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# GRY HORSE DAM FISHERIES MITIGATION PROGRAM

## Fish Passage and Habitat Improvement in the Upper Flathead River Basin



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# HUNGRY HORSE DAM FISHERIES MITIGATION PROGRAM

# FISH PASSAGE AND HABITAT IMPROVEMENT IN THE UPPER FLATHEAD RIVER BASIN

Prepared by:

W. Ladd Knotek,
Mark Deleray
and
Brian Marotz

Montana Department of Fish, Wildlife, and Parks

Prepared for:

U. S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

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## INTRODUCTION

In the past 50 years, dramatic changes have occurred in the Flathead Lake and River system. Degradation of fishery resources has been evident, in part due to deterioration of aquatic habitat and introduction of non-endemic fish and invertebrate species. Habitat loss has been attributed to many factors including the construction and operation of Hungry Horse Dam, unsound land use practices, urban development, and other anthropogenic and natural disturbances. Fish migration has also been limited by barriers such as dams and impassible culverts. Cumulatively, these factors have contributed to declines in the distribution and abundance of native fish populations (Liknes and Graham 1988; Thomas 1992).

Recovery of fish populations requires that we develop a watershed approach that incorporates long-term aquatic habitat needs and promotes sound land use practices and cooperation among natural resource management agencies. In this document, we 1) describe completed and ongoing habitat improvement and fish passage activities under the Hungry Horse Fisheries Mitigation Program, 2) describe recently identified projects that are in the planning stage, and 3) develop a framework for identifying, prioritizing, implementing, and evaluating future fish habitat improvement and passage projects.

## BACKGROUND

The construction and operation of Hungry Horse Dam (HHD) has had extensive impacts on aquatic habitat, aquatic invertebrates, and fish populations in the Flathead Lake and River system. In 1991, the *Fisheries Mitigation Plan for Losses Attributable to the Construction and Operation of Hungry Horse Dam* (Mitigation Plan) was prepared by Montana Fish, Wildlife, and Parks (MFWP) and the Confederated Salish and Kootenai Tribes (CSKT) (MFWP and CSKT 1991). This plan provided the Northwest Power Planning Council (NPPC) with documentation of fisheries and habitat losses associated with construction and operation of HHD and a flexible strategy to mitigate for these losses. Accepted annual fisheries losses included 250,00 juvenile bull trout (*Salvelinus confluentus*), 65,000 juvenile westslope cutthroat trout (*Oncorhynchus clarki lewisi*), and 100,000 adult kokanee salmon (*Oncorhynchus nerka*) in the Flathead system. The Mitigation Plan also identified 124 km of critical, low gradient spawning and rearing habitat that was inundated and lost when Hungry Horse Reservoir (HHR) filled.

The *Hungry Horse Dam Fisheries Mitigation Implementation Plan* (Implementation Plan) was subsequently developed by MFWP and CSKT, adopted by the NPPC in 1993, and funded by Bonneville Power Administration (BPA). The Implementation Plan (MFWP and CSKT 1993) describes specific, non-operational measures (activities that do not affect dam operation) to protect and enhance resident fish and aquatic habitat affected by HHD. General categories of approaches include fisheries habitat enhancement and stabilization, fish passage improvements, hatchery production and fish planting, and offsite mitigation. Offsite mitigation includes the use of habitat improvement, fish passage, and fish stocking conducted outside the interconnected

Flathead Lake and River system.

Fish habitat and passage improvements are fundamental activities in Hungry Horse Dam mitigation. In approving the Implementation Plan, the NPPC encouraged the "implementation of habitat improvement projects as a high priority." Montana's Fisheries Mitigation Guidelines also stress "natural fish reproduction and habitat whenever possible." These directives affirm the importance of maintaining and enhancing suitable habitat for long-term, self-sustaining fish populations. Our goal is to maximize mitigation achieved through habitat enhancement and fish passage.

## PROJECT AREA

The Implementation Plan designates that HHD mitigation be conducted in the Flathead drainage (Figure 1). Onsite project areas include waters upstream of Kerr Dam that are directly connected to Flathead Lake or the upper Flathead River system and allow two-way movement of fish. Waters flowing into the South Fork Flathead River (South Fork) drainage upstream of HHD and waters that could be reconnected to the system through mitigation projects are also considered onsite.

Offsite project areas are the remaining waters in the entire Flathead drainage that are separated from the contiguous lake and river system by physical barriers or by the lack of two-way movement of fish. Projects in offsite areas are designed to expand the range of fish species of special concern, create reserves for genetically distinct fish sub-populations, and increase diversity of angling opportunities.

Fish habitat losses attributed to HHD construction include blocked access to the South Fork above the dam and flooding of the once free-flowing river system. The dam created a barrier to migration that eliminated at least 40% of the bull trout (DV) and westslope cutthroat trout (WCT) spawning runs from Flathead Lake. About 137 km of the South Fork and 584 km of tributary stream habitat was blocked from use by Flathead Lake fish populations. Hungry Horse Reservoir filling inundated spawning and rearing habitat in 58 km of tributary stream with gradients < 6% and approximately 66 km of the South Fork. Populations of fish isolated by the dam now use HHR as a surrogate for Flathead Lake. An inadvertent benefit of the dam resulted when a nearly pristine native species assemblage was isolated from non-endemic species introduced downstream.

In the remaining Flathead drainage, DV and WCT distribution and abundance have declined. Approximately one-third of the remaining spawning areas have been degraded by excessive sediment inputs, which have decreased egg to fry survival to < 30% (Weaver and Fraley 1991; 1993). An additional one-third of the remaining spawning reaches are inhabited by introduced fish species that may compete or hybridize with genetically 'pure', native stocks.

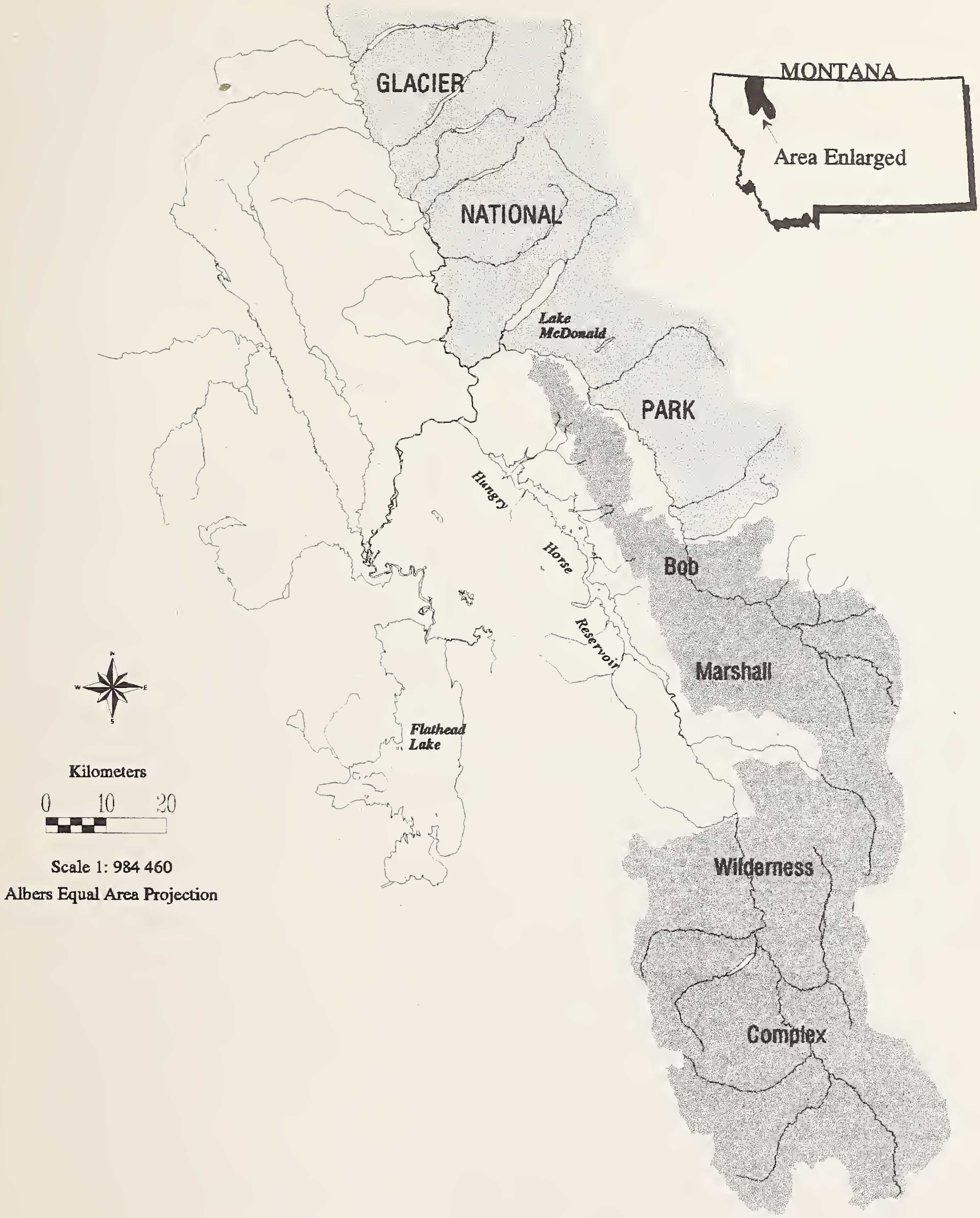


Figure 1. Onsite areas for Hungry Horse Dam Fisheries Mitigation.

Many onsite and offsite stream reaches have been blocked to fish passage by man-made or natural barriers. Fish passage problems in tributaries to HHR were documented following reconstruction of roads to accommodate higher water levels (Morton 1955; Montana Fish and Game Commission 1963). Sixteen percent of existing WCT and DV spawning and rearing habitat above the full pool elevation was blocked by poorly placed culverts (MFWP and CSKT 1991). Natural barriers include beaver dams and sections of stream channel that intermittently become dry due to subsurface water flow. Eliminating such barriers can expand the habitat available to migratory fish, providing the species and genetic composition of populations above and below the barrier are compatible. Because of concerns regarding genetics, disease, and invasion of introduced species, projects involving natural fish passage barriers will be evaluated on a site-by-site basis.

## ENHANCEMENT OF NATIVE SPECIES

The distribution and abundance of many native fish species in Montana, including DV and WCT, have declined in recent decades (Liknes and Graham 1988; Thomas 1992). The purpose of habitat improvement activities is to restore or enhance natural processes in aquatic ecosystems. Our intent is to employ a watershed approach to protect and expand current habitats and benefit diverse species assemblages. However, in selecting and planning projects under Hungry Horse Fisheries Mitigation, work that will benefit native fishes is given the highest priority. Enhancement efforts are focussed on DV and WCT for several reasons: 1) both species once maintained popular fisheries, but have exhibited dramatic declines in abundance and distribution in the Flathead basin and throughout their native ranges; 2) MFWP is strongly emphasizing native species management to protect and maintain native fishes, species assemblages, aquatic habitat, and angling opportunity; and 3) the Mitigation Plan identifies and quantifies losses for these species, which the region as a whole has accepted.

### *Bull Trout*

As the largest native fish in the Flathead system, DV has always been a high profile species. Concern for this species prompted MFWP to begin closing DV spawning streams to angling in the North Fork Flathead River (North Fork) in the 1950s, and the Montana Chapter of the American Fisheries Society and MFWP recommended that DV be added to a watch list of "Fish Species of Special Concern" in 1986. On October 30, 1992, a group of Western Montana conservation groups formally petitioned the United States Fish and Wildlife Service (USFWS) to list DV under the Endangered Species Act (ESA) of 1973. The USFWS subsequently published a "positive 90-day finding", indicating that listing may be warranted and initiated a formal status review. Presently, DV are proposed for listing as threatened under the ESA and are a Fish Species of Special Concern in Montana. The USFWS is currently examining these previous discussions and will publish a final rule in 1998.

Remaining DV populations are threatened by habitat degradation, barriers to migration, and introduced fish species. In the contiguous Flathead system, DV are primarily adfluvial. Offspring are generally spawned and reared in the upper drainage tributaries, and depend on passage to and from Flathead Lake to complete their life cycle. DV populations may be compromised by competition with introduced species and hybridization with brook trout (*Salvelinus fontinalis*), which inhabit many of the spawning tributaries. Past and ongoing activities that target DV include habitat improvements in Big Creek and Hay Creek (Hungry Horse Implementation Group 1994). Several habitat improvement and fish passage projects that will benefit DV upstream of HHD are also underway.

*Westslope Cutthroat Trout*

Westslope cutthroat trout are also an important native species in the Flathead River drainage. Populations have been impaired by habitat degradation, competition with introduced species, and hybridization with rainbow trout (*Oncorynchus mykiss*) throughout their native range in western Montana and northern Idaho. The current distribution of WCT has been reduced to < 10% of its historic range and this species is presently listed as a Fish Species of Special Concern in Montana. In 1997, WCT were petitioned for listing under ESA.

Westslope cutthroat trout populations in the Flathead basin exhibit variable life-history patterns and consist of unique metapopulations (i.e., stocks) among drainages. Subpopulations consist of a) adfluvial stocks that spawn and rear in Flathead River tributaries, but mature in Flathead Lake; b) fluvial stocks that spawn and mature in the Flathead River system; and c) resident stocks that complete their life cycle in Flathead River tributaries. Currently, information on the abundance and distribution of specific WCT stocks is limited, but population and species level declines are evident. Existing habitat improvement and passage work that focuses on WCT recovery includes Elliot Creek, Taylor's Outflow, and HHR fish passage projects (Hungry Horse Implementation Group 1994). Operational mitigation to increase production of HHR will also directly benefit WCT (Marotz et al. 1994; Marotz et al. 1996).

*Nongame and Desirable Introduced Species*

Habitat improvements and removal of passage barriers are important for native fish assemblages, wildlife, and aquatic ecosystems. Healthy, self-sustaining fish populations reflect functional aquatic systems that support other native flora and fauna. Although projects goals emphasize benefits to native trout, improvements such as riparian enhancement, stream bank stabilization, and placement of instream cover help to restore basic requisites of many species. Removal of fish passage barriers benefits many species that use these corridors for migration or dispersal. For example, removal of passage barriers on HHR tributaries that target WCT populations will also allow native mountain whitefish (*Prosopium williamsoni*) and suckers (*Catostomus* spp.) to access historical spawning habitat.

Certain habitat enhancement projects, particularly offsite projects, are also designed to benefit introduced species. Chemical rehabilitation of closed-basin lakes allows us to recover degraded fisheries. For example, lakes that have become overpopulated with illegally introduced yellow perch (*Perca flavescens*) or sunfish (*Lepomis* spp.) can be rehabilitated to improve the number and diversity of angling opportunities in the area, while displacing some angling pressure from recovering native populations. Past rehabilitation projects on Lion Lake and Rogers Lake have included stocking rainbow trout (RBT) and arctic grayling (*Thymallus arcticus*), in addition to WCT. Habitat improvement work may also target introduced trout populations in streams where reestablishment of natives is not possible. Certain waters with introduced trout species will be enhanced if, in doing so, native species recovery efforts are not compromised.

## GOALS OF FISH PASSAGE AND HABITAT IMPROVEMENT PROJECTS

Habitat improvements are intended to provide environmental factors necessary for long-term successful reproduction, rearing of juveniles, cover, food, and growth of fish in treatment areas. We will promote self-sustaining fish populations through enhancement of natural recruitment. Fish passage projects are designed to reclaim spawning and rearing habitat that has been isolated or lost to the Flathead River system because of man-made or natural barriers. Offsite projects will improve fishery resources of waters which are not directly linked to the contiguous Flathead system. These activities will increase diversity of angling opportunities and create reserves for genetically distinct stocks of existing fish species.

Through these efforts, we will attempt to replace the maximum proportion of fish numbers identified in the mitigation loss statement. All activities will be consistent with maintenance of genetic integrity in fish species and protection of plant and animal species that are endangered, threatened, or of special concern.

# ONGOING AND COMPLETED PROJECTS 1991-1996

## ELLIOTT CREEK ENHANCEMENT

### Background

Elliott Creek (a.k.a. Paladin Springs Creek or Swims Creek) is a low gradient spring creek that flows into the Flathead River 3.6 km upstream of Flathead Lake (Figure 2). The stream was impounded by a micro-hydro dam (no longer functional) at its upstream end and now flows

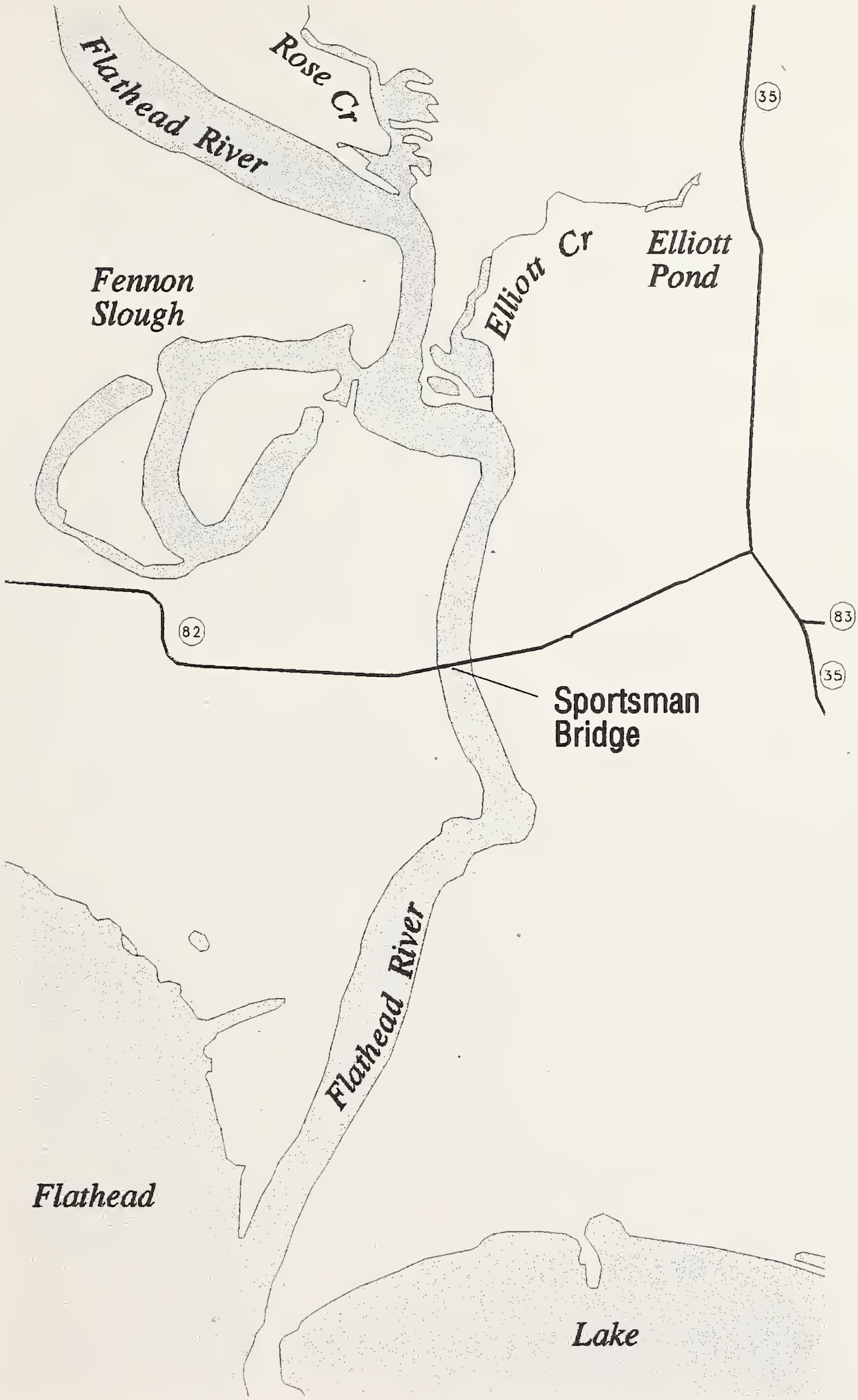


Figure 2. Location of Elliott Spring Creek.

approximately 1.2 km from the created pond to the Flathead River. Stream flows average 0.4 cms, riparian vegetation is well-developed, and substrata are comprised primarily of clays, fines, and organic debris.

Elliott Creek offers abundant rearing habitat for juvenile trout, but a brook trout (BT) population has dominated the fish assemblage. The goal of this project was to replace the resident BT population with a self-sustaining WCT population through eradication of BT, improvement of spawning habitat, and successive WCT imprint plants. Establishment of WCT in Elliott Creek would contribute to the Flathead Lake and River fisheries.

**Enhancement Activities**

The pond and stream were treated with rotenone to remove BT in fall 1991. Licensed applicators applied roughly 42 L of 5% rotenone solution to reach a 1.5 mg/L concentration. Conditions were optimal during treatment. The pond was reduced to minimum pool when rotenone was applied. The outlet was blocked, reducing discharge in the stream while rotenone was applied downstream. Over 2,000 BT were removed, but the population could not be completely eradicated because of groundwater seeps, which act as refuges from the toxicant.

Suitable spawning habitat was limited in Elliott Creek and available gravel substrate was heavily embedded with fine sediments. We designed and constructed a 32 m artificial spawning channel in the existing streambed 6 m immediately downstream of the pond outlet (Figure 3). The spawning channel was created with three, 7.5-m gravel sections which were separated by two 4.5-m cobble segments. Before gravel was added, aquatic vegetation and loose organic debris were removed, exposing a layer of hard clay. The spawning channel was created with three layers of substrate. First, a layer of oversized cobble (75-100 mm diameter) was laid on the clay bottom along the entire reach. This was capped with smaller cobble. A 15-20 cm layer of spawning gravel was placed on top of the cobble in the three 8-m sections. Spawning gravel size composition (Appendix A) was based on data from natural WCT reads (Weaver and Fraley 1991).

Instream habitat modifications created variable flow velocities and turbulence along the spawning channel. Placement of spawning gravels was designed to promote water upwelling through reads at the downstream end of slow water zones. Upwelling produces favorable conditions for egg incubation and pre-emergent survival by removing fines and providing aerated water.

Approximately 5,000, 125-mm and 5,000, 50- to 75-mm WCT fry were stocked in Elliott Creek in 1991 and 1992, respectively. In 1992, 15,000 WCT eyed eggs were also planted in man-made spawning reads. Survival rates were 80-90% to hatch and averaged 21% (range 4-40%) to emergence. Eyed egg plants and fry stocking have continued since 1993.

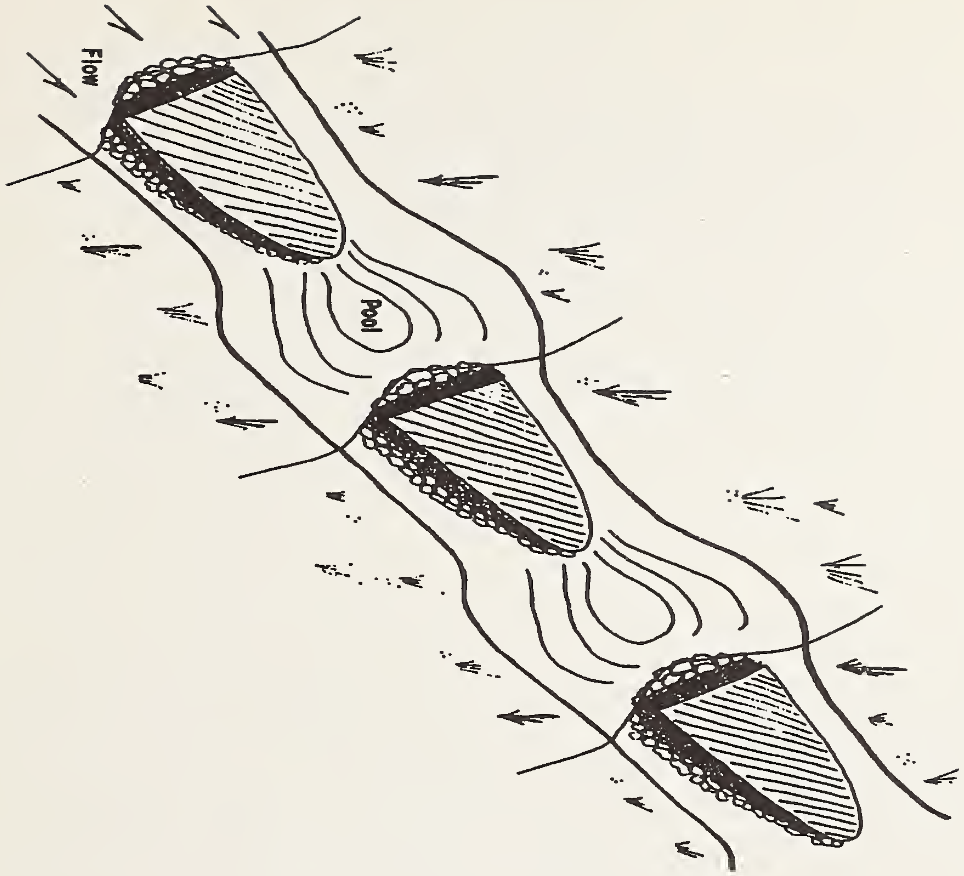


Figure 3. Design of spawning channel created on Elliott Spring Creek.

**Monitoring**

Trout populations were monitored in Elliott Spring Creek and Pond in 1993-1996 (Table 1). A fish (weir) trap was installed at the upper end of the pond to capture emigrating trout, particularly BT, which migrate upstream from the pond to spawn in the fall. Trout abundance and species composition were also assessed in the stream downstream of the pond using traps and electrofishing. BT captured by trapping and electrofishing were removed.

Results of sampling (Table 1) indicate that planted WCT reside in the pond and stream. However, BT abundance remains high in both locations. WCT used the artificial spawning channel in 1996; three redds were observed in the creek in June. The reads were assumed to contain WCT eggs since no RBT have been observed in the stream since sampling began in 1993. Additional spawning, including imprinted (adfluvial) WCT are anticipated in coming years.

Plans for monitoring include assessment of adult WCT returns, juvenile emigration rates, and resident trout population size and composition. Results thus far indicate that rotenone is not effective in eradicating BT when spring seeps are present. We will evaluate alternative fish toxicants (such as antimycin) that may be more effective in future eradication attempts.

Table 1. Summary of Elliott Creek fish sampling, 1992-1996.

| DATE | SAMPLE LOCATION | SAMPLING METHOD | NO. OF BT | NO. OF WCT |
|---|---|---|---|---|
| 1/93-3/93 | Pond | Trap | 71 (73-232 mm) | 0 |
| 12/93 | Pond | Trap | 17 (74-242 mm) | 2 (size unavail.) |
| 5/93 | Stream* | Electrofishing | 4 (189-210 mm) | 9 (107-132 mm) |
| 8/93 | Stream | Electrofishing | 59 (54-241 mm) | 75 (35-211 mm) |
| 12/93 | Stream | Electrofishing | 27 (72-292 mm) | 26 (51-220 mm) |
| 12/93-2/94 | Stream | Trap | 24 (102-220 mm) | 10 (100-265 mm) |
| 1/94-2/94 | Pond | Trap | 41 (95-261 mm) | 4 (Size unavail.) |
| 5/94 | Stream | Electrofishing | 31 (110-177 mm) | 22 (?-256 mm) |
| 12/94-5/95 | Pond | Trap | 65 (82-280 mm) | 30 (70-240 mm) |
| 4/96 | Stream | Electrofishing | 60 (83-241 mm) | 11 (91-184 mm) |

* Stream sampling was conducted downstream of the pond.

## BIG CREEK SEDIMENTATION CONTROL

### Background

Big Creek is a tributary to the North Fork that provides important DV and WCT spawning and rearing habitat. Ski resort development, timber harvest, and road construction within this drainage have increased fine sediment levels through point-source and nonpoint-source inputs (Weaver 1993). Increased sedimentation threatens to impair trout populations by reducing egg survival, fry emergence, and juvenile rearing capacity, and has likely contributed to recent decreases in DV redd densities at long-term monitoring sites (Figure 4).

Roads and skid trails constructed during past logging activities are a major source of fine sediments in the Big Creek watershed. A section of a Big Creek tributary adjacent to United States Forest Service (USFS) Road #316A (T52W, R22W, S14) is one location where sediments were input directly into the stream (Figure 5). At this site, an abandoned logging road and skid trail caused rerouting and collection of runoff above (up slope of) the stream. Saturation of the abandoned road prism caused approximately 50 $m^3$ of road bank and supporting hillside to "slump" downward, blocking a portion of Road 316A and the stream. Excessive sediment transport and deposition threatened DV and WCT spawning habitat downstream.

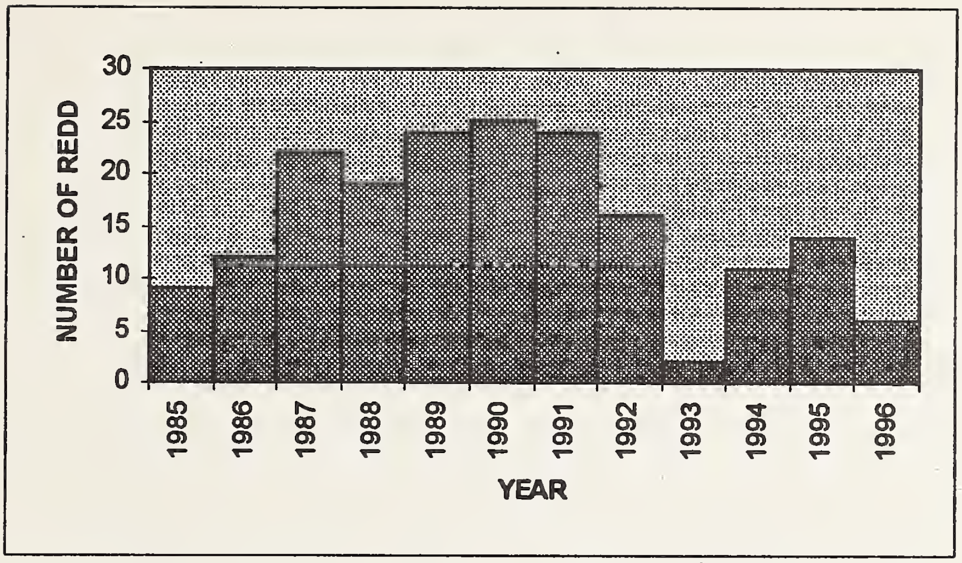


Figure 4. Bull trout redd counts in long-term monitoring sections at Big Creek.

The goal of mitigation efforts was to alleviate a major sediment source and reduce direct inputs into this stream through removal of slumped material, bank reshaping, and revegetation. The project was carried out by MFWP Special Projects crew members and an excavating contractor, but costs were shared by MFWP, USFS, American Timber Company, and F.H. Stoltze Land and Lumber Company. Mitigation funds were used as a catalyst to initiate corrective measures in the stream. The USFS will continue stream restoration activities to minimize cumulative sediment problems.

**Rehabilitation Activities**

Initial stream rehabilitation work took place in September 1994. Specialized equipment was needed to remove the sediment source without disrupting vegetation already becoming reestablished along the road cut and slumped area. A private contractor used a Schaeff HS 40 C Super Hoe (all-terrain excavator) to remove and transport slump materials.

Sediments were removed from approximately 30 m of creek channel and redistributed along the upper bank. Log barbs were placed to build up the stream bank and deflect water away from the slump. The slope was returned to grade and the road cut was also pulled back and sloped. After excavation was completed, exposed banks were covered with Polyjute 407 g fiber matt to reduce erosion and promote revegetation. A wilderness seed mixture was incorporated into the fiber matt, along with other containerized native plants. Willow, dogwood, and snowberry sprigs (6500) were also planted the following spring and summer (1995).

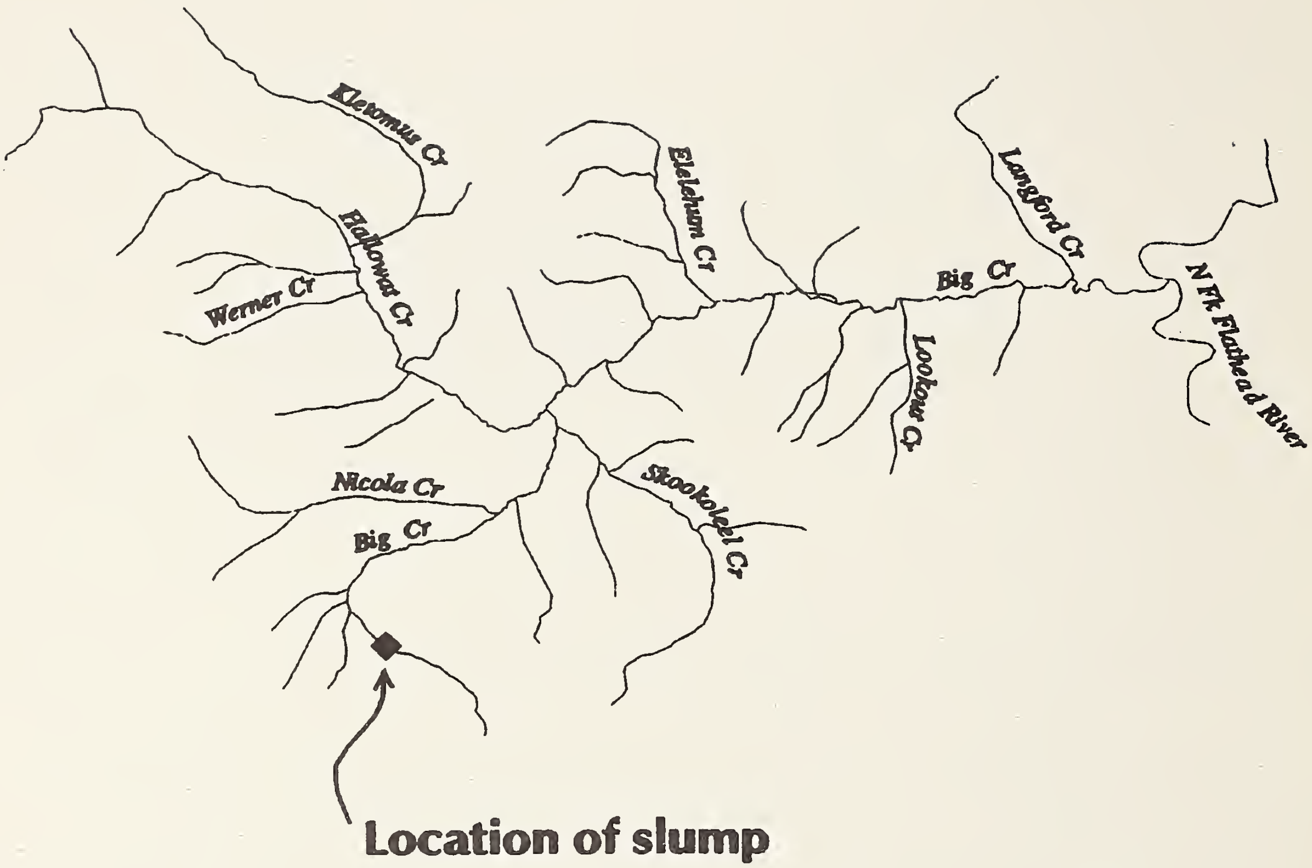


Figure 5. Location of sedimentation control project in the Big Creek drainage.

## Monitoring

The fiber mat, containerized stock, and sprigs were damaged by snowmobile trail grooming the following winter. Therefore, the area was replanted with native containerized plants and approximately 4,000 willow sprigs in 1995. The site was revisited in the fall (1995). Native willow cuttings had developed leaves and appeared to be growing better than the container or rooted nursery stocks. The seed mixture was growing well, providing a thick matt of herbaceous vegetation.

Sediment reduction should contribute to increased fry emergence and juvenile survival. Annual sediment core sampling near the confluence of Big and Skookoleel creeks (see Figure 5) indicates that sediment levels are stable or declining after peaking in 1990 (Figure 6). Mitigation activities may have contributed to improved habitat conditions along with better land use practices (Mathieus 1996). Long-term effects of reduced sediment inputs will be monitored via continued sediment core sampling and fish population monitoring.

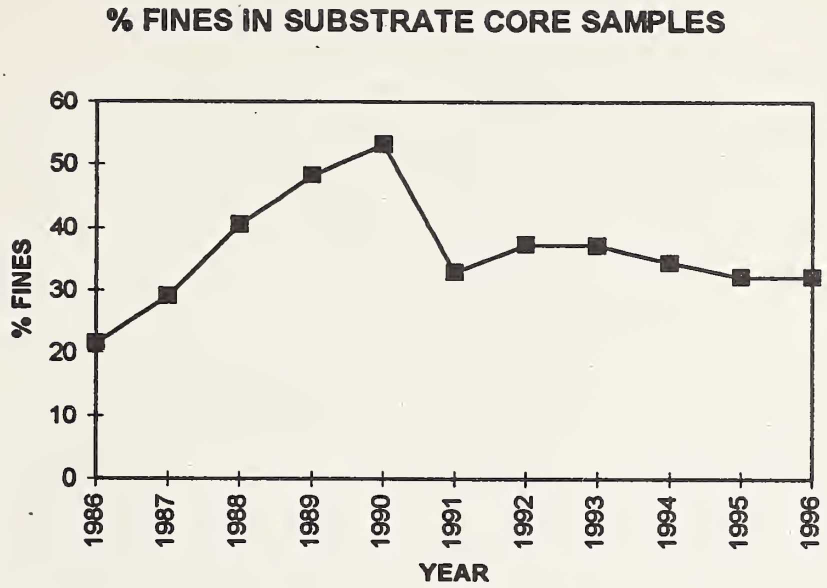


Figure 6. Levels of fine sediments (<6.5 mm in diameter) in substrate core samples from Big Creek (Tom Weaver, MFWP, unpublished data).

## HAY CREEK ENHANCEMENT

### Background

Hay Creek, a tributary of the North Fork, supports resident and migrant WCT and can provide DV spawning and rearing habitat. Several problems, including excessive bedload deposition and barriers to fish passage, were identified as limiting factors for fish residence, spawning, and migration.

Excessive sediment deposition likely resulted from increased water yield after large portions of the upper basin were logged prior to the mid-1970s. Streambank instability was exacerbated by a narrow bridge crossing Hay Creek on the North Fork Road (Rd. 486). Excessive deposition caused Hay Creek to braid into multiple channels that inundate a bordering pasture and timber lands. As streamflows decrease in late summer, the channel system gradually dewaters, stranding fish to die in isolated pools. In most years, dewatering and beaver dam barriers also preclude upstream movement of migrant trout on their spawning run. Passage is possible only when flows remain high during the lowest flow (summer-fall) period. Although juvenile DV have been found in most reaches of Hay Creek, densities are extremely low. We often observed incomplete age structures, with entire year classes missing or reduced. Generally only a few fish in the 300-400 mm range were found. This is not typical of DV populations in other Flathead River tributaries. Previous studies indicate that water temperatures, streambed substrate characteristics, and other habitat requirements for migratory DV are present in Hay Creek (Read et al. 1982).

In September, 1993, MFWP Special Projects personnel installed five piezometers near Hay Creek to measure groundwater depth. Monthly monitoring continued through 1996 in conjunction with stream discharge measurement. In cooperation with the Bureau of Reclamation (BOR), streambed elevations were also surveyed to assess the depth of groundwater below the dewatered stream reach. This information was used to assess the likelihood of returning streamflow to the dewatered portion of the stream.

We organized a cooperative project with the BOR and private land owners to alleviate the problems mentioned above. The BOR provided technical assistance and completed a feasibility study in 1994. As a result, the planned enhancement project was divided into three phases that address fish habitat concerns in different stream segments. Phases I and II were completed in 1995 and 1996. Effects of these projects will be monitored in 1997 and the need for Phase III will be assessed.

**Project Area**

Hay Creek is located approximately 40 km northwest of HHD. The study section includes the reach of Hay Creek from the North Fork Road Bridge downstream to the confluence of Hay Creek and the North Fork. This 2.9 km stretch was divided into four distinct reaches based on habitat characteristics and problems.

Prior to enhancement work, the *upper reach* was characterized by heavy sediment deposition and several braided channels. Deposition of sediments caused a constantly changing network of channels in this reach. Shallow, braided channels also accumulated excessive logs, sticks, and brush in the area.

The *marsh reach*, located just downstream of the upper reach, is a typical braided stream with low gradient and few distinct flow channels. Materials deposited in this area include sand, silt, clay, and organic material. Numerous beaver dams impounded water and further restricted flows through this section. The marsh reach is about 610 m in length and incurs the greatest water loss of the four sections. Near the lower end of the reach, distinct channels begin to form which combine near the beginning of the middle reach.

The *middle reach* has one distinct channel that flows through a pasture and meadow for approximately one km. This section had no flows during portions of the summer, despite its clay bottom that would normally experience minimal seepage loss. The channel is eroded into soil material ranging in size from small gravel to loams and clays. During no flow periods, pools of water persist at several locations indicating that the groundwater table is at or near the bottom of the streambed. No major instream enhancement work is planned for the middle reach. However, this section is the most heavily impacted by grazing.

The *lower reach* begins about 215 m above the mouth of Hay Creek. At this point, the stream once again separates into several channels. In addition, several sloughs and inactive channels are present. Due to heavy vegetation, accumulated debris, and the side channels and sloughs, the exact discharge point into the North Fork is undefined. Work in the confluence area will be considered in the final phase of the project.

**Phase I**

After appropriate permits were obtained, MFWP personnel, a BOR engineer, and private land owners began work on Phase I in the upper reach of Hay Creek. During September 25-29, 1995, flows were redirected from the main channel to allow instream work. Deposited sediments were excavated and natural meander was restored through bank armoring and habitat improvements. Approximately 345 $m^3$ of sediment was removed from the streambed, consolidating 760 m of braided channel into a single channel. The goal of redirection efforts is to have 80% of low flow and 50% of high flow pass through the main channel, thus maintaining the stream's flood capacity. About 15 $m^3$ of spawning gravel were added to the excavated channel along with 15 $m^3$ of boulders for instream cover and fish holding areas. In addition, ~150 linear m of logs were incorporated for flow deflection (barbs) and bank stabilization. Bank areas disturbed during construction were revegetated with 4,000 native willow cuttings gathered in spring (1995). These areas were also seeded with a native grass seed mix to improve bank stability.

To monitor the success of Phase I, flows were measured above and below the upper section in 1994-96 (Table 2), and piezometer readings were recorded through spring of 1996. In addition, we established photo points to assess stability of the stream channel and the progress of bank revegetation.

Table 2. Summary of flow measurements in upper and middle sections of Hay Creek, 1994-96.

| | Discharge (cfs) | | | |
|---|---|---|---|---|
| Date | Upper Reach | Middle Reach (Below Phase I & II Work) | Overflow Channel Created in Phase I | Loss of Flows in Project Section |
| 9/94 | 13.5 | 0 | NA | 100% |
| 5/95 | 70 | 15 | NA | 79% |
| 10/95 | 37 | 7 | 0 | 81% |
| 7/96 | 158 | NA | 44 | - |
| 8/96 | 26 | 15.5 | 2 | 40% |
| 9/96 | 36 | 18 | 0 | 50% |

Water loss was decreased after Phase I of the project and flows reached the North Fork in fall (1995). Approximately 50% of flows were still being lost to infiltration and diversion in the marsh reach. Some loss is beneficial to maintain groundwater interchange with the adjacent wetland.

**Phase II**

Phase II began in September of 1996 and focussed on improvement of the Hay Creek channel in the marsh reach. Project design included construction of a 125 m, low level embankment (0.6-1.0 m high) located just downstream of the overflow channel built in Phase I. The embankment was created in a section that consisted of many low gradient side channels which diverted surface water from the main channel, even at low flows. The purpose of the embankment is to limit the surface area covered by Hay Creek at low flows, while allowing high flows to flood the adjacent wetland (via water from the overflow channel). To further facilitate flow in the main channel, several beaver dams were removed and a natural channel morphology was restored where sediments had accumulated. Beaver dams on side channels and areas where flow is not desired were left intact to help force flows to the main channel and provide wetland habitat. Beaver management will likely become a periodic maintenance activity until the system equilibrates.

Hay Creek flows reached the North Fork again in 1996. Frequent flow measurements will continue over the next several years to monitor the success of the project. We also established permanent photo points, a 150 m fish population monitoring section just above the marsh reach, and will conduct DV redd counts beginning in 1997.

**Phase III**

The need for Phase III is contingent on the success of Phases I and II. Prior to project activities, flows reaching the North Fork seemed inadequate for DV passage. In 1995 and 1996, flows were enhanced and reached the mouth of Hay Creek. Present concerns are that: a) Hay Creek does not have a definite termination point and b) water velocities at the mouth of Hay Creek are too low and dispersed for migrating trout to locate the mouth. If necessary, Phase III will require either improvements of the existing channel or construction of a short section of new channel to allow migrating fish to access the creek.

**Riparian Enhancement**

Livestock grazing in the middle and lower sections of Hay Creek has damaged riparian vegetation and led to bank instability. Exclusion of livestock would complement completed projects by preventing physical damage to stream banks and allowing reestablishment of vegetation. We are working with the USFS, Montana Department of Natural Resources and

Conservation, and private land owners to alleviate this problem.

## TAYLOR'S OUTFLOW RESTORATION

### Site Description and Background

Taylor's Outflow is a small spring creek system located near Columbia Falls, MT (T30N R20W SEC9,10,16). It rises from a series of springs in the floodplain of the Flathead River and flows approximately 2.6 km into two shallow, man-made ponds (2.5 ha surface area each), before emptying into the main stem Flathead River (Figure 7). Stream discharge ranges from 1.6 cfs to 15.3 cfs. During spring runoff, elevated groundwater levels increase stream discharge. Water temperatures are also variable in the stream (0.3-15.6 °C) and in the ponds (0.3-23.6 °C).

A small, man-made dam at the pond outlet acted as a barrier to fish migration into Taylor's Outflow from the Flathead River. Upper sections of the stream had been heavily grazed by livestock, resulting in damage to stream banks and sediment deposition in the channel. Some reaches had also been dredged and straightened by landowners in the early 1900s. The stream and ponds supported a large, introduced BT population.

In 1992, an agreement was signed by MFWP and all landowners adjacent to the stream. Our goal was to restore passage and increase the area of suitable spawning and rearing habitat for WCT in the Flathead River system. Since BT compete with native WCT, initial efforts focused on eradication of the BT population in preparation for re-establishment of a native species assemblage. Enhancement of spawning and rearing habitat began in the upper reaches, and genetically pure WCT were planted to establish a population. In 1996, construction of a fish ladder was completed to provide fish passage from the Flathead River. Channel reconfiguration began in the head end of the drainage in 1996 and will continue in downstream sections in 1997-98.

### Chemical Rehabilitation

In August 1993, a total of 98 L of rotenone (5% Noxfish and 5% Powdered Cube Root) was applied by MFWP personnel. Five liquid rotenone drip stations were placed in headwater and main channel sections of the stream. Drip stations released enough rotenone to achieve a toxicity of 2-4 mg/L for 12-24 hours. Noxfish was added to the man-made ponds to achieve a 1 mg/L rotenone concentration. An additional 4 L of Noxfish was sprayed in shallow, marsh areas created by two beaver dams upstream. A compressed powdered cube root mixture (cube root, sand, and gelatin) was thrown into spring seeps and slowly released rotenone as it dissolved. This mixture released a lethal concentration of rotenone at seeps of up to 0.25 cfs for 24 hours (Utah Fisheries Division, pers. comm.).

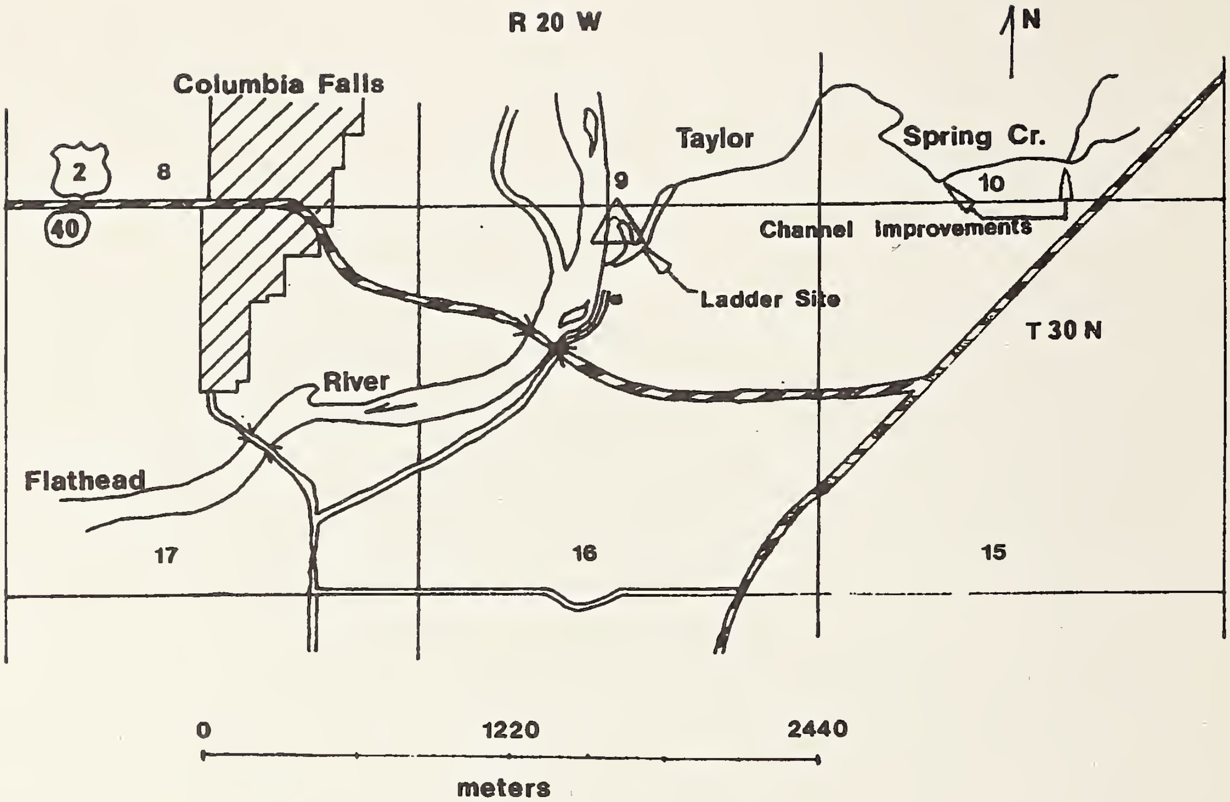


Figure 7. Taylor's Outflow project site near Columbia Falls, Montana.

Prior to rotenone treatment, BT, sculpin (*Cottus* spp.), and RBT were present in Taylor's Outflow. Brook trout were the most abundant fish species. Post-treatment fish surveys have included electrofishing, redd surveys, and monitoring upstream and downstream movement with fish traps. Three years after rotenone application (1996), WCT and BT were the only species observed in the system, but the assemblage was dominated by BT. Eradication of BT was unsuccessful because of the groundwater seeps, which act as refuges from the toxicant. We are presently considering whether other fish toxicants (e.g., antimycin) may be needed for future attempts at BT eradication.

**WCT Imprint Plants**

A total of 5,600 WCT juveniles were stocked between 1993 and 1996. One thousand of these fish were implanted with coded wire tags in 1994. In 1995, we began planting 20,000 eyed eggs annually and plan to continue this schedule in the future. Westslope cutthroat trout continue to be captured and observed during post-treatment fish surveys. Construction of the fish ladder in 1996 allowed passage by spawning adults. We began monitoring fish movement at the fish ladder (including WCT returns) in 1997.

**Riparian Enhancement**

Habitat improvements on Taylor's Outflow include revegetation of stream banks and fencing to exclude livestock. We installed >3,000 m of four-strand, barb wire fence and constructed five stock watering sites in upper sections. To minimize further soil erosion, the watering sites were built following specifications and techniques developed by the Natural Resources Conservation Service (NRCS).

Revegetation of the stream banks in grazed sections (upper half of drainage) began in spring of 1994 and will continue through 1998. Rooted native plants are purchased at local nurseries. Unrooted willow shoots are cut by MFWP personnel in the Coram Experimental Forest and Flathead National Forest near Hay Creek. Approximately 2,750 native sprigs and rooted plant stock have been planted, including willow, wild rose (*Rosa woodsii*), common snowberry (*Symphoricarpus albus*), box elder (*Acer negundo*), water birch (*Betula occidentalis*), quaking aspen (*Populus tremuloides*), dogwood (*Cornus* spp.), and cottonwood (*Populus robusta*). Existing and planted vegetation have responded well to protection afforded by fencing.

**Channel Improvements**

In addition to sparse bank vegetation, we identified several other limiting factors for trout spawning and rearing in the upper reaches of Taylor's Spring Creek. Grazing and loss of riparian vegetation had caused the stream to become wide, shallow, and embedded with fine sediments. Suitable spawning gravels and instream cover were also limited.

In summer 1996, we began implementing habitat improvements in a 300 m stream section near the head of the drainage (see Figure 7). Our goal was to address factors limiting trout production, while restoring a more natural channel morphology. We consulted Rosgen (1996) in designing and restoring meander, riffle and pool sequences, and altering channel dimensions. However, we were limited somewhat by the narrow riparian zone (between pasture fences) in some areas. Straw bales were pinned into substrates using rebar to delineate modified channel dimensions. We excavated fine sediments from pool and run areas and placed the material behind the bails to create point bars. A suction dredge was also used to remove accumulated sediments. Root wads and stumps were placed on banks that appeared highly susceptible to erosion and in selected pools to provide cover. All disturbed areas and point bars were replanted with native grasses.

Spawning habitat was enhanced by adding spawning gravels to two areas and creating a 15 m spawning channel. In June, 1.5 $m^3$ of gravel was added to two 7-10 m reaches to accommodate eyed-egg plants. In August, a spawning channel was created using cobble (4.6 $m^3$), overlaid by washed gravel (5.3 $m^3$) of appropriate size (Figure 8). Design of the channel was based on the methods and materials described in the 'Elliott Creek Enhancement' section of this


Figure 8. Design of trout spawning habitat designed at Taylor's Spring Creek.

report. Woody debris was added on the margins of the spawning channel to provide overhead cover. We designed all of the spawning areas to match flow (0.2-0.4 m/s) and depth (8-30 cm) characteristics typical of natural WCT spawning habitat.

**Fish Ladder**

Prior to 1996, upstream migration of fish from the Flathead River into Taylor's Outflow was blocked by a dam at the lower pond outlet. Plans for a fish ladder to bypass this barrier had been delayed since 1992. In September, 1996, we completed construction of a fish ladder in the north arm of the lower pond (Figure 7). An outlet pipe was also installed near the dam to allow water circulation in the south end of the pond. In 1997, completion of the project created access for spawning WCT from the Flathead River and Lake system for the first time.

The ladder is about 30 m long and consists of a series of eight step-pools created by installing notched steel weirs at 0.3 m elevation intervals (Figure 9). Each pool is approximately 3.7 m long and 2.4 m wide. We used large rock and cobble to armor the excavated channel and anchor the steel plates. We also installed a 15 m long barb just upstream of the ladder outlet to protect the structure from high spring flows in the Flathead River. Construction of the fish ladder and barb took six d and required an excavator and backhoe. After ladder construction was completed, we replanted the project site area with a hydro-seed matrix containing native grass seed. Willow sprigs and native shrubs will be planted in spring of 1997.

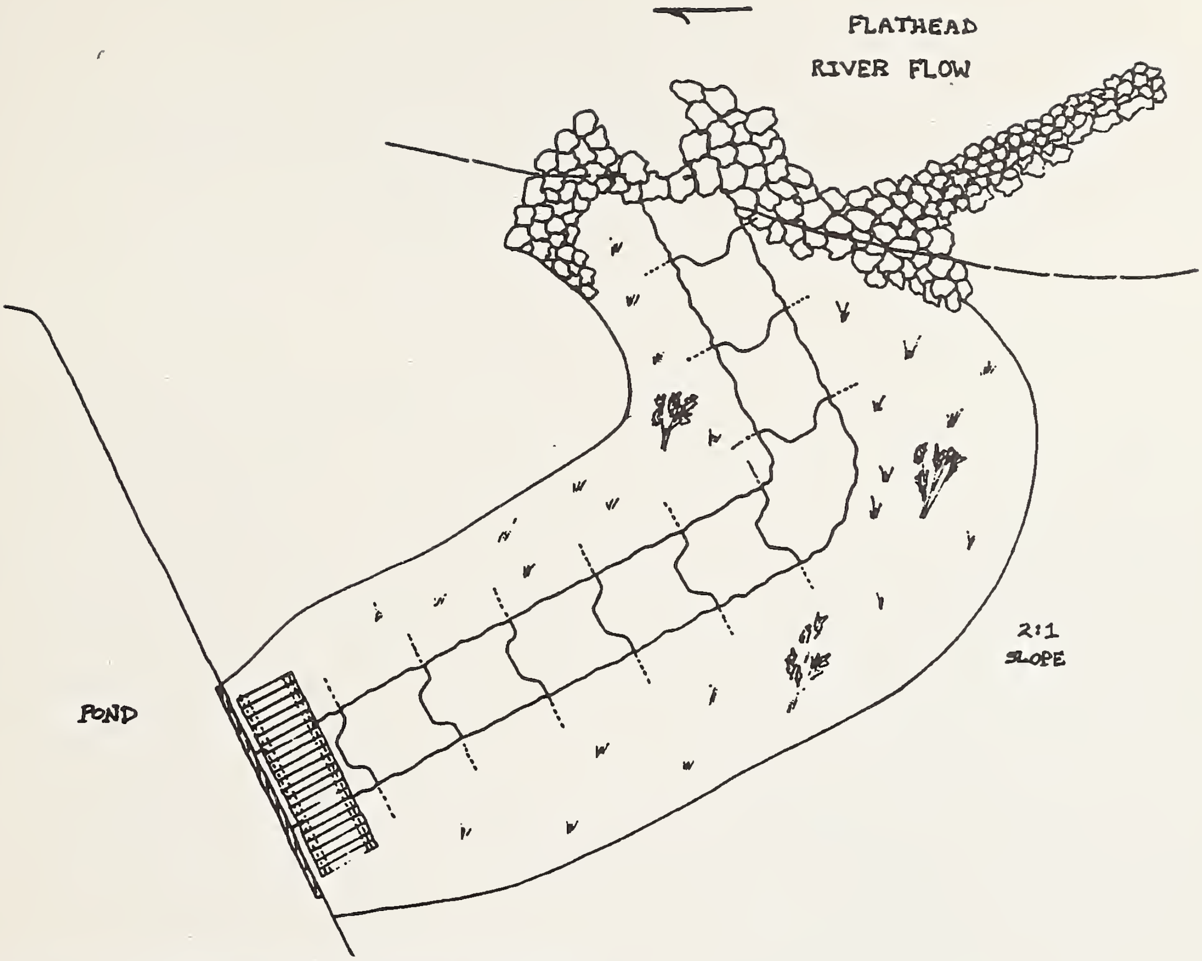


Figure 9. Design for fish ladder at Taylor's Outflow.

Several WCT and RBT were observed using the ladder within three days after construction. In 1997, we will use a fish trap to monitor upstream and downstream movement of fish through the ladder.

## FISH PASSAGE BARRIERS ON HUNGRY HORSE RESERVOIR TRIBUTARIES

### Background

Three important native fishes (WCT, DV, and mountain whitefish) inhabit HHR. These migratory fish rely on tributary streams for spawning and rearing habitat; juvenile WCT and DV rear in tributaries for one to four years after emergence. Upon completion of the dam in 1952, HHR inundated approximately 58 km of low gradient, high quality tributary habitat. A substantial amount of the remaining spawning and rearing habitat above full pool elevation has been blocked by man-made barriers.

Fish passage problems caused by poorly placed culverts surrounding HHR were documented following road reconstruction to accommodate higher water levels (Morton 1955; Montana Fish and Game Commission 1963). Culverts on USFS Road 38 prevent fish passage to 16% of the stream habitat historically available in second, third, and fourth order tributaries of HHR. Montana Fish, Wildlife, and Parks, BOR, the USFS signed a Memorandum Of Agreement in 1993 to repair fish passage problems on some HHR tributaries.

**Estimating Fish Losses**

Two person crews conducted population estimates in HHR tributaries to determine WCT density and abundance. Crews used the two-pass procedure of Zippen (1956) in established 150 m monitoring sections. Flows were less than 10-15 cfs when sampling was conducted. A braided nylon net with 6 mm mesh blocked the lower boundary of the section, while the upper boundary was delineated by a stream morphology break such as a chute or riffle. To collect fish, we electrofished downstream with a backpack mounted Coffelt BP1c Variable Voltage Pulsator (VVP) powered by a Tanaka AC110 generator. On Emery and Felix creeks, we used a bank shocking unit with a hand-held anode connected to a Coffelt VVP with 75 m of electrical cord.

The loss of juvenile trout that could recruit to the reservoir from blocked streams was calculated based on WCT population estimates in tributaries currently not impacted by passage barriers. Four east-side HHR tributaries (second and third order streams with 2-5.7% gradients) were used as references to estimate the number of age 1+ and older WCT per 100 m of stream. Population estimates from Emery, Tiger, Lost Mare and Hungry Horse creeks (reference streams) were compiled annually from 1986 to 1990. By averaging the estimates, we calculated a mean abundance of 89 WCT per 100 m of stream. These four tributaries were assumed to be at carrying capacity for 1+ and older WCT. May and Huston (1975) found that roughly one third of juvenile adfluvial WCT out-migrated from Young Creek to Lake Koocanusa annually. Stream population estimates were, therefore, divided by three to determine annual losses to HHR.

Production estimates from the reference HHR tributary streams were extrapolated to lost or blocked habitat, as stratified by stream size and gradient. Estimated annual WCT juvenile losses in blocked streams totaled more than 5,200 (Table 3). Extended over a 50 year culvert life, this translates to a loss of over 260,000 wild juvenile WCT. Table 3 estimates do not reflect stream size and preferred gradient.

Table 3 represents estimates for lost WCT and does not address losses of mountain whitefish or DV spawning and production. Selected HHR tributaries have estimated mountain whitefish runs of 2,000 to 9,000 adult spawners. At roughly 5,000 eggs per female, this can account for millions of mountain whitefish fry produced annually. These losses must also be considered when evaluating effects of culvert barriers, particularly in larger streams such as Felix Creek.

Table 3. Estimated annual juvenile WCT production in tributaries to HHR that are impacted by road culvert barriers.

| Stream Name | Stream Order | Length Above Barrier (km) | Average Gradient | Estimated Annual Loss of WCT Migrants |
|---|---|---|---|---|
| Felix | 3 | 3.8 | 2.5 | 1,127 |
| Murray | 2 | 1.1 | 6.8 | 326 |
| Harris | 2 | 1.8 | 8.2[a] | 534 |
| N. Logan | 2 | 2.8[b] | 4.8 | 831 |
| McInernie | 2 | 2.2[b] | 5.0 | 653 |
| Margaret | 2 | 2.7[b] | 4.1 | 801 |
| Riverside | 3 | 3.2 | 9.8[a] | 949 |
| Total | | | | 5,221 |

[a] Gradient greater than preferred by adfluvial WCT.
[b] Barrier during spring flows.

**Improving Fish Passage**

When completed, seven projects on Felix, Harris, Murray, McInernie, Riverside, N. Logan and Margaret creeks would completely open 18.5 km of habitat to migrating fish (Figure 10). Most of the fish passage barriers on Road 38 require complete replacement of culverts. Felix Creek, a third order stream and the largest with a culvert barrier, presents the greatest potential for trout production. Felix Creek contains abundant spawning gravels and preferred gradient upstream of the Road 38 crossing. Murray Creek was another high priority project due to recent barrier development. Until the late 1980s, fish were able to pass the Road 38 culvert. However, recent erosion created a complete barrier, eliminating fish passage at the culvert. Immediate action was needed to maintain the adfluvial run in Murray Creek. Margaret, Harris, and Riverside creeks also contain excellent spawning habitat upstream of culvert barriers. Fish passage in McInernie and North Logan creeks was likely limited only at high flows. Therefore, baffles were installed in culverts to provide velocity shelters, which should allow improved access to upstream reaches.

Elimination of culvert barriers will significantly improve WCT recruitment to HHR. Expanding the amount of accessible tributary spawning and rearing habitat will increase recruitment of juvenile trout and, provided that survival remains high, should increase adult trout numbers. Culvert improvements are cooperative, cost-share projects among the Hungry Horse Reservoir Deep Drawdown Fisheries Mitigation Program, the Hungry Horse Dam Fisheries

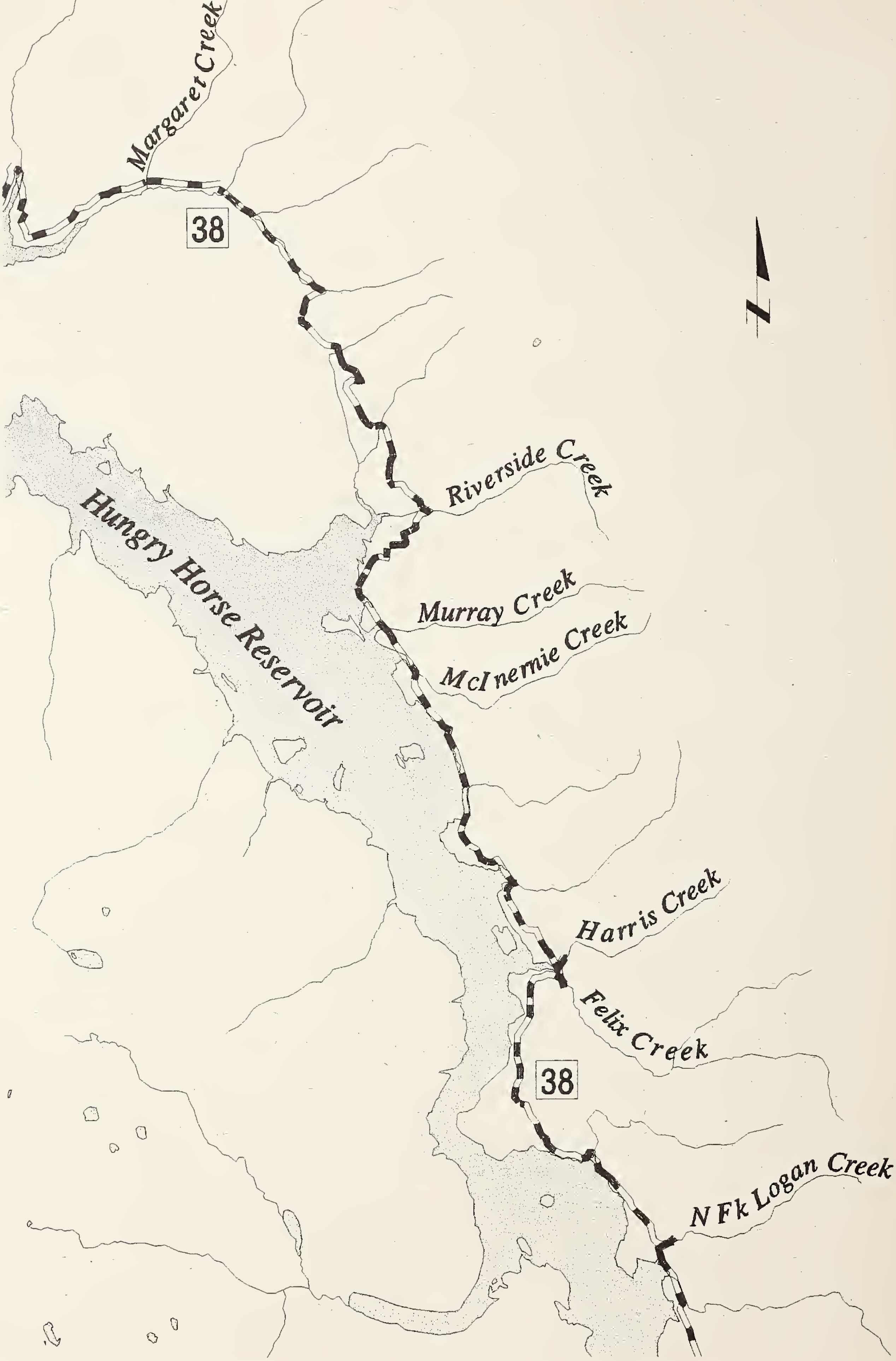


Figure 10. Locations of culvert improvement projects on HHR tributaries (labeled streams).

Mitigation Program, USFS, BOR, the Flathead Basin Commission, and The National Fish and Wildlife Foundation's 'Bring Back the Natives' Program. A tentative timetable, project measures, and USFS cost estimates for individual projects are listed in Table 4.

Table 4. USFS actual and projected costs for culvert improvements on Road 38.

| Creek | Action | Year of Completion | Actual or Projected Costs |
|---|---|---|---|
| Felix | Culvert Replacement | 1997 | $270,000 |
| Harris | Culvert Replacement | 1997 | $60,000 |
| Riverside | Culvert Replacement | Completed 1996 | $89,800 |
| Murray | Culvert Replacement | Completed 1995 | $56,700 |
| Margaret | Culvert Replacement | Completed 1995 | $50,500 |
| McInernie | Baffle Installation | Completed 1994 | $10,000 |
| N. Logan | Baffle Installation | Completed 1994 | $10,000 |
| Total | | | $547,000 |

**Monitoring**

Results of culvert improvements will be assessed using several monitoring techniques. Long-term sampling in the HHR drainage includes WCT redd counts and juvenile (electrofishing) population estimates in reservoir tributaries and an annual gill-net series on HHR (Weaver et al., In preparation). WCT redd counts are conducted by walking downstream in established monitoring sections that include high quality spawning habitat. Surveys are conducted after peak spring runoff within one month after WCT spawning ended. We record characteristics of redds such as size, presence or absence of cover, noted red locations using pace counts, and verify counting techniques and results among different personnel.

Elimination of fish passage barriers should lead to increases in redd and juvenile trout densities in stream sections upstream of Road 38. Redd counts in 1996 indicated that completed projects improved fish passage (Table 5). We also observed high numbers of age-0 WCT in streams where redd counts were high. If increases in juvenile production result, we should detect them in annual population monitoring (electrofishing) estimates.

Table 5. WCT redd counts in 1996 on HHR tributaries where culvert improvements are planned or completed.

| Creek | Action | Completed by Spring 1996? | Number of Redds Downstream of Culvert | Number of Redds Upstream of Culvert |
|---|---|---|---|---|
| Felix | Culvert Replacement | No | 0 | 0 |
| Harris | Culvert Replacement | No | 1 | 0 |
| Riverside | Culvert Replacement | No | 0 | 0 |
| Murray | Culvert Replacement | Yes | 2 | 5 |
| Margaret | Culvert Replacement | Yes | 0 | 30 |
| McInernie | Baffle Installation | Yes | 2 | 18 |
| N. Logan | Baffle Installation | Yes | 3 | 10 |

In 1996, we also attempted to capture adult WCT at the mouth of Felix and Harris creeks (downstream of culvert barriers) to monitor upstream migration and evaluate the success of WCT imprint plants (marked with coded wire tags) in these streams. Only 4 adult WCT were captured, which corroborates results of redd surveys (Table 6). None of these fish contained coded wire tags.

## SEDIMENT SOURCE SURVEYS ON HUNGRY HORSE RESERVOIR TRIBUTARIES

### Background

The South Fork Flathead River drainage, upstream of Hungry Horse Dam, is one of the most intact native fish assemblages in western Montana and the lower 48 states. It remains one of the last strongholds for DV. Most DV in this drainage are believed to occupy HHR or the South Fork as adults. These fish migrate into tributary drainages to spawn. Juvenile DV rear in tributaries from one to four years before moving downstream to the reservoir or river.

Land ownership in the South Fork drainage (4307 $km^2$) is almost entirely Flathead National Forest. Reservoir tributaries and the lower third of the South Fork watershed are managed timberlands, while the upper two-thirds of the South Fork drainage lies within the Bob Marshall Wilderness Area.

Existing threats to this DV population are primarily tied to impacts from forestry practices in the nonwilderness portion of the watershed (Montana Bull Trout Scientific Group 1995b) and HHD operations (excessive reservoir drawdown). One major concern is fine sediment sources resulting from road construction in tributary drainages. Sediment accumulation in streams has been shown to decrease DV egg survival and fry emergence (Weaver and Fraley 1991). In this project, we surveyed roads built near several key DV spawning and rearing tributaries (core areas) to identify sediment sources. Results of the survey and a final report were presented to the USFS to facilitate repair of problem areas.

### Methods

Prior to the project, MFWP field personnel received two days of training to ensure consistency and correct identification of sediment problems. Twenty-one man-days were required to survey approximately 84 km of closed roads in the Wounded Buck, Wheeler, Sullivan, Quintonkin, Bunker, and Spotted Bear creek drainages between June 28 and July 6, 1995. Surveyors walked the entire road length and documented all potential sediment sources adjacent to stream courses caused by road culverts, ditches, and associated road construction. Field notes, maps, and photographs of all sites were compiled for analysis.

### Results and Future Surveys

Sediment sources in each of the drainages surveyed are presented in Table 6. This baseline information was used in prioritization of USFS road reclamation projects. Initial on-the-ground work will began in the Wheeler Creek drainage in 1997.

We plan to continue road surveys in DV and WCT core areas in the future. Assessments will be expanded to include instream and point sediment source surveys. Prompt identification of problems in core areas is critical because access to project sites becomes limited after road reclamation in completed.

Table 6. Summary of sediment source problems identified in South Fork road surveys.

| DRAINAGE | USFS ROAD | PROBLEMS IDENTIFIED |
|---|---|---|
| Wheeler Cr. | 1666A | C |
| | 1666 | A,C |
| | 1611 | A,B,C |
| Wounded Buck Cr. | 895C | B,C |
| Sullivan Cr. | 2801 | A,B,C,D,E |
| | 2804 | C |
| | unnamed | E |
| | 975 | A,C |
| | 2802 | A,B,C,E |
| | 2816 | A,B,C,D |
| Quintonkin Cr. | 381 | B,C |
| | 381A | B,C |
| | 5345 | C |
| | 1612 | A,B,C,E |
| | 2806 | A,B |
| Bunker Cr. | 549 | A |
| Spotted Bear R. | 564 | A,B |
| | 10102 | A |
| | 11401 | A |

A = Crushed, misaligned, plugged, or blown out culvert
B = Road or bank slump
C = Water running down road grade
D = Misplaced ditch
E = Road grade washed out

## SLASH PILE INSTALLATION IN HUNGRY HORSE RESERVOIR: A PILOT STUDY TO MEASURE ENHANCEMENT OF BENTHIC INSECT PRODUCTION

### Introduction and Background

Water temperature, nutrient levels, and duration of optimum conditions are key determinants of productivity in HHR. Rapid refilling during spring runoff weakens the reservoir thermal structure and delays accumulation of temperature units. Fluctuating water levels and accompanying wave action also impede establishment of rooted aquatic plants, dislodge tree stumps, and disrupt substrata. Reservoir drafting dewaters large expanses of substrate, which limits suitable littoral habitat and decreases benthic insect production (Fillion 1967; Benson and Hudson 1975; Davies 1976; Kaster and Jacobi 1978). Effects of drawdown may be intensified in early spring, when reservoir pool elevations are lowest. Decreased benthic production is particularly evident when dewatering is associated with freezing air temperatures (Paterson and Fernando 1969; Danell 1981). Cumulatively, these effects limit food production and the availability of preferred water temperatures and may restrict fish growth rates.

During their first year of residence in HHR under the present dam operation strategy, WCT attain approximately 55% of their annual growth (length) and 68% of their biomass from August through November. Growth from September through November accounts for 48% of the annual growth in weight (May et al. 1988). Aquatic insects make up a large proportion (12 to 25 %) of the food supply for WCT in HHR (May et al. 1988). Aquatic insects dominated the diet in May, were second to terrestrial insects June through October, and remained an important diet component through December (May et al. 1988). Aquatic dipterans constitute nearly all of the aquatic insects found in WCT diet.

Benthic insect production is generally associated with submerged vegetation and woody debris (Grimas 1961; Cowell and Hudson 1968; Paterson and Fernando 1969; Oliver 1971; Pinder 1986). Depletion of woody debris over time due to decomposition is likely to reduce insect abundance. Because of the importance of aquatic insects as WCT food, higher benthic production could result in increased fish production.

The goal of this study was to determine if installing stable woody substrate would increase aquatic insect production in HHR. The test compared insect emergence on anchored pine tree bundles (slash piles) to emergence from untreated substrate. If slash piles significantly improve insect numbers, addition of woody debris structures could be used for increasing benthic carrying capacity in the reservoir. Increased insect production in inundated areas could be used to offset the negative impacts of substrate dewatering, suboptimal thermal structure, and limited vegetation in the reservoir drawdown zone.

## Methods

The study was conducted in Murray Bay (T29N, R17W, S18) on the east shore of HHR in 1991 and 1992. Nine slash bundles were constructed by anchoring pine tree tops in a cement base. A 3.7-m tall metal framework of 102-mm diameter pipe (Figure 11) was also anchored by the cement. This framework consisted of a 3.7-m vertical pipe with an 'L'-shaped arm attached 0.9 m below the top. This framework guided rope and held the insect emergence trap. We placed structures at 3 m depth intervals ranging from 9.1 to 33.5 m below full pool level. An emergence trap spanned the top of each structure. Emergence traps were also placed over untreated reservoir substrata near each slash pile at the same depth interval.

Emergence traps were 0.7 m in diameter, conical in shape, and made of 560 micron nitex cloth. A removable collection jar with nitex mesh panels was attached to the cod (small) end. A float on the cod end inverted the cone so the large diameter opening was close to the slash material. Insects emerging from slash or substrate entered the wide end of the net and swam up into the collection jar at the top of the trap. Crew members emptied traps every two weeks, from June through November. We preserved samples in labeled vials with 95% ethanol. In the lab, all macroinvertebrates were identified to order, weighed (wet weight), and enumerated. A subsample of dipterans (chironomids) was sent to a contractor for species identification (Appendix B). We used a paired, two-sample t-test to determine if there was a significant difference between aquatic dipteran emergence from slash piles and untreated substrate.

## Results

In 1991 and 1992, there were 25 and 46 successful sampling periods for paired traps, respectively. There was a significant difference between the number of Chironomid pupa captured over slash piles and untreated substrate for both years. In 1991, traps over slash piles collected many more pupa per sampling period (13.1) than traps over untreated substrata (5.1, p=0.01). Results were similar in 1992; pupa emergence from slash piles (11.5 pupa per trap) was higher than from untreated areas (6.2, p=0.01). In 1992, slash piles also produced significantly more Chironomid adults and total aquatics per sampling period than untreated substrate (Table 7). Chironomid subfamilies observed in HHR included Tanypodinae, Diamensinae, Chironominae, and Orthocladiinae.

In 1991, several factors contributed to trap error and resulted in loss of samples. Factors included low reservoir pool elevations which dewatered trap sites, mechanical trap failure, and small (insectivorous) sculpins entering traps. In 1992, we improved trap success by modifying sampling techniques, trap mechanics, and screening collection jars, which barred sculpin entrance. Only those trap pairs that we felt were effective and unbiased were included in analyses.

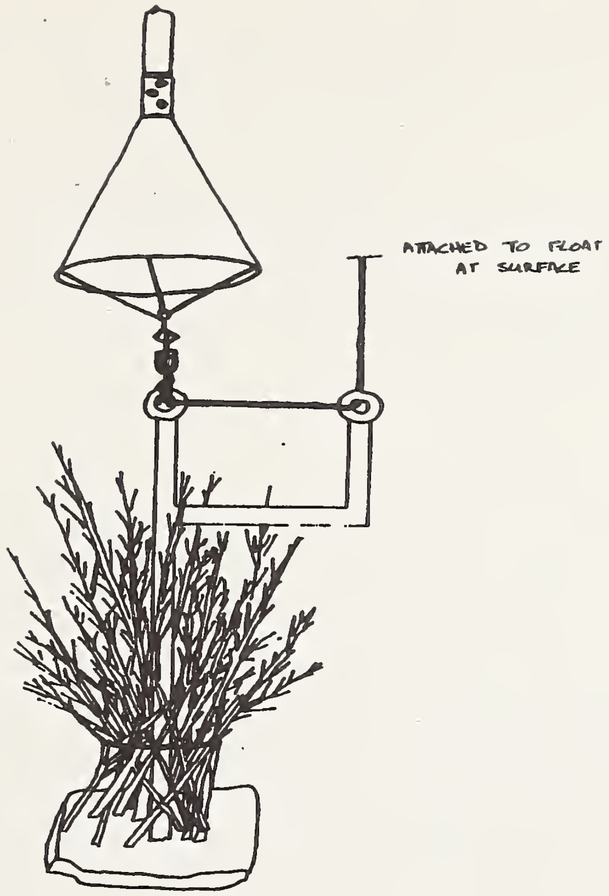


Figure 11. Diagram of slash pile and collection apparatus used to measure benthic insect production.

**Discussion**

Slash piles apparently offered a stable substrate with adequate nutrient value and large surface areas, which improved dipteran production. Other investigators have described similar results when comparing areas with and without woody material. Paterson and Fernando (1969) found that areas with woody debris or grass supported greater standing crops of benthic organisms than areas cleared of organic material or those with clay substrates. Cowell and Hudson (1968) reported that mean densities of chironomids were up to up to 11 times greater on submerged trees than on open reservoir bottom.

Greater insect production can directly benefit fish populations, particularly WCT, in HHR by providing a greater food base and additional cover. Divers observed juvenile mountain whitefish and northern squawfish using slash piles for cover and forage. It is possible our mean two-week sample numbers for slash pile dipteran emergence are lower than actual production due to fish predation.

Table 7. Aquatic Dipteran production and t-test p-value for paired slash piles and untreated substrate (n=71) in HHR in 1992.

| | Mean Number Trapped Over Slash Piles | Mean Number Trapped Over Untreated Substrate | Paired 2-Sample T-Test P-Value |
|---|---|---|---|
| Dipteran Pupae | 11.5 | 6.2 | 0.015 |
| Dipteran Adults | 8.6 | 2.6 | 0.011 |
| Total | 20.1 | 8.8 | <0.01 |

Due to failure of the reservoir to refill, fluctuating surface levels, and limited sample size, we were unable to determine which depth interval produced the greatest number of aquatic insects. However, we did demonstrate that insect production can be enhanced with slash piles. Adding additional woody material to HHR could be used to increase benthic production, but the efficiency and cost-effectiveness of this alternative need to be evaluated.

## RESERVOIR REVEGETATION AND RIPARIAN ENHANCEMENT

### Overview

Riparian vegetation adjacent to streams, lakes, and reservoirs plays a critical role in the protection and enhancement of water resources. These "buffer zones" not only help provide food and habitat for fish and wildlife, but are useful for mitigating effects of non-point pollution such as sedimentation. Therefore, revegetation is a regular component of habitat mitigation projects and has led to investigations that will help improve our success in reestablishing native plant species in denuded areas.

Revegetation tests were developed to identify native plants that would survive and become established in the HHR drawdown zone. Primary objectives and anticipated benefits of this project are 1) improved water quality through decreased soil erosion and bank slumping, 2) increased insect production and fish habitat, 3) improved aesthetics by reducing the amount of exposed soil along shorelines, 4) establishment of healthy native plant species to displace or delay the spread of invading noxious plants, and 5) enhanced habitat for waterfowl nesting, brooding, and feeding, and improved ungulate forage on traditional winter range.

**Willow Survival Experiments**

During 1991 and 1992, MFWP established test plots of four native willow species in the drawdown zone of HHR to determine which species could be established in a fluctuating reservoir environment. Field personnel collected willows from a site with similar elevation relative to the test plots and an abundant supply for future cuttings. Montana Fish, Wildlife, and Parks personnel and volunteers from the Flathead Anglers Association planted the willows in pre-surveyed plots. Willow species were drummonds (*Salix drummondiana*), bebbs (*S. bebbiana*), sandbar (*S. exigua*) and geyers (*S. geyers*).

The experiment began during spring 1991 in Emery Bay on the east shore of HHR. Test plots for each willow species consisted a row of 15 unrooted cuttings at each substrate elevation from 3,560 feet msl (full pool) to 3,500 feet msl at four foot elevational increments and a total of 225 plants per plot. Elevations were first measured using a surveyors transit and standard fore- and back-sighting methodology. Test plot elevations were marked with paint prior to planting. This assured that each horizontal row of willows would be simultaneously inundated and dewatered as the reservoir surface rose and fell. Willow cuttings ranged from 7 to 15 mm in diameter and were planted to a depth of 20 cm to assure that wave action, which can re-sort the reservoir substrate to a depth of 10 cm, would not dislodge the plants.

After the test plots were established, inundation took place during June through August. Depending on elevation, willows were inundated varying amounts of time. The sprigs were inundated for 211 d at 3,500 ft elevation (60 ft drawdown), 106 d at 3,536 ft (24 ft drawdown), and 42 d at 3,560 ft (full pool).

Survival was observed from full pool to elevation 3,528 or 32 feet below full pool (Figure 12). We evaluated the project in the fall of 1991 and again in the spring and fall of 1992. Plants inundated longer than 98 days and planted at a depth greater than 20 feet in the drawdown zone showed poor survival. Of the plants that survived inundation, drummonds willow showed 12.8 % survival, geyers willow showed 10.2 % survival, and sandbar willow showed 2 % survival. Mortality rates were nearly 100% for the fourth species, bebbs willow.

Poor reservoir refill conditions during 1992-1994 enabled willows to become firmly established. Results from other studies suggest that once established, willows become more tolerant of intermittent flooding (Rhoades 1991). Monitoring of willow survival will continue after the reservoir successfully fills, thus inundating established test plots at or near full pool.

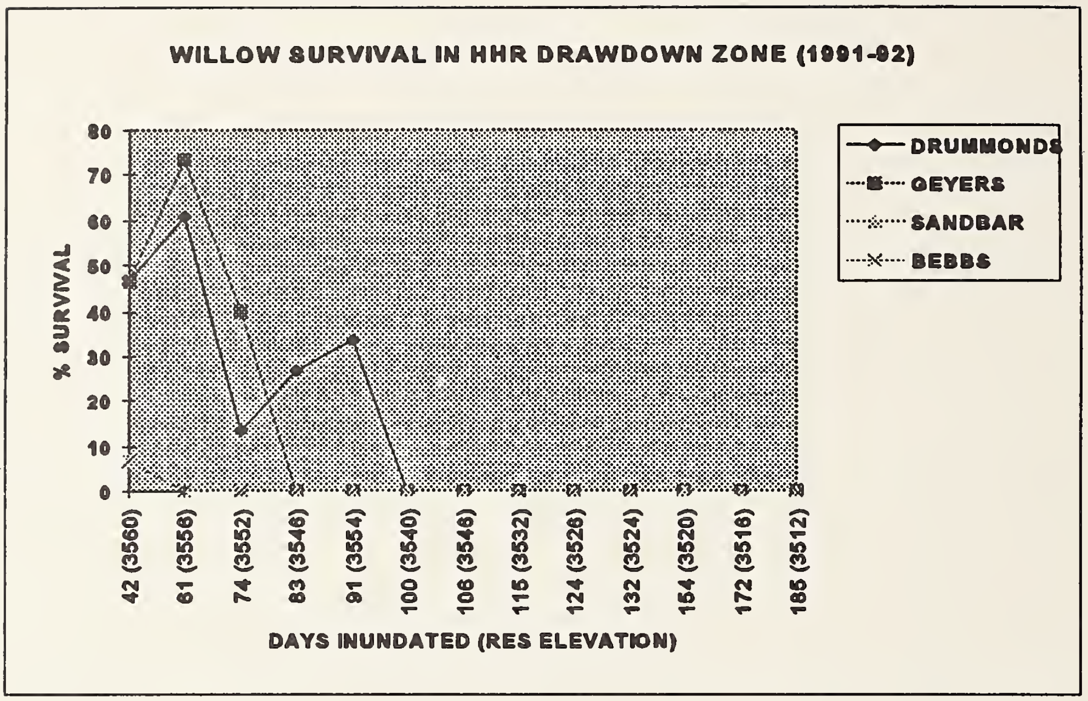


Figure 12. Survival rates for four species of willow in the HHR drawdown zone, 1991-1992.

Additional experimental plots using rooted stock were established in 1992 to assess the relative survival of unrooted cuttings and rooted stock. We measured survival for these plants from 1995 to 1996 (Figure 13). Preliminary monitoring results indicated greater survival rates in rooted stock. However, cost comparisons indicated that unrooted cuttings may be more economically feasible, even at the lower survival rate.

**Seeding Plots**

In 1994, MFWP, BOR, and USFS (Spotted Bear Ranger District) personnel cooperatively established grass seed plots to revegetate mud flats near the upper end of HHR. Preliminary monitoring was conducted to analyze soil profiles and existing vegetation. This procedure narrowed selection of the seed mix, which consisted of red top (*Agrostis alba*), Garrison creeping foxtail (*Alopecurus arundinaceus*), reed canary (*Phalatis arundinacea*), sheep fescue (*Festuca ovina*), and slender wheatgrass (*Agropyron trachycaulum*).

Seeding took place in May and September at a rate of 20 kg/ha using an electric all terrain vehicle seeder. A total of 402 kg of seed was broadcast over approximately 20 ha. In spring plants, 346 kg of seed was spread on the east shore of HHR at the base of Crossover and Dry Park Mountains. Fall planting (57 kg of seed) occurred in the upper reaches of HHR on the west shore. Grass establishment and growth will be monitored to determine long-term success.

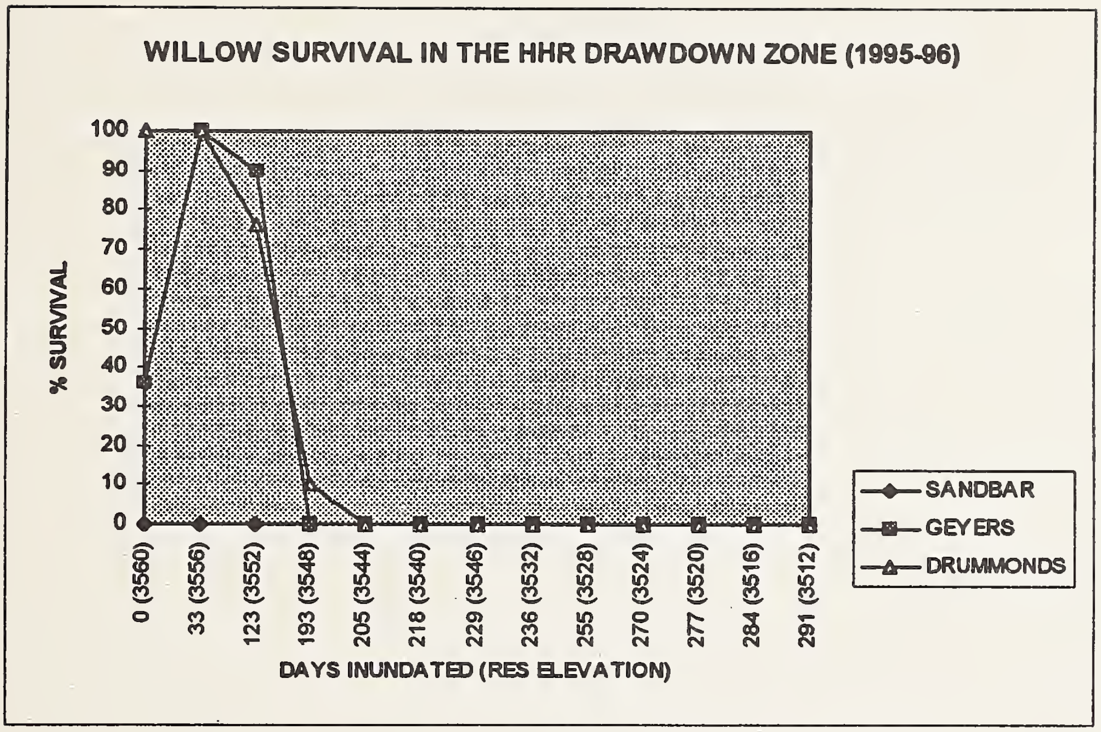


Figure 13. Survival rates for three species of willows in the HHR drawdown zone, 1995-1996.

**Future Projects**

Recent summer drafting of HHR to meet flow targets in the lower Columbia River called for by the National Marine Fisheries Service (NMFS) have been shown to reduce biological productivity in the reservoir. Impacts may be partially mitigated through reservoir revegetation. Based on previous results, we recommend that summer drafts be limited to 3 m rather than the 6 m recommended by NMFS. The top 3 m of HHR should then be revegetated to compensate Montana for impacts caused by salmon recovery actions.

We recommend additional tests to establish vegetation below the 3 m drawdown zone using other biotechnical approaches such as brush matting, wattling, and using other native woody species, grasses and sedges. We plan to evaluate these techniques in various substrates and at different bank slopes to determine the most effective means of reestablishing vegetation.

## Offsite Mitigation

A major objective of the mitigation program is to create or enhance fisheries in lakes and streams not directly connected to the Flathead River system (offsite areas) through chemical rehabilitation and hatchery planting, habitat improvements, or fish passage improvements. These projects provide immediate fisheries that are popular with anglers and may reduce fishing pressure on populations targeted under the mitigation program (onsite areas).

### Lake Rehabilitation

More than 50 lakes in the Flathead basin have been impacted by illegal fish introductions. In some cases, introduced species such as yellow perch and pumpkinseed (*Lepomis gibbosus*) have become established and have eliminated once productive salmonid fisheries. Since 1992, we have used approved toxicants to eliminate undesirable fish populations in several lakes (Figure 14) and established more desirable species such as WCT, RBT, and Arctic grayling.

#### *Lion Lake*

In the 1960s and 1970s, Lion Lake near HHR provided a popular RBT and WCT fishery. By 1992, the lake contained only small northern pike (*Esox lucius*), yellow perch, pumkinseed, largemouth bass (*Micropterus salmoides*)and BT which are species that were established by illegal introductions. The goal of the project was to eliminate the existing fish assemblage and replace it with WCT and RBT populations. In fall 1992, we applied 925 L of rotenone to treat the 14 ha lake. The lake was restocked with WCT fingerlings in spring 1993 and has been stocked with juvenile and adult WCT and RBT each year since.

The Lion Lake fishery has been an extremely popular since trout were re-established. Fishing pressure increased from 48 angler-days (MFWP 1991) to 3,304 angler-days (MFWP 1995) after rehabilitation. In the 1995 Montana Statewide Angling Pressure survey (MFWP 1995), Lion Lake ranked first among 509 lakes in northwest Montana (MFWP Region 1) in angler pressure per acre and was twelfth in total angling pressure. In 1995-96, Canyon Sportsman Group conducted an informal creel survey on Lion Lake and reported that catch rates averaged 0.84 trout/h.

No illegally introduced fish species were detected in annual population monitoring or creel reports for Lion Lake through 1995. However, yellow perch were discovered in Lion Lake in 1996, indicating that re-introduction has occurred since rotenone treatment. The long-term effects of yellow perch re-introduction are contingent on how abundant the population becomes. Prior to rehabilitation, pumpkinseed dominated the fishery and the lake's potential for supporting a large yellow perch population is unknown.

### *Rogers Lake*

In November 1993, MFWP, in cooperation with the USFS and National Fish and Wildlife Foundation, treated 97 ha Rogers Lake with rotenone to eliminate populations of yellow perch, BT, and redside shiners (*Richardsonius balteatus*). The lake supported a self-sustaining Arctic grayling fishery until illegal yellow perch introductions in the mid-1980s decimated the population.

In spring 1994, Arctic grayling fry and WCT were re-introduced. The lake now serves as a genetically pure reserve for the Red Rocks Lake strain of Arctic grayling and supports an extremely popular fishery. Fish growth rates have been high since restocking; Arctic grayling reached 350 mm TL in just two years. No illegally introduced species have been detected in annual monitoring since 1994.

Rotenone treatment in 1993 was accompanied by a cooperative project to enhance spawning habitat in the Rogers Lake inlet, the only tributary to the lake. The project was completed by MFWP and a local Eagle Scout troop. A 25-m section of spawning channel was improved by stabilizing banks and removing fine sediments and debris. Four $m^3$ of cobble was also placed in the channel to provide additional spawning substrate for Arctic grayling. In 1996, more than 1,000 Arctic grayling were observed spawning in the channel. Angler use of Roger's Lake increased after rehabilitation from 272 angler-days (MFWP 1991) to 1,033 angler-days (MFWP 1995) and is still increasing.

### *Bootjack Lake*

Bootjack Lake (27 ha) near Whitefish, MT was treated with rotenone in October, 1996, to eliminate a large, stunted population of pumkinseed. This trophy trout fishery had also been extremely productive and popular prior to illegal fish introductions in the 1980s. Fishing pressure had continued to decline prior to rehabilitation. Annual angling pressure estimates were 615 angler-days in 1993 (MFWP 1993) and 130 angler-days in 1995 (MFWP 1995). Less than 100 WCT and RBT (380-530 mm) were recovered along with thousands of pumkinseed (15-150 mm) and redside shiners (50-100 mm) after treatment. Annual stocking of WCT and RBT will begin in 1997.

A 30-m spawning channel had been previously constructed (1993) in Bootjack Creek, a tributary to the lake, to enhance spawning habitat. The project was sponsored by the local Trout Unlimited Chapter, the Sportsman and Ski Haus sporting goods store in Kalispell, MT, and MFWP. At least three pairs of trout spawned in the channel in 1996.

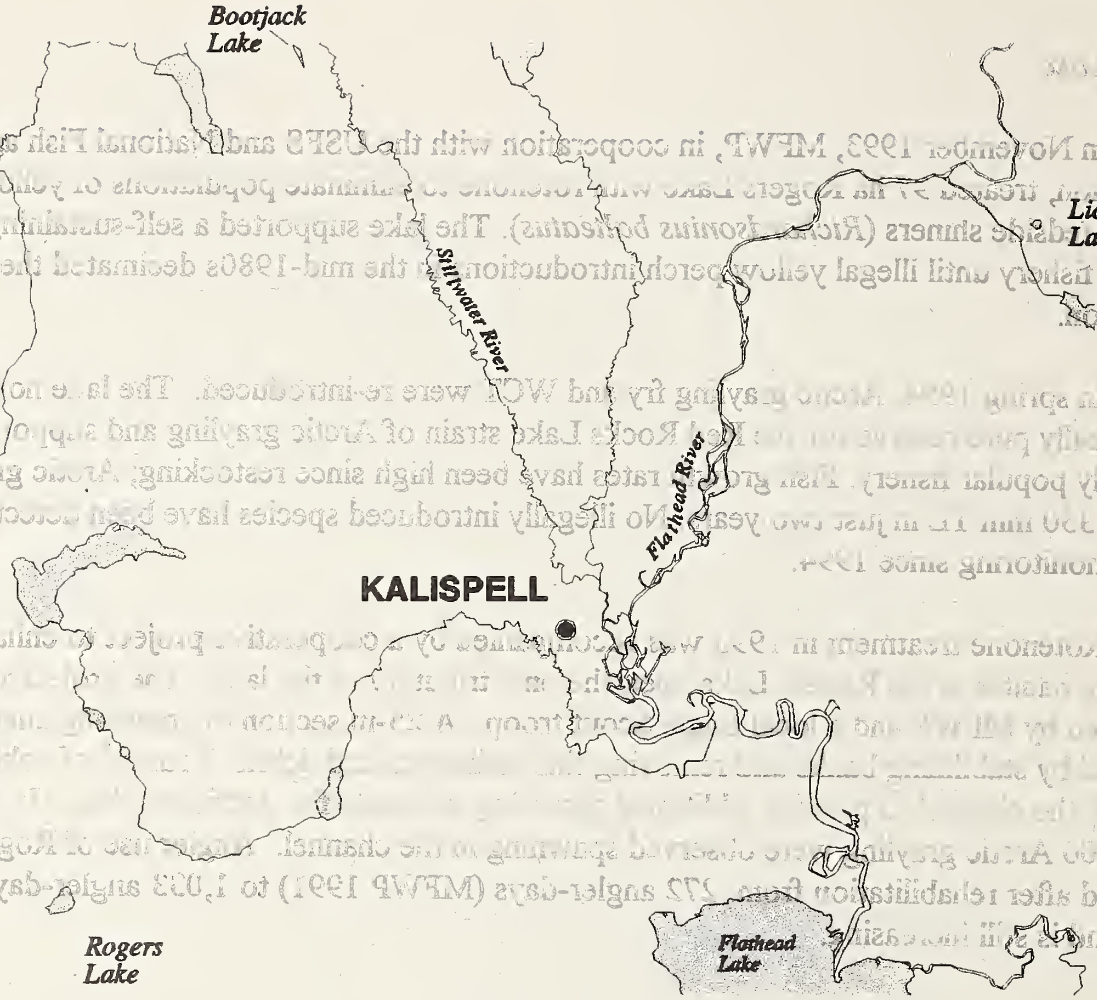


Figure 14. Location of offsite lakes that have been rehabilitated using rotenone.

**Coolwater Fisheries Enhancement**

Many lakes in the Flathead basin are managed for warmwater and coolwater species such as largemouth bass, yellow perch, and northern pike. In 1993, we cooperated in two habitat enhancement projects at Halfmoon Lake (25 ha) near West Glacier and Echo Lake (294 ha) near Bigfork, Montana. Both support largemouth bass and yellow perch, but have minimal shoreline and submerged cover. Projects were sponsored by several local sportsmen groups and the Hungry Horse Fisheries Mitigation Program at MFWP. Burlington Northern donated 500 railroad tie plates for use on these and other projects.

Fourteen and 20 tree and stump bundles were placed in Halfmoon Lake and Echo Lake, respectively, in spring 1993 to provide cover for juvenile and adult largemouth bass and yellow perch. The structures were made by binding tree tops, logs, and stumps together and attaching the metal tie plates. Bundles of various sizes and dimensions were constructed and placed at a range of depths from 2-8 m.

## PROJECTS UNDER CONSIDERATION

The Implementation Plan lists potential sites targeted for habitat and passage improvement projects (Table 8). Completed or ongoing projects from this list were described in the previous section. Other projects were not pursued for various reasons; e.g., anticipated benefits were minimal, project was not feasible, and target population is no longer viable. Dayton Creek and Stoner Creek projects have been initiated and will likely also be components of Kerr Dam Mitigation habitat improvement work.

Since development of the Implementation Plan, other sites have been identified and are being considered for mitigation projects. Evaluation and planning for these projects is underway.

### *East Swift Creek Passage*

East Swift Creek is the only tributary to Upper Whitefish Lake. During low flow periods, particularly in late summer and fall, the stream becomes dewatered. Reconstruction of the stream channel would improve spawning and rearing habitat for DV and WCT and reduce juvenile stranding and mortality. We will examine the feasibility of placing an impermeable (clay) barrier to subsurface flow to raise the water table. Surface flow would allow fish passage through typically dewatered stream habitat and upstream into historically used spawning habitat. Even partial success would increase the number of years during which passage would be possible.

To evaluate the effectiveness of the clay barrier, we plan to test this technique on a smaller stream where fish passage is impeded by subsurface flow. Possible test sites include Geiffer Creek, Cyclone Creek, and West Swift Creek in the Flathead River drainage. Additional test sites, such as Lion Creek, Dry Gulch and Green Gulch in the Clark Fork River drainage, are also being considered. In 1997, we will select a test site and evaluate the technique with assistance from the BOR Technical Assistance Program. If successful, this technique has wide application for streams that are periodically dewatered.

### *Fish Passage in Paola Creek and Tunnel Creek*

Paola and Tunnel Creeks are tributaries of the Middle Fork that contain DV and WCT spawning and rearing habitat. Road culverts act as barriers to fish passage on these streams. The culvert at USFS Road 1638 blocks upstream migration on Paola Creek. No fish were found in Paola Creek in 1996 surveys. On Tunnel Creek, the Highway 2 culvert is a barrier to upstream

Table 8. Status of fish passage and habitat improvement projects identified in the Implementation Plan.

| Project Name | Project Type | Site Description | Objective | Status |
|---|---|---|---|---|
| Hay Creek | Habitat and fish passage improvement | Trib. to North Fork | DV reproduction and migration | Phases *I & II complete, III* ongoing |
| Coal Creek | Habitat improvement | Trib. to North Fork | DV reproduction | Not pursued to date |
| Big Creek | Habitat improvement | Trib. to North Fork | DV reproduction | Began in 1994 by USFS & MFWP |
| Stoner Creek | Habitat and fish passage improvement | Trib. to Flathead Lake | WCT reproduction and migration | Kerr Mitigation Coop[a] |
| Dayton/Ronan Creeks | Habitat improvement | Trib. to Flathead Lake | WCT reproduction | Planning stage, Kerr Mitigation Coop[a] |
| Taylor's Outflow | Habitat improvement | Trib. to Flathead River | WCT reproduction | Habitat restoration 1994-97, fish ladder completed in '96 |
| Elliott Creek | Habitat improvement | Trib. to Flathead River | DV and WCT reproduction | Completed in 1993, monitoring |
| Mill Creek | Habitat improvement | Trib. to Flathead River | WCT and kokanee spawning | Completed prior to HH Mitigation |
| Brenneman and Siderius sloughs | Habitat improvement | Sloughs on the Flathead River | create kokanee and WCT spawning stream, improve emigration | Not Pursued: too expensive relative to certainty of benefits |
| Hungry Horse Spawning | Habitat improvement | Three tributaries to Hungry Horse Reservoir | WCT reproduction | Future project |
| Hungry Horse Passage | Fish passage improvement | Seven tributaries to Hungry Horse Reservoir | WCT migration | Baffles or new culverts on 5, last 2 completed in '97 |

[a] Anticipated cooperative projects targeted under Kerr Dam Mitigation

passage. This stream historically supported runs of migratory WCT and other species. Resident WCT were the only species present in the most recent inventory. Fish population estimates and genetic analyses for these streams will be continued in 1997. If appropriate, we will assess the feasibility of baffle installation or culvert replacement to allow passage.

*Repair of Sediment Sources in Tributaries*

Several bank slumps and point sources of sediment have been identified at Hungry Horse Creek, Emery Creek, and Wheeler Creek (tributaries of HHR) and at Skookoleel and Nicola

Creeks in the Big Creek drainage. These streams provide important DV and WCT spawning and rearing habitat in the North Fork and South Fork drainages. A recently completed project on Big Creek helped to control erosion of a slumped road grade. Elimination of sediment inputs in these and other tributaries is designed to curb cumulative, adverse impacts on downstream spawning and rearing habitat. Proposed actions include stabilization of stream banks and control of sedimentation through bank sloping and revegetation. Sediment-source surveys that were conducted on USFS roads in the South Fork may be expanded to help identify additional sites.

*Survey of Sullivan Creek Drainage*

Road surveys conducted in 1995 included all those in the Sullivan Creek watershed. Sullivan Creek supports more spawning and rearing habitat than any HHR tributary (excluding the South Fork) and had the highest number DV spawning redds in 1996. Despite high use by DV, the drainage has been subjected to poor land-use practices and still has sediment and water yield problems.

In 1997, we will work with the USFS to survey the entire stream course. Point sediment sources and availability of large woody material will be assessed. Prompt identification of problems in the upper drainage is critical because many of the roads will be reclaimed by the USFS within the next five years. Once road reclamation is complete, we will not have easy access to project sites in the head of the drainage.

*Hungry Horse Wetlands Project*

In cooperation with the BOR Technical Assistance Program and the USFS, we are proposing to create several shallow basins in the upper end of HHR to increase aquatic invertebrate production and provide wildlife habitat. An increase in insect production would provide additional food for WCT and DV populations and contribute to increased growth rates and survival in HHR. Wetlands would also benefit many wildlife species, such as elk (*Cervus alaphus*), deer (*Odocoileus* spp.), moose (*Alces alces*), and waterfowl, that use wetland areas for some life stage or portion of the year in the South Fork drainage.

Wetland basins will be 0.3-0.5 m deep and located in the drawdown zone of HHR (1-5 m below reservoir full pool). We are considering small tributaries of the reservoir, water diversion, and other alternatives as water sources. Berms enclosing the basins would be revegetated with native grasses and willows to minimize wave erosion prior to natural establishment of vegetation. Macroinvertebrates would be delivered directly to the reservoir through outflow from the wetland areas, terrestrial insect deposition, and inundation of the wetlands as HHR levels rise each spring. In 1997, we will begin a pilot project to evaluate the feasibility of wetland creation.

*Taylor's Spring Creek Habitat Improvement*

Taylor's Spring Creek, a small tributary of the main stem Flathead River near Columbia Falls, MT, is the site of two ongoing habitat projects. We will evaluate the work completed in 1995-96 in upper sections of the stream and continue to downstream sections. Project objectives are to improve riparian vegetation, channel morphology, bank stability, and instream cover to enhance WCT spawning and rearing habitat. In spring 1997, two improperly placed culverts were replaced to eliminate artificial grade controls and major sediment sources.

*Griffin Creek Fencing Project*

Griffin Creek is a small, second order stream in the Stillwater River drainage. Most of this drainage is inhabited by introduced trout species (BT, RBT) which compete or hybridize with WCT. The upper reaches of Griffin Creek are isolated from downstream sections by a natural barrier which prevents fish migration. As a result, the upper reaches remain a refuge and genetic reserve for WCT.

Habitat in these upper reaches has been degraded by poor land-use practices, particularly overgrazing. In 1997, we plan to collaborate with the USFS to modify the grazing lease and fence a 7 km section of the stream to exclude cattle from riparian areas.

*Dayton Creek Habitat Improvement*

Dayton Creek is one of the few Flathead Lake tributaries that flows directly into the lake and supports WCT spawning and rearing habitat. Sections of the drainage have been degraded by overgrazing and excessive water diversion for agriculture. This system also carries extremely high nutrient loads into Flathead Lake (Stanford et al. 1997). The fish species composition of the drainage is not known, but remnant WCT populations are present.

Beginning in 1997, we will work cooperatively with CSKT to assess the feasibility of habitat improvement work in this drainage. The entire drainage will be surveyed to identify degraded reaches and sources of water loss. We will determine fish species composition and the distribution of WCT. Much of the stream lies on private land, so we must gain support from landowners and water-right holders for the project to be possible. Landowner contacts will be completed cooperatively with CSKT and the Flathead Focus Watershed Coordinator.

## Offsite Mitigation

### *Lake Rehabilitation*

Past rehabilitation projects on Lion, Rogers, and Bootjack lakes have been very successful in removing illegally introduced fish species and creating popular fisheries. These lakes were treated with a chemical fish toxicant (rotenone) to remove introduced species, such as yellow perch and pumpkinseed, that had become overpopulated and had eliminated once productive trout and Arctic grayling populations.

Several other lakes are being considered for rehabilitation projects. Skyles Lake, Spencer Lake, Murray Lake, Dollar Lake, Little McGregor Lake, and Hubbart Reservoir all supported excellent trout fisheries until non-endemic, warmwater fish were introduced. The Many Lakes region southeast of Kalispell also contains several small lakes that could support popular fisheries after rehabilitation. We are currently evaluating the feasibility and public support for projects on these water bodies.

MFWP has also developed a list of lakes (>30) in northwest Montana capable of supporting accessible put-and-take trout fisheries. This 'Family Fishing Initiative' to encourage angling participation by families and youth may require rehabilitation of small lakes to eliminate trout competitors.

# FUTURE PROJECTS

Ongoing fish passage and habitat improvement projects and those currently being considered were identified primarily through past sampling and monitoring activities and public scoping. These projects have focussed on major problems, perceived as limiting factors for fish populations. Prioritization was not critical because few sites were considered and some projects were not feasible.

The Implementation Plan includes criteria for prioritizing future habitat and fish passage projects. Since development of this plan, other considerations in selecting projects have been identified. In order to adapt to these realities, we have incorporated pertinent criteria from the Implementation Plan and other considerations into a framework for identifying, selecting, and implementing new projects that will maximize the effectiveness of future mitigation activities.

**Identifying Project Sites**

Future project opportunities will likely arise from several sources. Montana Fish, Wildlife, and Parks encourages inquiries and proposals by interested landowners and personnel from cooperating agencies. Several completed and ongoing projects stemmed from observations and ideas of people outside of MFWP. We will continue to investigate 'leads' as they occur. Fish passage and habitat-related problems have also been documented in past reports and studies. For example, extensive fish and habitat inventories have been completed for streams in the North Fork and Middle Fork (Read et al. 1982; Weaver et al. 1983). Other survey and monitoring information is presented in Weaver and Fraley (1991), the Flathead National Forest Plan (Brannon 1985), Flathead National Forest Plan Amendment 3 (WCT and DV standards; Flathead National Forest 1990), and the Coal Creek Fisheries Monitoring series (Weaver 1988; 1991; 1992; 1993). These reports are valuable references for information on habitat quality and quantity, past anthropogenic disturbances, and fish distribution and abundance when completing watershed assessments.

In drainages where projects are proposed, but fish and habitat information is incomplete (or absent), we will implement more comprehensive survey approaches. Information will be collected to help identify major problems and limiting factors for fish populations (Table 9) as part of our watershed assessment. Compatibility with databases of the affected land management agency will be incorporated in survey designs. For example, the USFS employs an R1/R4 inventory procedure for collecting fish habitat and salmonid fish species data in streams (Overton et al. 1995). Information sharing and cooperative data collection necessitates that we incorporate these standard procedures and inventory variables to maximize efficiency.

Detailed inventories will also be designed in certain target drainages (see priority areas below) where specific habitat problems have been identified. For instance, systematic road surveys to identify point sediment sources were completed in key DV spawning tributaries (1995) to facilitate action by the USFS. Instream surveys in the same drainages are planned to expedite repairs before scheduled road closures are completed. In addition to on-the-ground inventories, technologies such as aerial photography, geographic information systems (GIS), and global positioning systems (GPS) will be useful for pinpointing accurate locations and mapping.

**Project Screening and Prioritization**

Potential projects are evaluated in light of factors such as access, land owner and land manager approval, expediency, cost share opportunity, probability of success, and the screening and prioritization considerations discussed below. These considerations are intended to serve as a framework for prioritizing onsite projects if project opportunities exceed time and resource availability. As resources allow, the fisheries mitigation program will annually implement a variety of projects in onsite and offsite areas.

Table 9. Limiting factors targeted in fish passage and habitat improvement projects.

| ANTHROPOGENIC DISTURBANCES | |
|---|---|
| Problem | Examples/Causes |
| sedimentation | overgrazing riparian area, bank slumps, road slumps, runoff from roads, overland flow |
| low instream flows | irrigation, other diversions, excessive infiltration |
| limited spawning habitat | limited spawning gravels, low flow velocity or lack of upwelling |
| limited rearing habitat | lack of pool (overwinter) habitat, woody debris, overhanging banks or other cover |
| limited fish passage | culvert barriers, dams, stream dewatering |
| high water temperature | lack of riparian (shading) vegetation, surface discharge from lake/reservoir outlet |
| competition and/or introgression | introduced fish species: BT, RBT, yellow perch, pumpkinseed, etc. |
| **NATURAL LIMITATIONS** | |
| Problem | Examples/Causes |
| sedimentation | landslides, bank slumps, debris torrents |
| low instream flows | subsurface flows |
| limited fish passage | beaver dams, log jams, natural geologic barriers, subsurface flows |
| limited spawning habitat | poor recruitment or retention of spawning gravels, gradient too high or low |

*Considerations Identified in the Implementation Plan*

The Implementation Plan lists several criteria to be considered when prioritizing habitat improvement and fish passage projects. These considerations provided direction for projects identified in 1992 (Table 8) and provide a basis for planning future projects.

Project prioritization was partially based on migratory distance from Flathead Lake. Habitat improvement projects in tributaries flowing directly into the lake and the main stem Flathead River were to be higher priority than work in the upper basin. In investigating tributaries near Flathead Lake, we have acted on most of the feasible opportunities for projects. Most of these drainages are extremely degraded and dominated by introduced species.

Other considerations listed in the Implementation Plan include: 1) evaluation of watershed stability regarding likelihood of continued degradation of habitat improvement reach, 2) species present, 3) cost effectiveness of habitat gained per unit cost (e.g., cost per mile), and 4) cause of fish passage barriers (natural or man-made).

In removing fish passage barriers, the quantity of spawning and rearing habitat upstream and the expediency of repairing the blockage will be examined. Prior to opening passage, fish stocks above and below the barrier will be surveyed to assess the species assemblage, relative abundance, and genetic integrity of native stocks. Historically fishless waters should remain isolated unless passage is deemed desirable through an appropriate environmental assessment process which will focus on plant and animal communities. Genetically pure fish stocks protected from contamination by a barrier will remain isolated unless the threat of contamination is eliminated.

*Predator Trap in Flathead Lake*

In many North Fork and Middle Fork tributaries, adfluvial (adult) DV and WCT redd counts have decreased despite adequate habitat quality. Large increases in lake trout numbers and predation in Flathead Lake and the main stem Flathead River have contributed to recent declines in adfluvial DV and WCT abundance (Carty et al. 1997, Deleray 1997). This limiting factor conflicts with habitat and passage improvement projects targeting adfluvial trout that mature in Flathead Lake. Most DV in the Flathead system are adfluvial, while WCT stocks are comprised of adfluvial, fluvial, and resident components. Therefore, projects in the Flathead system that target WCT will likely show greater fishery benefits. Efforts to enhance DV populations will initially concentrate on disjunct and South Fork populations unless conditions change in Flathead Lake. "Disjunct" populations are defined as those in headwater lakes that appear to be self-reproducing and functionally isolated from the Flathead Lake system (e.g., Upper Whitefish Lake).

Because of the complexities involved with the Flathead Lake ecosystem, MFWP and CSKT (co-managers of the lake) have assembled a panel of fisheries experts to advise the agencies on management strategies for the lake's fishery. The panel is modeled after a similar panel that provided advice to Yellowstone National Park on the illegal introduction of lake trout into Yellowstone Lake. The panel, scheduled to convene in November 1997, will be made up of researchers and managers from across the United States and Canada. Regional biologists from MFWP, CSKT, USFWS, and the University of Montana will provide technical information and historical data.

*Working at Drainage Level*

The effectiveness of habitat improvement and fish passage work will be enhanced if benefits of individual projects complement one another. By targeting whole watersheds or large sections of the basin, cumulative and interactive effects of related projects will more effectively improve habitat quality and increase fish abundance. A watershed analysis will be completed to identify the type of limiting factors for fish. Ongoing work in the Taylor's Outflow drainage is one example of this approach. Enhancement of spawning and rearing habitat in most of the middle and upper drainage has been coupled with WCT imprint plants, eradication of BT, and a fish passage project to provide access for migratory WCT from the Flathead River.

At the Flathead Basin scale, mitigation projects can only complement larger efforts related to public education and proper land use. Successful watershed level progress must include improved land use practices in headwater areas (e.g., Forestry Best Management Practices, Streamside Management Zone Laws, and Riparian Forest Wildlife Guidelines), control of point- and nonpoint source pollution, riparian protection, and water quality conservation measures in the lower system.

*Priority Areas*

The Flathead basin is composed of a complex of private holdings, state and federally managed forests, tribal lands, wilderness, and national park lands. Although wilderness and national park lands are considered onsite, it is unlikely that fish passage or habitat enhancement projects will be appropriate in these areas because they remain pristine. Habitat quality in the remainder of the basin ranges from extremely degraded urban and pasture streams to nearly pristine USFS lands in the South Fork. The current condition and potential for recovery varies greatly in these areas.

In general, the Flathead system can be subdivided into several categories based on habitat quality and fish species composition:

(A) High quality habitat with native species assemblage

(B) High quality habitat with strong native fish populations and persistent introduced species

(C) Moderately degraded habitat with native species assemblage

(D) Moderately degraded habitat with strong native fish populations and persistent introduced populations

(E) Moderately degraded habitat dominated by introduced species; native fish infrequent

(F) Extremely degraded habitat dominated by introduced species or relatively devoid of fish; native fish infrequent or absent

Habitat quality was broadly categorized based on how closely channel features resemble the natural state, the condition of riparian areas, and the level of land-use related impacts. Native fish assemblages are those that are >95% 'pure' based on genetic analyses. 'Strong' native populations are self-sustaining, consistently detectable, and make up more than 50% of the fish assemblage (by number).

Areas A-D represent priority areas, i.e., tributary drainages that currently contain the strongest remaining populations of native fish. Figure 15 shows onsite priority areas for DV and WCT in the Flathead basin. Bull trout priority areas were based, in part, on DV 'core areas' designated by the Montana Bull Trout Scientific Group (1995a; 1995b). However, core areas also include disjunct populations, certain offsite areas, and portions of wilderness and national park land that are not as suitable for the purposes of Hungry Horse Fisheries Mitigation.

Tributaries of the South Fork (including HHR) and the North Fork (on the west side of the drainage) comprise the most extensive priority areas outside of national park and wilderness lands. The entire South Fork drainage above HHD is an important stronghold for native fish. An unforeseen benefit of HHD is that it has prevented introduced fish species in the lower Flathead system from accessing HHR and its tributaries. This basin is still comprised of a native species assemblage and lies entirely within the Flathead National Forest. Reservoir tributaries and the lower third of the drainage are managed timberlands, while the upper two-thirds lies within the Bob Marshall Wilderness Complex. The uniqueness of this ecosystem and its value as a reserve for native species should be recognized and preserved.

Portions of the North Fork and Middle Fork that are within the United States, but outside Glacier National Park and wilderness areas, support a large proportion of the remaining adfluvial DV and WCT populations in the Flathead system. Although these areas have been heavily logged in the past 40 years, most of the tributary drainages still support native fish communities.

We consider priority areas for WCT and DV to be the most important zones for conservation and enhancement of native fish populations in the Flathead basin. Priority areas represent systems that, although often impacted by anthropogenic disturbances, are still self-sustaining ecosystems. Since our goal is to secure and provide high quality habitat that supports native species, these areas are the logical starting point. Pristine ecosystems and key habitat reaches (much of category A above) are valuable resources that must be preserved. Conservation

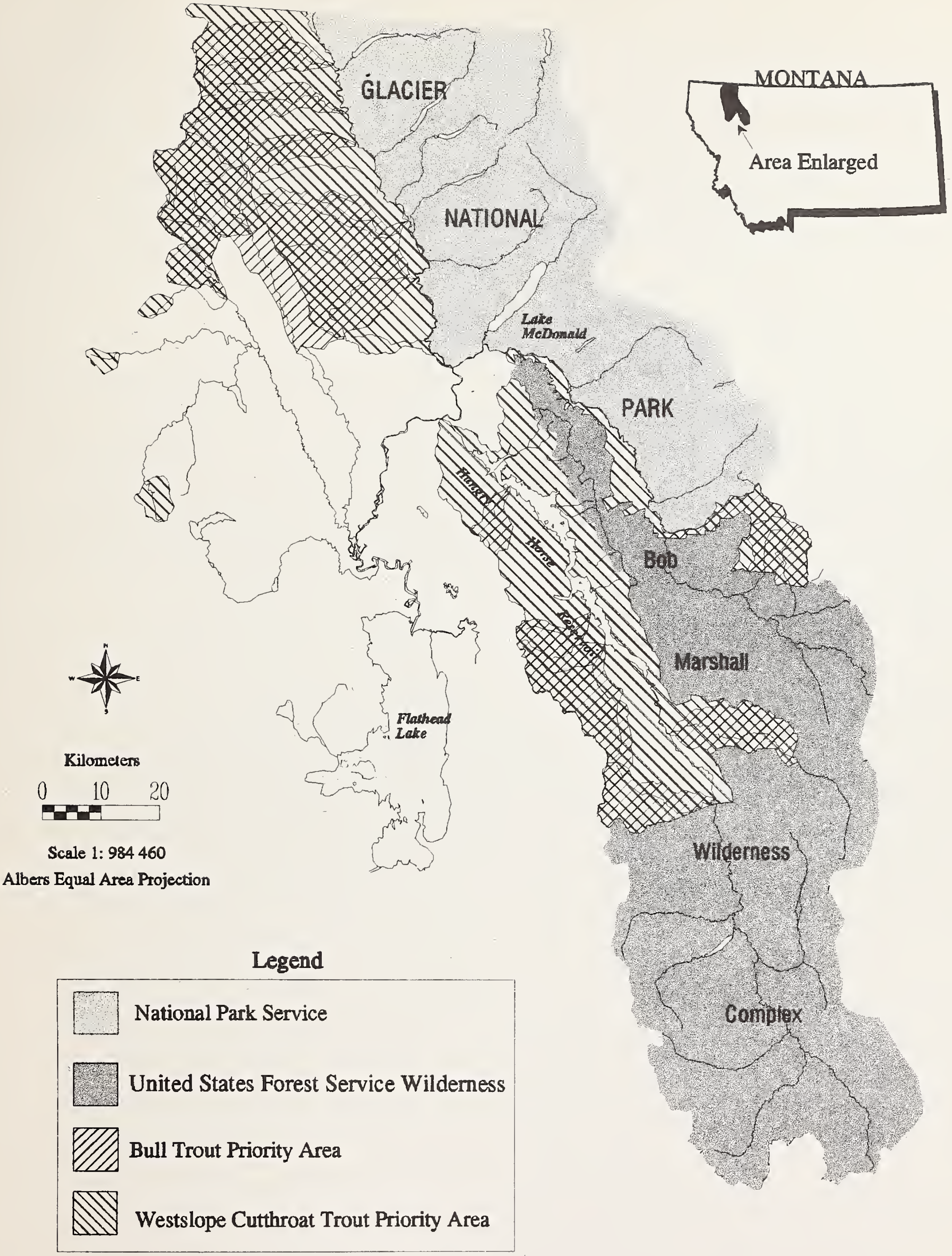


Figure 15. Onsite DV and WCT priority areas for Hungry Horse Fisheries Mitigation. National Park and wilderness lands are not included because fish passage and habitat improvement projects are unlikely to be implemented in these areas.

easements will be considered in the future for securing these habitats. We will also look for opportunities to connect adjacent priority areas by opening migration corridors. Sites with moderately degraded habitat and/or persistent introduced fish (categories B-D) will be enhanced to improve habitat or remove introduced fish. For example, in small systems such as Elliott Spring Creek we plan to improve habitat and remove introduced fish to expand existing "A" zones. Migration corridors in the main stem Flathead River and major tributaries will be considered for mitigation after priority areas.

*Highly Disturbed Areas*

Projects in extremely perturbed drainages (categories E and F) will be used to complement work in priority areas and expand the area of functioning ecosystems. These sites will be evaluated individually, based on recovery potential and cost effectiveness. Basins with potential for recovery of native fish will be given the highest priority. In areas that have been extremely degraded, recovery of native fish populations may not be realistic. Enhancement and management of introduced species may be the best option for maintaining some ecosystem vitality. These areas are also more appropriate for testing experimental, innovative habitat improvement techniques.

*Offsite Projects*

Offsite activities, particularly lake rehabilitation projects, will be pursued each year to supplement onsite fish passage and habitat improvement work. These projects are extremely valuable for producing immediate fisheries and building public support for the mitigation program. Offsite areas can also support genetic reserves for specific fish stocks if conditions can be made suitable for natural recruitment. In the past, we have completed treatment of lakes in late fall, so they are not likely to create scheduling conflicts with stream habitat and fish passage projects.

Offsite projects will initially focus on small, closed-basin lakes rather than large water bodies. A review of case histories and recent stocking programs revealed that hatchery introductions have been most successful in small lakes in northwest Montana (e.g., Lion Lake, Rogers Lake, and Hubbart Reservoir). We have seen poor survival of direct hatchery plants in larger systems such as McGregor Lake, Libby Reservoir (Dalbey 1997), and Flathead Lake (Carty et al. 1997).

**Project Implementation**

Implementation of on-the-ground projects includes many elements: preliminary data collection, permits, environmental assessments, project design, coordination with landowners and cooperating agencies, public scoping, and budgeting. Many of the methods and guidelines for implementation of projects are described in the Implementation Plan.

Experts will be consulted for specific needs that lie beyond the expertise of the mitigation staff. For example, we have employed the BOR's Technical Assistance Program to aid with project design and engineering at Hay Creek, the subsurface dam test site, and the Hungry Horse Wetlands project.

Once projects have been selected, it may take years before they are completed. Unforeseen impediments are common. The Flathead Valley is a contentious political arena with many conflicting interest groups. Unanimous support of landowners, cooperating agencies, anglers, and interest groups is not always possible; public and professional scoping are critical. Large projects are often designed in phases that incorporate new information and project progress over several years. The scope of some efforts may also increase as progress occurs. Once apprehensive landowners recognize benefits of the project, they are more likely to seek involvement.

*Cooperative Projects*

Private entities and government agencies other than MFWP own or manage >99% of the property in the Flathead basin. Since MFWP is not directly responsible for lands where most projects are implemented, we actively seek cooperative projects and consensus among all landowners involved. Cooperative efforts in the past have included cost-share agreements with CSKT, other federal and state agencies, private landowners, timber companies, local businesses, and sportsman clubs. We have also used fisheries mitigation funds as a catalyst to facilitate action by other managing agencies. For instance, surveys were conducted on USFS roads adjacent to key DV spawning and rearing tributaries in the South Fork drainage to expedite USFS repair of point sediment sources.

*Innovative Approaches and Pilot Projects*

Habitat and fish passage improvements constantly provide new challenges. Some problems can be corrected using existing techniques, while others require that we develop and test new approaches. Project designs are often unique or modified to accommodate site specifications. We have also attempted to design and test new approaches that have wide applicability. Examples include the completed fish ladder at Taylor's Outflow and the planned subsurface dam test to restore surface flows to dewatered streams.

*Landowner Agreements and Conservation Easements*

Landowner support and agreements are sought each time projects occur on or adjacent to private land. Signed documents ensure that MFWP and landowners understand the rationale, long-term goals, and expectations for a project. These documents also help to protect the interests of both parties should land ownership change hands or unforeseen circumstances arise.

Conservation easements are used extensively in wildlife mitigation programs to protect critical habitat and contribute to public hunting, fishing, and other recreational opportunities. In these legal contracts, private property owners and agencies agree to prohibit or limit uses that would diminish the conservation value of the land, while maintaining acceptable traditional uses. Because conservation easements are permanent, future owners are bound by the terms of the agreement. Conservation easements can be a valuable tool for securing high quality riparian habitat before serious human-related degradation occurs. It is a proactive approach that we hope to apply in future fisheries mitigation projects.

*Adaptive Management*

Enough uncertainty exists in the science of species recovery that success depends on the ability to change course as new information becomes available. In this document, we have described actions that were developed on the current state of knowledge in species recovery; many methods are yet experimental. Procedures will be evaluated quantitatively and compared to scientific literature so that success or failure can be demonstrated. New techniques will be applied on a small scale to evaluate their effectiveness before expanding applications to full scale. Adaptive management is of paramount importance for a successful mitigation program.

## MONITORING AND EVALUATION

Habitat restoration is a learning process that incorporates existing knowledge and methods, site-specific problems, and experimentation with new techniques. It is essential that ongoing and future projects are monitored to determine if intended benefits were accomplished, if unforeseen benefits or damage resulted, and if additional limiting factors persist.

Habitat improvement projects are based on the premise that better habitat will benefit fish populations. In some instances, such as fish passage improvements, progress can be easily demonstrated. The presence of migratory fish or their redds upstream of a former barrier indicates new access. Monitoring of other projects can be problematic because benefits to fish populations are indirect. For example, elimination of point sediment sources is intended to improve fish production, but depends on cumulative reduction of fines in spawning gravels, successful spawning, and eventual increases in fry emergence. Once sediment sources are abated, it may take decades to flush fine sediments from a watershed. Other benefits of habitat restoration, such as aesthetics and stream stability are difficult to quantify. These improvements are best illustrated by a photographic time series or "photo point." Photo points for all past and ongoing fisheries mitigation projects have been established and are available through MFWP.

Because there are many approaches used to improve aquatic habitat, a range of monitoring techniques that incorporate direct and indirect effects of project work is needed. Therefore, a multi-tiered, basin-wide approach will continue to be employed. Direct benefits of habitat projects are assessed through techniques that address limiting factors targeted at the project site (Table 10).

Indirect benefits of habitat and passage work are difficult to separate from cumulative and interactive effects of land-use practices, angling pressure, and other influences. Factors that limit migratory DV and WCT are also difficult to isolate because these species use different habitats and portions of the drainage at various life stages. Therefore, our monitoring strategy incorporates techniques that vary in scale and sensitivity to population-level changes. Monitoring activities include: McNeil streambed coring, substrate scoring, thermograph stations, WCT and DV red counts, WCT and DV juvenile estimates, river population estimates, and gill-net series on Flathead Lake and HHR (Figure 16). Many of these activities are completed cooperatively with MFWP Fisheries Management staff, USFS, and Montana Department of Natural Resources and Conservation. Results of monitoring activities will be described in Weaver et al. (In preparation).

Measurements of the size range of materials in the streambed are indicative of salmonid spawning and the quality of incubation habitat. Research in the Flathead basin has shown negative relationships between fine sediment (<6.35 mm) levels and emergence success of WCT and DV (Weaver and Fraley 1991; 1993). Field crews use a standard 15.2 cm hollow core sampler (McNeil and Ahnell 1964) and separation procedures (Shepard and Graham 1982) to collect and analyze substrate samples in known spawning habitat. Annual streambed coring sites (21) in tributaries of the North Fork, Middle Fork, South Fork, HHR, Stillwater River, and Whitefish River have been sampled for more than a decade to monitor fine sediment levels.

Spawning depressions (reads) are excavated in tributaries by adults that have presumably r returned to their natal stream to spawn. Red counts serve as an index of migratory adult abundance. Timing, location, and size of reads are used to distinguish among species and in discriminating resident and migratory fish. We have established DV and WCT monitoring sections in tributaries of the North Fork (4 DV sections, 2 WCT sections), Middle Fork (4 DV, 2 WCT), HHR (4 DV, 10 WCT), and South Fork upstream of HHR (5 DV). Annual red counts have been completed for 4-18 yrs in these sections using consistent methods, often by the same MFWP personnel.

Table 10. Strategies to monitor fish passage and habitat improvement projects.

| Project Type | Monitoring Strategies | Expected Response Time (Relative) |
|---|---|---|
| Fish Passage | fish traps and redd counts above former barrier, stream discharge and velocity | moderate |
| Spawning Habitat Enhancement | redd counts, juvenile population estimates | long |
| Fencing to Exclude Livestock | photo points, stream cross-sections, fish population monitoring sections, sediment scoring, nutrient levels | long |
| Repair Sediment Sources | sediment coring, substrate scoring in downstream habitat | direct: moderate<br>cumulative: long |
| Restore Natural Stream Channel Morphology | riffle/pool ratios, stream cross-sections, population monitoring sections, photo points | moderate |
| Enhance Instream Cover or Pool habitat | physical habitat measurements | moderate |
| Construct or Enhance Fish Passage Barrier | genetic inventories, population monitoring and species composition | short |
| Lake Rehabilitation | creel surveys, pre- and post-treatment population monitoring (gill-netting), invertebrate sampling | short |

Juvenile DV and WCT monitoring reaches have also been established to measure annual recruitment in tributary spawning and rearing streams. Population estimates are completed in 150 m sections by electrofishing and using a two-pass removal method (Zippen 1956). Monitoring reaches are located in the following drainages: North Fork (6 DV sections, 2 WCT sections), Middle Fork (2 DV, 1 WCT), South Fork tributaries of HHR (1 DV, 11 WCT), Stillwater River(1 DV, 1 WCT), and upper Whitefish River (2 DV, 1 WCT).

Whirling disease and genetic introgression are two major threats to native fish stocks in the Flathead basin. We routinely assist with sample collection for disease testing and genetic analysis. Fish samples are often collected concurrently with other monitoring activities such as electrofishing estimates. Removal of fish passage barriers also requires genetic evaluation and monitoring. For instance, we are currently evaluating the frequency of hybridization and timing of spawning for RBT and WCT in Taylor's Outflow. If genetic introgression is detected, we must consider excluding RBT from the system.

Fish abundance and size structure are assessed in larger river reaches using mark-recapture (visual snorkel) estimates. These estimates are rotated annually in consistent sections of the

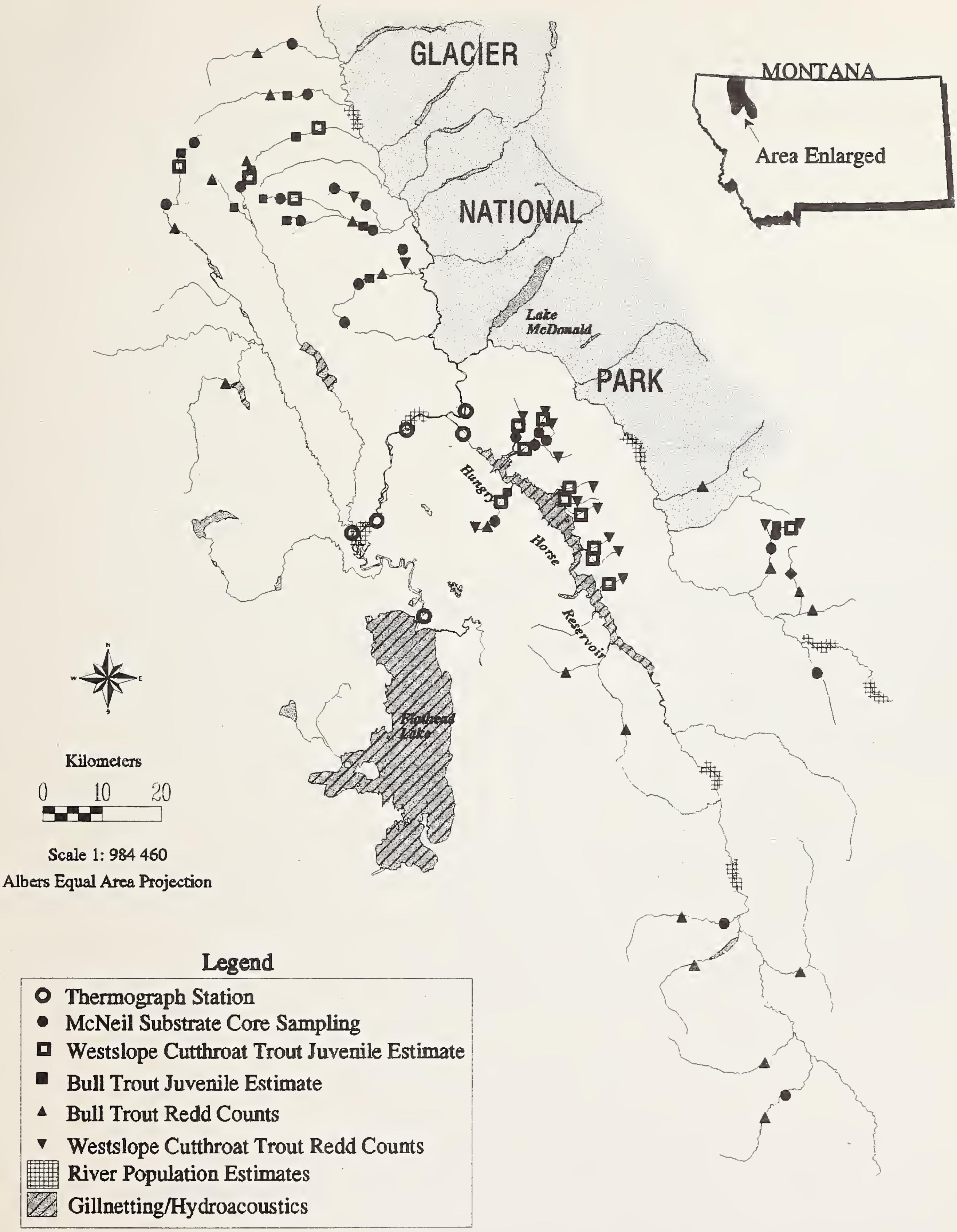


Figure 16. Long-term fish and habitat monitoring sites (MFWP) in the upper Flathead basin.

North Fork (3 km), Middle Fork (3 km, 3 km), and South Fork (2.4 km, 4.4 km). We also use boat electrofishing catch-per-unit-effort estimates to monitor community structure and relative population abundance in two reaches (2 km, 3 km) of the main stem Flathead River. Samples taken in these surveys are also used in age and growth analyses to monitor effects of selective withdrawal at Hungry Horse Dam. Thermal effects of selective withdrawal are monitored directly with a series of thermograph stations located throughout the lower river system.

Fish communities in HHR and Flathead Lake are monitored using annual gill net series. Experimental floating and sinking gill nets are set at locations throughout the lake and reservoir in spring (4/25-5/15) and fall (10/25-11/10), respectively, to assess relative fish abundance and species composition. Nets fish designated areas and depths to provide comparable trend data between years (Shepard and Graham 1983). At sampling sites, we set both sinking and floating experimental gill nets (overnight) perpendicular to shore. Gill nets are 38 m long and 2 m deep, consisting of panels with 19, 25, 32, 38, and 51 mm mesh sizes. The following data are collected from captured fish: abundance, total lengths and weights, stomach contents (food habits), and scales for age and growth information. Specific methods are described by Deleray (1997).

An extensive hydroacoustic estimate with verification gill-netting is also completed each summer on Flathead Lake (Deleray 1997). Although the estimate is most effective for pelagic species (e.g., kokanee), we also collect age and growth, diet composition, and other information for surface oriented and demersal species such as WCT and DV. Additional data on fish abundance, movements, and food habits are collected using Merwin traps in Flathead Lake and the lower Flathead River. Merwin trapping is conducted by HHR Excessive Drawdown Mitigation Program (Flathead River) and the USFWS (to monitor Flathead Lake kokanee test).

Many of the above activities are part of a surface water quality 'Monitoring Master Plan' developed for the Flathead basin. Other agencies and organizations cooperating in monitoring include The Flathead Basin Commission, The University of Montana's Flathead Lake Biological Station, Montana Department of Environmental Quality, Montana Department of Natural Resources and Conservation, USFS, CSKT, and Plum Creek Timber Company. Much of this information, such as water quality and aquatic invertebrate measurements from Flathead Lake and the Flathead River system, complements data collected through fisheries mitigation efforts.

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**Appendix A.** Gravel sizes for Elliott Creek spawning channel.

| Gravel Size | % of Mixture |
|---|---|
| 19 - 38 mm | 36 |
| 10 - 19 mm | 24 |
| 6 - 10 mm | 15 |
| ≤ 6 mm | 25 |

**Appendix B.** Taxonomic groups of Chironomidae collected in HHR.

Subfamily Tanypodinae
- *Procladius sp.* (Holotanypus gp.)

Subfamily Diamensinae
- Protanypini
  - *Protanypus sp.*

Subfamily Chironominae
- Chironomini
  - *Chironomus sp.* (Riparius gp.)
  - *Cryptochironomous sp.*
  - *Paracladopelma sp.*
  - *Sergentia sp.*
  - *Tribelos sp.*
- Tanytarsini
  - *Tanytarsus sp.*

Subfamily Orthocladiinae
- *Heterotrissocladius sp. (Subpilosis gp.)*
- *Paracladius sp.*

## GLOSSARY OF ABBREVIATIONS AND ACRONYMS

| Acronym or Abbreviation | Full Name |
| --- | --- |
| BOR | Bureau of Reclamation |
| BPA | Bonneville Power Administration |
| CSKT | Confederated Salish and Kootenai Tribes |
| ESA | Endangered Species Act of 1973 |
| HHR | Hungry Horse Reservoir |
| HHD | Hungry Horse Dam |
| Implementation Plan | The Hungry Horse Dam Fisheries Mitigation Implementation Plan |
| MFWP | Montana Fish, Wildlife, and Parks |
| Middle Fork | Middle Fork of the Flathead River |
| Mitigation Plan | Fisheries Mitigation Plan for Losses Attributable to the Construction and Operation of Hungry Horse Dam |
| NMFS | National Marine Fisheries Service |
| North Fork | North Fork of the Flathead River |
| NPPC | Northwest Power Planning Council |
| NRCS | Natural Resources Conservation Service |
| South Fork | South Fork of the Flathead River |
| USFS | United States Forest Service |
| USFWS | United States Fish and Wildlife Service |

*Fish Species*

| | |
| --- | --- |
| DV | Bull Tout (*Salvelinus confluentus*) |
| BT | Brook Trout (*Salvelinus fontinalis*) |
| RBT | Rainbow Trout (*Oncorhynchus mykiss*) |
| WCT | Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*) |

Bonneville Power Administration

PO Box 3621 Portland, Oregon 97208-3621

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