continue to be handled through artificial propagation.

Drawdown of Lake Koocanusa causes the lake elevation to drop as much as 115 feet. At the time of drawdown (August-May 15), bull trout juveniles utilize for food the terrestrial and aquatic insects produced within the shallows of Lake Koocanusa. Drawdown causes reservoir waters to recede, making terrestrial and aquatic insects produced in the shallow waters to become unavailable to juvenile bull trout. The shift in available food from nearshore sources to deeper water sources greatly reduces the diversity and volume of organisms available to bull trout. Current research has documented the loss of insect diversity (Marotz et al., 1996) as a result of drawdowns, but has not yet determined whether this loss has caused the forage base of juvenile bull trout to become a limiting factor. Bull trout residing in the reservoir are typically large enough to be piscivorous and are then less directly dependent on insect production.

Temperature changes as a result of reservoir creation include an increase in summer surface water temperature. Summer surface water temperature is dependent on runoff and weather and reaches an average of 60^oF (15.5^oC) by August. The 60^oF thermal layer reaches to a depth of 11 ft on average. The reservoir surface temperature can reach above 69^oF (20.5^oC) in unusually low runoff years. Bull trout are not usually found in water with temperatures exceeding 64^oF (18^oC). The bull trout preference for water temperatures below 18^oC may render the top few feet of Lake Koocanusa unusable for bull trout in late summer. However, thermal avoidance of higher water temperatures by bull trout does not necessarily mean forage success will decline. Current research has not yet determined whether the forage base available to juvenile or adult bull trout in Lake Koocanusa is a limiting factor in the summer.

Upstream and downstream fish passage facilities are not present at Libby Dam. The creation of Libby Dam is thought to have disrupted historical migratory pathways for migratory bull trout populations by eliminating bull trout genetic exchange upstream of Libby Dam. However, a migratory population still exists below Libby Dam and spawns in several high quality tributaries between Libby Dam and Kootenai Falls. It is not clear whether this migratory population is descended from the population isolated by Libby Dam or represents a unique population adapted to downstream tributaries.

Genetic exchange from upstream populations is still possible but Libby Dam is not designed for safe fish passage. Entrainment of bull trout through hydropower turbines or spillways has been documented but is not considered significant (Skaar, 1996). Water depth, prey sources and temperature preferences reduce the potential for significant entrainment of bull trout. However, kokanee, a bull trout prey resource, are entrained at Libby Dam in measurable numbers (Skaar, 1996). Kokanee entrainment provides salmonid populations downstream an additional source of food (Montana Bull Trout Scientific Group, 1996c). It has not been determined whether the degree of entrainment currently limits the reservoir kokanee population.

Downstream

Downstream effects on bull trout by operation and construction of Libby dam are closely related to upstream affects where migration is concerned. The disruption of bull trout migration into the upper Kootenai River basin by Libby Dam impacts downstream populations by denying the trout access to high quality spawning habitats above Lake Koocanusa. In addition to migrational barriers, bull trout populations that remain below Libby Dam are negatively affected by flow release strategies from Libby Dam. Existing release strategies at Libby Dam attempt to provide the reservoir with its lowest annual elevation by March 15. Initiation of drawdown depends on runoff forecasts, power requirements, and biological release needs but generally begins the first week of August. During the 1997 drawdown, the reservoir dropped 115 feet between elevations 2450 feet and 2335 feet. Flow releases affect downstream populations of bull trout by altering the natural flow regime, temperature and creating repeated and prolonged changes to the wetted perimeter. Gas supersaturation is a problem during spill events. Those have not occurred since 1985, but remain a possibility.

Downstream temperature guidelines were developed for the protection of coldwater fishes. Downstream water releases at Libby Dam duplicate the natural pre-project river temperatures with the exception of mid summer (USACE, 1984). The guidelines call for water that is colder in the summer months than would be found prior to Libby Dam. Surface water temperature in the Kootenai River is measured daily below Libby Dam, outside the town of Leonia and in Bonners Ferry. The waters downstream of Libby dam reach their highest temperatures in August and coldest temperatures in March. In general, average water temperature range increases as it moves downstream towards Bonners Ferry. Cold water gets colder downstream and warm water becomes warmer (Table 4.1.1-1).

Table 4.1.1-1. Kootenai River annual minimum and maximum water temperatures (degrees F), 1995-1997.

	Libby Dam	Leonia	Bonners Ferry
Minimum	34.5	30.0	30.0
Maximum	61.2	63.6	64.6

Libby Dam regulation of downstream water flow has an effect on juvenile bull trout rearing and spawning habitat. The lowering of peak outflows to 27,000 cfs, the maximum project discharge, has allowed delta formation at the mouths of some tributaries. It does not appear that these deltas impede upstream or downstream migration; however, the situation may change if the formation is allowed to continue. Peak flows over 60,000 cfs in May and June were reported before the construction of Libby Dam. Today, peak high flows are captured behind Lake Koocanusa to refill the reservoir and prevent downstream flood damage. The reduction of peak flow for flood control has made Kootenai Falls a permanent migration barrier to bull trout. This has increased the risk of extinction to the lower Kootenai River bull trout populations by denying them access to spawning habitats above the falls. Spawning opportunities for bull trout populations below Kootenai Falls are limited primarily to O'Brien Creek and possibly the Yaak River and Callahan Creek. To date, no redds have been found in either the Yaak River or Callahan Creek (Montana Bull Trout Scientific Group, 1996c).

In addition to flood control and power production, flow releases are used to support recovery of endangered species such as the white sturgeon and several Columbia River salmonids. Drawdown is initiated by a release of water for Columbia River juvenile salmon migration which may last through September. The August release of reservoir waters for downstream salmonid passage causes a trophic impact to juvenile bull trout by lowering the shoreline elevation during the productive summer months. The salmon release causes higher flows in August than normal creating the potential for juvenile bull trout stranding if ramping rates are not followed. The Draft White Sturgeon Recovery Plan (USFWS, 1996) recommends withholding the salmon releases. According to the plan, these higher than normal flows for salmon can cause a loss of productivity in Kootenay Lake and strand juvenile sturgeon in backwater habitats.

Between the months of October and December, winter power peaking controls the flow release strategy from Libby Dam. This peaking results in wide fluctuations of flow between 4,000 and 10,000 cfs which has profound effects on the wetted perimeter of the Kootenai River when compared to flows above 10,000 cfs (B. Marotz, MDFWP, 1998, pers. comm.). Changes to the wetted perimeter can have a direct impact on available habitat for juvenile bull trout and aquatic insects that thrive in shallow water and form the primary food source for juvenile bull trout (Thomas, 1992). Aquatic insect production is reduced through desiccation or freezing as water recedes from the shallows. Lost aquatic insect productivity represents a trophic impact to downstream populations of juvenile bull trout and other salmonids.

Gas supersaturation causes gas bubble disease in fish and invertebrates. This disease is fatal if nitrogen bubble accumulation in the tissues of affected organisms becomes severe. At Libby Dam, fish injury from high nitrogen levels can occur between the dam and Kootenai Falls where the saturation level can reach 139% in the event of spill. Depending on duration of the spill, the high levels of gas may reach the Libby, MT and possibly Kootenai Falls. Kootenai Falls would act to remove excess nitrogen as water passes over the falls and return the water to the state standard of 110%.

Refill of the reservoir takes place in May and June as spring runoff is captured behind the dam. As described before, refill impacts to bull trout are related to the capture of high flows and the migrational barrier to bull trout that it represents at Kootenai Falls. Upstream impacts in the reservoir from refill are unknown. A pulsed release of high water for sturgeon spawning also occurs during the refill period. High flows released for sturgeon spawning are normal for the river and probably do not impact bull trout downstream. Sturgeon flows from the dam peak at or above 25,000 cfs, and may increase bull trout entrainment although it has not been documented as a significant problem. The releases have been shown to benefit sturgeon by prompting a migration from Kootenay Lake to known spawning reaches upstream (USFWS, 1996).

Effects of Proposed Operations

There are some proposed changes to flood control and project operations at Libby Dam (see Sec. 3.1). Impacts to the Kootenai Basin bull trout populations from Libby Dam have been reduced under the proposed operations while maintaining flow objectives and other requirements of ESA for species other than bull trout. The proposed operations for bull trout address large downstream river fluctuations the summer and implementation of new ramping rates.

Effects of sturgeon flows

Under the proposed operations, sturgeon spawning flows and incubation flows occur between June and July at a time when river inflow is higher than project discharge. A pulsed release of high water for sturgeon spawning occurs during the refill period. High flows released for sturgeon spawning are designed to more closely match natural conditions and as such may benefit bull trout downstream. At the end of the incubation flows, the river is returned to minimum flows of 4,000 cfs and is sustained until the salmon flows are initiated August 1. It is our determination that the sturgeon spawning and incubation flows are *likely to affect, but not likely to adversely affect* bull trout.

Effects of salmon flows

Downstream impacts to bull trout from salmon augmentation flows are tied to stage increase. Before initiating the augmentation flow, the Kootenai River downstream of Libby Dam is at or near minimum flow for several weeks. In response to the rise in stage from augmentation flows, the river margins become flooded. Nearshore oriented juvenile bull trout then move into and forage among the newly flooded river margins where limited food production is present, at least for the first 3-5 weeks. Reducing this impact is dependent on reducing the degree of rise in stage due to the salmon releases. Since the augmentation flows follow the earlier peak in flow associated with the sturgeon spawning flow a few weeks earlier, the two flows together create a “double peak” in summer stage. The minimization of this double peak is the focus of new flow shaping procedures designed to protect bull trout, as well as juvenile sturgeon and other river-resident fish. In order to minimize a double peak in river flows after the sturgeon operation due to releases for salmon, the estimated volume of water above elevation 2,439 would be released in a linear amount from the start of the incubation flows until August 31. This release would be in addition to inflow. This procedure will spread out the salmon augmentation flows over a longer period and minimize any increases in stage downstream. It is our determination that the salmon and steelhead augmentation releases may affect, but are not likely to adversely affect bull trout.

Effects of Ramping Rate Changes

New ramping rates are included in the proposed operations for the benefit of bull trout (see Sec. 3.1). The new ramping rates address changes in wetted perimeter especially as flows are reduced below 10,000 cfs, for the months April through August. The project would be operated in an attempt to meet the ramping rates except for flood control, power and project emergencies. In addition, no daily power peaking will be allowed during April through August. Weekly power peaking is permitted only above 10,000 cfs, except during the period specifically set aside for white sturgeon spawning and incubation. No other changes are proposed for downstream releases.

Bull trout stranding and invertebrate production losses should be reduced with the new ramping rates. However, there exists the potential for loss of benthic organisms, which could affect bull trout food availability, in September and possibly into October. This might affect growth (especially of juveniles) and possibly adult fecundity.

Flow releases affect downstream populations of bull trout by altering the natural flow regime, and water temperature, and creating repeated and prolonged changes to the wetted perimeter. Ramping rates are a major tool used to manage changes to the wetted perimeter. By limiting the rate at which the perimeter is dewatered below 10,000 cfs, bull trout juveniles and adults can expect to see an improvement in stranding and invertebrate loss impact through August. Slower ramp down of discharge allows a larger percentage of invertebrates to move towards the channel and avoid desiccation. Limiting all daily and weekly peaking of the project to flows above 10,000 cfs will also help preserve invertebrate populations within the Kootenai River. Because of the lack of restriction on September and October ramping rates, it is our determination that the downstream release protocols at Libby Dam under the proposed operations *likely to affect, and may adversely affect* bull trout.

Effects of Reservoir Operations

At the time of drawdown (August-March), bull trout juveniles feed on terrestrial and aquatic insects produced within the shallows of Lake Koocanusa. For that portion of the population still dependent on the invertebrate food base, the receding waters cause terrestrial and aquatic insects produced in the shallows to become unavailable. Assessing direct and indirect forage impacts from reservoir operations would be difficult and as such, little information exists to document whether drawdown has a measurable affect on bull trout survival.

Juvenile adfluvial bull trout spend up to 3 years residing in tributaries prior to migrating to the reservoir (Oliver, 1979). Research conducted by Chisholm et al. (1989) in Lake Koocanusa revealed that 95% of all bull trout caught were 300mm or larger. Jeppson and Platts (1959) found that bull trout of several northern Idaho lakes switched to piscivory at the time they reach 300 mm in length (Chisholm et al., 1989). It is likely that most of the adfluvial population is large enough to be piscivorous at the time they reach the reservoir, making these bull trout less susceptible to impacts from lost invertebrate production. For those bull trout still dependent on invertebrate food sources, reservoir drawdown reduces terrestrial insect availability but only slightly (Marotz et al., 1996). During refill in the summer, juvenile bull trout feed in shallow waters recently subjected to long periods of desiccation. However, newly wetted areas may take up to two years to fully recolonize with aquatic insects.

Piscivory by bull trout in Lake Koocanusa appears to be opportunistic (G. Hoffman, MDFWP, pers. comm., 1999). Bull trout feed on kokanee, peamouth chub, northern pikeminnow and other species (Dalbey et al., 1998). Some of these forage fish are dependent on benthic items, while kokanee are planktivorous. In either case, drawdowns would affect the forage species. However, it is not known whether food is limiting for bull trout in Lake Koocanusa at this time. Aside from pointing out that the Lake Koocanusa food web is impacted by reservoir fluctuations, the MBTSG (1996d) did not identify direct impacts to the bull trout population using the reservoir.

It is our determination that bull trout *may be affected, but are not likely to be adversely affected* by reservoir operations.

4.1.2 Flathead River Basin

The following sections describe operational effects on bull trout in the Flathead system.

Hungry Horse Reservoir/South Fork Flathead River

The construction and operation of Hungry Horse Dam and Reservoir has impacted bull trout primarily in two ways: 1) the dam eliminated use of the South Fork Flathead basin by adfluvial spawners migrating upstream from Flathead Lake, and 2) ongoing reservoir operations affect the habitat, food, and overall biological productivity conditions available to bull trout and other fish species residing in the reservoir. Young bull trout are most affected by reservoir operations. Seasonal reservoir operations as now implemented are not expected to impact access of adult bull trout into reservoir spawning tributaries or to the upper South Fork Flathead.

As discussed previously, MDFWP estimated that the construction of Hungry Horse Dam permanently blocked 38 percent of the total drainage available to adfluvial westslope cutthroat and bull trout migrating upstream from Flathead Lake (Zubik and Fraley, 1987). The MDFWP estimated that potential habitat for 2,100 adult bull trout spawners was lost. Following dam closure, impounded bull trout populations continued to exhibit and retain the adfluvial life history, living much of their lives in the reservoir and then spawning and rearing in adjacent or upstream tributaries. Based on annual gill net surveys carried out since 1958 and on the index spawning stream surveys conducted since 1993, MDFWP has concluded that the Hungry Horse bull trout population is considered "stable" (Marotz et al., 1996). The MDFWP attributes this to the fact that most spawning and rearing tributaries remain undisturbed and in excellent condition. The MDFWP also places importance on the near natural fish community assemblage found throughout the South Fork basin. The dam itself has physically prevented predatory non-native fish species such as lake trout, from migrating upstream and becoming established in the drainage basin.

Even though Hungry Horse bull trout populations have remained secure over the years, routine reservoir operations are likely to have some negative effects on the species. There are several adverse biological responses associated with seasonal reservoir storage management. These responses have been identified from Hungry Horse empirical field research and computer modeling simulations carried out by MDFWP. Studies have shown that evacuating reservoir storage shrinks the size of the aquatic environment for all organisms in the food web. Phytoplankton production (base of the food chain) is reduced as the reservoir surface area becomes smaller. Production of zooplankton, an important food for young trout, follows the level of phytoplankton abundance and becomes less with decreased reservoir volumes, particularly during the more productive warmer summer months. Reservoir drawdown dewaters bottom substrates that are or could be inhabited by benthic fish food organisms such as dipteran insects. Aquatic insects living in bottom sediments are often exposed to the atmosphere and directly killed by drawdowns. MDFWP studies (Marotz et al., 1996) have shown that it takes at least two years for dipterans to effectively recolonize previously dewatered bottom sediments. During the summer months, lack of refill and/or the 20-foot draft associated with the anadromous fish BiOp water requirements, draws the water level away from the vegetated shoreline and reduces surface deposition of flying or wind blown terrestrial insects. Terrestrial insects are an important food item to westslope cutthroat and other fish species that bull trout may prey on. A reduced reservoir pool also concentrates younger fish and exposes them more to predation.

Hungry Horse Reservoir cannot intentionally be operated for optimal fish habitat which would be provided if full pool was maintained year round. Rather, the reservoir is managed for and drawn down in the winter to provide adequate flood control storage space. Wintertime hydropower operations can also cause the pool to be drafted. With the supplemental 1998 BiOp requirement to operate in the fall and winter to assure a 75 per cent confidence of being at the flood control rule curve on April 10, it is expected that the incidence of deep power drawdowns will be less than in past years. This is a time when juvenile, subadult and adult bull trout are residing in the reservoir and winter conditions for them should improve somewhat over the long term. Summer refill may also increase with the BiOp requirement to provide storage for salmon.

However, the reservoir elevation will not be held at full pool for long and the 20-foot salmon water draft will prevent benthic insects from being established in the summer drawdown zone. For young bull trout, this operational requirement will diminish their summertime food supply (zooplankton and benthic insects) during the most productive period and make them somewhat more susceptible to predation. Piscivorus adult bull trout would be expected to benefit slightly since prey species would be more concentrated with the reduced pool. Long term, it is difficult to predict the overall impacts to the Hungry Horse Reservoir bull trout. The population may or may not respond favorably to the newer operational constraints as required by the anadromous fish BiOp. The trend results from continued annual bull trout spawning surveys in the index streams may help to answer this question.

Mainstem Flathead River and Flathead Lake Bull Trout

Hungry Horse Dam operations influence fish habitat conditions in the mainstem Flathead River in several ways. These operations have: 1) caused reduction of the Flathead River's springtime peak flows and altered flow conditions during other times of the year, 2) caused more immediate and short term river flow fluctuations associated with hydropower operations, 3) provided summertime releases for salmon flow augmentation and other discharges to meet mainstem resident fish minimum flow target of 3,500 cfs in the mainstem, and 4) changed downstream water temperature changes. From a resident fish standpoint, including bull trout, some of these changes can be construed as positive, while others may have negative effects.

The South Fork Flathead River yields an average of about 30 percent of the total Flathead River basin's inflow to Flathead Lake. About 70 percent of the flow comes as uncontrolled natural runoff from the North and Middle forks and other tributaries. As such, the river basin above Flathead Lake still retains a normal streamflow hydrograph with flows peaking during the spring and early summer snow melt period. Mainstem peak flows (May and June) have been reduced, however, because of the influence of Hungry Horse Reservoir's refill and flood protection operations. With Hungry Horse Dam operational since 1953 (45 years), there has been 12 years when the flood stage of 14 feet (52,000 cfs) was exceeded at Columbia Falls. This compares to an estimated 35 years of flood stage exceedence if the dam had not been constructed. Since completion of the dam, the average annual Columbia Falls peak flow has been 45,433 cfs. If the dam were not present, the average annual peak (calculated) would have been 70,215 cfs for the same period. There could be some subtle changes in mainstem fish habitat related to the reduction of springtime peak flows of this magnitude. Mainstem side channel areas are probably less extensive due to Hungry Horse flood control operations. Greater flood protection may also have helped to promote more rural residential development near the river, causing some degradation to fish habitat. It is doubtful, however, that the actual reduction of peak spring flows has had direct or meaningful habitat impact on bull trout in the mainstem or effected their migratory behavior from or to Flathead Lake.

Hydropower generation is an important project purpose at Hungry Horse Dam. Hydropower production at the dam is dependent on system demand, the reservoir water supply, and generating unit availability. Since the mid-1980's, there has been a series of operational guidelines instituted under auspice of the Northwest Power Planning Council's Fish and Wildlife

Program and the 1995 salmon and 1998 steelhead BiOp's to reduce hydropower impacts and to better protect resident and anadromous fish populations. Overall, these measures have constrained the project's flexibility to produce power, but power generation is still viable and normally emphasized when conditions allow (Carter, USBR, 1998, pers. comm.). These guidelines are discussed in Section 3, Project Descriptions. In accordance with the 1998 supplemental BiOp, the reservoir is operated in the fall and winter to maintain at least a 75 percent chance of being at flood control elevation by April 10. This requirement can significantly reduce winter drafting of the reservoir for power generation. At the start of the new calendar year, water forecasts are assembled the beginning of each month and decisions are made as to the opportunity for power generation. If reservoir refill is at or above the flood control run curve, power peaking operations are typically implemented. Power generation can continue through the spring and summer if runoff is favorable for reservoir refill. There is great variation as to when and how much power is generated. Hungry Horse power peaking discharges can be ramped from a low of 145 cfs up to about 11,200 cfs. This condition represents the maximum expected swing in powerplant discharges under load following conditions. From June 1 to September 30, this amount of discharge change is spanned over a 6 hour period. At other times, ramping can be done more rapidly.

With power peaking, artificially imposed flow changes to the mainstem Flathead are added to whatever natural flows are incoming from the North and Middle fork drainages. Natural inflows dampen the effects of power peaking discharges from Hungry Horse Dam. Power peaking at the dam has been most common during the winter and summer months. Given their migration behavior and timing, adult bull trout are not expected to be affected by peaking power operations. This is because the fish are normally migrating through deeper water sections of the river, in areas not subject to repeated varial zone flooding and dewatering from peaking operations. Furthermore, upstream spawner migration through the mainstem occurs during the high runoff spring period, a time not significantly affected by flow changes from power peaking. With completion of spawning in headwater tributaries, the adult fish return to Flathead Lake in the early fall. This is a time when Hungry Horse Dam is most likely to be releasing water to meet the 3,500 cfs minimum at the Columbia Falls gauge and with salmon flow augmentation already finished, additional storage is not available to provide a large amount of power generation.

Juvenile bull trout migrating downstream through the mainstem Flathead River, on the other hand, may be adversely impacted by both summer power peaking and the salmon water release regime. Young bull trout are normally found in shallow water shoreline margins and riffle areas. These are habitats that are typically associated with the varial zone - inshore and shallow areas subject to repeated flow and river stage changes from power peaking. Within the varial zone, there can be reoccurring wetting and drying of the substrate. Thus, the varial zone is more devoid of aquatic insects on which young salmonids feed. These barren areas are less likely to provide the food that juvenile bull trout need as they migrate through the Flathead River towards the lake. Also, rapid flow reductions from Hungry Horse down ramping can strand young fish if they are unable to escape over and through draining or dewatered substrate.

With reservoir refill in early summer, Hungry Horse is called on by the Technical Management Team to be drafted up to 20 feet to elevation 3,540 feet for salmon flow augmentation. This water is usually moved over a 30-45 day period and needs to be passed downstream by the end of August. In addition to the reservoir's inflow, about 455,000 acre-feet of reservoir storage space is evacuated. Potentially aggravating the problem for young resident salmonids is the manner in which salmon water releases are made. If the discharge from the reservoir results in an unnatural second peak flow and/or erratic releases, then adverse impacts to juvenile salmonids in the mainstem can result. With a second flow peak, juvenile bull trout are likely to follow a rising river stage and move into the near shore, low velocity zones that were previous dewatered and rendered devoid of aquatic macroinvertebrates. Power peaking can also be incorporated into the salmon water releases which can further exacerbate flow and stage swings in areas occupied by juvenile salmonids. However, for a given year and water conditions, however, it may be possible to schedule salmon flow augmentation more protective of mainstem resident salmonids. For instance, in 1998, releases were made in such a way that the salmon flows in July and August were feathered into the natural decline of the uncontrolled spring freshet and a second (artificial) peak was essentially eliminate. Hungry Horse releases were held steady through most of the period. Ramp down near the end of the 5,000 cfs release, spanned a two week period to reduce the potential for juvenile fish stranding.

The minimum flow target of 3,500 cfs at the Columbia Falls gauge is probably most beneficial to juvenile bull trout during the latter part of their migration to Flathead Lake. Releases from Hungry Horse are often made during the fall and winter months to meet this flow. Some juvenile bull trout are probably still in the mainstem in the fall period when the minimum flow is provided and a few fish may overwinter in the river before reaching Flathead Lake. Instream flow (IFIM) studies are to conducted over the next three years (B. Marotz, MDFWP, 1998, pers. comm.) to better quantify resident fish flow needs in the Flathead River section subject to Hungry Horse discharges.

Operation of the selective withdrawal system at Hungry Horse Dam now allows water temperatures in the regulated mainstem to mimic predam natural conditions particularly during the optimum summer and fall fish growth period. Previous to selective withdrawal operations in 1995, Hungry Horse water discharges were cold hypolimnetic releases averaging around 4^{o} C throughout the year. Now, once the reservoir stratifies in the early summer, warmer surface water is released. The system is operated till sometime in the fall. With selective withdrawal in place, the MDFWP expects the diversity of predam aquatic insects species to be restored in the mainstem and fish growth rates to increase. Studies are underway to document the changes. Another expectation is that lake trout predation on juvenile westslope cutthroat and bull trout will be reduced because elevated water temperatures in the mainstem during the summer months should deter their presence in the river. The selective withdrawal system should therefore improve survival of juvenile bull trout that migrate through the mainstem reach.

Flathead River Downstream of Kerr Dam

Water stored in Hungry Horse reservoir provides summer enhancement flows for anadromous fish in the Columbia River. This water is released usually in July and August and is a component of the Reasonable and Prudent Alternative as defined in the 1995 and 1998 Supplemental BiOps. During the summer months, Flathead Lake is held at full pool and Hungry

Horse releases are passed through Kerr Dam in accordance with the FERC relicense provisions. At other times of the year Flathead Lake may be less than full and Hungry Horse releases are shaped at Kerr Dam in accordance with the FERC license flow and ramping requirements (see Table 2.1.2-7).

Given the FERC relicense provisions, operations at Hungry Horse dam are not likely to adversely affect bull trout in the lower Flathead River. Seasonal minimum flow and ramping restrictions have been instituted to improve aquatic habitat conditions in the lower Flathead River. Existing densities of trout in the lower Flathead River were estimated at 30 adult fish per river mile according to DosSantos (1988), with only an occasional bull trout observed. Past river regulation and agricultural practices in the tributaries have greatly limited the lower Flathead River fisheries. The dramatic short-term flow fluctuations resulting from historic Kerr dam operations (prior to FERC relicensing) was the primary factor for limited trout populations. It is hoped that the FERC required flows and ramping rates will significantly improve salmonid populations in the lower Flathead River, including bull trout. However, improved conditions as a result of the change in operations at Kerr Dam may not be able to overcome existing degraded spawning and rearing conditions in tributaries to the Flathead, where bull trout survive today.

Summary of Operations Effects

Hungry Horse Reservoir/South Fork Flathead River

Hungry Horse Reservoir flood control, hydropower, and salmon flow augmentation operations are *likely to affect* bull trout that reside in the reservoir. These operations, however, are not expected to adversely impact and may actually benefit adult bull trout since prey fish are more concentrated and available during drawdown periods. Young, subadult bull trout, on the other hand, are likely to be adversely affected with reservoir drawdowns as they transition from feeding on benthic macroinvertebrates to other fish. Within the drawdown zone, benthic insect production is eliminated and cannot be fully restored until the zone is reflooded for at least two years. Therefore, drawdowns potentially reduce benthic insect availability to sustain smaller forage fish populations and to young bull trout that have emigrated to the reservoir from upstream tributaries. It should be noted that the1995 and supplemental 1998 BiOp reservoir refill requirements to meet salmon flow augmentation have significantly constrained (reduced) the magnitude of Hungry Horse Reservoir drawdowns when compared to previous years. Accordingly, these operations should benefit bull trout and other fish species over the long term.

Mainstem Flathead River and Flathead Lake

Hungry Horse Dam operations are *likely to affect* some bull trout that are migrating through the mainstem Flathead River below its confluence with the South Fork. Hungry Horse releases for flood control and hydropower during the spring time is not expected to affect adult bull trout migrating upstream from Flathead Lake because most flow is associated with natural snowpack runoff originating from the North and Middle Fork basins. These fish are moving through deepwater river sections and are not subject to stranding from natural flow or dam discharge reductions. Adult bull trout that return to Flathead Lake after fall spawning are also not expected to be adversely affected by Hungry Horse Dam releases, since a minimum flow of 3,500 cfs must be maintained in the mainstem.

Hungry Horse Dam operations are *likely to adversely affect* juvenile and subadult bull trout as they emigrate to Flathead Lake from headwater tributaries. These age classes are in the mainstem during the late spring, summer, and fall period and some may overwinter before reaching the lake. They are more likely to inhabit shallow water and shoreline margins of the river. They are therefore vulnerable to stranding in the varial zone from hydropower peaking operations or from rapid reductions in summertime dam discharges associated with salmon flow augmentation. On the other hand, if dam discharges for salmon flow are delayed long after the spring runoff has subsided, young bull trout are likely to reoccupy shallow water areas that are devoid of aquatic macroinvertebrates food organisms. This lack of food could reduce their fitness and ability to survive and result in fewer fish reaching Flathead Lake.

Hungry Horse selective withdrawal operations are *likely to affect, but unlikely to adversely affect* (may benefit) both adult and juvenile bull trout migrants since a return to spring, summer and fall natural water temperatures (warmer) in the mainstem will increase both insect and prey fish growth and production. Lake trout predation of young bull trout is also expected to be reduced because lake trout will not be attracted to the mainstem river section with resultant warmer water.

Flathead River Downstream of Kerr Dam

Hungry Horse operations are *not likely to affect* bull trout residing in the Flathead River downstream of Kerr Dam. This is due to the fact that new FERC relicensing provisions have made significant changes in Kerr Dam operations. It is more common now to shape Hungry Horse storage releases in accordance with these requirements. Kerr Dam is operated to meet stringent seasonal lake level objectives and downstream Flathead River flow targets. These flow requirements have increased minimum flows and constrained hydropower peaking operations and are designed to improve overall habitat conditions in the river for a variety of aquatic species.

4.1.3 Pend Oreille Basin

If, as Rieman and McIntyre (1993) suggest, the chance of extinction of a bull trout population increases if fewer than 100 redds or 1,000 total individuals are present, then the Pend Oreille/lower Clark Fork population is probably not in danger of extinction (see Table 2.1.3-2 and Table 2.1.3-3). It appears more or less stable, but at a somewhat depressed level. However, based on criteria in USFWS (1998a), the population is probably functioning at risk. Habitat impacts have been documented over time, as have possible impacts to food sources (Sec. 2.1.3, Pend Oreille Basin). These include impacts from land uses and development. Operation of Albeni Falls Dam is suspected by IDFG (Maiolie and Elam, 1993a, 1993b) as a factor in production of kokanee in Lake Pend Oreille, because of winter drafting below elevations where clean gravel is available for spawning on the lake shore. High levels of total dissolved gases coming out of the Clark Fork in spring and summer may be of concern.

Direct effects on bull trout from operation of Albeni Falls Dam are probably few or none. There is no evidence of barriers to tributaries; in fact, historical low lake levels were lower than those regulated by the dam. Albeni Falls Dam itself poses a migration barrier; the falls prior to dam construction were not considered a barrier (Gilbert and Evermann, 1895). Thus, restricted migration has restricted genetic mixing, but the extent to which this has adversely affected the population is not clear. There may be a thermal effect which restricts use of the Pend Oreille River above the dam, at least in warmer months. Whether this is true in winter has apparently not been demonstrated.

It is possible there is a trophic effect on bull trout from dam operation as it affects kokanee. However, research has apparently not as yet shown that to be the case. The current operation of Albeni Falls Dam includes the higher winter pool experiment to provide better access for kokanee to lakeshore spawning habitat. That experiment is scheduled to continue only through the 1998-99 winter operating season, although it might be extended on a year-by-year basis following that.

The winter test pool to benefit kokanee might benefit bull trout over the present condition if it is successful, by increasing the prey base, though unless food were limiting, the benefit might be difficult to detect. IDFG is monitoring the results of the test; so far they are not conclusive (M. Maiolie, IDFG, pers. comm). IDFG has requested that the test be extended (Mealy, 1998). The reasons they cite are that 1997 high flows reduced all age classes and nullified benefits of a test, and the spawner count in 1997 was at a record low. Because of the possibility of factors other than shoreline spawning gravel access affecting kokanee life history and survival, the ultimate benefit of the higher winter pool test is not clear. Whether or not the test is continued, if the kokanee population declines further, then it is possible that bull trout populations may decline. While it is not clear that food is limiting for bull trout at this time, there may be a slight risk to bull trout from any operation that does not support the kokanee prey base. If at a future time the Corps continues the test, bull trout will probably not be harmed by that action, and some benefit may result. No jeopardy would be expected in that case.

The current and proposed operations of Albeni Falls Dam are *not likely to affect* bull trout. However, the placement of Albeni Falls Dam as a barrier to upstream migration must be considered among cumulative impacts which *may adversely affect* the adfluvial bull trout population in the area.

4.1.4 Upper Columbia Basin

Operations at Grand Coulee Dam *may adversely affect* the small numbers of bull trout which inhabit Lake Roosevelt. However, the bull trout population appears very small to near non-existent based on Spokane Tribe fishery data. Past land management practices in streams tributary to Lake Roosevelt have had (and continue to have) a more adverse affect on bull trout that utilize those tributaries for spawning and rearing.

Flood control, hydropower, and salmon flow operations of Grand Coulee Dam *are likely to adversely affect* bull trout residing in Lake Roosevelt. However, over the years, only a few bull trout have been documented in the reservoir and only on rare occasions. Bull trout are also not extensively found in tributaries to Lake Roosevelt and degraded habitat conditions in those streams may be more of a limiting factor than reservoir operations.

4.1.5 MidColumbia Basin

This section discusses the possible effects to bull trout based on current operations of the Army Corps of Engineers' Chief Joseph Dam, above and below the dam. Chief Joseph Dam is located approximately 52 miles downstream of Grand Coulee Dam.

In order to understand the potential impacts Chief Joseph Dam may have on bull trout, it must be understood that the stage was set when Grand Coulee Dam was constructed in 1939. This was one of the first person-made barriers to the bull trout as there were no fish ladders or means for any species of fish to migrate past this structure. Then in 1949 construction of Chief Joseph Dam began, with full operation occurring in 1955.

Lake Rufus Woods, the reservoir behind Chief Joseph Dam, fluctuates very little throughout the year, with a normal operating range between elevation 950 feet and 956 feet. This range must be maintained because of a plethora of constraints and to optimize power revenues that are generally coordinated with Grand Coulee Dam. In order to maintain this elevation range, releases are coincided with Grand Coulee releases.

Chief Joseph Dam was constructed without a fish ladder like Grand Coulee. This set up a situation where bull trout could migrate downstream through the dam but were unable to return. Another result of the two dams being constructed on the Columbia River is the reach between the two dams became more of a lake (reservoir) environment instead of a fast moving river.

The slower moving water (reservoir) instead of a fast moving river usually has a more constant and higher water temperature. According to Fraley and Shepard (1989) and Rieman and McIntyre (1995), bull trout are temperature sensitive. When temperature is above 15^{o} C. (59^{o} F) it is believed to limit bull trout distribution. Not only is it possible for a temperature change but a complete habitat change occurred because of the two dams. With bull trout having more specific habitat requirements than other salmonids (Rieman and McIntyre, 1993), this complete habitat change could have been devastating to the bull trout trapped between the two dams. Some of the habitat components that appear to influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrates, and migratory corridors (Oliver, 1979; Pratt 1984; Fraley and Shepard, 1989; Goetz, 1989; Hoelscher and Bjornn, 1989; Sedell and Everest, 1991; Howell and Buchanan, 1992; Rieman and McIntyre, 1993, 1995; Rich, 1996; Watson and Hillman, 1997). One of the outcomes of this changed environment is the possibility of migratory fish becoming resident fish. Another drawback to the bull trout is apparently growth of resident fish is generally slower than migratory fish; resident fish tend to be smaller at maturity and less fecund (Fraley and Shepard, 1989; Goetz, 1989).

The result of the two dams being constructed and the development of Lake Rufus Woods is that impassable dams have caused declines of bull trout primarily by preventing access of migratory fish to spawning and rearing areas in headwaters and precluding recolonization of areas where bull trout have been extirpated (Rieman and McIntyre 1993). According to the U.S. Fish and Wildlife Service (1998b), bull trout are extirpated in the reach between Chief Joseph Dam and Grand Coulee Dam.

The greatest concern below the dam is water quality as it relates to total dissolved gas levels (TDG). Due to the height of the spillway and the configuration of the stilling basin, TDG levels can exceed the Washington State water quality standard of 110%. This problem is most acute during the spring and summer when both Grand Coulee and Chief Joseph Dams may be spilling water due to high runoff, and insufficient power demand does not allow all inflow to pass through the generating units.

The result of high TDG is that supersaturation of dissolved atmospheric gases can lead to gas bubble disease (GBD). Fortunately for the bull trout, spawning occurs during late summer and early fall. Therefore, GBD should not be a problem during spawning season. However, it can be a problem for any bull trout that may be present in the Columbia mainstem during spring runoff. A recent study was performed comparing the effects of GBD in resident versus migratory salmonids (Shrank et al., 1997). The result was that resident fish experienced a higher rate of mortality than non-resident fishes. Although the test was performed on chinook salmon and not bull trout, one could surmise that since both are salmonids and bull trout have a more critical habitat requirement, the effect could be the same or worse for bull trout exposed to high TDG. The current operations at Chief Joseph Dam could still produce elevated TDG during peak run-off freshets. Thus there could be an adverse effect (GBD) on resident bull trout and juvenile fishes below Chief Joseph Dam. It is unknown whether bull trout are present in the mainstem in any abundance during periods of peak runoff, or if so, whether they occur in locations and depths that would make them susceptible to high dissolved gas levels.

Aside from the possible impacts of dam construction and operation, there were other factors such as legal recreational angling, poaching, and State-sponsored eradication programs (Thomas, 1992) which may have contributed to the extirpation of bull trout in various reaches of the Columbia. Bull trout were often targeted for removal by anglers and government agencies because bull trout preyed on salmon and other desirable species (Simpson and Wallace, 1982; Bond, 1992).

Because of the reduced numbers of bull trout, dam operations have the potential to be detrimental, but evidence is not conclusive at this point. Operations of Chief Joseph Dam are *likely to affect, and may adversely affect* bull trout.

4.1.6 Clearwater River Basin

There are five suppressing factors to bull trout utilizing the Dworshak reservoir area: habitat degradation (fire, roads, salvage timber harvest, mining, agriculture), loss of prey species (kokanee) through entrainment associated with reservoir drawdown for flood control or salmon flow augmentation to the lower Snake River, passage barriers associated with reservoir drawdown limiting access back into the North Fork, hybridization in the North Fork of the Clearwater River that is managed by the U.S. Forest Service, and competition in the reservoir with lake trout. As a keystone predator the bull trout is dependent on the production of suitable and adequately diverse prey fish species, including salmon and steelhead smolts downstream of Dworshak Dam (fluvial bulltrout) and kokanee (adfluvial bulltrout) during their rearing and migration lifestages. Outside of the timeframes of salmonid abundance, other suitable prey fish may need to be available to assure fitness through overwintering.

Seasonal drafting from Dworshak Dam for flood control, downstream flow augmentation for chinook salmon migration, and/or dam repair and maintenance activities have caused the loss of kokanee, the primary prey species for bull trout in Dworshak reservoir. The kokanee exit the reservoir through the dam during these drafts of water that may reach 80 feet below reservoir surface elevation. An event occurred in December 1997-January 1998 where high early spring melt resulted in runoff that forced Dworshak to rapidly evacuate water to provide flood control storage space. It is believed that the cold weather prior to the draft caused the kokanee to redistribute to greater depths available close to the dam structure. This action caused high entrainment of the self-sustaining kokanee population from the reservoir into the lower reach of the North Fork Clearwater River below Dworshak where up to 98% of the population was lost as estimated by Idaho Department of Fish and Game (IDFG). If this estimate is close to representative, then the kokanee population used by foraging adfluvial bull trout in Dworshak Reservoir were starting at functionally zero to begin anew. Several anglers during the spring-summer of 1998 have reported catches of relatively large bodied kokanee, so some spawners may have survived. In response to this event, Idaho Department of Fish and Game proposed an interim plan to stock trout and kokanee in Dworshak Reservoir during 1998, with support from the Nez Perce Tribe. The proposal is a near term effort to rebuild the kokanee population to a viable naturally reproducing population (self-sustaining) and to provide a trout fishery while the kokanee population is rebuilding. The stocking efforts do not diminish the need to substantially reduce or eliminate the entrainment loss of kokanee through Dworshak Dam.

Past drawdowns of up to 80 feet also resulted in a substantial reduction in water surface area at the primary inlet supplying flow into the reservoir from the North Fork of the Clearwater River. A centralized channel is cut through the rather narrow delta increasing turbidity and creating a shallow water, higher velocity partial barrier for both bull trout access to cooler water and rearing habitat, as well as kokanee access to their primary spawning habitat.

The US Army Corps of Engineers, Bonneville Power Administration, Idaho Department of Fish and Game, and the Nez Perce Tribe are cooperatively working to reduce the numbers of kokanee lost during dam operation. The coordinating committee has been formed to investigate and implement experimental strobe light system. Researchers with the Nez Perce Tribe have submitted proposals for 1999 and future years funding from BPA to access the population status of bull trout in and near Dworshak Reservoir and study the effects of drafting Dworshak Reservoir on the bull trout and kokanee food chain.

Based upon current data, bull trout populations occuppying in and near Dworshak Dam and reservoir on the North Fork of the Clearwater River are *likely to be affected, but unlikely to be adversely affected* by operation of the dam for flood control and/or flow augmentation for listed Snake River salmon migration as requested by NMFS in their 1995 BiOp (NMFS, 1995) and 1998 Supplemental BiOp (NMFS, 1998). Reservoir operations influence the quantity and quality of suitable habitat in the reservoir and streams both upstream and downstream for bull trout and their most abundant prey, kokanee salmon. Continued operations of Dworshak Reservoir for flood control and/or flow augmentation are likely to affect the local bull trout populations because of extreme reservoir drawdowns on the productivity of kokanee prey, entrainment of kokanee through the dams, and the creation of a partial barrier for both bull trout and kokanee into the cooler water of the North Fork of the Clearwater River. While project activities may affect these localized populations, the proposed action is not likely to jeopardize the Columbia River population segment because the viability of bull trout in Dworshak reservoir is strongly dependent on the status and productivity of the population originating from habitat managed by the U.S. Forest Service and others in the North Fork of the Clearwater River that supplies flow to Dworshak reservoir.

Bull Trout Conservation Planned Projects

The following projects may have benefits to bull trout in the Clearwater basin.

The US Army Corps of Engineers supports the stocking of 70,000 sterile rainbow trout (2.0/lb.) and 500,000 kokanee (2 inches in length) in 1998 and 50,000 sterile rainbow trout (2.3-3.0/lb.) and 5,000,000 kokanee (2 inches in length) per year from 1999 through 2001. The fish will be reared by Idaho Department of Fish and Game and will be stocked in the Dworshak Reservoir.

Research done by Idaho Fish and Game suggests that the strobe lights would prevent kokanee from exiting the reservoir through Dworshak Dam. The US Army Corps of Engineers and Idaho Fish and Game are currently researching various methods of strobe light usage in Dworshak Reservoir.

The operation of Dworshak adopts the adaptive management approach. Under this approach, operations are modified in-season and/or year-to-year based upon new scientific information or to support studies for long-term configuration changes through the RPA 26 framework process of the NMFS 1995 BiOp (NMFS, 1995) for chinook and sockeye salmon. The Technical Management Team will make in-season recommendations to the Action Agencies based on runoff conditions, fish migration and other factors. The Action Agencies will continue to coordinate through the regional forum with NMFS, USFWS, NPPC, states, and Tribes on different proposed reservoir operations and consider TMT recommendations in making final decisions on the operation of all of the FCRPS projects. Operations may be modified on a case-by-case basis if recommended by the TMT, Implementation Team, or to adjust the operations in coordination with NMFS and USFWS.

4.1.7 Lower Snake River and McNary Projects

The 1995 BiOp (NMFS, 1995) and 1998 Supplemental BiOp (NMFS, 1998) for threatened Snake River spring/summer and fall chinook ESUs and endangered Snake River sockeye salmon ESUs and threatened Snake River steelhead ESUs require spill for increased Fish Passage Efficiency (FPE). This increased high volume and rate of spill for salmon passage is likely to increase the entrainment rate of individual bull trout that migrate into the lower Snake River reservoirs to feed seasonally. Once entrained, bull trout can become stranded, isolated, or significantly delayed from passing back upriver due to the weir and orifice design in adult ladders targeted for salmon and steelhead passage.

Bull trout populations associated with the lower Snake River hydropower dams and reservoirs are *likely to be affected, but unlikely to be adversely affected* by operation of the dams for hydropower and/or flow augmentation for listed Snake River salmon migration as requested by NMFS in their 1995 BiOp (NMFS, 1995) and 1998 Supplemental BiOp (NMFS, 1998). Reservoir operations influence the quantity and quality of suitable habitat in these reservoirs for bull trout and their most abundant prey in the mainstem lower Snake River (chinook smolts), and in the access to tributary streams below the dams. The hydropower corridor also contributes to shifts in water temperature that act to prolong the warm water periods, thus retarding bull trout retreat back to cooler water in the tributaries. Adult passage ladders at each mainstem dam on the lower Snake River were constructed primarily for optimal salmon passage relying upon salmon abilities and tendencies to jump overflow weirs and swim through submerged orifices arranged in series. Bull trout do not exhibit the physical abilities of salmon to burst swim strongly or jump; thus they require vertical slot type passage structures open throughout the depth of the ladder's water column. Currently designed ladders result in blockage or delay for a bull trout that is entrained into the tailwaters of a mainstem dam. Bull trout do pass at some undetermined rate as evidenced occasionally in snapshots and videos of individuals in the observation windows of the ladders. Continued operations of the lower Snake River hydropower dams and reservoirs for electrical power production and/or flow augmentation and/or increased spill operations for enhancing listed Snake River salmon migration as requested by NMFS in their 1995 BiOp (NMFS, 1995) and 1998 Supplemental BiOp (NMFS, 1998) has the potential to likely affect local bull trout populations whose individuals migrate into the mainstem river. While project activities may affect these localized populations, the proposed action is not likely to adversely affect or jeopardize the proposed Columbia River population segment.

4.1.8 Lower Columbia River

Construction Effects

Historically, bull trout were widely distributed in the mainstem Columbia River and its tributaries. Migratory bull trout historically occurred in the Columbia River and many of its tributaries (Bond, 1992). Bull trout were reportedly caught in the early fish wheels on the lower Columbia River near McCord Creek in Oregon downstream of the present location of Bonneville Dam (Donaldson and Cramer, 1971). Prior to the construction of numerous storage and hydropower dams throughout the basin, bull trout populations had access to hundreds of miles of mainstem and tributary spawning, rearing, foraging, and migration habitat. Bull trout populations have been largely extirpated from the mainstem Columbia River including The Dalles, John Day, and McNary reservoirs (USFWS, 1994). A remnant population of fluvial bull trout using the lower Columbia River still remains in the Hood River system (Buchanan et al., 1997).

Major hydrological changes have occurred in many basins containing bull trout due to the construction of Columbia River and tributary dams for hydroelectric power, water storage, or diversions for agricultural purposes. In addition to the loss of migration corridors, some basins have lost all native salmon and steelhead production due to impassable barrier dams in the Columbia and Snake rivers. The loss or reduction of salmon and steelhead as prey species for bull trout could affect growth and reproductive potential for surviving bull trout populations. Linkage to the Columbia or Snake rivers may have been important to the life history of many bull trout populations (Buchanan et al., 1997).

Bull trout movement and migration were probably altered on the lower mainstem Columbia River after the construction of Bonneville Dam in 1938 (Buchanan et al., 1997). Additional alterations in movement and migration most likely occurred as many other dams were completed throughout the Columbia River basin. Passage barriers or the elimination of migration corridors can be a major limiting factor for some populations of bull trout. Passage barriers can isolate populations and prevent the exchange of genetic information (Buchanan et al., 1997). Dam construction and operation and the resultant ecosystem changes from free-flowing rivers to reservoirs undoubtedly changed, altered, or eliminated bull trout migration patterns in the lower Columbia River and its tributaries.

Cumulative Effects

In addition to dams acting as passage barriers, other limiting factors have played a major role in the decline of bull trout populations in the lower Columbia River basin. These cumulative factors include habitat loss and degradation, overharvest, genetic and random risks, introduction of non-native fish, climatic change, ecosystem change, and others (Buchanan et al., 1997).

Bull trout were more widely distributed historically than currently, but it is not clear as to the effect of habitat loss and habitat degradation on bull trout distribution. Bull trout need high quality habitat to survive. Channelization, water withdrawals, riparian vegetation removal, and other watershed disturbances have adversely impacted aquatic systems by elevating water temperatures, reducing water quality and quantity, and increasing sedimentation (Buchanan et al., 1997).

Overharvest of animals by humans has been a factor in the extirpation of many species. Bull trout are aggressive and readily take lures or bait making them highly susceptible to angling pressures. Bull trout have historically provided a wide range of angling opportunities. However, recent protective management strategies have included severe angling restrictions (Buchanan et al., 1997).

Bull trout have coexisted and evolved with rainbow trout, cutthroat trout, chinook and sockeye salmon, and many other native, aquatic species. However, the introduction of non-native salmonids to native bull trout habitat can be a limiting factor for some bull trout populations. Introduced lake trout can displace and eliminate native bull trout (Donald and Alger, 1992). Moyle (1976) and Bond (1992) suggested that introduced brown trout have been associated with the decline of bull trout populations. Brook trout interactions and hybridization with bull trout are a serious threat to some bull trout populations in the Columbia River basin (Buchanan et al., 1997). Habitat changes such as increasing water temperatures may exacerbate the effects of non-native species on bull trout (Rieman and McIntyre, 1993). Increased water temperatures may allow non-native brook trout to dominate over native bull trout populations. The introduction and proliferation of other non-salmonid fish species in the Columbia River basin also may have altered bull trout distribution within the reservoir systems.

There is no clearly defined basis for understanding the minimum amount of genetic diversity needed to ensure the survival of bull trout populations. Rieman and McIntyre (1993) estimated that the probability of bull trout extinctions would increase if there were substantially less than 100 redds or 2,000 total individuals. They also stated that habitat changes that eliminate or isolate segments of populations might increase their susceptibility to random processes like natural mortality rates, sex ratios, and chronic or catastrophic environmental events. This is due to the population being smaller and less diverse in distribution or structure. This loss of genetic diversity could reduce fitness and increase sensitivity to environmental alterations. The loss or isolation of local populations increases the risk of extinction. The presence of several subpopulations in a local area increases the probability that at least one subpopulation will survive periods of risk or disturbance (Rieman and McIntyre, 1993).

Natural cyclic droughts and heat waves can adversely impact bull trout populations. These events can be devastating to small, fragmented bull trout populations. Environmental catastrophic events such as extended droughts will continue to limit bull trout populations that are already pressured by other limiting factors. Concerns over global warming underscore the threats to bull trout survival. Many global climate models predict air temperature increases of 1-5^{o} C for North America over the next century. Such warming would likely reduce the range or cause the extinction of some bull trout populations (Buchanan et al., 1997).

Ecosystems supporting bull trout populations are the result of the geologic history of the basin, the erosional history of the watershed and its surrounding land forms, the evolutionary history of the biotic community, and the cultural history of the human economies that have altered the ecosystems (Lichatowich et al., 1995).

Large-scale anthropogenic changes on landscapes over time may be difficult to document or visualize as to its direct effect on present bull trout populations. These changes throughout an entire ecosystem may make basinwide protection, restoration, and recovery efforts impossible. Bull trout populations have adapted to local habitats and environmental conditions. Restoring the productive capacity of a basin or ecosystem requires an understanding of the historical nature of the stream habitats in which the bull trout populations have evolved and adapted over a wide span of time. Intensive livestock grazing, timber harvest, agricultural practices, mining, chemical poisoning projects, and non-point pollution and sedimentation have altered watersheds and rendered large aquatic areas unsuitable for bull trout (Buchanan et al., 1997).

Current Operational Effects

As previously described, bull trout have been extirpated from much of the lower mainstem Columbia River including The Dalles, John Day, and McNary reservoirs. The only known population that uses the lower mainstem Columbia River is a remnant fluvial population from the Hood River system in Oregon. This small population rears in the Bonneville pool. Only limited information is currently available on this remnant population. Buchanan et al. (1997) listed this Hood River population as having a “high risk” of extinction due primarily to the small population size. This small population is highly susceptible to random processes such as an increased natural mortality rate or catastrophic environmental events such as droughts, fires, or volcanic activity. Nevertheless, the construction of the lower mainstem Columbia River dams have altered migration and movement of bull trout within the system. The few documented sightings of bull trout in the Bonneville pool suggest that the lower Columbia River remains an important habitat for Hood River bull trout.

4.2 Kootenai River White Sturgeon

This section describes anticipated effects of operation of the FCRPS on Kootenai River white sturgeon.

The provision of spring spawning flows during the 1990s to benefit Kootenai River white sturgeon may be responsible for the sturgeon eggs produced and the presence of at least a handful of juvenile recruits. There is consensus (USFWS, 1997) that flows are a major factor in spawning of Kootenai River white sturgeon; however, the link to recruitment is less well established.

Because of other potential factors affecting survival and recruitment of juvenile sturgeon, it is difficult to say whether dam operations to provide spring flows remove risks to continued survival of the population. However, cessation of spring flow enhancements for spawning would likely create a jeopardy situation. Thus, spawning flow releases are probably necessary, but not sufficient, to recover the population.

There are other dam-related factors influencing the survival of sturgeon. They include power peaking, which could be adverse because of relatively rapid fluctuations and ramping rates. The effects of rapid ramping include possible displacement of juvenile sturgeon, and loss of food organisms due to dewatering. These effects are especially critical in the summer growing season. It is also possible that bull trout themselves could be stranded in river margins in the event of sudden decreases in flow; however, existing and proposed ramping guidelines (see Sec. 3.1) should guard against such occurrences.

A possibility of spill exists if outflow requirements exceed turbine capacity (about 25-27,000 cfs). No spill has occurred in recent years, but flood water evacuation, or the need to pass high levels of inflow if the reservoir is full, could result in spill and high levels of dissolved gas. Supersaturated water might persist as far as Kootenai Falls, at which point it should be dissipated. Assuming sturgeon are not found above Kootenai Falls, there should thus be little risk of gas bubble disease for sturgeon. Adult and juvenile sturgeon are generally demersal in any case, so they may remain below compensation depth (the depth below which increased water pressure forces dissolved gases to remain in solution). If sturgeon do inhabit the reach between Kootenai Falls and Libby Dam, they would be at more risk, but again, their demersal habits might protect them from adverse effects. However, larval sturgeon do move upwards in the water column (Brannon et al, 1985), and thus could be vulnerable to the effects of high total dissolved gas. Thus far there is no documented evidence of sturgeon living or spawning above Kootenai Falls, so there appears little risk to larval sturgeon from spill at Libby.

The proposed operations to limit power peaking and slow summer ramping rates are anticipated to have a beneficial effect on Kootenai River white sturgeon. There is to be no daily load fluctuation, and weekly fluctuations only above 10,000 cfs, during summer months (April-August). Because this is a critical time of year for growth and biological production, there should be a benefit to sturgeon as a result of increased productivity of aquatic insects and other food organisms upon which juvenile sturgeon depend. There is also less risk to juvenile sturgeon of being displaced downstream out of optimal habitat due to sudden increases in flow. The 10,000 cfs criterion provides protection for organisms in the main channel; above that flow there is less risk of major decreases in wetted perimeter when flows drop. However, the lack of restrictions on September (and also possibly October) ramping rates may create problems for juvenile sturgon, as well as for other fish and invertebrate species inhabiting the mainstem Kootenai.

The operations of Libby Dam are *likely to affect, and may adversely affect* Kootenai River white sturgeon.

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