Fish Passage Assessment: Big Canyon Creek Watershed

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Fish Passage Assessment: Big Canyon Creek Watershed

**Mountain Snake Province
Clearwater Subbasin
Project No. 1999-016-00
Contract No. 4557**

Final Report

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PREFACE

This report presents the results of the fish passage assessment as outlined as part of the *Protect and Restore the Big Canyon Creek Watershed* project as detailed in the CY2003 Statement of Work (SOW). As part of the Northwest Power Planning Council's Columbia Basin Fish and Wildlife Program (FWP), this project is one of Bonneville Power Administration's (BPA) many efforts at off-site mitigation for damage to salmon and steelhead runs, their migration, and wildlife habitat caused by the construction and operation of federal hydroelectric dams on the Columbia River and its tributaries.

The proposed restoration activities within the Big Canyon Creek watershed follow the watershed restoration approach mandated by the Fisheries and Watershed Program. Nez Perce Tribal Fisheries/Watershed Program vision focuses on protecting, restoring, and enhancing watersheds and treaty resources within the ceded territory of the Nez Perce Tribe under the Treaty of 1855 with the United States Federal Government. The program uses a holistic approach, which encompasses entire watersheds, ridge top to ridge top, emphasizing all cultural aspects. We strive toward maximizing historic ecosystem productive health, for the restoration of anadromous and resident fish populations.

The Nez Perce Tribal Fisheries/Watershed Program (NPTFWP) sponsors the *Protect and Restore the Big Canyon Creek Watershed* project. The NPTFWP has the authority to allocate funds under the provisions set forth in their contract with BPA.

The project's administrative and participant information is listed below:

BPA Project No.: 1999-016-00

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Performance Period: August 15, 2003 – February 28, 2004

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The document begins with the location of the project, followed by a summary of the problem, and the specific project objectives and goals. Next in the document is the work to be performed including the project methodology. The culvert inventory results are then outlined. The discussion and conclusion portions of this report delineate and discuss the specific crossings that are of the highest priority for replacement and the rationale for those selections. If more detailed information about this project is needed, contact the project leader or sponsor listed above. If more detailed information is needed about background information, historical or present watershed conditions, please consult the CY2003 SOW for this project or the *Big Canyon Creek Aquatic Assessment*.

ACKNOWLEDGEMENTS

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Field Crews:

Wolfgang Benson, Richard L. Christian, Chet Hagen, Dawn Wilson, John Van Woerkom,

Private Landowners:

The cooperation that was extended to field crews by all private landowners was greatly appreciated. In general, the response received by the crews was overwhelmingly supportive. Although the cooperative landowners are too numerous to list, the Nez Perce Tribe is indebted to these individuals. Without their cooperation and local knowledge, this inventory would not have been possible. Thank you all very much.

INTRODUCTION

PROJECT OVERVIEW

In the state of Idaho vast numbers of relatively small obstructions, such as road culverts, block thousands of miles of habitat suitable for a variety of fish species. To date, most agencies and land managers have not had sufficient, quantifiable data to adequately address these barrier sites. The ultimate objective of this comprehensive inventory and assessment was to identify all barrier crossings within the watershed. The barriers were then prioritized according to the amount of habitat blocked at each site and the fish life history stages impacted. This assessment protocol will hopefully prove useful to other agencies and become a model for use in other watersheds.

Big Canyon creek has a long history of development. The watershed over time experienced numerous sustained impacts. Agriculture, logging, road construction, grazing, and floodplain development have modified the watershed. The extensive removal of riparian and upland vegetation has undoubtedly altered the hydrologic regimes within the watershed (both ground and surface water). Original channel types have been altered to the extent that width/depth ratios, sinuosity, gradient, substrate composition, streambank stability, and channel patterns are currently contributing to degradation of aquatic resources. In response to these modifications, the ecosystem is now more sensitive to disturbances, is characterized by a lower recovery potential and higher streambank erosion potential (Big Canyon Aquatic Assessment 2001). General ecological problems impacting Big Canyon Creek include, among other factors, fish migration barriers (Big Canyon Aquatic Assessment 2001).

The Big Canyon watershed is part of the Lower Clearwater assessment unit scale. The 2001 draft Clearwater Subbasin Assessment identified connectivity/fish passage as a primary limiting factor for steelhead and Chinook salmon at this scale. This project addressed this major gap in the current knowledge of fish passage within the Big Canyon watershed. According to the best available information at the onset of this inventory, road crossings appeared to have greatly limited the amount of habitat available for anadromous fish species within this watershed. The most current information was clearly insufficient to prioritize and fund fish passage projects in the watershed

FISH

The Big Canyon watershed provides habitat for a variety of anadromous and resident fish. In the early 1980's, Nez Perce biologists surveyed streams and stream habitat conditions in lower Big Canyon Creek and two of its major tributaries and found a total of eight fish species (Kucera and Johnson 1986).

More recently, Nez Perce biologists surveyed streams and found nine species of fish within the watershed. These fish species include rainbow trout/steelhead (*Oncorhynchus mykiss*), paiute sculpin (*Cottus beldingi*), speckled dace (*Rhinichthys osculus*), bridgelip sucker (*Catostomus columbianus*), redbelt shiner (*Richardsonius balteatus*), northern pike minnow (*Ptychocheilus oregonensis*), chislemouth sucker

(*Acrocheilus alutaceus*), smallmouth bass (*Micropterus dolomieu*) and pumpkinseed (*Lepomis gibbosus*) (Chandler, personal com., 2003).

Big Canyon Creek and its major tributaries were important historically as reproductive habitat for Snake River Basin steelhead, which the National Marine Fisheries Service (NMFS) listed as Threatened under the ESA (February 5, 1999, 56 FR 5740). Protection of current wild A-run steelhead populations is important for genetic and biological diversity.

Local oral histories of the Nez Perce Tribe refer to the region's once significant salmon runs. Like many anadromous streams in the Columbia River Basin, salmon and steelhead populations have declined significantly from historic levels (Witty 1994). Within the watershed, both anadromous and resident fisheries habitat were affected by past land management, including road building, logging, large woody debris clean out, stream straightening, riparian revegetation, grazing, water projects and noxious weed encroachment (Big Canyon Aquatic Assessment 2001). These anthropomorphic disturbances within the watershed have all been previously indicted in being causal factors to the loss of biological diversity and integrity within ecosystems in general (Hughes & Noss 1992).

Currently, the anadromous stocks found within the watershed include wild A-run steelhead and potentially Chinook salmon. Big Canyon Creek and its major tributaries have one of the top producing wild A-run steelhead populations in the Nez Perce Reservation (Kucera and Johnson 1986).

Snake River fall Chinook salmon are distributed from the mouth of the Clearwater River at the Snake River upstream to its confluence with Lolo Creek. Fall Chinook salmon are also listed as Threatened (December 28, 1993, 58 FR 68543). Although not found during the most recent sampling effort (Chandler, personal com., 2003), salmon were probably historical inhabitants of Big Canyon creek and may continue to utilize the stream at certain times of the year.

Although not within the designated critical habitat for salmon, as a major tributary to the Clearwater River, activities within the adjacent project area influence the quality of aquatic resources downstream. It is believed that considerable potential exists for improving anadromous fish populations in these and other areas of Big Canyon Creek (Big Canyon Aquatic Assessment 2001).

WATERSHED BACKGROUND

The mouth of Big Canyon Creek joins the Clearwater River almost 50 miles above the confluence of the Snake and Clearwater Rivers near Lewiston Idaho. It flows for almost 30 miles within the Nez Perce Reservation (Kucera, et.al. 1986). Little Canyon Creek is the major tributary and flows about 18 miles where it discharges into Big Canyon Creek, 2.3 miles from the mouth. Many smaller streams and intermittent tributaries flow into the Big Canyon system throughout its length (Figure 1). The watershed geology is described as Columbia River basalt and is characterized by rolling plains bisected by stream valleys and extreme fluctuations in stream flow. Most of the land mass is used for agriculture with dry land grains and cattle as the most important products (Big Canyon Aquatic Assessment 2001).

Figure 1. The Big Canyon Creek watershed.

BARRIER REPLACEMENT ISSUES AND CONCERNS

Within stream continua, the conceptual idea of biological succession usually has no place because of the interconnected nature of running waters. As predicted by The River Continuum Concept, each reach of stream is connected to all other reaches. Thus, the organisms that live there possess a continuous linkage to each other and are not temporally discrete units (Vannote *et al.* 1980). This allows for migration, both upstream and downstream, to adjust to changing biological conditions.

Headwater, forested reaches of streams offer decreased abundances of invertebrates, relative to more open downstream reaches (Gregory *et al.* 1987). Prey in these headwater sections are also not as easily captured by predaceous fishes. In addition increased habitat complexity has been shown to increase fish abundance (Moore & Gregory 1989). Thus, the fisheries productivity of riverine systems is determined by habitat conditions and food resources. Refugia offered by complex, downstream, lateral habitats is also crucial during flood events for all aquatic vertebrates (Gregory *et al.* 1991). Furthermore, it has been demonstrated that habitat loss associated with land use practices was the single most important factor in species endangerment (Flather *et al.* 1994). This discussion helps to explicate the need to maintain the ability of fishes to disperse throughout the stream network under varying instream conditions.

Due to the watersheds road network, many streams are crossed multiple times by roads. The roads greatly affect the quality and continuity of aquatic ecosystems by interrupting the flow of water and material throughout the length of the stream.

Roads and culverts act like dams that constrict stream flows through a single narrow area (an undersized culvert) often preventing the transportation of material downstream. These constriction points also cause gravel buildup (substrate deposition) and channel widening at the culvert inlet. Wide, shallow channels do not provide quality habitat for aquatic organisms. The channels below culvert outlets are typically down cut and scoured by the high velocity water caused by the constriction. These appear as small to large waterfalls at culvert outlets.

Roads and undersized culverts have been shown to function as barriers to the upstream movement of many fish and wildlife (amphibian, insect) species. Culvert outlets not in contact with stream bottoms (i.e. those with waterfalls) do not allow for access since many organisms have no jumping abilities or are too small to negotiate the height of the falls. Undersized culverts constrict flows and increase water speeds creating high velocity barriers and eliminating substrate from culvert bottoms. Substrate, such as gravel and rocks, provide low velocity areas for organisms to rest on their upstream migration. The presence of barriers can isolate small populations, limiting or preventing genetic exchange between populations, and preventing the re-colonization of historic or recovering habitats.

Culverts also limit or prevent seasonal upstream movement by fish. Juvenile salmon and trout living in large rivers or streams often seek refuge in small tributary streams during high water events. Without access to refuge habitats, fish may be washed downstream into poor quality or overcrowded habitats. This could reduce the

chances for survival for both individuals and for populations, including those already on the Endangered Species list.

In addition to biological concerns, many culverts are in need of replacement to reduce the risk of road fill failure and subsequent addition of sediment into streams. Historically, most culverts were sized to pass 25 to 50 year storm events. In many cases, this sizing is not adequate to handle water and wood movement during large flood events. Culverts sized for a 100-year storm event are the same width as the stream channel and are able to easily pass the water and most debris associated with a large event.

Within the Big Canyon watershed there were 119.6 miles of stream inventoried for barriers. It was determined that nearly thirty percent of these total inventoried stream miles are currently blocked by barrier structures. This represents 35.8 miles of currently unavailable habitat for anadromous salmonids within the watershed (Figure 2).

These concepts all work simultaneously to demonstrate the need to maintain connectivity and decrease habitat fragmentation. They demonstrate the very real necessity to *reconnect* the broken linkages created by fish migration barriers. Culvert replacements will also help address other areas of concern, including sedimentation and habitat degradation.

PROJECT GOALS AND OBJECTIVES

The purpose of this project included four key objectives:

- 1) to inventory all of the sites where roads cross streams within the Lapwai watershed;
- 2) to assess these crossings to determine if they are upstream migration barriers to juvenile and/or adult fish;
- 3) to inventory all known non-road crossing migration barriers within the watershed; and,
- 4) finally to select the highest priority man-made barriers for future replacement recommendations.

These objectives are an integral part of the broader ongoing project within the Big Canyon watershed. The ultimate goal of the larger project is to holistically approach the protection and restoration of the ecological and biological functions of the watershed, to assist in the recovery of anadromous and resident fish species.

Figure 2. The passable and impassable stream sections within the Big Canyon watershed.

METHODS

For the purposes of this survey, a road crossing was defined as any obvious site where a road crosses a stream channel. By definition, all sites that may have been historic crossings but have not been used in the recent past were not surveyed. Essentially then, if field crew personnel could not determine if there had ever been a crossing there, it was not considered a stream crossing. This functional definition precludes the inclusion of erroneous crossings, such as, old logging skid trails.

One of the key assumptions regarding this methodology related to certain types of road crossings. Bridges, fords and open-bottom arch culverts were assumed to always pass fish, and thus no quantitative measurements were taken at these sites. Any potential impact to fish passage was noted under the qualitative assessment.

The basic method used to inventory all stream/road crossings in the Big Canyon watershed was modified from the USDA-Forest Service protocol entitled, *Explanations and Instructions for Passage Through Road/Stream Crossings Inventory Form* (Jacobson 2003). Likewise, the methodology used to assess all crossings in the watershed was taken from the Forest Service protocol entitled, *Region 1 Fish Passage Evaluation Criteria* (Jacobson 2003). Because of obvious time constraints due to the sheer number of estimated crossings within the watershed, it became necessary to trim this protocol to allow for the completion of as many crossings as possible over the course of the field season. Because all replacement structures would eventually undergo the more rigorous “full” Forest Service survey protocol, some of the information contained within that protocol could be deleted from this condensed method. Also, any survey which actual fish passage could not be determined with this protocol would have to undergo the full protocol to allow for further hydraulic analysis.

The basic premise was the same in both protocols; however, various aspects of the Forest Service protocol were removed to meet the needs of this survey. Also to expedite the field collection portion of this project, an electronic data form was utilized on a handheld palm pilot to collect all data. Appendix A shows the actual modified data form used for these inventories. Following is a more detailed discussion of the actual protocol used with explanations of any changes that were made from the original protocol, where necessary.

TIER 1: FISH PASSAGE ASSESSMENT

The number of road/stream crossings was initially estimated using the Nez Perce Tribe Land Service’s department. This information was then displayed on a map for use over the field season. The crossings outlined on these maps were known to be inaccurate; however, this provided the necessary framework to begin the actual inventory process. It was also determined from these maps that not all stream orders could physically be inventoried or assessed. Thus, only crossings located on second order or greater streams were considered.

With the locations of the structures from the above maps, the next step of this process was to contact private landowners. This was done to obtain access to private land that had structures present.

PHASE 1: BARRIER ANALYSIS

The first phase of this protocol involved inventorying the stream crossings. As previously stated, the USDA- Forest Service protocol *Passage Through Road/Stream Crossing Inventory* was the methodology which was modified and used to conduct this portion of the project. While still at the site, the structures were then assessed to determine passage status, using the *Region 1 Fish Passage Evaluation Criteria* protocol without modification. Following is a more detailed description of how this inventory protocol was modified with explanations for any differences.

SITE

The basic information regarding the site descriptors was included on this portion of the data sheet. These items included all of the following: the unique stream crossing identifier; the road name and milepost; a road log of the crossing location; ownership information; the stream name; the waypoint of the site; the surveyor's names; and the date and time of the survey. This differed from the Forest Service protocol in that all of the information related to the forest and district was not collected, as none of these inventories were conducted on Forest Service ownership. Also, a legal description, route number, INFRA milepost and watershed HUC were not included on the data sheet, as this information was deemed to be extraneous.

CROSSING STRUCTURE

The type of structure, including the width and height, was recorded on the data sheet used in this protocol. If multiple structures were present at a site, this information was also noted, as per the Forest Service protocol. Unlike the Forest Service protocol, additional information regarding the rust line and ford data were not collected. The structural material was not recorded, as it was deemed to be unnecessary information for this inventory. Likewise, the type of corrugations present was not recorded. This type of data was not considered essential in determining fish passage, but necessary only when considering replacement structure options.

The inlet type and outlet configuration information were combined in this inventory. All original outlet configuration data was collected. However, the only data collected regarding the inlet was the presence of an apron or trashrack. Of course, the "other" category was also maintained to provide flexibility. No information regarding the fill volume was collected at the time of the initial surveys. It was determined to be more efficient to collect this information when conducting the full survey on only the crossings to be replaced.

The next deviation from the original Forest Service protocol was the longitudinal and tailwater cross-section surveys. These surveys were not conducted in this abbreviated protocol, as they were not necessary to determine fish passage in most instances. Streambed substrate within the culvert and bankfull widths was noted in the method used here. The bankfull width was measured as per the video, *A Guide to Field Identification of Bankfull Stage in the Western United States*. Bankfull widths were

never taken at pool habitat types, due to the unique hydrological conditions associated with pools. In condensing the Forest Service protocol, the substrate particle size was not recorded. This information was not essential in determining fish passage. In addition, the channel slope was not measured, again because this relates more to actual replacement than to fish passage.

All of the calculations within this methodology were performed electronically by the HanDbase software. This greatly increased the efficiency of the field collection, as well as decreasing the likelihood of mathematical error. The final portion of the condensed protocol employed here was photographing the structure. Four pictures of each structure were taken, at each site. The first photograph was taken from the inlet looking upstream. The remaining pictures were taken as per the Forest Service protocol.

A site sketch was not done, unless the structure had very unique characteristics. If further explanation or clarification of a site was needed, a site sketch was drawn. However, this was only done when essential to explain very unique situations. None of the optional channel reference data was collected. Some of this information was determined within the prioritization portion of the procedure outlined below. The final step in this condensed protocol was to evaluate fish passage, prior to leaving the site. This was done using the *Region 1 Fish Passage Evaluation Criteria* (Jacobson 2003). The flow charts included in Appendices B and C were the guiding instruments in determining fish passage by life history stage.

POST-ANALYSIS DATA REVIEW

After the data was collected, it was reviewed to assure for quality and completeness. This was accomplished first using the original HanDbase data. After this review was complete, the data was exported directly into Microsoft Excel for further interrogation. If any sites contained information which could not be verified from the office, the site was revisited.

PHASE 2: HYDRAULIC ANALYSIS

All structures that were either assessed as “grey” or were replacement candidates must then undergo the full, unmodified *Passage Through Road/Stream Crossings Inventory* protocol. These grey sites were structures that passage could not be determined from the field data for one or more life history stage. As alluded to previously, after the assessment was completed, any crossings which were assessed as grey would then be analyzed using the USDA- Forest Service “FishXing” software to determine passage.

The following tier describes the actual prioritization of the sites. With this information the replacement sites were identified. This allows for the determination of which specific sites would need the hydraulic analysis conducted, and consequently, which sites would require full surveys.

TIER 2: STRUCTURE PRIORITIZATION

The criteria developed to evaluate the stream crossings in the Big Canyon watershed involved three steps. The first step in the prioritization involved simply reviewing the data with specific objectives in mind. The second phase in the selection process involved the objective evaluation of the crossings, using the best available information. The final portion of the selection process involved comparing all possible combinations of crossings per stream.

As part of the first part of this selection process, all crossings which were deemed passable to all life histories were eliminated. These crossings included all bridges, fords, open-bottom arches, and structures that were categorized as “green surveys” (passable) or natural channel simulation by the USDA-Forest Service, Region 1 Fish Passage Screening Criteria, unless noted as a qualitative assessment. Also as part of the initial data snooping process, all known, permanent, natural downstream barriers were to be included in determining fish passage, but excluded from consideration for replacement. Obviously, that necessitates the removal of any barriers inventoried upstream of these structures from replacement consideration.

CRITERIA FOR PRIORITIZING STREAM CROSSINGS

The initial portion of the objective evaluation involved determining which barrier crossings were the first encountered within a stream network, when proceeding upstream from the mouth of a stream, hereafter referred to as “first barriers”. These barrier structures were considered the highest priority within the watershed. This created two categories of barrier crossings for further consideration, the first barrier encountered and the remaining crossings. It was then decided that each of the remaining barriers through the third structure per stream network be compared. Therefore, there were a total of three barrier categories created.

The second phase of this step of the evaluation process involved obtaining miles re-opened by replacement of each barrier structure. This information was obtained through the Nez Perce Tribe Land Service’s department and was obtained for all barriers through the fourth upstream site encountered, or the end of the inventoried stream network. The mileage re-opened was then weighted relative to the three priority categories by calculating the relative percent of miles re-opened by category. Thus, the first barrier encountered within a system that would re-open the most miles of habitat (regardless of quality) was used as the denominator when calculating the relative percentages for that category (See Appendix A). The same process was utilized when obtaining the relative percent of miles for all second and third barriers.

Then, the option of replacing multiple structures within a given stream system was examined. This pair-wise comparison was conducted because in specific circumstances it may be more beneficial to replace two structures along the same stream than it would to replace one structure on two different streams. It also allows for more flexible management decisions and broader depth of comparisons. This broader depth of comparison will allow for a multi-year approach in that it demonstrates which crossings are the highest priority after the first barrier is replaced.

The third portion of this step was the consideration of the impacted life history stages. In considering life history importance, it was concluded that this factor should be ranked relatively equally to the amount of habitat blocked by a given structure. Thus, it was determined that an adult or juvenile migration barrier should each be given a weighting factor of five, while a grey site, or a site where fish passage was unknown, should receive a two and one-half weighting factor for each impacted life history stage.

The final portion of this stage simply involved the summation of these values to obtain an empirical rank for each site. This empirical rank was obtained for each of the first three barriers within the stream network, which allows for comparisons of barriers for replacement. This rank was also obtained for combinations of the first two and first three barriers encountered within the system.

It is critical to highlight some of the basic assumptions that are involved in the above prioritization scheme. One of the key issues was that all bridges, fords, open-bottom arches, “green surveys” (passable) and natural channel simulation structures were assumed to pass all fish and life history stages, unless a qualitative reason existed. Another assumption was that the first barrier encountered within a given stream network was of the highest priority. This assumption presumes that anadromous, or migratory, species are of a higher priority than resident populations. A final assumption is that miles of habitat re-opened and life history impacted are of relatively equal importance to fish passage.

TIER 3: REPLACEMENT DESIGN SURVEYS

After the completion of all of the above and prior to actual replacement, each structure to be replaced must have design replacement surveys conducted. These surveys allow for cost estimates and options to replacement. With the completion of these surveys managers can determine if actual replacement is the best option, or if other mitigation efforts might be employed to allow for fish passage.

RESULTS

There were a total of seventy-nine sites surveyed in the Big Canyon watershed (Figure 3). Almost one-third of these crossings were located on the mainstem of Big Canyon, or its unnamed tributaries (Table I). Approximately one quarter sites were located on Long Hollow Creek, which is a tributary to Little Canyon Creek. The remaining sites were mixed amongst the other streams within the watershed. The following table summarizes the inventories conducted on each stream and tributary within the Big Canyon watershed.

Table I. A summary of the total number of surveys conducted within the Big Canyon watershed outlined for individual streams.

Stream Name	Total Surveys
Big Canyon	17
Little Canyon	2
Holes	14
Long Hollow	22
Cold Springs	7
Unnamed Tributary to:	
Big Canyon	10
Holes	4
Long Hollow	2
Cold Springs	0
Little Canyon	1
Total	79

There were a total of fifty-four culverts surveyed within the watershed, which is roughly two-thirds of the total inventories. Of these surveys, almost sixty percent were circular (Table II). The remaining sites were characterized mostly as fords and bridges. The following table gives a further categorization of all inventoried crossings.

Table II. A summary of structure types surveyed within the Big Canyon watershed.

Structure Type	Number of Sites Inventoried
Culvert	
Circular	31
Squashed Pipe-Arch	19
Log Culvert	0
Open-Bottom Arch	4
Box	0
Ford	6
Bridge	18
Other ¹	1
Total	79

¹ The other category was either an open-bottom or squashed pipe-arch; the type was not able to be determined.

BARRIER ANALYSIS

The actual analysis included two distinct parts. The first portion of determining fish passage was the quantitative assessment, which will be discussed in more detail immediately following this discussion. The other part of the analysis was the qualitative assessment of passage. The qualitative portion will be discussed after the quantitative discussion. Figure 3 depicts all of the structures inventoried within the watershed, including quantitative and qualitative assessments.

QUANTITATIVE ANALYSIS

The following table depicts the overall fish passage assessments for all surveys by life history (Table III). Table IV gives a more detailed depiction of the total barriers conducted by stream and life history stage. Some of these categories will be discussed in more detail later in this document. The following table is an overall summary of the sites inventoried. The qualitatively assessed barriers will be discussed in a later section.

The outlet drop of the structures assessed by far accounted for the majority of the quantitative barrier assessments within the Big Canyon watershed. The other most common reason for a structure being assessed as a fish migration barrier was the overall slope of the structure.

Table III. A summary of quantitative passage status in the Big Canyon watershed.

Structure Assessment	Fish Passage	
	Juvenile	Adult
Barrier Crossings (Red)	30	21
Passable Crossings (Green)	6	14
Unknown Passage (Grey)	6	7
“Natural Channel Simulation”	12	12
Bridges	18	18
Fords	6	6
Log Culverts	0	0
“Other” ¹	1	1
Total	79	79

¹ The “other” category was either an open-bottom or squashed pipe-arch; the type was not able to be determined. This structure was determined to be a natural channel simulation.

Figure 3. All Big Canyon watershed stream crossing surveys.

Figure 3 above shows where all of the inventories were conducted within the Big Canyon watershed. This figure also contains the assessment of each site. The red dots indicate impassable sites, green dots indicate passable, and grey dots indicate unknown passages. The remaining sites are light blue, which stands for all structures that were assumed to pass fish (e.g. bridges, fords, and etc.). These surveys include only the sites that were quantitatively identified as barriers. The sites that were assessed to be qualitative barriers and all other unique sites, like waterfalls and irrigation diversions, will be discussed separately.

The table below lists all barrier structures by stream and life history impacted. This information is also graphically displayed in the Figure 4. The total barrier column indicates the number of different barriers per stream for both juveniles and adults. There were a total of thirty barrier sites within the Big Canyon watershed for both life history stages combined. As would be expected, the juveniles had more impassable structures than the adults. However, most structures were either a barrier or passable to both adults and juveniles.

Table IV. A summary of quantitative fish passage status within the Big Canyon watershed outlined for individual streams.

Stream Name	Barriers per Stream		Total Barrier Sites
	Juvenile	Adult	
Big Canyon	7	6	7
Little Canyon	0	0	0
Holes	3	0	3
Long Hollow	4	3	4
Cold Springs	4	4	4
Unnamed Tributary to:			
Big Canyon	8	4	8
Holes	2	2	2
Long Hollow	1	1	1
Cold Springs	0	0	0
Little Canyon	1	1	1
Total	30	21	30

Figure 4. All quantitative barriers in the Big Canyon watershed.

QUALITATIVE ANALYSIS

Of the seventy-nine total sites surveyed, there were six total sites qualitatively identified as migration barriers to juveniles and/or adults. However, only three of those were quantitatively passable, or unknown passage, sites that had qualitatively impassable assessments (Table V and Figure 5). This assessment was a subjective determination of whether the surveyors thought something may have been a barrier to fish passage. This portion of the survey was included to capture situations not accounted for in the quantitative part of the survey. These sites included debris at inlet, handmade dams and a cement weir. The following table outlines the three sites that were qualitatively determined to be fish barriers. Again, these sites were barriers captured only in the qualitative assessment, not as part of the quantitative assessment. The stream crossing number shown in this table simply represents a unique site identifier used by the crews when conducting the inventories. The “B” is used to distinguish this site as being located in the Big Canyon watershed. The “B” is followed by either “420” or “422”, which was utilized to distinguish the crew conducting the survey. A final note about the stream crossing number is the last four digits, which represent the specific site number.

Although there were thirty juvenile and twenty-one adult quantitative barriers, the total number of qualitative and quantitative barriers in the Big Canyon watershed was thirty-four and twenty-five, respectively. This total number was derived from the addition of the quantitative and the qualitative assessments and included the handmade dam on Big Canyon. This dam was assessed as a probable barrier. Due to the construction materials of the dam (stream substrate) and the fact that water was still able to flow somewhat through the interstitial spaces of the dam, the barrier status was not easily categorized. Only dams that totally blocked water flow and met the respective height criterion were considered totally impassable structures.

Table V. A description of qualitative fish passage barriers within the Big Canyon watershed.

Stream Name	Stream Crossing	Site Description	Barrier Status	
			Juvenile	Adult
Tributary to Holes	B-420-0042	1 foot Inlet Drop	Impassable	Impassable
Long Hollow	B-422-0020	Cement Weir	Impassable	Passable
Big Canyon	B-422-0024	Handmade Dam	Probable ¹	Probable

¹ Probable is defined as likely being a fish passage barrier to this life stage.

Figure 5. All qualitative barriers and non-road crossing sites.

NON-ROAD CROSSING SITES

Other factors affecting fish passage were noted whenever they were encountered. These factors included items that were not road crossings but had an impact on passage. Again, due to the nature of this inventory, seasonal barriers were included in the inventory when encountered, but not included in prioritizing for replacement. The only non-road crossing site not previously mentioned in the qualitative discussion above was a dry section located on the mainstem of Big Canyon (Figure 4).

This dry channel does not appear to currently limit use of the upper reaches of the stream by steelhead. It would appear that the timing of migration by this species is such that they have access at the critical time(s) of the year (Dick Yetter, personal com. 2002).

SPECIAL CASE SITES

Although the above sites were the only non-road crossing structures inventoried, there was a report of a waterfall. This natural feature was located on Sixmile creek, approximately 0.5 miles downstream of site B-420-0045. The legal description of the approximate location of this waterfall was T35N, R01W, ¼ NE of ¼ NW of S17 (Figure 6). Due to time constraints and access issues, this site was not investigated.

Some sites were not visited or surveyed, due to the inability to obtain permission to access these sites. There is no way of knowing for certain how many actual crossings were not inventoried for this reason. However, it is estimated that the number of crossings is between five and ten. The specific areas that were not inventoried are within Little Canyon creek. These sites, therefore, contain an unknown number of crossings. However, discussions with private landowners living in the area resulted in the determination that any crossings were seasonal use fords, mostly not drivable with anything other than an All Terrain Vehicle. The following figure outlines the specific area on Little Canyon creek that was not visited.

Figure 6. Stream segments not inventoried within the Big Canyon watershed.

HYDRAULIC ANALYSIS

The second phase of tier one, the hydraulic analysis of undetermined fish passage, was not conducted for any of the surveys inventoried herein. This analysis could not be conducted, as weather conditions would not permit after the completion of the above inventories. However, the position of these surveys within the watershed was such that they did not warrant further investigation or analysis.

REPLACEMENT PRIORITIZATION

The second tier in the process was the actual prioritization of the assessed structures. The following section of this document will address the specific sites that were of the highest priority for replacement consideration. As stated in the methods section, first, second and third barriers were prioritized, as well as all possible combinations thereof. Figure 7 outlines the specific locations of all of the first three barrier crossings within the watershed. Likewise, the combinations of these first three barriers can be derived from this figure. Therefore, the reader is referred back to these figures when reading the following sections.

FIRST BARRIERS

Within the Big Canyon watershed, there were nine barrier crossings considered as first barriers (Table VI). Two of the nine crossings did not undergo further consideration in the prioritization process. The reasoning for each will be discussed specifically in the replacement priority section to follow. The remaining seven crossings are shown below in their relative prioritization order. All of these sites involve only one structure per location. The highest possible rank score for this category was a value of twenty.

Table VI. All first barrier crossings within the Big Canyon watershed.

Stream Name	Stream Crossing	Barrier Status		Habitat Blocked ¹ (mi.)	Rank ²
		Juveniles	Adults		
Long Hollow	B420-0021	Impassable	Impassable	2.388	20.0
Cold Springs	B420-0014b	Impassable	Impassable	2.376	20.0
Tributary to Big Canyon 3	B-422-0022	Impassable	Impassable	0.838	13.5
Big Canyon	B420-0016	Impassable	Impassable	0.174	10.7
Tributary to Big Canyon 2	B420-0043	Impassable	Unknown ³	0.012	7.6
Tributary to Little Canyon	B420-0025	Impassable	Impassable	0.323	6.4
Holes	B420-0027b	Impassable	Passable	0.213	5.9

¹This refers to the miles of habitat known to be currently blocked by this structure. This figure does not include any first order streams that were not inventoried.

²The rank is the total score assigned to this crossing, based on the prioritization criteria outlined in the methods section of this document.

³Unknown barrier status indicates that more data needs to be collected at this structure to allow for performing the FishXing analysis.

Figure 7. All first, second and third barrier crossings within the Big Canyon Creek watershed.

SECOND BARRIERS

Seven structures were identified as the second barrier within the stream network encountered during upstream migration, referred to as “second barriers”. All of these sites are depicted in Table VII below in their relative order of replacement importance. The highest possible rank score for this category was a value of twenty.

Table VII. All second barrier crossings in the Big Canyon watershed.

Stream Name	Stream Crossing	Barrier Status		Habitat Blocked ² (mi.)	Rank ³
		Juveniles	Adults		
Long Hollow	B420-0018b	Impassable	Impassable	2.369	20.0
Holes	B420-0026b	Impassable	Unknown	0.945	11.5
Cold Springs	B420-0007	Impassable	Impassable	0.236	11.0
Big Canyon	B420-0009	Impassable	Impassable	0.077	10.3
Long Hollow	B420-0020	Impassable	Impassable	0.065	10.3
Tributary to Big Canyon 1	B420-0037	Impassable	Unknown	0.352	9.0
Tributary to Big Canyon 3	B-422-0021	Impassable	Unknown	0.231	8.5

¹This refers to the miles of habitat known to be currently blocked by this structure. This figure does not include any first order streams that were not inventoried.

²The rank is the total score assigned to this crossing, based on the prioritization criteria outlined in the methods section of this document.

THIRD BARRIERS

There were also ten structures were identified as the third barrier within the stream network encountered during upstream migration, referred to as “third barriers”. All of these sites are depicted in Table VIII below in their relative order of replacement importance. Some of these sites contained more than one structure at each location, which is depicted in the total number column of the table. The highest possible rank score for this category was a value of twenty, due to life history considerations.

Table VIII. All third barrier crossings in the Big Canyon watershed.

Stream Name	Stream Crossing	Barrier Status		Habitat Blocked ¹ (mi.)	Rank ²
		Juveniles	Adults		
Long Hollow	B-422-0020	Impassable	Passable	8.102	20.0
Tributary to BC 1	B420-0038	Impassable	Impassable	1.203	11.5
Holes	B420-0032b	Impassable	Impassable	0.706	10.9
Big Canyon	B420-0010	Impassable	Impassable	0.554	10.7
Cold Springs	B420-0006b	Impassable	Passable	2.071	7.6
Long Hollow	B420-0019	Unknown	Passable	0.650	3.3
Holes	B420-0031b	Unknown	Passable	0.249	2.8

¹This refers to the miles of habitat known to be currently blocked by this structure. This figure does not include any first order streams that were not inventoried.

²The rank is the total score assigned to this crossing, based on the prioritization criteria outlined in the methods section of this document.

POSSIBLE COMBINATIONS OF REPLACEMENT SITES

As stated in the methods section of this document, after all crossings through the third barrier were investigated, a comparison of different combinations of barrier replacements was conducted. This process was done to accommodate the potential ecological and biological value of replacing more than one structure per stream. The following table outlines the comparisons of the first two barriers within a stream section, for all possible combinations within the Big Canyon watershed, hereafter termed “first two barriers”. Likewise, the analysis of all possible combinations of the first three barriers was conducted. Table X depicts all possible combinations of third barrier sites. The first barrier crossings not considered previously will not be considered in this context either. It must also be noted at this time that some stream systems will have multiple first and second barrier combinations, which are all considered. The highest possible rank score for the first two barriers was a value of thirty and for the first three barriers was a value of forty.

Table IX. Comparative values of replacing the first two barriers.

Stream Name	Crossing Position ¹		Habitat Blocked ² (mi.)	Rank ³
	1	2		
Long Hollow	B420-0021	B420-0018b	4.757	30.0
Cold Springs	B420-0014b	B420-0007	2.612	25.5
Long Hollow	B420-0021	B420-0020	2.453	25.2
Big Canyon	B420-0016	B420-0009	0.251	20.5
Tributary to BC 3	B-422-0022	B-422-0021	1.069	19.7
Holes	B420-0027b	B420-0026b	1.158	14.9
Tributary to BC 1	B420-0040b	B420-0037	0.638	13.8

¹Crossing position refers to the relative position of the barrier within the stream network.

²This refers to the miles of habitat known to be currently blocked by this structure. This figure does not include any first order streams that were not inventoried.

³The rank is the total score assigned to this crossing, based on the prioritization criteria outlined in the methods section of this document.

Table X. Comparative values of replacing the first three barriers.

Stream Name	Crossing Position			Habitat Blocked ¹ (mi.)	Rank ²
	1	2	3		
Long Hollow	B420-0021	B420-0018b	B-422-0020	12.859	35.0
Big Canyon	B420-0016	B420-0009	B420-0010	0.805	30.6
Cold Springs	B420-0014b	B420-0007	B420-0006b	4.683	28.6
Long Hollow	B420-0021	B420-0020	B420-0019	3.103	24.9
Tributary to Big Canyon 1	B420-0040b	B420-0037	B420-0038	1.841	23.9
Holes	B420-0027b	B420-0026b	B420-0032b	1.864	23.9
Holes	B420-0027b	B420-0026b	B420-0031b	1.406	16.1

¹This refers to the miles of habitat known to be currently blocked by these structures. This figure does not include any first order streams, as they were not inventoried.

²The rank is the total score assigned to this crossing, based on the prioritization criteria outlined in the methods section of this document.

DESIGN REPLACEMENT SURVEYS

The third and final tier of this analysis was performing the design replacement surveys. Again due to inclement weather at the end of the season, this portion of the analysis was not conducted.

DISCUSSION

This inventory and assessment included seventy-nine stream sites. Over seventy percent of these crossings were culverts. The majority of the remaining sites (25 inventories) were bridges and fords, while only one was a unique structure. The only unique structure was a culvert, located on Long Hollow creek. This particular culvert type could not be definitively distinguished as an open-bottom or squashed pipe-arch. All natural features were excluded from replacement prioritization. In fact the only structures that were considered for replacement were the impassable culverts and any other sites which were qualitatively assessed as impassable.

The sites identified during this inventory as qualitative barriers ranged in scope from transient, seasonal to permanent barriers. As this survey was a “snapshot in time”, transient barriers, such as handmade dams or woody debris plugging inlets, were included within the context of the qualitative assessment when encountered. Although the total number and type of transient barriers were included within the results section of this document, they were not considered in the context of structure replacement. Every effort was made during the course of this survey to capture all of the other potential factors that may affect fish passage. However, it is unrealistic to assume that all such structures were inventoried, as that was beyond the scope of this survey.

As previously mentioned, there were some sites that did not get inventoried or assessed. It is estimated that these sites numbered between five and ten. However, these sites may not need further clarification to enable managers to make informed decisions about structure replacement priorities within the Big Canyon watershed. A further discussion about this topic will follow.

REPLACEMENT PRIORITY DISCUSSION

When using this rating system for prioritizing the stream crossings for replacement, there are a few key factors that become immediately apparent. For instance, when reviewing the information on the first barriers, depicted in Table VI, it is obvious that the first two sites listed by far re-open the most habitat. One of these sites is located on Long Hollow Creek, while the other is located on Cold Springs Creek. Both of these structures current block a relatively large and equal amount of upstream habitat. Their priority level is also reflected in their rank, relative to the other sites listed in this table.

As mentioned in the results section of this document, there were two sites which did not undergo prioritization for replacement. These specific sites were located on Sixmile creek and an unnamed tributary to Big Canyon (“Tributary to Big Canyon 1”).

One of the sites that was not considered further in the prioritization process was B-420-0045, located on Sixmile Creek. This structure was not included within the final recommendations for replacement because it is located upstream of a possible natural barrier, which was previously discussed in the results section of this document (see Figures 6 and 7).

The other site that was not considered for replacement was B-420-0040b. This crossing, located on an unnamed tributary to Big Canyon, was removed from consideration for replacement because there was very limited and poor quality habitat

above this site. The habitat upstream of this specific crossing was heavily impacted by cattle. Also, road construction along both banks had almost entirely disconnected the stream from the surrounding springs and hyporheic zone. At the time this survey was checked for quality assurance, the stream channel was dry. The GIS determination of the amount of habitat upstream of this site was about 0.28 miles. However, after the site re-visit, it is apparent that this is an over-estimate of the amount of habitat at this particular location.

Again there is an obvious candidate for replacement consideration when viewing the data related to the second barrier crossings (Table VII). The site on Long Hollow creek (B-420-0018b) will open approximately 2.4 miles of habitat when replaced. It is by far the most important second barrier crossing to be mitigated amongst this group. The next highest amount of re-opened habitat is on Holes creek (B-420-0026b) at less than one mile. Even though the crossing on Holes creek opens less than one mile of habitat, it is also distinct from the remaining second barrier crossings in this respect. However, due to the life history stages impacted, the overall ranking for this site does not distinguish it from the remaining crossings.

When reviewing the data for all third barriers, the case for structure replacement is much more definitive for the first choice (Table VIII). However, there was a difference in the ranking and miles re-opened in terms of structure prioritization. The site that ranked as the highest priority site would re-open just over eight miles of habitat, relative to 1.2 miles for the next crossing and 0.7 miles for the third highest mileage re-opened. Further down the list there was a site that would re-open over two miles of habitat. Following is a more thorough discussion of this occurrence and the reasoning each specific site's rank was determined to be what it was relative to other sites.

The Long Hollow site (B-422-0020), which would open the most habitat, also ranked as the highest priority of this group for replacement. This was followed by the tributary to Big Canyon #1 (site B-420-0038) that would re-open 1.2 miles of habitat, then by a site on Holes creek (B-420-0032b), which would only re-open seven-tenths of a mile. One can see from this table that even though the Cold Springs site (B-420-0006b) that would re-open over two miles of habitat did not rank as high. Again, this was due to accounting for the life history stages impacted by each passage obstruction (See Appendix A for a sample calculation).

However, the Long Hollow site (B-422-0020) above is not an actual road crossing, but rather a cement weir across the stream's active channel. As such, it was not quantitatively assessed, but instead qualitatively assessed as a migration barrier. This particular site is a barrier to juvenile life stages, but is not likely an adult migration barrier.

Although, caution should be used when deciding on these third barrier replacements to determine which structure(s) is/are of the highest ecological replacement value. Very little is known of the habitat quality upstream of these sites. Also, after replacing one or two of the other first and/or second barriers, a reassessment should be performed to determine which site is the highest priority at that time. Comparisons of multiple replacement options may demonstrate that efforts would be more efficiently and effectively focused within a given stream network, instead of viewing all barriers independently of one another.

BARRIER COMBINATIONS DISCUSSION

It is apparent after reviewing Table IX of the comparisons among the first two barrier crossings that Long Hollow creek is of the highest value to replace and/or mitigate. Long Hollow has two different possible combinations of two barrier structures. The first combination (B-420-0021 and B-420-0018b) is of significantly more value to replace, both in terms of the amount of habitat and overall rank.

The other Long Hollow crossings (B-420-0021 and B-420-0020) which would be of importance to replace are relatively equal to the next highest priority crossings, located on Cold Springs creek (B-420-0014b and B-420-0007). These two groups of crossings block almost identical amounts of habitat and ranked almost equal for replacement priority. The determination of which of these streams will be the focus of replacement consideration should also include other factors not directly accounted for within this discussion. These factors will attain more attention at the conclusion of this discussion.

When reviewing Table X of the first three barriers, it is again demonstrated that Long Hollow should be the focal stream for replacement efforts. A key distinction between comparing the first two or three replacement candidates arises when viewing this table. The second choice, based on the overall rank, is located on Big Canyon Creek in this context, unlike the second choice discussed in the first two barrier comparison above. Then the sites located on Cold Springs Creek, including the first two discussed above, rated as the third priority when considering the first three barrier combinations. The reason this ranking procedure produced this prioritization order was due to the amount of habitat re-opened by the barrier relative to the barrier position and the life history stages impacted at each location (See Appendix A for a sample calculation).

Again caution is urged when the final decision is made to include other factors not considered within this document. The total rank or the amount of habitat must be coupled with other factors, such as habitat complexity and quality. A more complete discussion of other considerations will follow.

This comparison of multiple structure replacement is meant to guide managers is making the ultimate decision as to the specific structures to replace. It is also meant to aid in the longer term planning of replacements, beyond the first replacement year. However, this document will ultimately address the sites that were of the highest replacement value at the time of this publication from a watershed-wide perspective.

HIGHEST PRIORITY REPLACEMENT CANDIDATES

Table XI depicts the *suggested* replacement priority for the Big Canyon watershed, using this selection process. As previously noted, the first barrier encountered within the watershed was considered a higher priority than all other barriers. Because of the emphasis placed on migratory fish species, some second and third barrier crossings were selected as a higher priority than others due to the higher priority assigned to other downstream crossings on the same stream. These sites in general had more diverse habitat and allow for addressing fish passage from a more

holistic, total stream perspective. Some sites were chosen with a relatively low overall rank score and/or miles of habitat blocked. These sites were chosen because they were located downstream of one of the other sites in this table, which obtained a high priority rank.

This table is a compilation of all of the best available information at this time to determine which specific crossings should be replaced, in what relative order and over the longest possible timeframe. Some of the sites listed in the table may be of relatively equal importance, thus, it must be stressed that this is a *relative* priority list. This relativity is reflected in the replacement order column in the table. The suggested replacement order delineated below highlights the sites of relatively equal replacement importance. Figure 7 shows these recommended top ten highest priority crossings.

Table XI. The recommended structure replacement priorities within the Big Canyon watershed.

Stream Name	Replacement Order	Stream Crossing	Barrier Order	Habitat Blocked (mi.)	Rank
Long Hollow	1	B-420-0021	1	2.388	20.0
Cold Springs	1	B-420-0014b	1	2.376	20.0
Long Hollow	2	B-420-0018b	2	2.369	20.0
Cold Springs	3	B-420-0007	2	0.236	11.0
Long Hollow	3	B-422-0020	3	8.102	20.0
Cold Springs	4	B-420-0006b	3	2.071	7.6
Tributary to Big Canyon 3	5	B-422-0022	1	0.838	13.5
Holes	6	B-420-0027b	1	0.213	5.9
Holes	7	B-420-0026b	2	0.945	11.5
Tributary to Holes 1	8	B-420-0032b	3	0.706	10.9

Table XII relates the amount of habitat currently blocked by each of the replacement candidate structures to the percentages of total habitat and total currently blocked habitat. As stated in the introduction, the total miles of habitat inventoried in the Big Canyon watershed was 119.6. Of these miles, it was determined that 35.8 miles are currently blocked (Figure 2). Likewise, 83.8 miles are currently passable to all fish life history stages. As an example, by replacing the first site in this table, managers could regain 2.00 percent of the total inventoried stream miles. Using the same example, one could re-open 6.67 percent of the total currently impassable miles of habitat.

Furthermore, if all of the sites in the table were replaced, approximately 20.2 miles of habitat would be re-opened. This equates to 16.9 percent of the total inventoried stream habitat and 26.6 percent of the currently blocked habitat. Replacing all of these sites would allow for fish passage on about 104 miles of stream (eighty-seven percent of the total habitat). This would reduce the amount of blocked habitat to

15.6 miles (thirteen percent of the total habitat). Beyond the crossings delineated as priorities here, the next priority crossings are much less distinct. This is due to the relatively insignificant amount of habitat blocked by these sites. Therefore, after these crossings are addressed, the barrier crossings which remain within the Big Canyon watershed will need to be re-assessed and analyzed to determine what the priorities are at that time.

Again, it should be stressed that after the selected candidates are addressed, the data should be reviewed prior to selecting any additional crossings. This could result in a change in the highest priority group, as the scope of inference will change.

As previously eluded to, the addition of some quantitative measure of habitat quality and complexity within the prioritization scheme would have greatly enhanced the biological significance of the selection criteria. However, at this time there are no watershed wide measures of these parameters. Therefore, this selection process could not incorporate those measures.

Table XII. The amount of habitat regained by the suggested structure replacement within the Big Canyon watershed.

Stream Crossing	Habitat Blocked (mi.)	Percent of Total Habitat¹	Percent of Total Habitat Blocked²
B-420-0021	2.388	2.00	6.67
B-420-0014b	2.376	1.99	6.64
B-420-0018b	2.369	1.98	6.62
B-420-0007	0.236	0.20	0.66
B-422-0020	8.102	6.77	22.63
B-420-0006b	2.071	1.73	5.78
B-422-0022	0.838	0.70	2.34
B-420-0027b	0.213	0.18	0.59
B-420-0026b	0.945	0.79	2.64
B-420-0032b	0.706	0.59	1.97
Total	20.244	16.93	56.55

¹This number represents the percent of habitat blocked by these individual sites, relative to the total inventoried miles of habitat within the watershed.

²This number represents the percent of habitat blocked by these individual sites, relative to the total miles of habitat currently blocked within the watershed.

Figure 8. The top priority replacement structures within the Big Canyon watershed.

OTHER ONGOING RESTORATION ACTIVITIES

There are some areas within the Big Canyon watershed in which other ongoing restoration efforts are occurring. These efforts include riparian fencing and plantings, road treatment to reduce sediment delivery to streams and biological inventories.

There are a variety of factors other than those outlined above that should be considered when finalizing the selection of specific structures to be mitigated. The aforementioned factor, other on-going restoration efforts within a specific stream system, is one such item. It may be determined at a later date that it would be of greater benefit from an ecosystem perspective to focus all restoration efforts within a subwatershed or basin.

It would also be of benefit to consider the possibility of creating partnerships for specific projects. This may create the possibility of addressing more barrier structures than one agency could otherwise do on their own. It also opens the prospect of attaining additional funds through cost-share opportunities.

PROBLEMS ENCOUNTERED/PROTOCOL DEVIATIONS

One of the relatively important issues of concern encountered while conducting the field portion of this project was the inability to obtain permission to access some sites. However, as stated in the results and discussion sections of this document, these sites are not considered fish passage barriers. Thus, these sites will not need any further investigation in the coming field season.

SUGGESTED PROTOCOL IMPROVEMENTS

It is the opinion of the author that the abbreviated version of the protocol used in conducting these surveys was of great value. It allowed for a more stream-lined approach to determine fish passage. This, in turn, allowed for more crossings to be assessed in the allotted timeframe. However, several areas could be addressed to improve the overall strength and breadth of this survey.

One such improvement would be the development of a standardized list of comments to be taken at every site. This would allow for continuity, as well as the inclusion of other selection factors when prioritizing sites for replacement. Some comments that could be included are: dry channel; fish observations, both relative numbers and by species, if possible; heavy livestock use; logging activities; and, other possible restoration opportunities.

It would also be of benefit to add a subjective evaluation of fish habitat quality. Here the focus might be on an indicator and/or focal species, such as *O. mykiss*. This might be as simple as “poor, good or pristine” and should be done immediately upstream and downstream of the structure. This might allow for another subjective selection criterion near the end of the selection process, when determining priority replacement sites. Obviously, this evaluation necessitates the need for training to initially calibrate crews.

The qualitative assessment mentioned above would yield some useable information, but the real need is for further, more comprehensive evaluations of habitat quality and complexity within the entire watershed. One possible way of accomplishing this would be to conduct a USDA- Forest Service, Level II, Hankin & Reeves habitat inventory on selected streams within the watershed (Hankin and Reeves 1988). This would enable managers to much more holistically address specific concerns.

SUGGESTED POSSIBLE FUTURE ACTIVITIES

Besides the aforementioned items to be addressed, there are a variety of other areas that need to be accomplished in the future. One aspect that needs to be addressed is the design replacement surveys, which should be conducted for all of the barrier sites selected for replacement. This would allow for cost comparisons amongst contractors.

At this point, the selected site(s) could be replaced. After they are replaced, this analysis should be re-ran to be able to compare all of the first barrier crossing sites, as this group will then include one or more additional crossings. However, the comparison of multiple crossings allows resource managers to focus their efforts for the near future without re-analyzing all of the current data.

Some additional areas that need future consideration brought to light by these inventories were possible educational opportunities. It was apparent from conducting these surveys that there are a variety of factors effecting fish passage that could easily be solved through education. For example, there were numerous hand-made dams for irrigation that were at least partial fish migration barriers. Another area that educational efforts should focus on includes items such as the consideration of fish passage in future projects and culvert installations. This would require considerable cooperation with other resource managers and agencies, such as SWCD, NRCS, USDI-BLM, IF & G and IDL.

Also as part of the collaborative effort to more holistically approach restoration, additional and more intense cooperation with other resource groups and agencies should be of the highest priority. This would allow managers to incorporate other ongoing restoration efforts within a given system into their activities and address watershed restoration more completely.

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APPENDIX A: FORMULA TO PRIORITIZE CROSSINGS

The formula used to obtain the empirical rank for replacement priority.

$$[10 \times (\text{miles}/A) + \text{Juvenile} + \text{Adult}] = \text{Relative Overall Rank}$$

miles = the miles of habitat re-opened for that specific crossing;

A = the most miles of habitat possible for that crossing order (one, two or three);

Juvenile = the barrier status for this life history stage (0 for passable, 2.5 for unknown and 5 for impassable); and

Adult = the barrier status for this life history stage (0 for passable, 2.5 for unknown and 5 for impassable)

Site B-420-0021, for example currently blocks 2.388 miles of habitat and is a barrier to both adult and juvenile life history stages. This example also blocks the most miles of habitat of any of the first barrier crossings encountered within the Big canyon watershed. The calculation to determine its rank would be as follows:

$$[10 \times (2.388/2.388) + 5 + 5] = 20.0$$

Thus, the overall ranked score for this site is 20.0. The same procedure and formula was utilized to obtain the empirical rank score for all first, second and third barriers encountered within the Lapwai watershed. It was also utilized to obtain all barrier combination rank scores.

APPENDIX B: FIELD INVENTORY FORM

Stream Crossing ID # _____

GENERAL SITE INFORMATION

Road Name: _____ Milepost: _____
From Junction of Road: _____
Road Ownership: _____ Land Ownership: U/S _____ D/S _____
Stream Name: _____
X/Y Coordinates: _____ Coordinate System: _____ Datum: _____
Surveyor Names: _____ Field Date: ____/____/____

CROSSING STRUCTURE

Structure Type:

☐ Circular ☐ Box ☐ Open-Bottom ☐ Pipe-Arch ☐ Ford ☐ Vented Ford ☐ Bridge ☐ Other: _____

Multiple Structures:

Structure ____ of ____ # Identical orifices: ____ # Different orifices: ____ # Overflow pipes: ____

External Structure Features:

☐ Inlet Apron ☐ Trashrack ☐ Outlet at stream grade ☐ Outlet freefall into pool ☐ Outlet freefall onto riprap
☐ Outlet cascade over riprap ☐ Outlet apron ☐ Other: _____

Baffles/Weirs/Other Internal Structures: ☐ Yes ☐ No

Material: _____ Describe: _____

Streambed Substrate in Structure:

☐ None ☐ Discontinuous Layer ☐ Continuous Layer

Overall Pipe Condition:

☐ breaks inside culvert (Location ____ ft. from ____) ☐ fill eroding ☐ debris plugging inlet (% blockage ____)
☐ bent inlet ☐ bottom worn through ☐ poor alignment with stream ☐ debris in culvert (rock wood)
☐ bottom rusted through ☐ water flowing under culvert ☐ other _____

COMMENTS

PHOTOGRAPHS---identify and provide captions

1. Upstream channel from inlet
2. Inlet from upstream
3. Outlet from downstream
4. Tailwater control

5. _____
6. _____
7. _____
8. _____
9. _____

Stream Crossing ID # _____

MEASUREMENTS

Culvert (ft): Width: _____ Length: _____
Channel Widths (ft): (1) _____ (2) _____ (3) _____ (4) _____ (5) _____
Elevations (ft): Benchmark (_____) _____ Inlet Invert (P2) _____ Outlet Invert (P4) _____
Pool Bottom (P5) _____ Tailwater Control (P6) _____ Benchmark (_____) _____

CALCULATIONS

Average Channel Width (ft): _____ ((Add 5 Channel Widths) / 5)
Culvert Width to Channel Width Ratio: _____ (Culvert Width / Channel Width)
Outlet Drop (ft): _____ (P6 - P4)
Residual Inlet Depth (ft): _____ (P2 - P6)
Residual Pool Depth (ft): _____ (P5 - P6)
Residual Pool Depth to Outlet Drop Ratio: _____ (Residual Depth / Outlet Drop)
Culvert Slope (%): _____ (P4 - P2) / Culvert Length * 100

QUANTITATIVE FISH PASSAGE EVALUATION

Juveniles:

☐ Natural Channel Simulation ☐ Green ☐ Red ☐ Grey

Adults:

☐ Natural Channel Simulation ☐ Green ☐ Red ☐ Grey

Comments:

QUALITATIVE FISH PASSAGE EVALUATION

Are there any additional features present that could affect fish passage?: ☐ Yes ☐ No

Describe:

Is this form completed?: ☐ Yes ☐ No Initials: _____

APPENDIX C: JUVENILE FLOW CHART

Region 1 Fish Passage Evaluation Criteria

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Juvenile salmonid fish passage evaluation criteria at flows less than bankfull flows for Region 1

(NOT INTENDED TO BE USED FOR DESIGNING NEW STRUCTURES)

Figure 1. Fish passage evaluation criteria for Region 1 juvenile salmonids.