



**ASSESSMENT OF FISHERIES LOSSES
IN THE UPPER SNAKE RIVER BASIN IN IDAHO
ATTRIBUTABLE TO CONSTRUCTION AND OPERATION OF
DAMS WITH FEDERAL HYDROPOWER FACILITIES**



Idaho Department of Fish and Game

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ASSESSMENT OF FISHERIES LOSSES IN THE UPPER SNAKE RIVER BASIN IN IDAHO ATTRIBUTABLE TO CONSTRUCTION AND OPERATION OF DAMS WITH FEDERAL HYDROPOWER FACILITIES

ABSTRACT

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 established a process for protecting, mitigating, and enhancing fish and wildlife affected by the construction and operation of hydropower projects in the Columbia River basin, and formed what is now known as the Northwest Power and Conservation Council (NPCC). In 1982, the council introduced a fish and wildlife program, and an amendment in 1995 included a two-step process for resident fish mitigation, the first of which was to complete assessments of resident fish losses related to the construction and operation of hydropower facilities. This report (1) quantifies lotic habitat lost as a result of construction of Anderson Ranch Dam and Reservoir, Black Canyon Dam and Reservoir, Deadwood Dam and Reservoir, Boise River Diversion Dam and Reservoir, Minidoka Dam and Lake Walcott, and Palisades Dam and Reservoir; and (2) estimates the number of salmonids that likely would have inhabited the lotic habitat lost due to reservoir construction and dam operation. Although anadromous salmon and steelhead historically occurred throughout much of the study area and were extirpated by these facilities, this report deals only with resident salmonids. These include native species (bull trout *Salvelinus confluentus*, redband trout *Oncorhynchus mykiss gairdneri*, Yellowstone cutthroat trout *O. clarkii bouvieri*, and mountain whitefish *Prosopium williamsoni*) and nonnative species (rainbow trout *O. mykiss*, brook trout *Salvelinus fontinalis*, and brown trout *Salmo trutta*). Taken together, these reservoirs inundated a total of about 198 km of riverine habitat. Factoring in the kilometers of inundation, the average abundance of salmonids in neighboring riverine habitat (based on a total of 180 surveys of fish abundance), and the number of years these dams have been in operation, it is estimated that riverine habitat for an estimated 1.3 million Yellowstone cutthroat trout, 4.3 million redband/rainbow trout, 2.8 million brown trout, 84,000 brook trout, 95,000 bull trout, and 50.1 million mountain whitefish have been lost due to inundation by these reservoirs. These calculations assume that current densities of salmonids are typical of densities since the construction of each dam. Taking into account this and other assumptions, it is likely that these estimates are conservative in nature and represent a minimum number of fish lost.

INTRODUCTION

The Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Public Law 96-501) established a process for protecting, mitigating, and enhancing fish and wildlife affected by the construction and operation of hydropower projects in the Columbia River basin. The act formed the Northwest Power Planning Council, now known as the Northwest Power and Conservation Council (NPCC). The council's purpose was to ensure the region a supply of inexpensive power and balance that goal with the needs of fish and wildlife. In 1982, the council introduced a fish and wildlife program. The council's program takes an adaptive approach to fish and wildlife mitigation and has been amended several times. In 1995, program amendments included a two-step process for resident fish mitigation (Section 10; NPCC 1995). The amendment requested that fish and wildlife managers complete assessments of resident fish losses related to the construction and operation of federal hydropower facilities. Secondly, the amendment called for the development of biological objectives for mitigation (e.g., escapement, harvest, and production goals).

The purpose of this report is to quantify lotic habitat lost as a result of construction of dams in the upper Snake River basin (i.e., the Snake River basin above Hell's Canyon Dam) that possess federal hydropower facilities, including Anderson Ranch Dam and Reservoir, Black Canyon Dam and Reservoir, Deadwood Dam and Reservoir, Boise River Diversion Dam and Reservoir, Minidoka Dam and Lake Walcott, and Palisades Dam and Reservoir. None of these structures have ever provided fish passage. A secondary purpose of this report is to estimate the number of salmonids (bull trout *Salvelinus confluentus*, redband trout *Oncorhynchus mykiss gairdneri*, Yellowstone cutthroat trout *O. clarkii bouvieri*, and mountain whitefish *Prosopium williamsoni*) that likely would have inhabited the lotic habitat lost due to reservoir construction. Because the operation of Deadwood Reservoir impacted losses below the reservoir (see methods), habitat lost due to operation of Deadwood Dam is also included.

Some would argue that reservoirs created behind dams create a net benefit to fish populations. They would argue that, after reservoir construction, fish populations expanded, and increased fisheries benefits resulted. That may be true in part, but benefits rarely accrue to native fish populations. At the present time, all native salmonids in the upper Snake River basin, except mountain whitefish, are or have been petitioned to be listed under the Endangered Species Act (USFWS 1995, 1998, 2001). Creation of migration barriers and reservoir construction and operation have been included as threats to species persistence in all listing petitions. In addition, fish management costs increase after reservoir construction, as reservoir fisheries typically require supplemental stocking with hatchery fish or new species introduction to support fisheries in altered habitat.

Losses of anadromous fish populations have been considered elsewhere and are not considered here. Losses to resident, native, non-game fish species will be reported later.

BACKGROUND AND DESCRIPTION OF STUDY AREAS

Anderson Ranch Dam and Reservoir

The South Fork of the Boise River has a diverse history. The earliest records show that salmon and steelhead were a crucial part of the subsistence for the Snake River and Shoshone Indian tribes. In addition to abundant fisheries resources, gold was discovered in the South Fork

Boise River in 1862. In the early 1900s, industrial and agricultural growth led to greater demands for water (Caldwell and Wells 1974). To meet those demands, the Federal government constructed the Deer Flat (1906), Boise River Diversion (1908), and Arrowrock (1915) dams. In 1941, Congress authorized the construction of Anderson Ranch Dam, which was completed in 1950. Anderson Ranch Dam was built for irrigation, hydroelectric energy, and flood control.

Anderson Ranch Dam is located in Elmore County, Idaho, near river km 60 on the South Fork Boise River (Figure 1). The dam is 47 km northeast of Mountain Home, Idaho. The earthen structure stands 138 m high with a crest length of 411 m. At maximum pool, the reservoir is 1,279 m above sea level and contains 609×10^6 m³ of water. Maximum depth exceeds 107 m. The reservoir inundated approximately 58 km of total stream habitat. The drainage area of the South Fork Boise River is 3,377 km². Average annual inflow to the reservoir is 884×10^6 m³/yr. The powerplant originally had a rated capacity of 27,000 kilowatts with two units installed. In 1981, both generators were rewound and modernized to an increased capacity of 20,000 kilowatts each. Net generation in fiscal year 2005 was 91,164,540 kilowatt hours.

Anderson Ranch Reservoir is situated in a steep, narrow, rugged canyon that in some places drops more than 305 m to the waters edge. Granitic and basaltic canyon walls range in slope from 20% to vertical cliffs. Vegetation on south-facing slopes includes sagebrush *Artemisia* spp., cheatgrass *Bromus tectorum* L., bluebunch wheatgrass *Pseudoroegneria spicata*, and bitterbrush *Purshia tridentata*. North-facing slopes are predominately quaking aspen *Populus tremuloides*, Douglas-fir *Pseudotsuga menziesii*, and Ponderosa pine *Pinus ponderosa*. Annual precipitation at the dam averages 53 cm. Most of the precipitation in the basin occurs at high elevation as snow from November to May (Water and Power Resource Service 1981).

Black Canyon Dam and Reservoir

Human development during the early 1800s brought significant change to the Payette River basin. Historically, the Payette River supported abundant salmon and steelhead populations (CBIAC 1956). The salmon runs were an important resource to the original inhabitants of the region. Black Canyon Reservoir resides within the ancestral fishing and hunting area of the Shoshone and Bannock Indian tribes (Martin and Mehrhoff 1985). In 1862, gold was discovered in the region and the population grew from about 3,000 to nearly 20,000 (Caldwell and Wells 1974). To support the mining communities, farmers increased agricultural production by irrigating more land (USFWS 1980). Water and power demands continued to grow, and the passage of the 1902 Reclamation Act provided the financial resources for large-scale irrigation and electrical power development (Quivik and Hess 1989). In 1905, the Secretary of the Interior authorized the Boise Valley Project, which included construction of three dams on the Boise River and two dams in the Payette Drainage.

Black Canyon Dam was part of the Payette Project. The initial plans for the Payette Project were to build a dam for diverting water, build a storage reservoir upstream to support the diversion dam, and build a canal system from the diversion dam to the Boise Valley (Quivik and Hess 1989). Black Canyon Dam served as the diversion location and Deadwood and Cascade reservoirs as storage reservoirs.

Black Canyon Dam was built in 1924 to divert water from the Payette River for irrigating land south and east of Emmett, Idaho (Quivik and Hess 1989). Black Canyon Dam is located 8 km northeast of Emmett, in Gem County, Idaho near river km 63 on the Payette River (BOR

1997; Figure 2). The concrete gravity-type structure stands 56 m high with a crest length of 317 m. At maximum pool, the reservoir is 761 m above sea level. The reservoir initially held 54×10^6 m³ of water, but by the early 1970s sedimentation had reduced total storage to approximately 31×10^6 m³. The Payette River drainage area above Black Canyon Dam is 6,941 km² (BOR 1997). Average annual inflow to the reservoir is $2,659 \times 10^6$ m³/yr. The reservoir inundated approximately 16 km of the Payette River and about 15 km of tributary streams.

The powerplant's originally capacity (in 1925) of 8,000 kilowatts was increased to 10,200 kilowatts by 1995 with the installation of forced air cooling and a stator rewind/upgrade. Net generation in fiscal year 2005 was 61,600,400 kilowatt hours. The Black Canyon control building (from which Black Canyon Dam and Powerplant, Anderson Ranch Dam and Powerplant, and Deadwood Dam are remotely operated) is located next to the powerplant.

Prior to dam construction, the Payette River flowed through a riverine environment likely dominated by a black cottonwood *Populus trichocarpa* complex with an understory of various shrubs and grasses. The surrounding uplands were a shrub-steppe vegetation community (Martin and Mehrhoff 1985).

Deadwood Dam and Reservoir

Deadwood Dam was built in 1931 to store water for downstream diversion at Black Canyon Dam during the irrigation season (Quivik and Hess 1989). Deadwood Dam is located in Valley County, Idaho near river km 29 on the Deadwood River (Figure 3). The dam is located 24 km north of Lowman, Idaho. The concrete-arch structure stands 50 m high with a crest length of 228 m. At maximum pool, the reservoir is 1,624 m above sea level and contains 200×10^6 m³ of water. The drainage area in the Deadwood River above Deadwood Reservoir is 290 km². Average inflow to the reservoir is 145×10^6 m³/yr. Deadwood Dam has no powerplant, but instead is controlled to maximize power generation at Black Canyon Dam, and for downstream agricultural uses. The reservoir inundated a total of approximately 25 km of stream habitat.

Deadwood Dam is situated in a narrow canyon bordered by two granite outcrops. The dam is surrounded by coniferous forest. Climate consists of short warm summers and long cold winters. Annual precipitation averages about 142 cm (Meuleman and Martin 1986).

Boise River Diversion Dam and Reservoir

The Boise River Diversion Dam was built in 1908 to supply water to the New York Canal. The Boise River Diversion Dam is located in Ada County 6.4 km southeast of Boise, Idaho (Figure 4). The dam is a rubble concrete structure 21 m high, with a crest length of 152 m. The dam has a diversion capacity of 79.7 m³/s. The dam is a run-of-the-river facility with storage of 4×10^6 m³ of water. Average annual inflow is $2,713 \times 10^6$ m³/yr. No fish bearing tributaries were inundated by the Boise River Diversion Dam. The reservoir inundated approximately 4.6 km of the Boise River.

In 1912, a powerplant and a 17-mile transmission line were constructed to supply construction power for Arrowrock Dam. The original plant has three vertical generators each with an original capacity of 500 kilowatts. Due to the deteriorated condition of the equipment and high operating costs resulting from full-attended operation, the powerplant was placed in ready reserve status in 1982. The plant was reconstructed in 2002 to 2004 and returned to service in June 2004. Net generation in fiscal year 2005 was 10,746,000 kilowatt hours.

The climate in the region is considered semi-arid. Annual precipitation is 36 cm. Summers are hot and dry and winters are cold and wet. At the rivers edge, black cottonwoods and willows *Salix spp.* are common. At higher elevation, sagebrush and grasslands dominate.

Minidoka Dam and Lake Walcott

In 1904, the Secretary of the Interior authorized the construction of Minidoka Dam for irrigation and power generation. Minidoka Dam is located 16 km northeast of Rupert, Idaho (Figure 5). The dam was completed in 1906, is a rock-fill structure with a concrete core, and stands 26 m high. The dam's crest length is 1,364 m. Elevation at full pool is 1,294 m, which is the optimal elevation for diverting water during the irrigation season. Water storage capacity is $259 \times 10^6 \text{ m}^3$ (BOR 1997). Average annual inflow to the reservoir is $5,778 \times 10^6 \text{ m}^3/\text{yr}$.

A power plant was added in 1909. The hydroelectric power plant was one of the first built by the federal government in the northwest (Martin and Meuleman 1989). The original powerplant was constructed upon the concrete buttress section of the dam, located at the right end of the rockfill section. The original generator Units 1-5 have been retired. Units 6 and 7 have been refurbished and continue to operate. At full head and flow, Unit 6 provides 3 megawatts, and Unit 7 provides 5.5 megawatts of power. In 1997, construction was completed at the Allen E. Inman Powerplant, which replaced the retired units (1-5) and houses two 10-megawatt horizontal shaft Kaplan Units. The combined generation capacity of all four units is 28.5 megawatts, with a combined flow of $245.5 \text{ m}^3/\text{s}$. Net generation in fiscal year 2005 was 79,173,000 kilowatt hours. The reservoir inundated approximately 62 km of the Snake River but almost no tributaries. Rock Creek and the Raft River are the two largest tributaries entering the Snake River within the boundaries of Walcott Reservoir.

The climate in the area of Minidoka Dam is considered semi-arid. Annual precipitation is 32 cm. Summers are hot and dry and winters are cold with a mean annual temperature of 9.4°C . Sagebrush/wheat grass steppe is the dominant vegetation with the occasional stand of junipers *Juniperus spp.* Riparian vegetation includes sedges and forbs with mixed willow, alders *Alnus spp.*, and cottonwoods (Lay 1999).

Palisades Dam and Reservoir

The initial use of irrigation in the South Fork Snake River region began in the early 1870s with the development of farming in the Rexburg and Blackfoot area. Prior to the presence of settlers from the eastern United States, the area was the traditional hunting and fishing grounds for the Shoshone and Bannock Indian tribes. By the early 1900s, over 202,350 ha of land were under irrigation, and the demand was increasing. Following the passage of the Reclamation Act of 1902, the United States Reclamation Service constructed four projects to meet the increasing eastern Idaho water demands. These projects, including Lake Walcott, Jackson Lake, American Falls and Island Park, failed to meet the increasing irrigation demand. A drought in the early 1930s combined with expanding industry and the human population increased the need for additional water storage. This need precipitated the development of the Palisades Project (Simonds 1995).

The area selected for the Palisades Project was a site known as "Grand Valley", located 11.3 km southeast of Irwin, in Bonneville County, Idaho near river km 1,450 on the South Fork Snake River (BOR 1996; Figure 6). The valley floor in this area was wide (1.6-3.2 km) and

sloped gently. Farming and grazing dominated the valley surrounding the riparian marshes. Common crops included dryland wheat and irrigated hay (Sather-Blair and Preston 1984). The valley was bordered on the south by the Caribou National Forest and the Targhee National Forest on the north. National Forest land surrounding the SFSR was comprised of a coniferous forest, aspen, and a shrub-steppe plant community (Sather-Blair and Preston 1984).

Palisades provides water for irrigation, flood control, recreation, and electrical power generation. The concrete gravity-type structure stands 82 m high with a crest length of 640 m. At maximum pool, the reservoir is 1,716 m above sea level. The dam impounds $1,481 \times 10^6 \text{ m}^3$ of water at full pool. The South Fork Snake River drainage area above Palisades Dam is 13,468 km² (BOR 1996). Average annual inflow to the reservoir is $5,923 \times 10^6 \text{ m}^3/\text{yr}$. The reservoir inundated approximately 38 km of the South Fork Snake River and about 79 km of tributary streams.

Palisades Dam and Powerplant were completed in 1957, with the last unit placed on line in 1958 and first reservoir spill in 1959. The dam was initially equipped with four power-generating units, which provided a total generating capacity of 118 megawatts. These were later upgraded (in the 1990s) to provide a continuous power output of 168 megawatts (Simonds 1995). From the start, the generators produced copious quantities of ozone, due to corona discharge, which deteriorated all metal parts and the winding. The original windings lasted less than 10 years. All the generators were rewound in the 1960s, using an epoxy-mica insulating system, instead of the original asphalt-mica insulating system. Corona was a problem, and ozone deterioration continued to the point that windings were seriously deteriorated by the late 1980s. Generators were rewound again in 1991-1995, increasing unit capacity to 44 megawatts. Station service switchgear was replaced in 2001, and penstock flow meters were installed in 2002. Net generation in fiscal year 2005 was 517,411,940 kilowatt hours.

FISH SPECIES

Historically, Shoshone Falls near Twin Falls, Idaho on the Snake River blocked upstream fish migration and created markedly different fish communities upstream and downstream of the falls. Upstream of the falls, salmonid communities were dominated by Yellowstone cutthroat trout and mountain whitefish. Other common native species included longnose dace *Rhinichthys cataractae*, speckled dace *Rhinichthys osculus*, Piute sculpin *Cottus beldingi*, mottled sculpin *Cottus bairdi*, redband shiner *Richardsonius balteatus*, Utah chub *Gila atraria*, and Utah sucker *Catostomus ardens*. Northern leatherside chub *Lepidomeda copei*, bluehead sucker *Catostomus discobolus*, and mountain sucker *Catostomus platyrhynchus* are also native but are uncommon.

Downstream from Shoshone Falls, salmonid communities were dominated by salmon and steelhead, as well as bull trout, redband trout, and mountain whitefish (Gilbert and Evermann 1894; Hubbs and Miller 1948; CBIAC 1956; USFWS 1980). At least three anadromous salmonids utilized the Boise and Payette rivers, including Chinook salmon *Oncorhynchus tshawytscha*, sockeye salmon *Oncorhynchus nerka*, and steelhead trout *Oncorhynchus mykiss* (Caldwell and Wells 1974).

Dam construction eliminated salmon and steelhead from areas upstream from dams. Following dam construction, salmonid communities downstream from Shoshone Falls were dominated by redband trout, bull trout, and mountain whitefish (Caldwell and Wells 1974;

USFWS 1980). Other common native species include white sturgeon *Acipenser transmontanus*, northern pikeminnow *Ptychocheilus oregonensis*, several sculpin species *Cottus spp.*, chiselmouth *Acrocheilus alutaceus*, longnose dace, speckled dace, peamouth *Mylocheilus caurinus*, redband shiner, and several sucker species *Catostomus spp.* Table 1 illustrates which fishes currently occur in or around the reservoirs included in this study.

Historically, bull trout, Yellowstone cutthroat trout, and redband trout populations in the upper Snake River basin contained resident and migratory life history forms (SBNFWAG 1998). Resident populations generally spend their entire lives in tributary and headwater streams, whereas migratory forms rear in tributary streams for several years and migrate to more productive downstream habitat in larger rivers (fluvial life forms) or lakes (adfluvial life forms). The coexistence of migratory and resident forms of trout can be important (Rieman and McIntyre 1995; Nelson et al. 2002). Migratory trout link resident populations to the species' gene pool. Barriers to migration isolate resident populations, which can cause isolated populations to become vulnerable to habitat degradation, loss of genetic diversity, and local extirpation (Novinger and Rahel 2003; Fausch et al. 2006).

The completion of these dams blocked fluvial salmonids from reaching headwater or tributary populations. Anderson Ranch Dam blocked 75% (2,543 km²) of the South Fork Boise River drainage and 24% of the entire Boise River drainage (BOR 1997); Black Canyon Dam blocked 81% (7,033 km²) of the Payette River drainage (BOR 1997); Deadwood Dam blocked 14% (288 km²) of the South Fork Payette River drainage and 3% of the entire Payette River drainage (BOR 1997); Boise River Diversion Dam blocked 65% (6,954 km²) of the Boise River drainage (BOR 1997); Palisades Dam blocked 90% (13,668 km²) of the South Fork Snake River drainage (BOR 1997). Minidoka Dam had little impact on fish movement because Shoshone Falls is only about 100 km downstream of the dam, and no major river drainages exist between Minidoka Dam and Shoshone Falls. Estimating fish loss from dam blockage is problematic without data from unaltered systems in the region. Surrounding watersheds have similar barriers to migrant fish populations. Thus, we did not attempt to directly quantify losses of large fluvial stocks attributable to migration barriers (i.e., the dams).

Anderson Ranch Dam and Reservoir

Prior to dam construction, salmon and steelhead dominated the fish community of the South Fork Boise River (CBIAC 1956; USFWS 1980). Despite the loss of anadromous populations, the South Fork Boise River continued to support a native fish community.

Prior to the completion of Anderson Ranch Dam, the resident native fish community was composed of bull trout, redband trout, mountain whitefish, northern pikeminnow, shorthead sculpin *Cottus confusus*, chiselmouth, and several sucker species (Caldwell and Wells 1974; USFWS 1980). Brook trout *Salvelinus fontinalis*, cutthroat trout *O. clarkii*, kokanee, rainbow trout, Redside shiner, smallmouth bass *Micropterus dolomieu*, and yellow perch *Perca flavescens* have been introduced (Table 1). Kokanee populations in the reservoir fluctuate significantly due in part to extreme high and low water conditions, which affects the quality of the fishery. The rainbow trout fishery in the reservoir is maintained by stocking catchable sized sterile rainbow trout.

Fish responses to the inundation of the South Fork Boise River were varied. Gebhards (1963) reported that, after impoundment, northern pikeminnow and sucker populations increased. Conversely, mountain whitefish, bull trout, and redband trout exhibited precipitous declines. The

declines were assumed to be caused by competition and predation from expanding pikeminnow and sucker populations, which flourished in the reservoir environment (CBIAC 1956; Gebhards 1963).

Black Canyon Dam and Reservoir

Prior to dam construction, salmon and steelhead dominated the fish community of the Payette River drainage (CBIAC 1956). At least three species of anadromous fish utilized the Payette River, including Chinook salmon, sockeye salmon, and steelhead trout (Caldwell and Wells 1974). Pacific lamprey *Lampetra tridentata* may have also been present. Black Canyon Dam was the first barrier to salmon migration up the Payette River. Shortly after the dam was completed in 1924, few if any salmon remained in the Payette River (CBIAC 1956). Despite the loss of anadromous populations, the Payette River continued to support a diverse native fish community.

Historically, the resident native fish community of the Payette River supported migratory and resident forms of bull trout and redband trout (SBNFWAG 1998). Mountain whitefish, largescale sucker *Catostomus macrocheilus* and bridgelip sucker *Catostomus columbianus*, northern pikeminnow, chiselmouth, redband shiner, longnose and speckled dace, mottled sculpin, shorthead sculpin, peamouth, and white sturgeon were also present. Black Canyon Reservoir provides only marginal fish habitat. Sand from upstream land disturbances has covered most habitats.

Deadwood Dam and Reservoir

Historically, the resident native fish community in the Deadwood River drainage was similar to but more simplistic than for the areas lower in the Payette River drainage. The reservoir is currently managed for bull trout, kokanee, redband trout, and cutthroat trout. Yearly intensive tributary management is required to prevent overpopulation and stunting of kokanee. Stocking of sterile hatchery rainbow trout also occurs annually. Cutthroat trout have been introduced and have established a marginal fishery. The Deadwood River below the dam has almost no fishery due to hypolimnetic coldwater releases throughout the growing season that inhibits fish growth and survival. In addition, from the 1930s to 1993, minimum winter stream flow below Deadwood Dam was typically 0-0.06 m³/s. Currently, minimum winter flow is about 1.42 m³/s. Historically, winter flow was likely greater since winter inflow is usually greater than 1.42 m³/s.

Boise River Diversion Dam and Reservoir

Barber and the Boise River Diversion dams were the first fish barriers (1908) to salmon migration on the Boise River, and effectively blocked all salmon migration (Caldwell and Wells 1974). Historically, the Boise River supported migratory and resident forms of bull trout and redband trout (SBNFWAG 1998). Also represented in the resident native fish community were white sturgeon, mountain whitefish, northern pikeminnow, shorthead sculpin, chiselmouth, several sucker species, and possibly Pacific lamprey (Table 1) (Caldwell and Wells 1974; USFWS 1980). Barber Dam does not create a reservoir and therefore this reach was not included in total length of river inundated for this study. There is virtually no fishery in the 4.6-km section of the Boise River above the Boise River Diversion Dam, as it is nearly entirely silt bottomed and is annually reduced to 2-6 m³/s or less in the winter, providing little habitat for salmonids.

Minidoka Dam and Lake Walcott

Yellowstone cutthroat trout and mountain whitefish were the dominant native salmonids in the reach above Minidoka Dam. Utah sucker, Utah chub, and mottled sculpin are other fishes commonly found in the Snake River above Shoshone Falls (Simpson and Wallace 1982). The fishery in Lake Walcott consists largely of a hatchery rainbow trout put-and-take operation, as well as an introduced smallmouth bass fishery.

Palisades Dam and Reservoir

Prior to the construction of Palisades Dam, the impounded reach of the South Fork Snake River supported a quality Yellowstone cutthroat trout fishery. Catch rates were estimated at 0.68 fish/h in the river above the dam site, similar to the river downstream (Miller and Roby 1957). Fishing in the river was somewhat seasonal due to the heavy spring flows and fluctuations from Jackson Lake. Historically the South Fork Snake River was known for its large cutthroat trout, and it was not uncommon to harvest trout up to 2.3 kg (Moore et al. 1981). Local anglers reported that these large fish became scarce within three to five years following the completion of Palisades Dam (Miller and Roby 1957). Large numbers of trout were reported in the afterbay of the dam in 1957. These fish were thought to be remnants of fish that spawned in tributaries above the dam (Miller and Roby 1957). Today the reservoir fishery is supported largely by stocking catchable and sub-catchable cutthroat trout from Jackson National Fish Hatchery. The fishery below the dam is impacted by low water flows during late fall and winter from Palisades Reservoir and Dam. Alteration of the spring hydrograph is thought to have favored spawning of rainbow trout, endangering the world-class cutthroat trout fishing (R. Van Kirk, Idaho State University, personal communication).

METHODS

Estimating native sport fish losses is exceptionally difficult, especially when pre-impoundment data are nonexistent or qualitative in nature. However, attempts have been made using post-impoundment fisheries information (Zubik and Fraley 1987; Marotz et al. 1998). In both studies, the authors estimated native fish losses by averaging population data from tributary and river reaches in the same geographical area, and applying those values to the amount of inundated habitat. A similar approach was used here to estimate the losses of salmonid fisheries (native and nonnative) resulting from the construction and operation of Anderson Ranch, Black Canyon, Boise River Diversion, Deadwood, Minidoka, and Palisades dams and reservoirs. In addition, the operation of Deadwood Reservoir has greatly impacted the fishery in Deadwood River from the dam to the confluence with the South Fork Payette River. Losses of redband trout, bull trout, and mountain whitefish in this 35.4-km section of river were also estimated. Estimates were made separately for each location.

An extensive literature search provided some information on pre- and post-reservoir conditions, including fish assemblages, available/lost habitat, environmental impacts, and fish densities. The most extensive quantitative data available stems from Idaho Department of Fish and Game's (IDFG) Native Salmonid Assessment project, funded by BPA. Over 2,500 surveys of fish abundance have been made on this project from 1998 to 2006, many of which were adjacent to the water bodies in question. Previous studies have shown that, for the most part, native salmonids have experienced obvious declines in abundance from historical levels, but have not experienced significant changes in the upper Snake River basin in the last 10-20

years (e.g., Meyer et al. 2003; Zoellick et al. 2006). Because data from this BPA-funded project was more quantitative in nature and more broadly distributed than previous data from the last 10-20 years, we used data from this project exclusively, and assumed this data would produce conservative approximations of historical abundance.

Fish sampling is described in detail in Meyer et al. (2006). In short, at each study site, fish were captured using electrofishing or snorkeling gear. When electrofishing, fish were identified, enumerated, measured to the nearest millimeter (total length, TL) and gram, and eventually released. The few hatchery rainbow trout (which in Idaho are sterilized before release) that were encountered were easy to differentiate from wild rainbow trout based on fin condition, and were not included in this study. Sampling in small streams was conducted by depletion electrofishing, using one or more backpack electrofishers (Smith-Root Model 15-D) with pulsed DC. Block nets were installed at the upper and lower ends of the sites to meet the population estimate modeling assumption that the fish populations were closed. Maximum-likelihood abundance and variance estimates were calculated with the MicroFish software package (Van Deventer and Platts 1989). At sites too large to perform backpack electrofishing, mark-recapture electrofishing was conducted with a canoe- or boat-mounted unit (Coffelt Model Mark-XXII) and DC (if possible) or pulsed DC. Recapture runs were made two to seven days after marking fish. Log-likelihood or modified Peterson estimates of trout abundance were made using the Mark Recapture for Windows software package (Montana Fish, Wildlife and Parks 1997). We could not estimate trout <100 mm at the mark-recapture sites due to low capture efficiencies of small fish. Where electrofishing was not possible due to access constraints or other logistical difficulties, snorkeling was conducted following the protocol of Thurow (1994). We counted all salmonids ≥ 100 mm, and total counts were used as minimal abundance estimates with no correction for any sightability bias.

Redband/rainbow trout were lumped with hybrids (Rainbow x cutthroat or redband x rainbow) for population estimates. Because electrofishing is known to be size selective (Reynolds 1996), trout were separated into two length categories, <100 mm TL and ≥ 100 mm TL; abundance estimates were made separately for these two size groups and pooled for an estimate of total abundance at each site. Raw data used for this study can be found in Appendix A.

River kilometers (km) and tributary length lost to inundation were measured using a geographic information system (ArcGIS) and were summed by stream order (Strahler 1964). Since pre-inundation sinuosity and channel trajectory was unknown, we calculated the number of kms of inundated stream by tracing the stream length for non-inundated streams adjacent to the reservoirs, and divided by the straight distance measurements for those streams. This correction on average was about 35%, so we multiplied straight distance measurements for inundated streams by 1.35.

We estimated total fish loss due to inundation using the stratified random sampling formulas from Scheaffer et al. (1996). For each location, we first summed the total length of stream inundated for each stream order, or stratum, and divided this total by 100 meters of stream (the typical length of most study sites on which abundance was based) to calculate the number of sampling units (N_i) in each stratum (L). Abundance of various sportfish from adjacent fish survey sites was standardized to density per 100 linear meters of stream. We calculated a mean abundance (\bar{y}_i) within each stream order (stratum), and an associated variance. For total population size (N_{census}), we used the formula:

$$N_{census} = \sum_{i=1}^L N_i \bar{y}_i$$

and for variance of N_{census} we used the formula:

$$\widehat{V}(N_{census}) = \sum_{i=1}^L N_i^2 \left(\frac{N_i - n_i}{N_i} \right) \left(\frac{s_i^2}{n_i} \right)$$

where s_i^2 is the variance of the observations in stratum i , and n_i is the sample size within stratum i . All sample sites, including dry and fishless sites, were included in these estimates. We estimated losses for each dam from the time of inundation to the year 2007. For Deadwood Dam and Reservoir, separate estimates were produced for above the dam (1931-2007) and below the dam (1931-1993, the year when winter flows were no longer 0.06 m³/s).

Our analysis assumes that there are currently no wild salmonids occupying the inundated reaches of river for each study location. This assumption is not far from the truth. Except for a few mountain whitefish, bull trout, cutthroat trout, and redband trout in Deadwood Reservoir, a few mountain whitefish, bull trout, and redband trout in Anderson Ranch Reservoir, and a few mountain whitefish and Yellowstone cutthroat trout in Palisades Reservoir, the small number of salmonids that may be encountered in these water bodies are mostly of hatchery origin. We also assumed our abundance estimates were not positively or negatively biased, although studies have shown that depletion estimates, which were the vast majority of our estimates, can drastically underestimate true abundance (Peterson et al. 2004; Rosenberger and Dunham 2005). Snorkeling counts also underestimate true abundance (Mullner et al. 1998). In addition, our big-river electrofishing and snorkeling estimates did not include fish < 100 mm, creating another source of negative bias. We also assumed that, in calculating total loss, all trout were equal, regardless of species. In other words, we assumed that niche overlap was complete for all trout, and simply summed loss estimates for each species of trout for an overall loss estimate at each facility. Finally, we assumed that current abundance is reflective of abundance since the time of construction of these dams, which is unlikely to be true. Taken together, it is likely that this assessment of loss drastically underestimates true losses.

RESULTS AND DISCUSSION

Anderson Ranch Dam and Reservoir

Anderson Ranch Reservoir inundated a total of about 58.1 km of stream, most of which was fifth- and sixth-order stream reaches (Table 2). Thirty-three estimates of fish abundance were available from the South Fork Boise River drainage near the reservoir. No data was available for fourth-order streams, so data were pooled for third- and fifth-order streams to extrapolate abundance for fourth-order reaches. Average linear density for bull trout, redband trout, and mountain whitefish among all nearby study sites was 0.05, 0.43, and 0.19 fish/m, respectively (Appendix A). Habitat for an estimated 1,533 bull trout, 37,725 redband trout, and 42,137 mountain whitefish have been lost annually since 1950 due to inundation of the South Fork Boise River and tributaries in Anderson Ranch Reservoir (Table 3), for a total of 81,405 salmonids lost annually, or a total of about 4.72 million salmonids through 2007.

Black Canyon Dam and Reservoir

Black Canyon Dam and Reservoir inundated a total of about 31 km of stream in the Payette River drainage, most of which was first-order and sixth-order in nature (Table 2). A total of 43 estimates of fish abundance were available from the Payette River drainage near the reservoir. Average linear density for brook trout, redband trout, and mountain whitefish among all study sites was 0.02, 0.14, and 0.24 fish/m, respectively (Appendix A). Habitat for an estimated 769 brook trout, 1,461 redband trout, and 75,715 mountain whitefish have been lost annually since 1924 due to inundation of the Payette River and tributaries in Black Canyon Reservoir (Table 3), for a total of 77,945 salmonids lost annually, or a total of about 6.55 million salmonids through 2007.

Deadwood Dam and Reservoir

Deadwood Reservoir inundated a total of about 25.2 km of riverine habitat in the Deadwood River drainage (Table 2). In addition, 35.4 km of river below Deadwood Dam contains almost no fishery due to historical dewatering of this section of river during the winter, and continued hypolimnetic cold-water releases from Deadwood Dam in the summer that prevent a fishery from developing. A total of 49 estimates of fish abundance were available from the Payette River drainage near Deadwood Reservoir. Average linear density for bull trout, brook trout, redband trout, and mountain whitefish among all study sites was 0.01, 0.01, 0.12, and 0.10 fish/m, respectively (Appendix A). Habitat for an estimated 98 bull trout, 265 brook trout, 2,751 redband trout, and 566 mountain whitefish have been lost annually since 1931 due to inundation of the Deadwood River and tributaries to the Deadwood River (Table 3). In addition, the operation of Deadwood Dam below the reservoir results in the annual loss of an estimated 6,647 mountain whitefish and 6,087 redband trout. These estimates result in a total of about 1.26 million salmonids through 2007.

Boise River Diversion Dam and Reservoir

Boise River Diversion Reservoir inundated a total of about 4.6 km of the Boise River (Table 2). Three estimates of fish abundance were available from the Boise River directly downstream of the reservoir. Average linear density for redband trout, brown trout, and mountain whitefish among all study sites was 1.12, 0.15, and 1.92 fish/m, respectively (Appendix A). Habitat for an estimated 5,168 redband trout, 699 brown trout, and 8,892 mountain whitefish have been lost annually since 1908 due to inundation of the Boise River by the Boise Diversion Dam (Table 3), for a total of 14,759 salmonids lost annually, or a total of about 1.48 million salmonids through 2007.

Minidoka Dam and Lake Walcott

Minidoka Dam inundated about 61.7 km of the Snake River (Table 2). No fish bearing tributaries are inundated by Lake Walcott. The only quantitative estimate of fish abundance in the vicinity of Lake Walcott is from the Snake River near Blackfoot, about 100 km upstream. Linear densities at this location for Yellowstone cutthroat trout, rainbow trout, brown trout, and mountain whitefish were estimated to be 0.01, 0.03, 0.16, and 3.48 fish/m, respectively (Appendix A). Habitat for an estimated 858 Yellowstone cutthroat trout, 1,738 rainbow trout, 9,976 brown trout, and 215,092 mountain whitefish have been lost annually since 1906 due to inundation of the Snake River by Minidoka Dam (Table 3), for a total of 227,664 salmonids lost annually, or a total of about 23.22 million salmonids through 2007.

Palisades Dam and Reservoir

Palisades Reservoir inundated a total of about 117 km of the South Fork Snake River and tributary streams (Table 2). A total of 51 estimates of fish abundance were available from the South Fork Snake River drainage near Palisades Reservoir. No data were available for mountain whitefish in fifth-order streams, so data were pooled for fourth- and sixth-order streams to extrapolate whitefish abundance for fifth-order reaches. Average linear density for Yellowstone cutthroat trout, rainbow trout, brown trout, and mountain whitefish among all study sites in the area was 0.39, 0.02, 0.07, and 0.39 fish/m, respectively (Appendix A). Habitat for an estimated 24,995 Yellowstone cutthroat trout, 15,477 rainbow trout, 34,543 brown trout, and 372,000 mountain whitefish have been lost annually since 1958 due to inundation of the South Fork Snake River and tributaries to Palisades Reservoir (Table 3), for a total of 447,015 salmonids lost annually, or a total of about 22.35 million salmonids through 2007.

CONCLUSION

Factoring in the number of years these dams have been in operation, it is estimated that riverine habitat has been lost for an estimated 1.34 million Yellowstone cutthroat trout, 4.46 million redband/rainbow trout, 2.81 million brown trout, 85,000 brook trout, and 96,000 bull trout, for a grand total of 8.71 million trout. In addition, an estimated 50.79 million mountain whitefish have been lost due to inundation by the above-mentioned reservoirs. Based on the above-mentioned assumptions, it is likely that these estimates are conservative in nature and represent a minimum number of fish lost.

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Table 1. Fish species found in and around individual water bodies in Idaho. Nat refers to native fish, Non refers to non-native fish, and blanks indicate fish that are absent from the area.

| Species | Black Canyon Reservoir | Palisades Reservoir | Anderson Ranch Reservoir | Boise River diversion reservoir | Deadwood Reservoir | Lake Walcott |
|--|------------------------|---------------------|--------------------------|---------------------------------|--------------------|--------------|
| Bull trout <i>Salvelinus confluentus</i> | Nat | | Nat | Nat | Nat | |
| Brook trout <i>Salvelinus fontinalis</i> | | Non | Non | | | |
| Lake trout <i>Salvelinus namaycush</i> | | Non | | | | |
| Brown trout <i>Salmo trutta</i> | Non | Non | | Non | | Non |
| Redband/rainbow trout <i>Oncorhynchus mykiss</i> | Nat | Non | Nat | Nat | Nat | Non |
| Cutthroat trout <i>Oncorhynchus clarkii</i> | Non | Nat | Non | Non | Non | Nat |
| Chinook salmon <i>Oncorhynchus tshawytscha</i> | Nat ^a | | Nat ^a | Nat ^a | Nat ^a | |
| Coho salmon <i>Oncorhynchus kisutch</i> | | | | | | Non |
| Kokanee <i>Oncorhynchus nerka</i> | | | Non | Non | Non | Non |
| Mountain whitefish <i>Prosopium williamsoni</i> | Nat | Nat | Nat | Nat | Nat | Nat |
| White sturgeon <i>Acipenser transmontanus</i> | Nat | | | Nat | | Non |
| Largescale sucker <i>Catostomus macrocheilus</i> | Nat | | Nat | Nat | | |
| Bridgelip sucker <i>Catostomus columbianus</i> | Nat | | Nat | Nat | | |
| Utah sucker <i>Catostomus ardens</i> | | Nat | | | | Nat |
| Bluehead sucker <i>Catostomus discobolus</i> | | Nat | | | | |
| Mountain sucker <i>Catostomus platyrhynchus</i> | | Nat | | | | |
| Northern pikeminnow <i>Ptychocheilus oregonensis</i> | Nat | | Nat | Nat | | |
| Chiselmouth chub <i>Acrocheilus alutaceus</i> | Nat | | Nat | Nat | | |
| Peamouth <i>Mylocheilus caurinus</i> | Nat | | Nat | Nat | | |
| Nonrthern leatherside chub <i>Lepidomeda copei</i> | | | | | | Nat |
| Utah chub <i>Gila atraria</i> | | Non | | | | Nat |
| Mottled sculpin <i>Cottus bairdi</i> | Nat | Nat | Nat | Nat | Nat | Nat |
| Piute sculpin <i>Cottus beldingi</i> | | Nat | | | | Nat |
| Shorthead sculpin <i>Cottus confusus</i> | Nat | | Nat | Nat | Nat | |
| Redside shiner <i>Richardsonius balteatus</i> | Nat | Nat | Nat | Nat | | Nat |
| Longnose dace <i>Rhinichthys cataractae</i> | Nat | Nat | Nat | Nat | Nat | |
| Speckled dace <i>Rhinichthys osculus</i> | Nat | Nat | Nat | Nat | Nat | |
| Carp <i>Cyprinus carpio</i> | Non | | | Non | | Non |
| Brown bullhead <i>Ameiurus natalis</i> | Non | | | Non | | Non |
| Channel catfish <i>Ictalurus punctatus</i> | Non | | | Non | | Non |
| Largemouth bass <i>Micropterus salmoides</i> | | | | | | Non |
| Smallmouth bass <i>Micropterus dolomieu</i> | Non | | Non | Non | | Non |
| Black crappie <i>Pomoxis nigromaculatus</i> | Non | | | | | Non |
| White crappie <i>Pomoxis annularis</i> | | | | | | Non |
| Bluegill <i>Lepomis macrochirus</i> | Non | | | Non | | |
| Yellow perch <i>Perca flavescens</i> | Non | | Non | Non | | Non |

^aCurrently maintained by stocking Non-migratory fish.

Table 2. Estimated kilometers of stream inundation by stream order for various water bodies in the upper Snake River basin in Idaho. Dashes indicate no streams of that stream order for that water body.

| Water body | Stream order | | | | | | | Total |
|--------------------------------------|--------------|------|------|-------------------|------|------|------|-------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Palisades Reservoir | 34.1 | 20.1 | 1.8 | 11.1 | 12.0 | 37.6 | - | 116.7 |
| Lake Walcott | 4.5 | - | - | - | - | - | 61.7 | 66.2 |
| Black Canyon Reservoir | 12.2 | 0.4 | - | - | 2.1 | 15.9 | - | 30.6 |
| Deadwood Reservoir | 4.3 | 8.8 | 9.1 | 38.5 ^a | - | - | - | 60.6 |
| Anderson Ranch Reservoir | 6.0 | 8.4 | 7.4 | 4.1 | 12.6 | 19.7 | - | 58.2 |
| Boise irrigation diversion Reservoir | - | - | - | - | - | - | 4.6 | 4.6 |
| Total | 61.1 | 37.7 | 18.3 | 53.7 | 26.7 | 73.2 | 66.3 | 337.0 |

^aIncludes 35.4 km of the Deadwood River below Deadwood Dam.

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Table 3. Estimates of annual fish lost due to inundation of riverine habitat and operation of dams in various water bodies in the upper Snake River basin, Idaho. For each water body, *n* is the number of study sites for which fish abundance data was available and from which annual fish losses were estimated.

| Water body | <i>n</i> | Years of impact | Yellowstone cutthroat trout | | Redband/rainbow trout | | Brown trout | | Brook trout | | Bull trout | | Mountain whitefish | |
|---------------------------------|----------|-----------------|-----------------------------|--------|----------------------------|--------|----------------------------|--------|----------------------------|--------|----------------------------|--------|----------------------------|---------|
| | | | <i>N</i> _{census} | 90% CI | <i>N</i> _{census} | 90% CI | <i>N</i> _{census} | 90% CI | <i>N</i> _{census} | 90% CI | <i>N</i> _{census} | 90% CI | <i>N</i> _{census} | 90% CI |
| Anderson Ranch Reservoir | 33 | 58 | | | 37,725 | 5,557 | | | | | 1,533 | 1,191 | 42,137 | 26,440 |
| Black Canyon Reservoir | 43 | 84 | | | 1,461 | 1,761 | | | 769 | 77 | | | 75,715 | 83,726 |
| Deadwood Reservoir, above dam | 49 | 77 | | | 2,751 | 1,096 | | | 265 | 228 | 98 | 85 | 566 | 82 |
| Deadwood Reservoir, below dam | 24 | 77 | | | 6,087 | 2,114 | | | | | | | 6,647 | 2,237 |
| Boise River Diversion Reservoir | 3 | 100 | | | 5,168 | 1,459 | 699 | 385 | | | | | 8,892 | 735 |
| Lake Walcott | 1 | 102 | 858 | NA | 1,738 | NA | 9,976 | NA | | | | | 215,092 | NA |
| Palisades Reservoir | 51 | 50 | 24,995 | 8,081 | 15,477 | 23,923 | 34,543 | 44,623 | 10 | 13 | | | 372,000 | 215,523 |

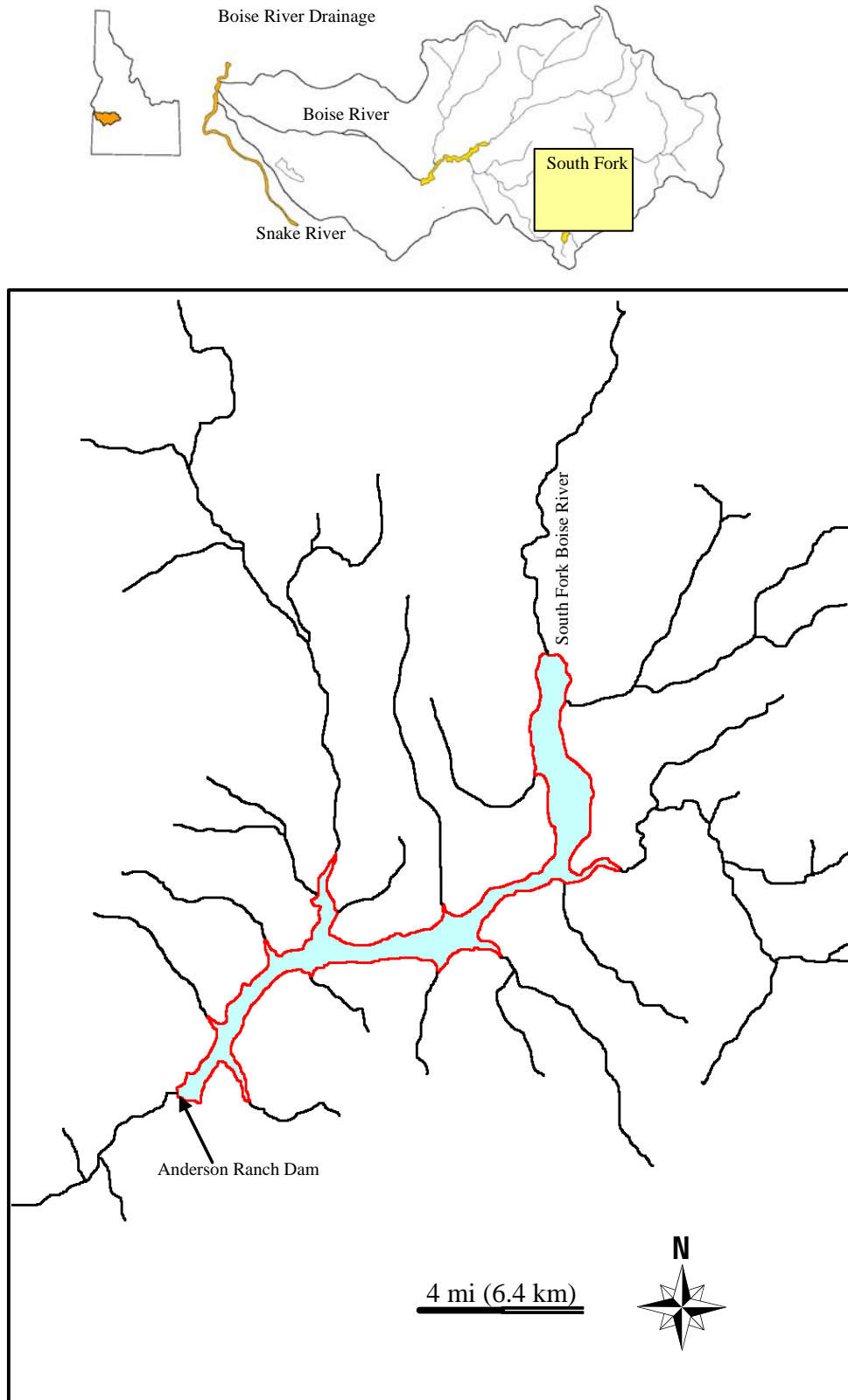


Figure 1. Anderson Ranch Reservoir and tributaries.

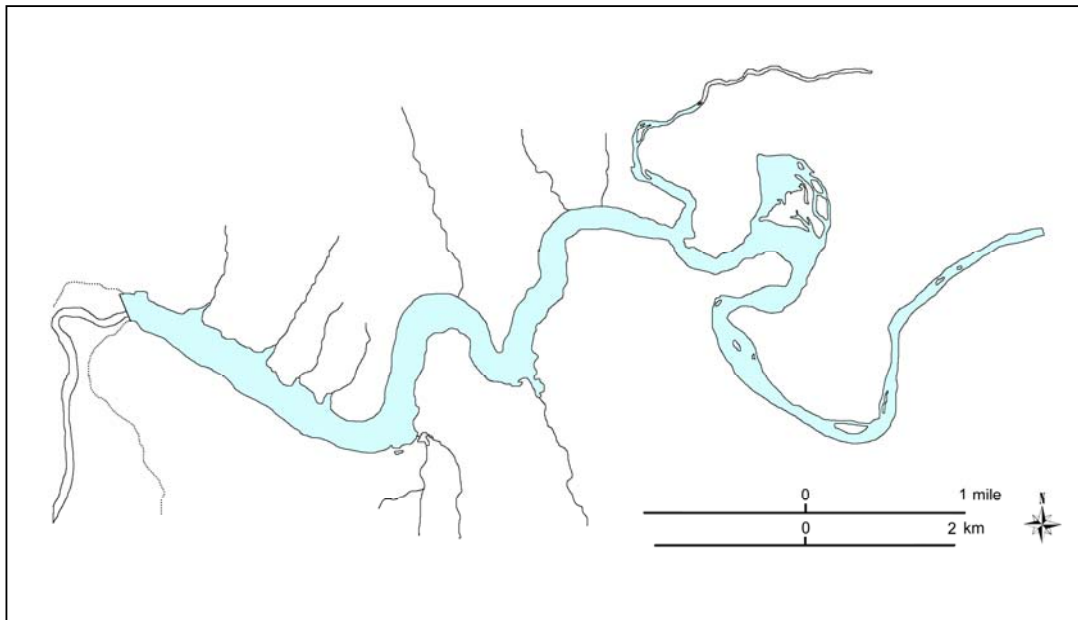
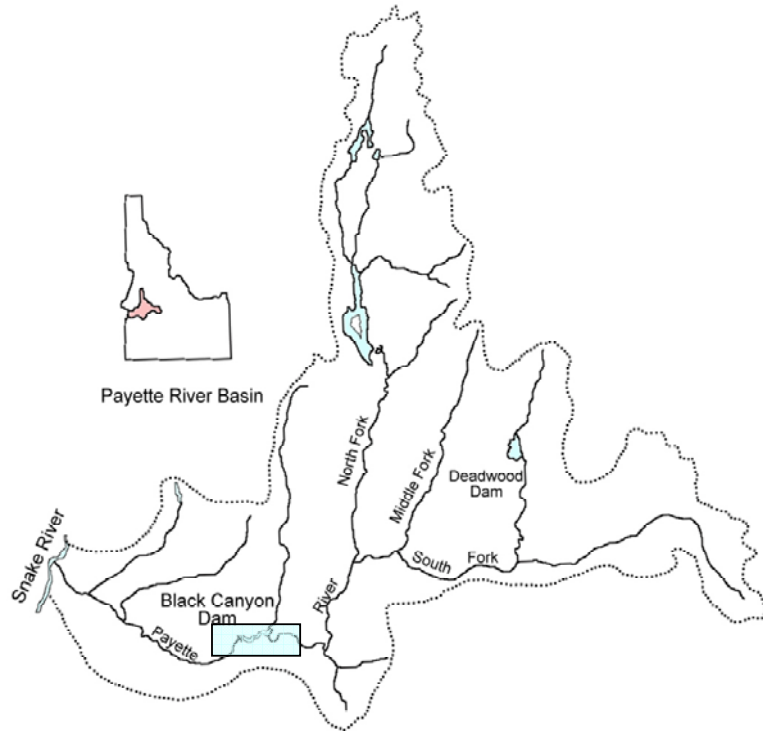


Figure 2. Black Canyon Dam and reservoir and tributaries.

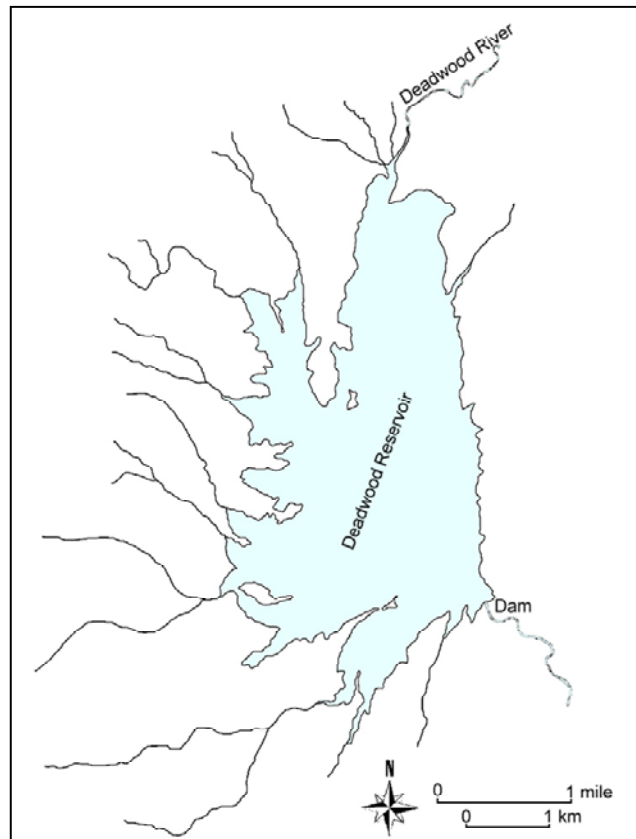
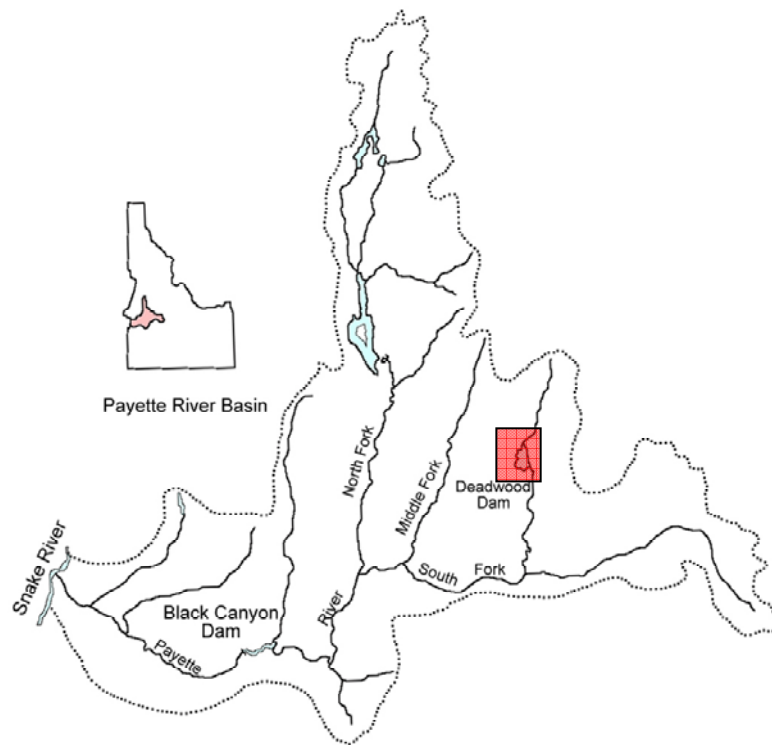


Figure 3. Deadwood Reservoir and tributaries.

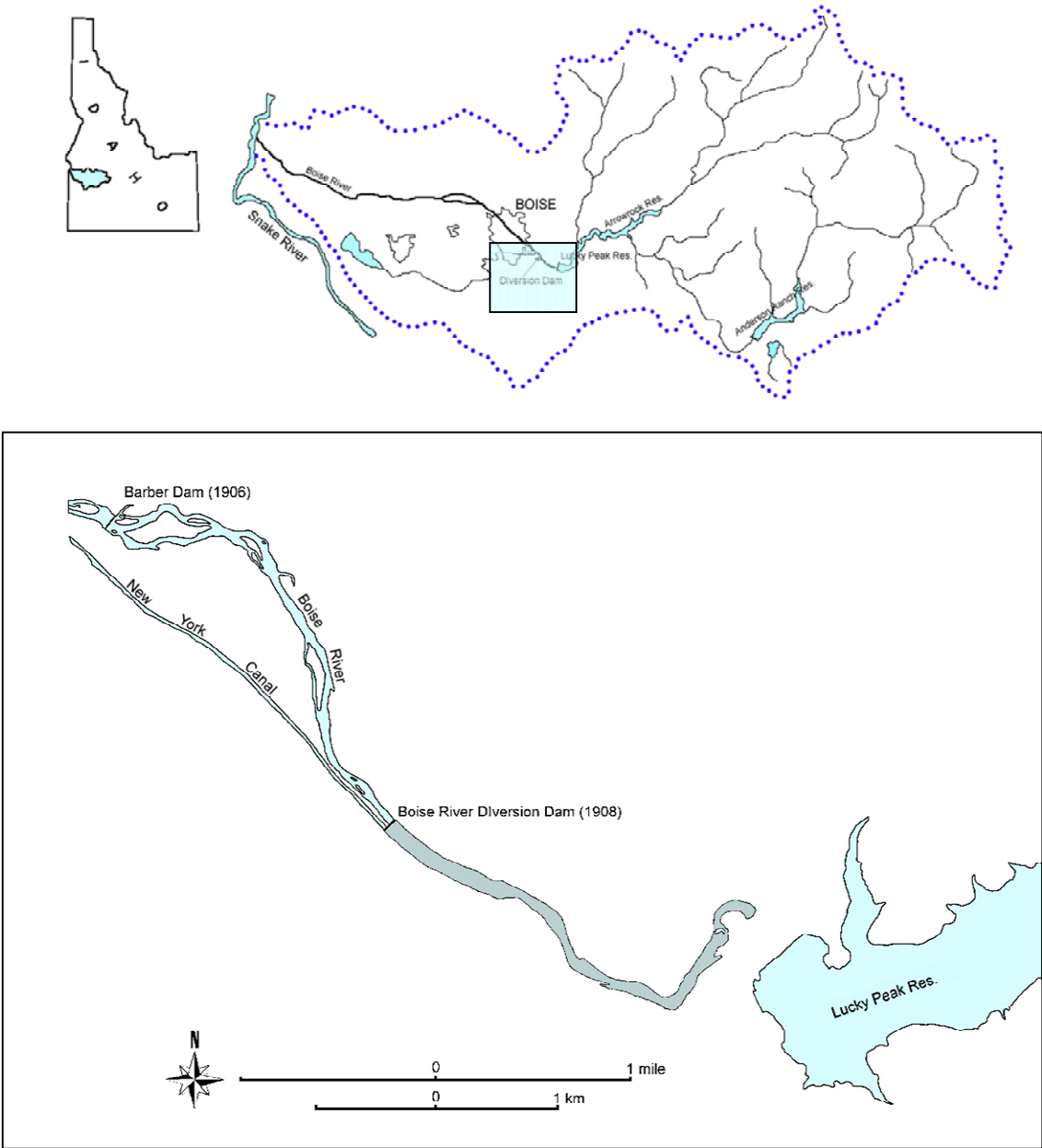


Figure 4. Boise River Diversion Dam and Reservoir.

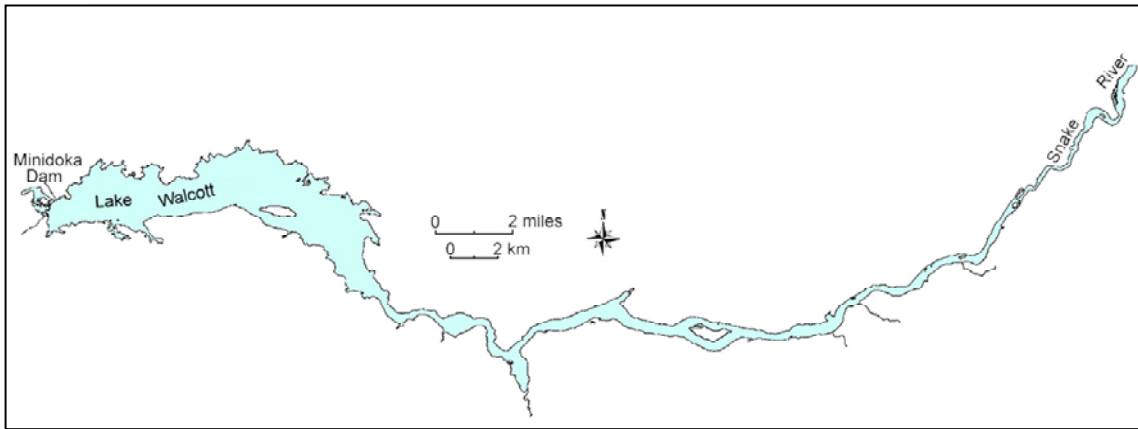
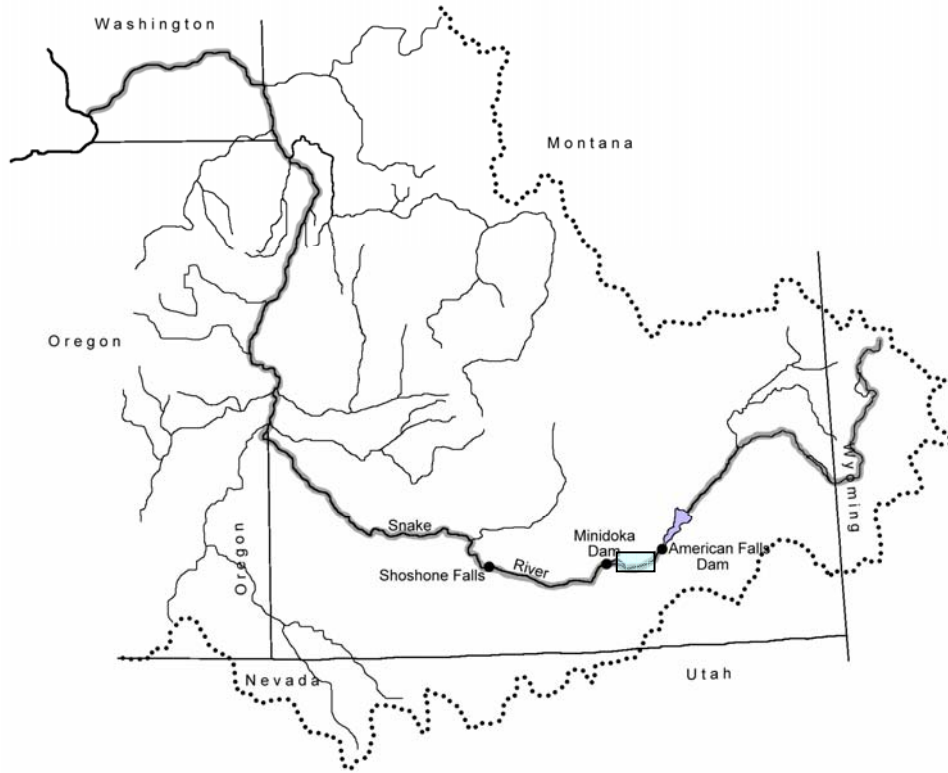


Figure 5. Minidoka Dam and Lake Walcott.

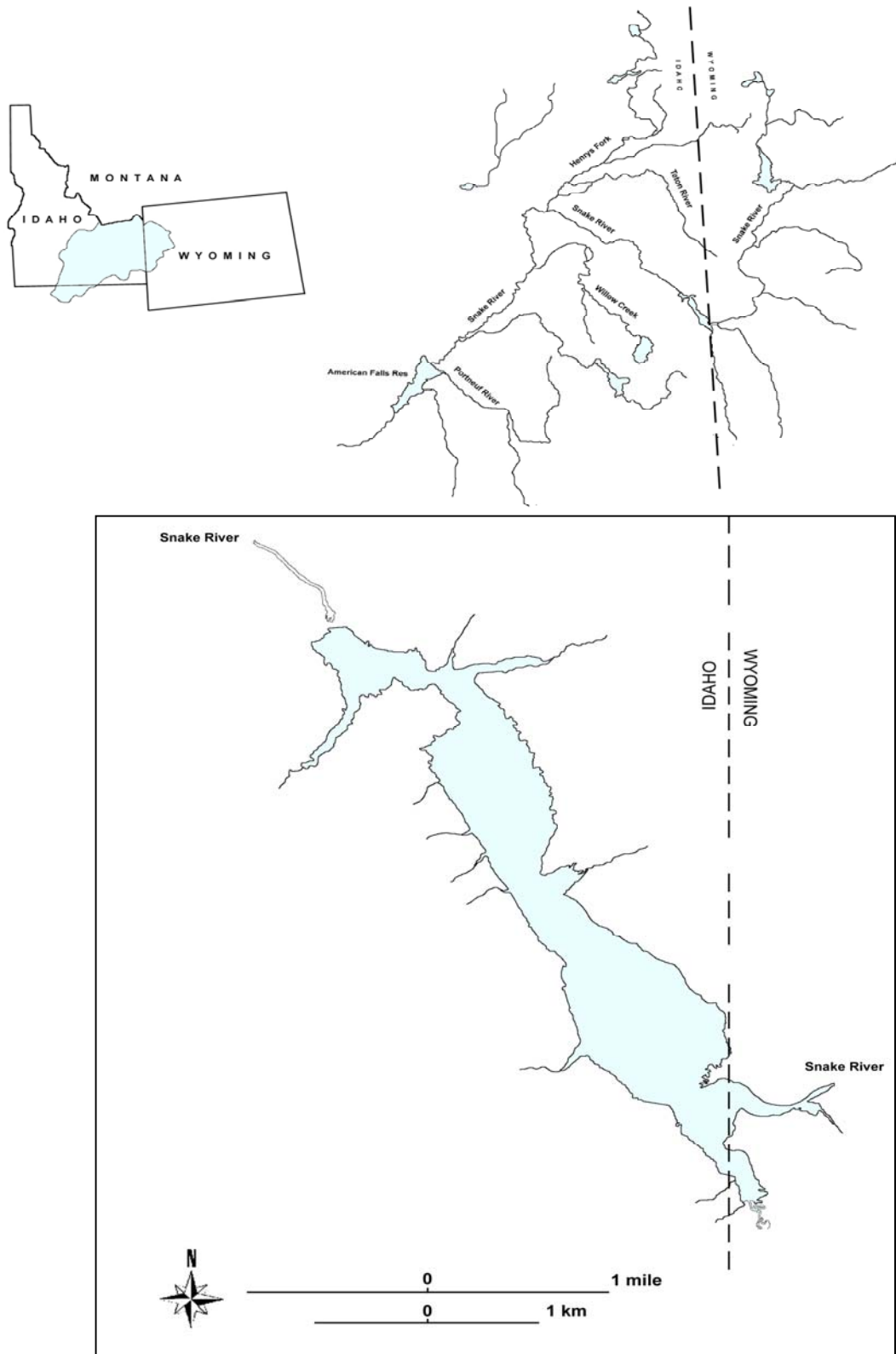


Figure 6. Palisades Dam and Reservoir.

Appendix A. Continued.

| SLIN | Used for: | Subbasin | Stream name | Site name | Sample date | UTM East | UTM North | GPS zone | Stream | | Reach | | Sampling technique | Linear densities (fish/m) | | | | | |
|------|--------------|------------------|------------------------------------|--------------------------------|-------------|----------|-----------|----------|-----------|-----------|------------|------------|--------------------|---------------------------|--------|--------|--------|--------|--------|
| | | | | | | | | | 1:100,000 | Width (m) | length (m) | NA | | MWF | YCT | BNT | HVB | BUT | BKT |
| 2099 | Deadwood | SF Payette River | SF Payette River | 24 | 9/9/2004 | 650273 | 4881098 | 11 | 3 | NA | NA | electrofsh | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2120 | Deadwood | MF Payette River | MF Payette River | sub for 30 | 9/9/2004 | 590240 | 4907966 | 11 | 4 | 14.00 | 80 | snorkel | 0.0375 | 0.0000 | 0.0000 | 0.0750 | 0.0000 | 0.0000 | 0.0000 |
| 2121 | Deadwood | MF Payette River | MF Payette River | sub for 142 | 9/9/2004 | 588024 | 4898044 | 11 | 4 | 20.00 | 50 | snorkel | 0.2800 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2122 | Deadwood | MF Payette River | MF Payette River | sub for 58 | 9/9/2004 | 588767 | 4900169 | 11 | 4 | 23.17 | 61 | snorkel | 0.9180 | 0.0000 | 0.0000 | 0.0000 | 0.1967 | 0.0000 | 0.0000 |
| 2123 | Deadwood | MF Payette River | MF Payette River | sub for 122 | 9/9/2004 | 587747 | 4897377 | 11 | 4 | 16.83 | 76 | snorkel | 0.1974 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2297 | Deadwood | MF Payette River | MF Payette River | 050 | 9/9/2004 | 580458 | 4883827 | 11 | 4 | 26.31 | 100 | snorkel | 0.0000 | 0.0000 | 0.0000 | 0.0600 | 0.0000 | 0.0000 | 0.0000 |
| 2300 | Deadwood | MF Payette River | MF Payette River | Reg 3, 1 A | 9/2/2004 | 592438 | 4915554 | 11 | 4 | 12.65 | 69.5 | snorkel | 0.0432 | 0.0000 | 0.0000 | 0.0432 | 0.0000 | 0.0000 | 0.0000 |
| 2301 | Deadwood | MF Payette River | MF Payette River | Reg 3, section 1 | 9/2/2004 | 591834 | 4914166 | 11 | 4 | 22.78 | 97.6 | snorkel | 0.0205 | 0.0000 | 0.0000 | 0.0512 | 0.0000 | 0.0000 | 0.0000 |
| 2302 | Deadwood | MF Payette River | MF Payette River | Reg 3, site 2 | 10/15/2004 | 590956 | 4911379 | 11 | 4 | 11.50 | 70 | snorkel | 0.5000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2303 | Deadwood | MF Payette River | MF Payette River | Reg 3 site 3 | 10/15/2004 | 590916 | 4909878 | 11 | 4 | 10.13 | 82 | snorkel | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2293 | Deadwood | SF Payette River | SF Payette River | Reg 3 - 1.3 mi. below hwy 21 | 9/10/2004 | 609145 | 4882252 | 11 | 4 | 20.06 | 110 | snorkel | 0.1636 | 0.0000 | 0.0000 | 0.2636 | 0.0000 | 0.0000 | 0.0000 |
| 2294 | Deadwood | SF Payette River | SF Payette River | Reg 3 - 2 mi downstream of Hwy | 9/10/2004 | 608869 | 4881592 | 11 | 4 | 22.17 | 158 | snorkel | 0.4430 | 0.0000 | 0.0000 | 0.4304 | 0.0000 | 0.0000 | 0.0000 |
| 2325 | Deadwood | SF Payette River | SF Payette River | Reg 3, Bear Creek | 8/19/2003 | 644633 | 4891138 | 11 | 4 | 19.67 | 57 | snorkel | 0.0877 | 0.0000 | 0.0000 | 0.1579 | 0.0000 | 0.0000 | 0.0000 |
| 2326 | Deadwood | SF Payette River | SF Payette River | Reg 3, Chanyon Creek | 8/19/2003 | 640403 | 4892274 | 11 | 4 | 13.33 | 73 | snorkel | 0.0959 | 0.0000 | 0.0000 | 0.3425 | 0.0000 | 0.0000 | 0.0000 |
| 2327 | Deadwood | SF Payette River | SF Payette River | Reg 3, Chapman Creek | 8/19/2003 | 635021 | 4888397 | 11 | 4 | 25.17 | 105 | snorkel | 0.2000 | 0.0000 | 0.0000 | 0.0952 | 0.0000 | 0.0000 | 0.0000 |
| 2328 | Deadwood | SF Payette River | SF Payette River | Reg 3, #6 | 8/19/2003 | 645958 | 4891102 | 11 | 4 | 20.20 | 55 | snorkel | 0.0727 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2329 | Deadwood | SF Payette River | SF Payette River | Reg 3, 31 | 8/19/2003 | 610157 | 4882107 | 11 | 4 | 38.00 | 70 | snorkel | 0.1429 | 0.0000 | 0.0000 | 0.6429 | 0.0000 | 0.0000 | 0.0000 |
| 2330 | Deadwood | SF Payette River | SF Payette River | Reg 3, 74.8 | 8/19/2003 | 613696 | 4880501 | 11 | 4 | 28.00 | 110 | snorkel | 0.0364 | 0.0000 | 0.0000 | 0.1182 | 0.0000 | 0.0000 | 0.0000 |
| 2331 | Deadwood | SF Payette River | SF Payette River | Reg 3, 76.3 | 8/18/2003 | 616156 | 4880666 | 11 | 4 | 17.80 | 160 | snorkel | 0.1688 | 0.0000 | 0.0000 | 0.5125 | 0.0000 | 0.0000 | 0.0000 |
| 2332 | Deadwood | SF Payette River | SF Payette River | Reg 3, 77.5 | 8/18/2003 | 617090 | 4880544 | 11 | 4 | 22.00 | 117 | snorkel | 0.2222 | 0.0000 | 0.0000 | 0.4017 | 0.0000 | 0.0000 | 0.0000 |
| 2333 | Deadwood | SF Payette River | SF Payette River | Reg 3, 79.7 | 8/18/2003 | 620160 | 4881000 | 11 | 4 | 30.50 | 75 | snorkel | 0.2267 | 0.0000 | 0.0000 | 0.0667 | 0.0000 | 0.0000 | 0.0000 |
| 2334 | Deadwood | SF Payette River | SF Payette River | Reg 3, 82.4 | 8/18/2003 | 623030 | 4883804 | 11 | 4 | 26.50 | 79 | snorkel | 0.2025 | 0.0000 | 0.0000 | 0.1013 | 0.0000 | 0.0000 | 0.0000 |
| 2335 | Deadwood | SF Payette River | SF Payette River | Reg 3, 83.1 | 8/18/2003 | 624041 | 4884444 | 11 | 4 | 18.17 | 148 | snorkel | 0.1014 | 0.0000 | 0.0000 | 0.3041 | 0.0000 | 0.0000 | 0.0000 |
| 2336 | Deadwood | SF Payette River | SF Payette River | Reg 3, 85.3 | 8/18/2003 | 625327 | 4885145 | 11 | 4 | 25.33 | 144 | snorkel | 0.2431 | 0.0000 | 0.0000 | 0.0278 | 0.0000 | 0.0000 | 0.0000 |
| 2337 | Deadwood | SF Payette River | SF Payette River | Reg 3, 86.7 | 8/18/2003 | 629264 | 4886201 | 11 | 4 | 19.17 | 78 | snorkel | 0.1538 | 0.0000 | 0.0000 | 0.2256 | 0.0000 | 0.0000 | 0.0000 |
| 2338 | Deadwood | SF Payette River | SF Payette River | Reg 3, 92.3 | 8/19/2003 | 636545 | 4889895 | 11 | 4 | 17.83 | 61 | snorkel | 0.1311 | 0.0000 | 0.0000 | 0.0770 | 0.0000 | 0.0000 | 0.0000 |
| 2559 | Lake Walcott | Snake River | Snake River | at Blackfoot | 9/26/2005 | 391056 | 4766226 | 12 | 7 | 70.5 | 2735 | electrofsh | 3.4845 | 0.0139 | 0.1616 | 0.0282 | 0.0000 | 0.0000 | 0.0000 |
| 904 | Palisades | Palisades/Salt | Blk Creek | Upper | 7/29/2002 | 476072 | 4770960 | 12 | 1 | 1.64 | 89 | electrofsh | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 897 | Palisades | Palisades/Salt | Blk Creek | lower | 7/27/2002 | 478445 | 4772484 | 12 | 1 | 2.13 | 92 | electrofsh | 0.0000 | 0.0435 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 898 | Palisades | Palisades/Salt | Barnes Creek | Upper | 7/27/2002 | 474645 | 4773186 | 12 | 1 | 1.65 | 91 | electrofsh | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 946 | Palisades | Palisades/Salt | Burns Creek | Upper | 8/25/2002 | 493881 | 4774054 | 12 | 1 | 1.40 | 87 | electrofsh | 0.0000 | 0.0115 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 928 | Palisades | Palisades/Salt | Camp Creek | middle | 8/12/2002 | 475883 | 4794662 | 12 | 1 | 1.44 | 101 | electrofsh | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 958 | Palisades | Palisades/Salt | Unknown Tributary to NF Bear Creek | Upper | 8/26/2002 | 473355 | 4796320 | 12 | 1 | 1.08 | 86 | electrofsh | 0.0000 | 0.0465 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 901 | Palisades | Palisades/Salt | Fish Creek | Upper | 7/28/2002 | 486110 | 4773306 | 12 | 2 | 1.94 | 80 | electrofsh | 0.0000 | 0.1000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 895 | Palisades | Palisades/Salt | City Creek | Upper | 7/26/2002 | 471900 | 4774061 | 12 | 2 | 1.46 | 91 | electrofsh | 0.0000 | 0.0220 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 894 | Palisades | Palisades/Salt | City Creek | Lower | 7/26/2002 | 471722 | 4774453 | 12 | 2 | 1.45 | 93.2 | electrofsh | 0.0000 | 0.0429 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 908 | Palisades | Palisades/Salt | Burns Creek | Lower | 7/30/2002 | 495975 | 4775588 | 12 | 2 | 1.68 | 100 | electrofsh | 0.0000 | 0.0400 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 785 | Palisades | Palisades/Salt | Barnes Creek | Upper (above 1st fork) | 10/22/1999 | 472335 | 4775758 | 12 | 2 | 3.17 | 77.74 | electrofsh | 0.0000 | 1.1963 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 784 | Palisades | Palisades/Salt | Barnes Creek | Lower | 10/22/1999 | 472268 | 4776309 | 12 | 2 | 2.71 | 101.3 | electrofsh | 0.0000 | 0.6910 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 889 | Palisades | Palisades/Salt | Trout Creek | upper | 7/25/2002 | 493736 | 4776961 | 12 | 2 | 2.11 | 100 | electrofsh | 0.0000 | 0.0150 | 0.0150 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 891 | Palisades | Palisades/Salt | Trout Creek | lower | 7/25/2002 | 494260 | 4778209 | 12 | 2 | 2.58 | 100 | electrofsh | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 887 | Palisades | Palisades/Salt | Bitters Creek | upper | 7/25/2002 | 490837 | 4779326 | 12 | 2 | 1.93 | 96.5 | electrofsh | 0.0000 | 0.0104 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 888 | Palisades | Palisades/Salt | Bitters Creek | lower | 7/25/2002 | 490812 | 4779621 | 12 | 2 | 1.45 | 100 | electrofsh | 0.0000 | 0.0100 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 890 | Palisades | Palisades/Salt | Unknown trib to McCoy Creek | lower | 7/25/2002 | 487540 | 4781565 | 12 | 2 | 1.42 | 90 | electrofsh | 0.0000 | 0.0111 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 896 | Palisades | Palisades/Salt | Unknown Trib of McCoy Creek | Middle | 7/27/2002 | 487350 | 4782313 | 12 | 2 | 0.97 | 90 | electrofsh | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 902 | Palisades | Palisades/Salt | Williams Creek | Only | 7/28/2002 | 490003 | 4783628 | 12 | 2 | 1.60 | 59.2 | electrofsh | 0.0000 | 0.1689 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 892 | Palisades | Palisades/Salt | Elk Creek | upper | 7/26/2002 | 482023 | 4786691 | 12 | 2 | 2.73 | 100 | electrofsh | 0.0000 | 0.2600 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 893 | Palisades | Palisades/Salt | Elk Creek | lower | 7/26/2002 | 481606 | 4787693 | 12 | 2 | 2.52 | 100 | electrofsh | 0.0000 | 0.2200 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 932 | Palisades | Palisades/Salt | Bear Creek | Middle | 8/13/2002 | 479088 | 4791637 | 12 | 2 | 8.36 | 115 | electrofsh | 0.0000 | 0.2696 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 929 | Palisades | Palisades/Salt | Camp Creek | Lower | 8/12/2002 | 475196 | 4793715 | 12 | 2 | 1.17 | 79.4 | electrofsh | 0.0000 | 0.1889 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 959 | Palisades | Palisades/Salt | Unknown Tributary to NF Bear Creek | lower | 8/26/2002 | 473129 | 4796047 | 12 | 2 | 1.99 | 100 | electrofsh | 0.0000 | 0.1900 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 906 | Palisades | Palisades/Salt | Iowa Creek | Upper | 7/29/2002 | 479818 | 4773734 | 12 | 3 | 2.98 | 85 | electrofsh | 0.0000 | 0.3412 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 779 | Palisades | Palisades/Salt | Comb Creek | @ mouth | 10/21/1999 | 485800 | 4775500 | 12 | 3 | 1.79 | 92 | electrofsh | 0.0000 | 0.3370 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 781 | Palisades | Palisades/Salt | Fish Creek | below confluence w/ Comb Cr | 10/23/1999 | 485809 | 4775782 | 12 | 3 | 3.23 | 92 | electrofsh | 0.0000 | 2.1196 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 907 | Palisades | Palisades/Salt | Iowa Creek | Lower | | | | | | | | | | | | | | | |

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