PACK RIVER
STREAM CHANNEL ASSESSMENT

Submitted to:

Avista Utilities
Noxon, Montana

and

Pack River
Technical Advisory Committee

Submitted by:

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EXECUTIVE SUMMARY

Located in northern Idaho, the Pack River is the second largest tributary to Lake Pend Oreille. The river contains important spawning and rearing habitat for Endangered Species Act (ESA)-listed bull trout and a number of other fish species. In 2000, the Pack River Watershed Council (Council) was formed in order to address known and potential impairments within the watershed. A Technical Advisory Committee (TAC) was formed in August 2001 to provide technical guidance to the Council. In 2002, Avista Utilities (Avista) provided the Council and TAC funding to conduct a characterization of the fish habitat, geomorphic features, and riparian habitat of the Pack River.

The overall goal of the Stream Channel Assessment was to conduct a baseline condition inventory of geomorphic features and fish/riparian habitat for the Pack River. This information will provide a framework for the development of the Pack River Watershed Management Plan and TMDL Implementation Plan.

Methods

The Stream Channel Assessment investigation included methodologies selected by the TAC for the inventory of geomorphic, riparian, and fish habitat conditions. Forty continuous miles of the Pack River from the McCormick Creek to the river's confluence with Lake Pend Oreille were surveyed in September 2002. The Rosgen stream classification system was used to characterize important geomorphic features of the Pack River and existing conditions and trends. Vegetation communities were sampled following the "greenline" methodology described in Winward (2000). To assess fish habitat, an R1/R4 Fish and Fish Habitat Survey (Overton et al. 1997), as adapted by the US Forest Service Sandpoint Ranger District, was completed.

Results

Fifty-four continuous sub-reaches were inventoried on the Pack River for geomorphic condition, riparian habitat, and fisheries habitat. Using overall Pack River gradient changes and gradation in substrate size, the 54 sub-reaches surveyed were grouped into larger reach segments as follows:

Reach A: Zuni Creek confluence to McCormick Creek confluence

Reach B: McCormick Creek confluence to Hellroaring Creek confluence

Reach C: Hellroaring Creek confluence to 2 miles downstream of Caribou Creek

Reach D: Two miles downstream of Caribou Creek confluence to US 95 bridge

Reach E: US 95 bridge to near Highway 200 bridge

Reach F: Near Highway 200 bridge to confluence with Lake Pend Oreille

Reference Condition

For comparative purposes, reference geomorphic, riparian and fish habitat conditions for Pack River sub-reaches were derived from high quality sub-reaches and available pertinent literature. The appropriate Pack River reference condition is dependant on the location of the reach within the river system.

- Geomorphic reference conditions for the Pack River are largely a factor of channel and valley shape and slope. These reference conditions are generally represented by a stable Rosgen B-type stream channel in Reaches A and B, while Reaches C, D, and E would be characterized by a stable C-type stream channel.

- Vegetation reference conditions of Reaches A through D can be characterized by the Western redcedar vegetation type, with a subdominant alder or willow type Reference riparian vegetation for Reach E included sub-reaches that had both western redcedar and black cottonwood as co-dominant types with a sub-dominant understory of willow.

- General fish habitat reference conditions are best reflected by the available literature for similar areas. For example, the reference amount of large woody debris is dependent on channel gradient and riffle width. According to Interior Columbia Basin Ecosystem Management Project (ICBEMP) (1997), for channels with a gradient of 2 to 4 percent, the 75th percentile for habitat includes large woody debris at a rate of 448 pieces per foot of riffle width for each mile.

Reach A: Sub-reaches 1-8

The stable geomorphic reference condition for Reach A is a Rosgen B type. In general, sub-reaches 1, 2, 4, 5, and 6 exhibited a stable B type channel morphology. Sub-reaches 3, 7, and 8 diverge from the stable channel characteristics as a result of differences in width to depth, entrenchment, and slope

Of all sub-reaches, those of Reach A have vegetation conditions most similar to that of the reference condition. In only two sub-reaches does the vegetation differ significantly from the western redcedar community reference state.

Slow water habitat was higher in Reach A than in most of the other reaches on the river. In general, pools in Reach A were formed predominantly as a result of boulder scour areas and, to a lesser extent, large woody debris. Both sub-reaches 1 and 5 had over 50 percent slow moving habitat while the remaining sub-reaches contained less. Sub-reaches 3, 4, and 7 were particularly lacking in pool habitat in Reach A.

Based on riffle width in Reach A, sub-reaches should contain 15 to 20 pieces of large woody debris per mile of stream channel. Three of the eight reaches had more than the reference amount of large woody debris, while the other five had less. Much of the woody debris found within the sub-reaches of Reach A was of small diameter (<12 inches).

Reach B: Sub-reaches 9-21

Roughly half the sub-reaches (13, 14, 15, 16, 20, and 21) exhibit a stable channel morphology (B3-type) similar to the reference reach. These channels seem to generally be in balance with their geomorphic setting. These sub-reaches are B stream types, with low-to-moderate gradients, gentle sideslopes, and cobble/boulder-gravel substrates that aid in channel stability. Though generally in overall balance with slope and sinuosity to the reference sub-reach, sub-reaches 15 and 20 may be functioning slightly at risk. Bankfull width/depth ratios for sub-reaches 15 and 20 are higher than expected from the reference sub-reach. The other sub-reaches within Reach B have channel morphologies that diverge from the desired type.

The sub-reaches of Reach B are highly vegetated with bank stabilizing vegetation types. However, the sub-reaches have significantly less late-seral habitat than those of Reach A.

Pool habitat was substantially decreased in Reach B as compared to Reach A. The significant decline in the presence of large boulders in Reach B resulted in significantly less pool habitat. Reach B also lacked significant large woody debris to create and sustain pool habitat.

Seven sub-reaches had no pool habitat. Sub-reach 9 had the highest amount of pool area. Sub-reaches 11 and 19 had moderate amounts of pool area. Sub-reaches 13 through 16, 18, 20, and 21 were severely limited by lack of pool habitat. This is likely a factor of many of the sub-reaches experiencing an aggrading condition, resulting in less pool habitat and increased riffle habitat.

Based on riffle width in Reach B, sub-reaches should contain approximately 10 pieces of large woody debris per mile of stream channel. Four sub-reaches had more than the reference amount of large woody debris. Overall, the amount of large woody debris found in the sub-reaches of Reach B was significantly less than the reference. Most of the woody debris found within the sub-reaches of Reach B was of small diameter (<12 inches). As a result, in general, the woody debris in the channel is performing little habitat forming functions.

Reach C: Sub-reaches 22-30

Reach C of the river represents a decrease in gradient and channel substrate size from Reaches A and B. As a result, sub-reaches in Reach C changed morphology dramatically. Reach C sub-reaches exhibit unstable C-type and F-type channel morphology. Sub-reaches in Reach C diverge from the reference condition completely (different channel type) or partially (same channel type, but significantly different characteristics).

The vegetation of sub-reaches of Reach C represent a much earlier stage of succession than those found in Reaches A and B. There is little to no late-seral vegetation, and early seral vegetation is dominated in all sub-reaches by willow. The dominance by willow in these sub-reaches indicates an even earlier level of succession than that of the alder dominated areas in Reach B.

As in Reach B, lack of slow or pool habitat was a limiting feature in fish habitat in Reach C. Formative features for development of pool habitat, such as boulder scour areas or large woody debris, were generally not present in Reach C.

Four sub-reaches had no pool habitat within the area measured. Sub-reach 29 had the highest amount of pool area compared to the reference reach. Sub-reaches 24, 27, 28, and 30 had minimal amount of pool area. Sub-reaches 22, 23, 25, and 26 were severely limited by a lack of pool habitat. As in Reach B, pool habitat was compromised in much of Reach C due to aggrading channel conditions that increased fast water habitat. Slow moving habitat, where it occurred, was generally a result of large woody debris obstructions. As a result of the overall lack of large woody debris throughout Reach C, the amount of pool habitat is reduced.

Based on riffle width and gradient in Reach C, sub-reaches should contain approximately 3.5 pieces of large woody debris per mile of stream channel. Four of the sub-reaches had more than the reference amount of large woody debris. Reaches 27 through 29 in particular had very high amounts of large woody debris compared to the reference condition.

Reach D: Sub-reaches 30-39

Reach D consists primarily of unstable sub-reaches of the F and C stream channel types. Only sub-reaches 36 and 37 (C4 types) appear to be in balance. The remaining sub-reaches within Reach D have channel morphologies that diverge from the reference condition.

Reach D represents an improvement in vegetation condition over Reach C. Seven of the sub-reaches exhibited some amount of late-seral vegetation (predominantly Western redcedar). In addition, Western redcedar was prevalent on the floodplain in the area just outside the greenline of the channel in these sub-reaches. More late-seral vegetation occurs in these sub-reaches than Reach C. However, the sub-reaches of Reach D still have significantly less late-seral habitat than the reference sub-reach. As a result of the channel entrenchment associated with many of these sub-reaches, high streambanks have resulted and upland vegetation types occupy a large percentage of the riparian area.

As in Reaches B and C, lack of slow habitat was a limiting feature in fish habitat in Reach D. However, there was more slow habitat present in Reach D than in both Reaches B and C. There was slightly increased amounts of pool-forming large woody debris obstructions in Reach D. Slow moving habitat was generally a result of these large woody debris obstructions.

Reach D had variable amounts of pool habitat depending on the sub-reach. Sub-reaches 31, 36, and 39 had the highest amount of pool area. Sub-reaches 34 and 35 had moderate amount of pool habitat. Sub-reaches 32, 33, and 37 were severely limited by a lack of pool habitat.

Based on riffle width and gradient in Reach D, sub-reaches should contain approximately 3.5 to 4.5 pieces of large woody debris per mile of stream channel. The amount of large woody debris found in the sub-reaches of Reach D was less than the reference in all but one case. As with all other reaches, most of the woody debris found within the sub-reaches of Reach D was of small diameter (< than 12 inches), was short (< than 6 feet) and did not qualify as large woody debris. The small woody debris is performing limited habitat function.

Reach E: Sub-reaches 40-52

Reach E is characterized primarily as a C type stream. The sub-reaches exhibit predominantly low gradient areas with moderate to high sinuosity, low to high entrenchment ratios, and moderate to high width/depth ratios. The dominant substrate in Reach E is fine gravel and sand. This is a finer particle size than all reaches described upstream. While only three sub-reaches exhibit channel types that deviated from the overall C reference type, many of the C-type sub-reaches exhibit characteristics that indicate a state of disequilibrium with their surroundings.

Reach E sub-reaches are generally represented by early-seral species (willow types) with additional large areas dominated by upland types. The presence of the early-seral species indicates riparian vegetation adjustment to disturbance effects. In addition, a prevalence of invasive species, particularly common tansy and Canada thistle, were noted throughout the Reach E sub-reaches. This occurrence of invasive species degrades the health of the riparian habitat creating monocultures and limiting the presence and reproduction of native grasses and forbs.

Reach E represents a shallow gradient meandering C stream channel type. This area would predominantly serve as migratory passage habitat for salmonids and is typified by broad expanses of alternating pool and riffle habitat. Thus, lack of deep, slow habitat was a limiting feature in fish habitat in Reach E. Where present, pools in these sub-reaches were generally a result of deep bed scour areas, and to a more limited extent, large woody debris.

Based on riffle width and gradient, sub-reaches should contain approximately 2 to 3.5 pieces of large woody debris per mile. In general, the amount of large woody debris found in the sub-reaches of Reach E was less than the reference. In sub-reaches 40 through 42, the amount of large woody debris exceeded the reference condition. As with all other reaches, most of the woody debris found was of small diameter (< than 12 inches), was short (< than 6 feet) and did not qualify as large woody debris.

Reach F: Sub-reaches 53 and 54

These sub-reaches were not typed, but have more lentic, wetland characteristics due to inundation and flooding caused by increased water levels of Lake Pend Oreille. The reservoir has flooded much of the land that was historically hayland. The surface water and raised water table in the area results in an altered hydrology, which created an area with a more lentic character. Hydrophytic vegetation such as bulrush and cattails predominate in the lower areas and cottonwoods occur away from the lotic portion of the area.

Conclusions and Recommendations

The Pack River is affected by several important and inherent characteristics that influence its natural channel form. These characteristics include:

- Arid climate and rain-on-snow, flashy hydrology,
- Geology and high erosivity of hillslope soils,
- Disturbance from fires,
- Steep, confined topography and high valley slope of the upper watershed, and
- Broad alluvial valley and gentle slope of the lower watershed.

In addition to inherent, natural watershed characteristics, two general types of human induced changes were found in the Pack River system. The first type includes changes due to direct modification of the channel itself. The second type is out-of-channel activity that likely modifies discharge and/or sediment load of the stream and ultimately results in stream channel response.

Likely human-caused factors affecting the current Pack River channel condition are listed below. Only factors that were documented in this investigation are included here.

- Increased human-caused sediment inputs resulting from road construction, mass failures associated with roads, and potential management issues associated with tributary watersheds;
- Reduction of (or changes in) riparian vegetation through timber harvest, agricultural land uses, and residential developments; and
- Localized channel modifications with riprap or similar bank stabilization, and in- channel manipulation.

Recommendations for improvement of Pack River watershed condition based on the results of this study include the following:

- Sediment from anthropogenic sources should be reduced. Sediment sources apparent from this field review included: sediment associated with roads and current and historic reduction/removal in vegetation in both uplands and riparian areas. Forestry control measures to prevent erosion from roads in the upper watershed is of paramount importance. A sediment source survey of tributary watersheds (particularly Caribou, Colburn, Sand, and Grouse creeks) should be conducted and efforts made to reduce any sediment contributions.

- Except where limited by topography, channel redesign of F stream types can be used to develop C channel types that are in balance with the landscape. Channel re-design of F type streams can occur in sub-reaches: 22, 24, 31, 38-41, and 43.

- Channel enhancement can also be used to rehabilitate stream channels that are similar to the reference type, but which exhibit other characteristics (such as high width/depths) that deviate from the reference condition. These include sub-reaches 3, 7-10, 17-19, 23, 26-35, and 46-52. Prescriptions for stabilizing channel dimensions should be developed for these sub-reaches on a case by case, considering the results of this investigation.

- The results of this study should be used to plan stream rehabilitation efforts more effectively by stream type.

- Late-seral (Western redcedar habitat type) vegetation can be encouraged, preserved, and maintained. This recommendation is particularly pertinent to all sub-reaches of Reach C, D, and E, and F.

- Land use practices that provide for increased riparian buffer width, particularly in sub-reaches of Reach C, D, E, and F, can be highly encouraged

- To assist in developing riparian buffer guidelines for the Pack River, a historic channel meander study can be conducted.

- The amount of late seral (Western redcedar habitat type) vegetation can be increased in areas in which bank height extends beyond the rooting capacity of current vegetation (bank re-shaping may be required in some areas to achieve this). Excessive bank height applies to sub-reaches of Reach E.

- Efforts to control invasive species including reed canarygrass in Reach E, can be increased. Specific control should be focused on sub-reaches 41-45, 47, and 51.

- In the short-term, large woody debris can be added to areas with amounts below reference condition. Emphasis should be placed on Reaches B through D, in an upstream to downstream order.

- The percentage of pool habitat area can be increased throughout the river, specifically in Reaches B through D. Pool habitat in these areas will likely improve with the increased presence of large woody debris.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Located in northern Idaho, the Pack River is the second largest tributary to Lake Pend Oreille and contains important spawning and rearing habitat for a number of fish species. The lower portion of the Pack River, however, is water quality-limited (State of Idaho's 303 (d) List of Impaired Waterbodies) due to excess sediment and nutrients (Idaho Department of Environmental Quality, IDEQ, 2001). Lateral channel migration of the river is a source of sediment input and a concern for landowners due to the erosion of streamside property. The Pack River also contributes the highest per-acre loading of nitrates and phosphorous to Lake Pend Oreille. Despite these habitat impairments, the Pend Oreille Sub-basin Summary lists the Pack River as being a high priority for restoration/protection and having high potential to increase bull trout numbers (Northwest Power Planning Council, 2001).

In order to address issues within the watershed, the Pack River Watershed Council (Council) was formed in 2000. A major goal of the Council is to develop a comprehensive watershed management plan that will also serve as a Total Maximum Daily Load (TMDL) implementation plan. Other goals of the Council for the Pack River include:

- Setting water quality standards for sediment and nutrients;
- Restoring the Pack River to fully support beneficial uses and reducing downstream impacts;
- Reducing bank erosion and providing for floodplain management;
- Developing guidelines for restoration and stabilization activities;
- Maintaining and improving fish and wildlife habitat; and
- Providing for monitoring and evaluation activities.

A Technical Advisory Committee (TAC) was formed in August 2001 to provide technical guidance to the Council to meet its goals. The TAC is comprised of representatives of federal, tribal, state, and local agencies, and other organizations.

In 2002, Avista Utilities (Avista) provided the Council and TAC funding to conduct a characterization of the fish habitat, geomorphic features, and riparian habitat along 40 miles of the Pack River. As a result of the Lower Clark Fork River Settlement Agreement, Avista works collaboratively with stakeholders and provides funding to conserve and enhance native fish populations in areas such as the Pack River Watershed. The work plan for the current investigation of the geomorphic, riparian and fish habitat condition of the river was authorized by a contract signed between Avista and Golder Associates (Golder) in August 2002.

1.1 Background

The Pack River Watershed is located in the northern portion of the Lake Pend Oreille Basin in the panhandle of Idaho. From its headwaters at Harrison Lake on the Selkirk Crest, the river flows approximately 45 miles through forested and agricultural lands to Lake Pend Oreille (Figure 1). Pack River is the second largest tributary to Lake Pend Oreille and is fed by a number of significant tributary watersheds, including Grouse and Rapid Lightning creeks. The Pack River provides important spawning and rearing habitat and a migration corridor for adfluvial bull trout (*Salvelinus* *confluentus*), Westslope cutthroat trout *(Oncorhynchus clarki lewisi)*, kokanee (*Oncorhynchus nerka*), and Gerrard rainbow trout (a race of *Oncohyrnchus mykiss*). Bull trout are listed as Threatened through the Endangered Species Act (ESA), and Westslope cutthroat trout are a species of concern.

The watershed supports diverse land uses, such as agriculture, timber harvest, residential development, and recreation. As a result, road development in the upper watershed and loss of riparian vegetation and associated root masses due to fire, salvage, timer harvesting, livestock grazing, and/or clearing, may cause delivery of fine sediment to the stream channel. Present and historic land uses and the Sundance fire in 1967 have impacted habitat conditions for bull trout and other fish species in the Pack River (Panhandle Bull Trout Technical Advisory Team 1998). The current overall habitat condition of the Pack River watershed has been rated low (Northwest Power Planning Council (NPPC) 2001.

1.2 Prior Investigations

The specific habitat information described in this report has not been assembled before. However, other associated data have been or are in the process of being assembled by a variety of agencies and organizations. One such study includes the Lower Pend Oreille Key Watershed Bull Trout Problem Assessment (Panhandle Bull Trout Technical Advisory Team, 1998), which identifies many of the limiting factors for bull trout in the Pend Oreille system. The Pend Oreille Sub-basin Summary also provides general information on fisheries and fish habitat within the Pend Oreille watershed (NPPC, 2001).

The Idaho Department of Lands (IDL) is currently preparing a series of Cumulative Watershed Effects (CWE) reports on the Pack River Watershed. The CWE reports include the following drainages of the watershed:

- Pack River headwaters
- McCormick Creek
- Hellroaring Creek
- Grouse Creek headwaters
- North Fork Grouse Creek
- Martin Creek
- Lindsey Creek
- Caribou Creek
- Homestead Creek
- Jeru Creek
- Berry Creek
- Colburn Creek
- Gold Creek

The CWE assessments rely on direct measurements made in the stream and on the surrounding landscape. These observations allow an understanding of the slope and stream processes at work in the watershed and the cause-and-effect relationships between disturbance in the watershed and the stream. The current condition of the stream can be determined, effects of future forest practices anticipated, and management practices developed to correct any adverse conditions (IDL 2000). It is important to note, however, that the CWE analysis is conducted on forested lands within the watershed and not on agricultural ground. The CWE analysis is also only completed on private lands when the lands are located within forested sections of the watershed.

The US Forest Service (USFS) – Sandpoint Ranger District has collected a variety of data on the Pack River watershed. In September 2002, the USFS completed a geomorphic and fisheries habitat inventory from Zuni to McCormick creeks. The USFS also maintains reports and a series of historical aerial photographs.

Some habitat data collected by a variety of agencies and organizations that is pertinent to or complement this investigation include:

- *Fish Habitat:* Idaho Department of Fish and Game (IDFG) has conducted redd surveys since 1983.

- *Water Quality:* The US Geological Survey (USGS) collected a variety of water quality data from 1973 to 1987 at its gauging station on the Pack River near Colburn, Idaho. The Pack River Watershed Council has a volunteer water-quality monitoring program and collected chemical and physical water quality data, including dissolved oxygen, temperature, pH, BOD, and nutrients, from four sites on the Pack River since 1999. The Idaho Department of Environmental Quality (IDEQ) is collecting temperature data with thermographs placed along the Pack River. IDEQ also contracted multi-spectral imaging analyses of the river, which will be available in 2003.

- *Sediment:* A bank erosion inventory was completed in 2001. The erosion inventory survey started at the US 95 bridge, near the town of Samuels, and proceeded downstream to the lake.

1.3 Goals and Objectives

The overall goal of the Stream Channel Assessment was to conduct a baseline condition inventory of geomorphic features and fish/riparian habitat for the Pack River. This information will provide a framework for the development of the Pack River Watershed Management Plan and TMDL Implementation Plan. In general, this characterization will assist Avista and the TAC to accomplish the following:

1. Inventory existing conditions;
2. Identify problem areas;
3. Evaluate functioning conditions of resources; and
4. Explore opportunities for management and restoration of ecological functions.

A preliminary assessment meeting was held by Golder, Avista and members of a monitoring sub-committee of the TAC on August 28, 2002 to identify project goals and objectives.

Golder personnel conducted field work for the current investigation during September 2002. Golder performed initial data gathering, Rosgen Level II geomorphic classification, R1/R4 fish habitat inventory, and a greenline riparian inventory on 40 miles of the river from its confluence with McCormick Creek to the river mouth at Lake Pend Oreille. A greenline riparian inventory was also conducted by Golder from Zuni Creek to McCormick Creek.

The USFS Sandpoint Ranger District conducted the Rosgen classification and R1/R4 fish habitat portion of the inventory for the reach of the Pack River between Zuni Creek and McCormick Creek (Reach A). The data obtained in this survey report are integrated into this document. A report summarizing the USFS inventory is also attached as Appendix A.

For the Stream Channel Assessment, Golder also developed a Geographic Information System (GIS)-based data storage and presentation system of the Pack River habitat data. This dynamic system contains reach and sub-reach-specific data layers with links to an updateable ACCESS database and photographs of the individual sub-reaches. The GIS product and instructions for use are presented in Appendix B.

1.4 Report Structure and Organization

This report is based on the data review and field inventory of existing conditions on the Pack River conducted in 2002 and includes the following:

- A description of the study area including details on climatic conditions, soils and geology, vegetation, current and historic land uses, and natural disturbances (Section 2.0);
- A description of the survey methods employed (Section 3.0);
- Stream classification, fish habitat, and riparian habitat results by reach and sub-reach (Section 4.0); and
- A synthesis of the data and discussion of the functioning condition of the reaches and sub-reaches as well as impacts to the current condition (Section 5.0).

2.0 STUDY AREA DESCRIPTION

2.1 Overview

The Pack River drainage is a 101,207 - acre watershed located on the eastern flank of the Selkirk Crest in the Panhandle region of northern Idaho (Pack River DRAFT Watershed Management Plan 2003) (Figure 1). The second largest tributary to Lake Pend Oreille, the watershed spans two counties (Bonner and Boundary). From Harrison Lake on the Selkirk Crest, the Pack River flows approximately 45 miles south-southeast to the northern tip of Lake Pend Oreille between the communities of Hope and Sandpoint, Idaho.

The Pack River watershed is highly dissected and is comprised of an extensive array of short, parallel-running tributaries (Figure 2). There are numerous small, unnamed tributaries, and several large ones. Tributaries on the northeastern side of the watershed include Zuni, Torrent, Zee, Pearson, Martin, Blane, Tavern, Sand, Grouse, Gold, and Rapid Lightning creeks. In the western portion of the watershed, major tributaries include the West Branch of the Pack River; and McCormick, Homestead, Jeru, Lindsey, Hellroaring, Caribou, Colburn, and Trout creeks.

Runoff in the Pack River drainage typically peaks in late spring. Rain-on-snow events can also occur during the winter, leading to rapid runoff events. There is currently no active flow gauging stations on the Pack River, but historical streamflow data from two USGS gauges are available. The period of record for USGS Gauging Station 12392300 (Pack River near Colburn) is from September 1958 to September 1982. During this time, the annual mean streamflow ranged from 142 to 530 cubic feet per second (cfs), with an average of 320 cfs per year. The period of record for USGS Gauging Station 12392390 (Pack River above Rapid Lightning Creek near Colburn) is from October 1988 to September 1993. During this time, the annual mean streamflow ranged from 281 to 542 cfs, with an average of 324 cfs.

Lands in the Pack River watershed are primarily federal, state, or privately owned. The USFS owns over 55 percent of the watershed as the Idaho Panhandle National Forest, located in the headwaters. Private landowners, located primarily in the lower watershed, account for an additional 36 percent. State lands cover 6.6 percent, while the Bureau of Land Management owns 2.4 percent.

There are no significant population centers in the watershed; residential population is dispersed throughout the lower portion of the watershed. Population data were obtained from the US Census Bureau for the 2000 census. Bonner and Boundary counties have populations of 36,835 and 9,871 and population densities of 21.1 and 7.8 people per square mile, respectively. Approximately 30 percent of the two counties' populations reside in incorporated cities. The remaining people live in unincorporated areas along valley floors and adjacent to main transportation routes.

2.2 Watershed Characteristics

The character and behavior of a river system at any particular location reflect the integrated effect of many upstream variables. The dominant variables controlling channel form and adjustment are discharge and sediment. The hydrologic regime and quantity and type of sediment are determined by a set of independent factors, notably climate, vegetation, soils, geology, basin physiography, and land use. A timescale of 10 to 100 years is the most significant with which to view these factors from an observational standpoint. Reasonably well-defined relationships can be expected among the independent factors and elements of channel form (Knighton, 1998).

The following sections provide details of these independent factors within the Pack River Watershed. To the extent possible, they are described over a 10 to 100 year time frame. The effects of these factors on the present form of the Pack River system are described in the Results and Discussion sections of this report.

2.2.1 Climate

Climate is of primary significance in that it provides the energy for the most important processes affecting the character and behavior of a river system. In combination with vegetation, climate directly influences basin hydrology and rates of erosion (Knighton, 1998).

Climatic conditions in the watershed are dominated by Pacific maritime weather. Winters are generally cloudy, warm, and wet. The north-south trending mountain ranges and deep valleys are the dominant influence on local climate. Prevailing weather is from the west, bringing air masses from the Pacific with high moisture content and moderate temperatures. Since the mountain ranges are more or less perpendicular to the prevailing weather, the air masses are forced to rise and cool, dumping their moisture as rain or snow on the mountains and rendering the adjacent valleys relatively drier (Pocket Water, Inc., 2000). This process can cause a variable climatic effect between tributaries draining from the Selkirk Mountains on the west side of the watershed and tributaries draining from the Cabinet mountains on the east side.

No weather stations are present in the watershed; however, there are three National Weather System Cooperative Network meteorological stations near the watershed that can aid in understanding climate patterns in the region. For a general understanding of the watershed's climate, averages of the three stations data are presented. Table 1 details temperature for the representative stations. Temperatures range from an average monthly temperature of 25.1^{o}F (-3.8^{o}C) in January to 65.4^{o}F (18.6^{o}C) in July. Average maximum temperatures range from 31.4^{o}F (-0.3^{o}C) to 82.6^{o}F (28.1^{o}C), while average minimums range from 18.8^{o}F (-7.3^{o}C) to 48.2^{o}F (9.0^{o}C).

TABLE 1

Monthly temperature summary for the Pack River area, Idaho

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bonners Ferry, ID Station 107386 Period of Record:12/7/1911 to 12/31/2001													
Average Max. Temperature (F)	32	38.7	48.1	59.8	68.8	75.2	83.5	82.6	72.3	57.1	41.6	34.1	57.8
Average Min. Temperature (F)	18.5	22.5	27.3	33.8	40.5	46.7	49.9	48.6	41.8	34.2	27.7	22.2	34.5
Average Temperature (F)	25.25	30.6	37.7	46.8	54.65	60.95	66.7	65.6	57.05	45.65	34.65	28.15	46.15
Sandpoint Experimental Station, ID Station 101079 Period of Record:5/1/1907 to 12/31/2001													
Average Max. Temperature (F)	30.2	36.8	45.5	57.1	66.8	73.6	82.4	81.7	71.1	56	38.9	31.6	56
Average Min. Temperature (F)	17.9	20.2	24.5	30.2	37.4	43.4	46.2	44.6	38.4	32.2	26.7	21.4	31.9
Average Temperature (F)	24.05	28.5	35	43.65	52.1	58.5	64.3	63.15	54.75	44.1	32.8	26.5	43.95
Priest River Experimental Station, ID Station 108137 Period of Record: 10/1/1910 to 12/31/2001													
Average Max. Temperature (F)	32.1	37.9	46.2	57.3	66.3	73.2	81.8	80.9	70.3	56.9	41.4	34	56.5
Average Min. Temperature (F)	20	22.8	27.6	33.9	40.2	45.8	48.4	46.9	41	34.1	28.3	23	34.3
Average Temperature (F)	26.05	30.35	36.9	45.6	53.25	59.5	65.1	63.9	55.65	45.5	34.85	28.5	45.4
Station Averages													
Average Max. Temperature (F)	31.4	37.8	46.6	58.1	67.3	74.0	82.6	81.7	71.2	56.7	40.6	33.2	56.8
Average Min. Temperature (F)	18.8	21.8	26.5	32.6	39.4	45.3	48.2	46.7	40.4	33.5	27.6	22.2	33.6
Average Temperature (F)	25.1	29.8	36.5	45.4	53.3	59.7	65.4	64.2	55.8	45.1	34.1	27.7	45.2

2.2.2 Precipitation

Precipitation varies both spatially and temporally and is the principal driver of streamflow in the watershed. Snowfall and resulting snowpack accumulation in the study area is an important component contributing to streamflow and aquifer recharge. In addition, snowpack accumulation and snowmelt are the predominant sources of temporal variations in stream flows in the Pack River Watershed.

Winter storms pass over the area from November through March causing a noticeably wet climate. Mid-winter storms periodically bring warm air masses resulting in rain-on-snow events at middle elevations of 2,250 feet mean sea level (msl) to 4,200 feet msl. Summer storms, however, generally pass farther north resulting in relatively dry seasonal conditions.

Due to the relatively mild climate, rain can occur even during winter months when snow accumulates and a warm, maritime Pacific storm brings rain melting the snow. As a result, winter melting of the snowpack in the Pack River Watershed may be significant, particularly at lower elevations in the drainage (Campbell, 1987 and Northwest Power Planning Council, 2001). Rain-on-snow often produces severe runoff and erosion with intense and damaging floods (Harr, 1981).

Table 2 details annual monthly average precipitation, snowfall, and snow pack from the three representative stations. The area receives 28.6 inches of precipitation annually, 72 percent of which occurs between October and April. During this period, the majority of the precipitation falls as snow and results in an average total snowfall of 23.7 inches.

TABLE 2

Monthly precipitation summary for the Pack River area, Idaho

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Bonners Ferry, ID													
Average Total Precipitation (in.)	3	1.91	1.58	1.27	1.66	1.7	0.96	0.97	1.35	1.94	3.09	3.07	22.49
Average Total SnowFall (in.)	21.7	11.8	5	0.5	0.1	0	0	0	0	0.5	8.5	18.9	66.8
Average Snow Depth (in.)	8	6	2	0	0	0	0	0	0	0	1	4	2
Sandpoint Experimental Station, ID													
Average Total Precipitation (in.)	4.05	3.22	2.74	2.08	2.31	2.25	1.01	1.21	1.72	2.63	4.26	4.58	32.07
Average Total SnowFall (in.)	23	13.6	6.4	0.9	0	0	0	0	0	0.5	6.7	20.3	71.3
Average Snow Depth (in.)	9	8	3	0	0	0	0	0	0	0	1	4	2
Priest River Experimental Station, ID													
Average Total Precipitation (in.)	4.02	3.04	2.7	2.08	2.31	2.26	1.05	1.15	1.59	2.57	4.01	4.42	31.22
Average Total SnowFall (in.)	26.4	14.6	6.6	0.9	0.1	0	0	0	0	0.7	10.1	23.8	83.2
Average Snow Depth (in.)	16	19	11	1	0	0	0	0	0	0	2	8	5
Station Averages													
Average Total Precipitation (in.)	3.69	2.72	2.34	1.81	2.09	2.07	1.01	1.11	1.55	2.38	3.79	4.02	28.59
Average Total SnowFall (in.)	23.7	13.3	6.0	0.8	0.1	0.0	0.0	0.0	0.0	0.6	8.4	21.0	73.8
Average Snow Depth (in.)	11	11	5	0	0	0	0	0	0	0	1	5	3

2.2.3 Vegetation

The amount, type, and stage of vegetation in a watershed can influence stream flows and consequently, channel characteristics. Vegetation acts as a stabilizing influence on bed and bank materials and as a constraint on stream lateral migration, particularly in forested systems (Heede, 1981). Within-channel accumulations of coarse woody debris can significantly affect channel morphology and sediment storage (Nakamura and Swanson, 1993). Large trees that fall into streams and floodplains help shape channels and create pools, provide cover and shade, introduce and store nutrients, dissipate stream energy, and contribute to overall channel stability (Murphy and Meehan 1991). Vegetation removal by fire or timber harvest can result in increased peak flows during storm events and decreased summer flows (Harr, 1981). Canopy cover adjacent to streams provides shade and helps to maintain cooler water temperatures during summer months. Conifers may also provide insulation during winter months, reducing freezing and formation of anchor ice.

The large number of cedar stumps along the river and the ecological setting indicate that the dominant habitat type in the riparian areas prior to large-scale logging activities was likely western redcedar/oak fern (*Thuja plicata/Gymnocarpium dryopteris*) (Hansen et al., 1995) and/or western redcedar/devil's club (*Thuja plicata/Oplopanax horridum*). Devil's club is still present along the river, but is quite sparse, and the cover of hydrophytic riparian forbs in general is now likely only a small fraction of the historic cover. Large western redcedar stumps can still be seen in many areas on the banks of the river.

The western redcedar habitat would have typically occupied low benches, valleys, and low terraces along the streams in the watershed. The western redcedar/oak fern habitat type occurs on drier sites than the western redcedar/devil's club habitat type. Several other coniferous trees generally grow with western redcedar, including, but not limited to, western hemlock (*Tsuga heterophylla*) subalpine fir (*Abies lasiocarpa*), western larch (*Larix occidentalis*), spruce (*Picea spp*.), grand fir (*Abies grandis*), ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), and western white pine (*Pinus monticola*).

Over the last 100 years, vegetation communities in the Pack River watershed have gone through several dramatic changes. The first substantial change resulted from extensive logging in the late 1800's. Logging in the Pack River Watershed distinctly altered the vegetation composition of the riparian area. The transition in plant species for the forested areas after intensive logging, but prior to the Sundance fire in 1969 was estimated from a 1961 forest inventory (Anderson, 1968). From this inventory, it appears that the large western redcedar was replaced primarily with smaller faster-growing conifer species. Probable pre-fire species composition within the forested area included western larch, subalpine fir, and spruce, with smaller amounts of hemlock, Douglas fir, white pine, western redcedar, lodgepole and ponderosa pine (Campbell, 1987). These tree species would have provided less canopy cover and thus would have had reduced shading effects. The transition to these smaller conifer species also would have resulted in smaller diameter large woody debris entering the system and the alteration of other riparian functions.

A second major impact to vegetation occurred in 1969. The Sundance fire of 1969 severely affected the vegetation of portions of the Pack River drainage. Revegetation in the Pack River drainage after the Sundance fire was has been studied extensively by (Stickney, 1984). During the first decade of regrowth, four early seral species dominated. These were ground cover species and included ceanothus, fireweed, western brake fern, and willow. During this period, trees did not exceed 10 percent of the total vegetation cover within the burned area of the drainage. This impact to vegetation in the upper watershed is still apparent as many of the upper reaches exhibit burned remnants of trees.

2.2.4 Geology and Soils

Bed and bank material composition influences channel adjustment (Knighton 1998). The geology and soils within a drainage also influence the hydrologic characteristics of the basin. In general, the soils and topography of the Pack River drainage cause a high tendency for soil erosion within the drainage.

Three major lithologies within the Pack River drainage have been identified (Savage, 1967 and Aadland and Bennett, 1979). The Cretaceous - Tertiary Age Kaniksu Batholith, an igneous intrusive, comprise the Selkirk Mountains on the northwestern side of the drainage. The batholith is composed of quartz monzonite, granodiorite, and quartz diorite. The northeast side of the drainage containing the Cabinet Mountains is primarily within the Belt Series metamorphic sedimentary type formed at shallower depths of the earth's crust. The metamorphosed rocks include argillite, siltite, quartzite, and dolomite. The lower elevations in the watershed consist of Quaternary glacial and fluvial deposits. Glaciofluvial deposits are located on slopes and valley bottoms where ice lobes caused water to pond.

The Cabinet Mountain Belt rocks weather into a variety of particle size classes, which are significantly more stable and resilient on hill slopes and in stream channels than the more uniform granitic sands of the intrusive batholiths. In both cases, the bedrock is typically covered with glacial till. Soils derived from Belt rocks are usually medium - textured with a moderate amount of rock fragments. Soils derived from the granitic Idaho batholith are sandier. Due to the erosive nature of granite and the large sediment sources created by retreating glaciers, these types of systems produce large volumes of coarse and fine sediments.

Most land types within the watershed have surface soils composed of Mount Mazama volcanic ash. The deposition occurred 6,700 years ago, when volcanic activity from Mount Mazama (Crater Lake) in the Oregon Cascade Mountains sent ash over northern Idaho. The ash is typically a silt-loam texture with little gravel or cobble. It has a high infiltration rate and permeability with a high water and nutrient holding capacity.

According to (Campbell, 1987), the Soil Survey of Bonner County identified five generalized soil associations in the Pack River drainage. The Pend Oreille–Rock Outcrop and the Priest Lake-Treble soils are deep, well drained soils that are predominantly gravelly-sandy loams with the exception of the silt loams that occupy the lower and cooler north-facing side slopes. These soils range in elevation from 2,100 to 5,000 feet. Above 4,800 to 5,000 feet, the moderately drained, rock outcrop-Prouti-Jeru association is present. The soils in this association are gravelly and /or very stony loams. The Bonner series occupies the lower reaches of the Pack River drainage. These soils developed on former glacial outwash terraces partially reworked by the river. The final soil classification is the Colburn-Selle-Elmira association. These soils range from poorly drained very fine sandy loams in the lower elevations to excessively drained loamy sand in the higher elevations.

2.2.5 Topography

Valley slope and topography determine the overall rate of energy loss along a river, and can modify the relationship between channel form and the primary variables (Knighton, 1998). The upper Pack River Watershed above the US 95 bridge crossing covers approximately 124 square miles and is characterized by moderate to steep slopes with a narrow floodplain. Elevations in the drainage range from 2,130 to 7,599 feet with a mean elevation of 4,210 feet (Campbell, 1987). Hill slopes average between 20 and 35 percent, but approach 80 percent near the drainage upper boundaries. The river gradient is much steeper in the upper watershed, ranging from 1 to 7 percent. The portion of the watershed downstream of the US 95 bridge opens into a broader alluvial valley with a wide floodplain. The river gradient in the lower watershed is generally less than 1 percent.

2.2.6 Land Use

Human activities have an increasing influence on watersheds and their associated stream channels. Indeed, one of the main incentives for taking a longer-term view of stream channel response in this assessment is to provide a framework for estimating the effects of human activities. If dangerous or expensive outcomes are to be avoided, the consequences of interference need to be understood. Indirect anthropogenic land use changes result from activities outside the channel, which modify the discharge and/or sediment load of the stream and ultimately results in stream channel response. Effects can be transmitted long distances from the initial change.

When dealing with indirect effects, there is an additional dimension to the problem. Offsite channel area changes, which can vary widely in intensity and location relative to the channel, need to be related first to flow and sediment regime of the river before their impacts on the channel can be accurately assessed. Spatial and temporal lags of variable magnitude are commonly involved (Knighton, 1998).

Historic land uses of the watershed affect the current geomorphic, riparian, and fish habitat conditions of the Pack River. Prior to European settlement, the area around Lake Pend Oreille was inhabited by the Kalispel Indians. Fur trappers and traders moved through the area during the early 1800’s. By the late 1800’s, with the advent of the railroad, the area was populated by a significant number of European settlers. A prehistoric and cultural history of the area is provided by (Betts, 2002).

Timber harvest in the upper watershed and grazing/agriculture in the lower watershed began in the area after major settlement started in the 1890’s. Logging during the early part of the last century resulted in the widespread removal of large cedars throughout the Pack River watershed. The remains of the cedars are still evident throughout the riparian area over the entire river length. Timber harvesting and related activities, such as road construction, can increase the production and delivery of fine sediment to streams. Construction of roads, skid trails, and landings can generate and transfer substantial amounts of sediment through the removal of vegetation and exposure of bare soil. In addition, removal of vegetation near stream channels reduces the sediment-filtering capacity and may reduce channel stability and large woody material. Large woody debris is a very important component of stream dynamics, creating natural sediment traps and energy dissipaters to reduce the velocity and erositivity of stream flows.

Historically, the river was also used as a flume by which logs were floated from the uplands to Lake Pend Oreille where they were gathered and sorted. After most of the large cedars were removed, logging in the area continued taking smaller trees in the upper watershed, while grazing/agriculture continued in the lower watershed. Other riparian vegetation was removed in the lower watershed to provide more grazing/agricultural land.

Use of land for agriculture has been ongoing for many years in the watershed (Pend Oreille Bull Trout Technical Advisory Team, 1998). Grazing occurs in the lower two-thirds of the watershed. Much of the area is considered open range. Crop production occurs in the watershed downstream of the US 95 bridge. Impacts to the stream channel in lower reaches have occurred over a long period of time and continue to be a factor in degrading habitat condition and decreasing complexity.

The watershed has an extensive road system on private, state, and Federal lands. Because of the sandy soils, fine sediment is readily transported from roads to stream channels. Three railroads (Burlington Northern Santa Fe, Union Pacific, and Montana Rail Link) and two highways (U.S. 95 and Idaho 200) cross the lower Pack River creating a risk to migrating listed bull trout from potential toxic spills.

Other land-use impacts to the Pack River watershed include the management of Lake Pend Oreille. The level of Lake Pend Oreille was raised and consequently managed after the development of the Albeni Falls Dam on the Pend Oreille River in 1949. Raising of the lake level flooded a portion of the lower Pack River in an area now known as the Pack River Flats. A review of historic aerial photographs indicates that flooding appears to have covered a portion of the lower river, shortening the channel length slightly. The flooding also filled many of the old oxbows in the lower portion of the river that previously were dry and disconnected from the river. This flooding converted the lower Pack River into a more lentic (wetland) type community than it was historically.

2.2.7 Flooding

High flow events generated by natural causes naturally affect the Pack River channel and floodplain as a pulsed type of disturbance. The overall extent to which channel morphology reflects the influence of extreme events cannot readily be assessed. However, significant changes to channel dimensions and planform can result. Factors such as prior watershed condition, valley width, and extent and type of riparian vegetation can modify flooding effects.

In addition to flooding, storms associated with peak flow events can trigger debris flows and slides, and lead to input of large quantities of sediment. These features commonly occur in the rain-snow transition zone, in saturated loam-clay-ash soil, and on steep slopes (30 to 80 percent). Debris flows or torrents can be significant feature, starting as an earth slide and then transporting debris. Areas with extensive logging and road construction can experience mass wasting. High flows and mass wasting can combine to produce a variety of channel responses including: scouring of substrate and banks; aggradation of sediment; accumulation of large woody debris; and lateral channel migration (Fitzgerald and Clifton, 1998).

Several major peak flow events have occurred in the Pack River Watershed over the past century. Large flood events are historically known to have occurred in the area in 1894, 1948, 1956, 1969, 1974, and 1997. Gauging data on the Pack River covers only a portion of this time. Data for the USGS gauging station 1239500 on the Priest River near Priest River, Idaho, however, is much more complete and available for the period of 1931 to the present. This gauging station recorded major flood events, in decreasing orders of magnitude, including 1997, 1948, 1974, 1956 and 1969.

The highest documented flow for which there are gauging records for the Pack River was 6,880 cfs in 1974 recorded at the USGS Gauging Station 12392300 station near Colburn. The next highest peak flow event (4,370 cfs) occurred in 1969.

2.2.8 Fire Effects

Fires interact with physical processes to influence the form and dynamics of watersheds, hydrology, geomorphology, and riparian plant communities (Arno and Allison-Bunnell, 2002). These interactions may be manifested in direct and immediate ecosystem changes, as well as indirect changes occurring over extended time periods (Yount and Niemi, 1990 and Gresswell, 1999). Following fires, various sedimentation processes, including overland flow, debris flows, earthflows, and mudslides, may increase sediment loading to channels and floodplains (Meyer et al., 2001 and Pierson et al., 2001). This contribution of sediment can have direct impacts on the stability of the stream.

Fire historically impacted the Pack River watershed with a major fire event in 1910. During the 1910 fires, more than three million acres of forestland were burned in northeastern Washington, northern Idaho, and western Montana. While there were many small fires in ensuing years, there were no more catastrophic fires until 1967, when the Sundance Fire burned a portion of the watershed

The Sundance Fire was one of several large fires that occurred in the inland Northwest in the summer of 1967. The fire is the subject of an extensive report published by the USFS (Anderson, 1968). An upper atmospheric high pressure ridge dominated the region throughout much of the summer, resulting in little precipitation and higher than average temperatures. The fire was started by lightning on August 11, 1967 on Sundance Mountain, but was not discovered until August 23. The major run of the fire occurred on September 1, when over 50,000 acres in northern Idaho burned in just nine hours. Approximately 26 percent of the Pack River watershed was burned by the Sundance Fire including the forested slopes of the Kaniksu batholith and a small amount of alpine area. In addition to the direct burn, there was also extensive blowdown of timber. Effects of the Sundance Fire are still visible in the riparian areas of the watershed (Campbell, 1987).

An analysis of Pack River hydrology following the Sundance Fire indicates changes in the timing and distribution of runoff within the watershed. The hydrology was characterized by an increase in March runoff (40 percent increase), a decrease in June runoff (23 percent decrease), higher peak flows (25 percent increase), and higher minimum flows (11 percent increase). A change in timing of runoff with an advancement of an average of 5 days was also documented. There was no measured change in the total amount of annual runoff. This lack of change in total amount of runoff is likely a result of the minority amount (26 percent) of the watershed that was affected by the burn (Campbell, 1987).

3.0 METHODS

The Stream Channel Assessment investigation included methodologies selected by the TAC for the inventory of geomorphic, riparian, and fish habitat conditions. The detailed procedures of the geomorphic classification, riparian inventory, and fish habitat methods used are provided in Appendix C.

3.1 Reach Determinations

Prior to conducting field surveys, existing information and data were compiled and reviewed including:

- USGS 7.5 minute topographic maps (6 maps) of the Pack River Watershed;
- Bonner County parcel ownership information and maps;
- GIS maps and databases obtained from the USFS and IDL;
- USFS maps of Kaniksu National Forest; and
- Digital 1991 and 1992 aerial photos.

This initial assessment included examination of current aerial photos and topographic maps to determine locations for reach delineations, access, and contacts for landownership. The 40 miles of the Pack River was divided into a series of segments or reaches. Reach delineation followed protocols established by the Riparian and Wetland Research Program Lotic inventory procedures (2000). Potential reach breaks were established in this review based on topography, tributary confluences, gradient, sinuosity, vegetation differences, geologic features, man-made barriers (bridges, fences, etc.), and accessibility.

Further on-the-ground analysis of the reaches is typically required to confirm extents of riparian width and to confirm that substrate composition, slope, riparian habitat type, hydrology, pool/riffle ratios; and land management are homogenous within the designated reaches. Observers verified the proposed reach boundaries. Adjustments of reach boundaries were made as a result of geomorphic features, access issues, vegetation, geography, location of fences, etc. As a result, some contiguous reaches may exhibit the same Rosgen classification, but are subdivided based on other characteristics, often a tributary confluence or vegetation/land management changes.

The upstream and downstream reach breaks were identified by Global Positioning System (GPS) coordinates (Appendix D). All GPS data were collected using Garmin Etrex GPS receivers. Data were collected in North American Datum (NAD) 27 and Universal Transverse Mercator system (UTM) feet. Data were verified for accuracy and precision by measuring known points such as bridges, and comparing to UTM coordinates and elevations represented on USGS topographic maps. Digital photos were also taken at the upstream and downstream ends of all reaches. Photographs of reaches are provided in Appendix E.

3.2 Geomorphic Classification

The Rosgen stream classification system was used to characterize important physical features of the Pack River and existing conditions and trends. For each designated reach, a Rosgen Level II Stream Classification was completed (Rosgen, 1996). Bankfull width, mean depth, maximum depth; flood prone area width; and sinuosity were measured in the field. Bankfull depth was recorded a minimum of 20 times across the width of the channel. The flood-prone width was measured at the elevation corresponding to twice the maximum depth of the bankfull channel.

The Rosgen Level II classification uses detailed field measurements that address sediment supply, stream sensitivity to disturbance, potential for natural recovery, channel response to changes in flow, and fish habitat potential. The results are a classification of each reach into a potential major stream type based on channel cross-section configuration, channel materials, and primary morphological criteria.

Specific objectives of the Rosgen stream classification system include:

1. Predicting a river's behavior from its appearance;
2. Developing specific hydraulic and sediment relationships for a given stream type;
3. Providing a means to extrapolate site-specific data to stream reaches having similar characteristics; and
4. Providing a consistent frame of reference for communicating stream morphology and condition.

Variables that are calculated from the field measurements obtained in the Rosgen assessment include:

- Entrenchment ratio (width of flood-prone area to width of bankfull channel);
- Width-to-depth ratio (bankfull width to mean bankfull depth);
- Dominant channel materials;
- Slope; and
- Sinuosity (ratio of stream length to valley length).

The end product of the Rosgen classification is a alpha-numeric code classification for the stream reach (e.g. B3) that provides information on physical character of the reach (types A-G) and type and general size of channel materials (1-6).

3.2.1 Description and Calibration of Bankfull

The stage or elevation of bankfull discharge is the single most important parameter used in determining the Rosgen Level II classifications. Bankfull discharge represents the upper level of the range of channel-forming flows that transport the bulk of available sediment over time (Wolman and Miller 1960). The bankfull height corresponds to the flow at which channel-shape maintenance is most effective. This flow has a recurrence interval of about 1.5 to 2.0 years in a large variety of rivers (Dunne and Leopold, 1978).

The following factors are used in identifying the bankfull stage:

- Presence of a floodplain at the elevation of incipient flooding;
- The elevation associated with the top of the highest depositional features;
- A break in slopes of the banks and/or a change in the particle size distribution;
- Evidence of an inundation feature such as small benches;

- Staining of rocks;
- Exposed root hairs below an intact soil layer; and
- Vegetation.

The bankfull stage is related to channel dimensions such as width and depth, and channel patterns such as meander length, radius of curvature, belt width, meander width ratio, and amplitude. In addition, the bankfull channel width is required to estimate two of the five primary Level II criteria (entrenchment ratio and width/depth ratio) (Rosgen, 1996).

A common error in performing Level II classifications is the failure of field observers to calibrate the elevations of appropriate field indicators of bankfull stage to known stream flows (Rosgen, 1996). In order to calibrate elevations of bankfull stage, the location of bankfull elevation and the 1.5 year discharge event were identified on the USGS River gauging stations.

The recurrence interval for various discharges was determined for USGS Gauging Station 12392300 (Pack River near Colburn) and USGS Gauging Station 12392390 (Pack River above Rapid Lightning Creek) prior to field inventory. Bankfull elevation and the corresponding elevation to the 1.5 year discharge were noted in the field and used to calibrate the bankfull field measurements.

3.2.2 Dominant Particle Size Determination

The pebble count method of Wolman (1954) was used to determine particle size distribution in the one riffle and one pool area located nearest the location of the Rosgen cross-section. A minimum of 100 particles was measured in each habitat type. Particles sampled in riffles were tallied separately from those sampled in pools. To obtain the median particle diameter (D50), the pebble count data were plotted on a log normal graph as a cumulative percent.

3.3 Riparian Inventory

Beginning at the upstream end of each reach break, 300 feet of streambank length were sampled following the “greenline” methodology described in Winward (2000) to characterize the riparian zone of the reach. The “greenline” refers to “that specific area where a more or less continuous cover of vegetation is encountered when moving away from the center of an observable channel” (Cagney, 1993). The streambank length of each community type that occurred within the 300 foot-long sample was recorded for both banks. In the two lowermost reaches of the Pack River (reaches 53 and 54), a more detailed description of riparian vegetation characteristics was produced.

3.3.1 Community Type Classification

One important component of the greenline methodology is classification of vegetation into community types. Plant community classifications listed in Winward (2000) were developed in more arid areas of the west, such as southeastern Idaho and Wyoming. . These classifications are more applicable to those areas and less fitting to the plant community types found in riparian areas of northern Idaho, such as on the Pack River. As a result, in implementing the greenline methodology, this study drew more extensively on plant community classifications developed for northwestern Montana described in (Hansen et. al., 1995).

Some vegetation community types found on the Pack River were not listed in either of the two plant community classifications used. As a result, the community types, stability class, and successsional status ratings of the types seen on the Pack River are best approximations of ecologically equivalent types listed in (Winward, 2000 and Hansen et. al., 1995). Ecologically equivalent types were determined using information in the existing classifications and professional judgment.

3.3.2 Successional Status and Stability Rating

Another important component of the greenline methodology is the categorization of plant communities into successional status of either “early” (‘E’) or “late” (‘L’), depending on whether they are at earlier or later stages of succession. This procedure does not allow for classification into a mid-seral stage. Vegetation assemblages that are at a mid-seral stage were categorized into the “early” or “late” stage, depending on which was more appropriate. Additionally, the classification developed by (Hansen et al., 1995) does not list successional stage and stability rating, but does provide extensive narratives for each habitat and community type. In these cases, a seral stage was derived from the information provided in the narrative using professional judgment.

A few important exceptions required additional professional judgment in deriving vegetation stability ratings and successional stages in this assessment:

- The willow and alder types similar to those documented on the Pack River are classified as mid-seral by (Hansen et.al., 1995). However, (Winward, 2000) only allows for an early or late seral rating. As a result, these types were rated either late or early depending on the successional stage that seemed most appropriate according to the situation.
- In some instances in the lower watershed, the reed canarygrass habitat type was well established and apparently stabilized low banks. It appears unlikely that colonization or replacement by other species will occur because of the density of the plant biomass. In these instances, the vegetation stability rating of the habitat type was increased.

3.4 Fish Habitat Inventory

An R1/R4 Fish and Fish Habitat Survey (Overton et al., 1997), as adapted by the USFS-Sandpoint Ranger District, was completed for the first and last 656 feet of stream length for each reach. This fish habitat inventory is designed to:

1. Define the structure (pool/riffle, forming features), pattern (sequence and spacing), and dimensions (length, width, depth, area, volume, etc.) of fish habitat; and
2. Facilitate the calculation of summary statistics for habitat descriptors.

The R1/R4 methodology is specifically designed to quantify available fish habitat at base-level flows. For each habitat unit, physical parameters including length, average wetted width and depth, number of pocket pools and their depths, pool maximum depths, and crest depths were recorded. For each habitat unit, left and right-bank length was visually estimated along with percent stable and undercut bank. Channel shape was determined for each habitat unit on the left and right sides of the channel, looking upstream. Large woody debris was recorded as single pieces or aggregates and was measured and enumerated in each habitat type for various decay classes. Decay classes range from 1-3 with 1 containing the least amount of decay. Size classes range from 1-8 with diameter and length of wood increasing as size class increases.

4.0 RESULTS

During the September 2002, survey crews collected data on the Pack River to obtain current condition information about each of the three river system features: geomorphic condition, riparian vegetation, and instream fish habitat. Data were gathered and summarized on a stream reach and sub-reach basis. The goal of this section is to describe the current conditions within each of the sub-reaches of the river. Synthesis of the data and discussion of the functioning condition with relationship to reference condition and watershed attributes are provided in Section 5.0 Discussion.

4.1 Reach Delineation

Fifty-four sub-reaches were inventoried on the Pack River for geomorphic condition, riparian habitat, and fisheries habitat. Since general bed material size decreased downstream in conjunction with channel slope on the Pack River, substrate size and gradient were good indicators for grouping similar sub-reaches. Using overall Pack River gradient changes and substrate size downstream gradation, the 54 sub-reaches surveyed were grouped into larger reach segments as follows:

Reach A: Zuni Creek confluence to McCormick Creek confluence (sub-reaches 1 to 8)

Reach B: McCormick Creek confluence to Hellroaring Creek confluence (sub-reaches 9 to 21)

Reach C: Hellroaring Creek confluence to 2 miles downstream of Caribou Creek Confluence (sub-reaches 22 to 30)

Reach D: Two miles downstream of Caribou Creek confluence to US 95 bridge (sub-reaches 31 to 39)

Reach E: US 95 bridge to near Highway 200 bridge (sub-reaches 40 to 52)

Reach F: Near Highway 200 bridge to confluence with Lake Pend Oreille (sub-reaches 53 and 54)

The location of the major reaches is depicted in Figure 3. The individual sub-reach locations are depicted in Figures 4a-4k.

4.2 Reach Descriptions

This section presents a general description of the location of the sub-reaches of the Pack River study area.

4.2.1 Reach A: Zuni Creek to McCormick Creek

Reach A is the most upstream reach and is in the forested portion of the watershed approximately five miles downstream of the headwaters at Harrison Lake. Sub-reaches 1 through 8 are included within this reach. Reach A is known to be an important spawning area for bull trout.

Immediately upstream of sub-reach 1 near the confluence of Zuni creek is a falls (approximately 20 to 25 feet high) that cascades over a stable nick point in fractured granite. In addition to Zuni Creek, which enters at the upstream portion of sub-reach 1, the West Branch of the Pack River enters sub-reach 3 from the northwest.

Another falls (approximately 30 to 35 feet high) occurs in sub-reach 4. The falls was observed to act as a fish barrier for bull trout and apparently prevents migratory fish from reaching additional portions of the river upstream. Sub-reach 4 should be considered the furthermost upstream extent of available habitat for adfluvial bull trout at this time due to the presence of the falls. Smaller tributaries also enter sub-reaches 5, 7, and 8. McCormick Creek enters from the northwest at the downstream end of this reach.

4.2.2 Reach B: McCormick Creek to Hellroaring Creek

This reach of the Pack River continues through the upper forested portion of the watershed. It extends from the confluence of McCormick Creek to the confluence of Hellroaring Creek. The sub-reaches 9 through 21 are included within this reach. Reach B is known as a likely important rearing area for bull trout.

The Upper Pack River Road crosses the Pack River at a bridge approximately 0.25 miles downstream of McCormick Creek at the boundary of sub-reaches 9 and 10. Sub-reaches 11 and 12 pass through a narrow bedrock and boulder canyon. Homestead Creek, Jeru Creek, Lindsey Creek, and a small tributary enter this reach from the northwest. Torrent Creek, Zee Creek, Pearson Creek, Martin Creek, Blane Creek, and two other small creeks also enter from the northeast. Hellroaring Creek enters sub-reach 21 at the downstream extent of this reach.

4.2.3 Reach C: Hellroaring Creek to near Caribou Creek

This reach continues through the forested portion of the upper watershed. Valley and Channel gradient are gentler (< 2 percent) in this Reach than in Reaches A and B above. Reach C extends from the confluence of Hellroaring Creek to approximately two miles downstream of Caribou Creek. Sub-reaches 22 through 30 are included within this reach.

Caribou Creek and two unnamed tributaries enter this reach from the northwest. Tavern Creek and an unnamed creek also enter from the northeast. The Upper Pack River Road bridge crosses the Pack River in the upstream portion of sub-reach 25. Caribou Creek enters at the downstream end of sub-reach 25.

A 15 foot vertical change in stream grade occurs at sub-reach 22. A failed concrete structure with a culvert is present in this sub-reach spanning the channel. The structure appears to allow adult bull trout to maneuver the vertical gradient and move upstream. However, it is unknown whether other species or lifestages are capable of passing up the vertical gradient.

4.2.4 Reach D: Near Caribou Creek to the US 95 Bridge

This reach transitions from the forested, mountainous region of the watershed to the gentler, broader valley of the lower watershed. In this reach, the Pack River extends from 2 miles downstream of the confluence with Caribou Creek to approximately 0.25 miles downstream of the US 95 bridge. Sub-reaches 31 through 39 are included within this reach. Colburn Creek and two smaller tributaries enter from the northwest. One small tributary enters from the northeast. US 95 crosses the Pack River at the downstream end of this reach.

4.2.5 Reach E: US 95 Bridge to Highway 200 Bridge

This reach is entirely within a broad alluvial valley dominated by agriculture. Reach E extends from the Highway 95 bridge to approximately 0.5 miles upstream of the Highway 200 bridge. This is a long sinuous reach with several meanders, a gentle gradient, and includes much of the lower portion of the river. This reach exhibits extensive lateral channel migration across the floodplain.

Reach E contains the sub-reaches 40 through 52. Sand Creek, Grouse Creek, Gold Creek, Rapid Lightning Creek, Trout Creek, and two unnamed tributaries enter this reach from the east. One unnamed tributary enters the reach from the west. Roadway bridges cross the river in five locations in this reach and railroad bridges cross in two locations.

4.2.6 Reach F: Highway 200 Bridge to Lake Pend Oreille

Reach F extends from 0.5 miles upstream of the Highway 200 bridge to the confluence of the Pack River with Lake Pend Oreille. This portion of the river contains numerous abandoned oxbows and overall is lentic in character compared to the upper reaches. Sub-reaches 53 and 54 are included within this reach. This area is primarily the river delta and a portion of it is called the Pack River Flats. The Highway 200 bridge crosses this reach at the upstream end. The results from Reach F are largely observational in nature and are presented as a separate reach due to the nature of the river in this location.

4.3 Geomorphic Condition (Rosgen Stream Types)

The following section provides a general description of the characteristics of the major Rosgen stream types found within the surveyed sub-reaches of the Pack River.

Rosgen “B” type

The reaches of the steeper, forested, upper Pack River are characterized by the Rosgen B stream type. Rosgen B stream types are moderately steep (between 2 and 4 percent), with rapids and riffles common and scour pools irregularly spaced. These stream types are moderately entrenched (1.4 to 2.2), with moderate width-to-depth ratios (>12) and sinuosity (>1.2). Vegetation has a moderate influence in determining channel stability in the Type B reaches. These B channel types are characterized by low to moderate sensitivity to disturbance and low streambank erosion. Fish habitat in B types is often associated with large woody debris that contributes to scour pool formation and cover (Rosgen, 1996).

Rosgen “C” type

Rosgen C types occur predominantly in the alluvial valley of the lower watershed. Rosgen C streams have a lower gradient, are slightly entrenched (>2.2), have moderate to high (>12) width-to-depth ratios, high sinuosity values (>1.4), and are characterized by riffle/pool sequences. These channels have characteristic point bars and broad, well defined floodplains. Vegetation has a high influence in determining channel stability, and when vegetation is disturbed and removed, these channel types are sensitive to both lateral (bank) and vertical (downcutting) erosion. Natural sediment supply is moderate to high except in those areas where streambanks are well vegetated. These streams are highly sensitive to changes in sediment and stream flow (Rosgen, 1996).

Rosgen "F" type

The F type occurs sporadically throughout the study area in locations where the floodplain is restricted by topography or where the stream has a more unstable form as a result of disturbances. The F stream types are deeply entrenched, often meandering streams with a high width/depth ratio (greater than 12). This stream type is typically creating a new floodplain at a lower elevation. This process leads to high levels of bank erosion, bar development, and sediment transport. The F stream types are found in low-relief valleys and gorges (Rosgen, 1996). Because of the entrenchment and high width-to-depth ratio, velocities can reach relatively high levels at flood flows because the floodplain is not developed enough to dissipate energies. Stream power is thus greater and may lead to increased damage to streambanks and beds.

4.3.1 Reach A: Sub-reaches 1-8

Reach A was characterized as primarily Rosgen type "B" (Table 3a). The sub-reaches have gradients of 1.7 percent to 15 percent, sinuosity at 1.0 to 1.3, entrenchment ratios of 1.2 to 6.5, and width-to-depth ratios of 20 to 42. The dominant substrate changes from bedrock (Rosgen type B1) in sub-reach 1 to boulder (B2) in sub-reaches 2 to 4, and to cobble (B3) in sub-reaches 5, 6, 7, and 8.

Six different stream types were documented in this reach. The majority of the sub-reaches exhibited a B - type morphology, typical of the natural channel type for the associated landscape. All reaches exhibit relatively steep slopes except for sub-reach 7.

With the exception of sub-reach 3, the sub-reaches of this section of the river are B1, B2, and B3 stream types depending on substrate size. One sub-reach diverges from the B - type morphology. Sub-reach 3 was classified as a C2b type and sub-reach 8 was a F3b. Synthesis of the geomorphic data for these types is presented in Section 5.0 Discussion.

TABLE 3a

Stream Type Characteristics of Reach A

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient (%)	Channel Sinuosity	Stream Type*
1	47.9	1.12	53.63	42.94	1.97	57.7	1.21	Bedrock	15	1.1	B1a
2	36.4	1.12	40.40	34.41	2.13	55.1	1.44	11.076	5.8	1.2	B2a
3	51.3	1.74	89.31	29.53	3.05	334.2	6.51	7.995	3.8	1.2	C2b
4	37.6	1.87	70.23	20.09	2.79	76.9	2.05	10.2765	4	1.1	B2a
5	31.5	1.54	48.49	20.43	4.13	72.8	2.31	6.4467	7	1.0	B3a
6	38.0	0.95	36.14	40.00	2.33	69.5	1.83	6.2673	4.5	1.3	B3a
7	40.8	1.15	46.96	35.57	1.90	62	1.52	5.3937	1.7	1.3	B3c
8	36.4	1.28	46.60	28.46	2.72	52.2	1.43	4.992	3	1.3	F3b

*Data collected and stream type determined by USFS: see Appendix A for detailed explanation of stream channel classification

4.3.2 Reach B: Sub-reaches 9 to 21

Reach B is mostly Rosgen B and C stream types with two sub-reaches exhibiting the F stream type, where the river flows through a constricted narrow boulder valley (Table 3b). The upstream portion of the reach is C3b type (sub-reaches 9 and 10) and the F type (sub-reaches 11 and 12). Four sub-reaches (13 to 16) in the middle portion of reach B are B3 type and three (17 to 19) are C3. The downstream portion (sub-reaches 20 and 21) of Reach B is a B3 type.

These sub-reaches have gradients of 2 to 6 percent, sinuosity of 1.0 to 1.5, entrenchment ratios of 1.1 to 3.0, and width-to-depth ratios of 19 to 65. The dominant substrate within Reach B is large cobble.

TABLE 3b

Stream Type Characteristics of Reach B

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient(%)	Channel Sinuosity	Stream Type
9	64.6	3.18	205.43	20.31	4.00	195.30	3.02	7.02	4	1	C3b
10	55.6	2.10	116.76	26.48	3.80	170.80	3.07	9.984	3	1.1	C3b
11	47.0	2.39	112.33	19.67	4.10	52.60	1.12	19.968	6	1	F2b
12	61.4	1.81	111.13	33.92	3.00	73.50	1.20	9.984	4	1	F3b
13	67.2	1.67	112.22	40.24	2.60	98.20	1.46	7.02	3	1.1	B3
14	57.0	1.53	87.21	37.25	2.70	91.00	1.60	9.984	2	1.1	B3
15	130.0	1.98	257.40	65.66	3.25	255.00	1.96	4.992	2	1.2	B3
16	68.5	1.65	113.03	41.52	2.70	100.70	1.47	4.992	2	1.5	B3
17	57.5	2.64	151.80	21.78	4.40	143.70	2.50	9.984	4	1.1	C3b
18	74.5	2.96	220.52	25.17	4.50	165.50	2.22	9.984	3	1.2	C3b
19	70.7	2.29	161.90	30.87	3.40	155.80	2.20	9.984	3	1.1	C3b
20	100.8	1.79	180.43	56.31	3.10	143.40	1.42	7.02	2	1.1	B3
21	75.6	2.20	166.32	34.36	3.05	136.10	1.80	9.984	2	1.1	B3

4.3.3 Reach C: Sub-reaches 22 to 30

Reach C sub-reaches are relatively heterogeneous (Table 3c). The upstream half is comprised of sub-reaches that are classified as F3 (sub-reach 22 and 24) and C3 (sub-reaches 23 and 25) types. The downstream portion of Reach C (sub-reaches 26 to 30) is comprised of sub-reaches classified as C4 stream type.

The sub-reaches within this reach are have gradients of 1 to 2 percent, sinuosity between 1.1 and 1.4, entrenchment ratios of 1.2 to 10.7, and width-to-depth ratios of 31 to 93. The dominant substrate is small cobble.

TABLE 3c

Stream Type Characteristics of Reach C

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient (%)	Channel Sinuosity	Stream Type
22	84.50	2.24	189.28	37.72	2.60	101.00	1.20	4.992	1	1.1	F3 /D
23	140.50	1.50	210.75	93.67	2.90	435.00	3.10	3.51	2	1.4	C3
24	102.20	2.14	218.71	47.76	2.60	145.50	1.42	3.51	1	1.1	F3/C3
25	76.50	2.45	187.43	31.22	3.80	244.40	3.19	3.51	1	1.1	C3
26	100.30	2.53	253.76	39.64	3.70	490.00	4.89	2.496	1	1.1	C4
27	96.70	2.00	193.40	48.35	2.70	298.00	3.08	2.496	1	1.1	C4
28	93.40	1.48	138.23	63.11	3.45	1000.00	10.71	1.755	1	1.1	C4
29	81.20	2.13	172.96	38.12	3.40	330.00	4.06	1.755	1	1.3	C4
30	111.20	1.44	160.13	77.22	2.60	265.00	2.38	1.248	1	1.2	C4

4.3.4 Reach D: Sub-reaches 31 to 39

Reach D has a mixture of "C" and "F" types (Table 3d). The river channel in this reach alternates between a downcut, entrenched system with little access to its floodplain (F types) and a meandering, wide channel (C types). Substrate size in Reach D is medium gravel in contrast to the larger substrate sizes in the upstream reaches.

The sub-reaches in Reach D have a gradient of 1.0 percent, sinuosity between 1.2 and 2.0, entrenchment ratios of 1.1 to 10.9, and width-to-depth ratios of 24 to 69.

TABLE 3d

Stream Type Characteristics of Reach D

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient (%)	Channel Sinuosity	Stream Type
31	111.00	2.84	315.24	39.08	4.45	195.00	1.76	0.8814	1	1.2	F4/C4
32	74.60	1.97	146.96	37.87	3.05	137.00	1.84	0.8814	1	1.3	C4
33	67.40	1.59	107.17	42.39	2.20	84.50	1.25	0.8814	1	1.3	F4
34	87.40	2.70	235.98	32.37	4.00	95.00	1.09	0.624	1	1.2	F4
35	106.90	1.53	163.56	69.87	3.10	117.00	1.09	0.624	1	1.4	F4
36	91.40	3.74	341.84	24.44	4.45	1000.00	10.94	0.4407	1	1.4	C4
37	114.00	2.96	337.44	38.51	3.75	1001.00	8.78	0.4407	1	1.3	C4
38	112.60	2.05	230.83	54.93	2.85	208.00	1.85	0.4407	1	1.5	F4/C4
39	97.50	1.99	194.03	48.99	2.95	140.50	1.44	0.4407	1	2	F4/C4

4.3.5 Reach E: Sub-reaches 40 to 52

Reach E transitions from a gravel-dominated system in the upper portion of the reach to sand substrates in the downstream portions (Table 3e). Nine of the 13 sub-reaches in the lower portions of the reach are classified as C4 or C5 types. Four sub-reaches in the upstream portion of the reach (sub-reaches 40, 41, 43, and 44) are classified as "F" types. The reach is characterized by gradients between 0 and 1.0 percent, sinuosity of 1.2 to 1.5, entrenchment ratios 1.1 to 12.3, and width-to-depth ratios of 16 to 50.

TABLE 3e

Stream Type Characteristics of Reach E

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient(%)	Channel Sinuosity	Stream Type
40	70.50	2.62	184.71	26.91	3.55	89.60	1.27	0.4407	1	1.4	F4
41	140.00	2.79	390.60	50.18	6.25	262.00	1.87	0.2223	1	1.3	F4/C4
42	101.00	2.61	263.61	38.70	4.75	450.00	4.46	0.156	1	1.5	C4
43	95.50	3.50	334.25	27.29	5.85	143.00	1.50	0.8814	<1	1.5	F4/C4
44	105.50	3.15	332.33	33.49	4.40	111.50	1.06	0.078	1	1.2	F5
45	107.90	5.76	621.50	18.73	8.05	470.00	4.36	0.078	<1	1.2	C5
46	115.00	5.63	647.45	20.43	8.25	775.00	6.74	0.039	<1	1.5	C5
47	116.00	6.42	744.72	18.07	10.70	1150.00	9.91	0.0195	<1	1.5	C5
48	122.00	7.30	890.60	16.71	9.60	1250.00	10.25	0.039	1	1.2	C5
49	106.20	6.23	661.63	17.05	8.00	1200.00	11.30	0.078	<1	1.2	C5
50	150.00	4.38	657.00	34.25	7.00	750.00	5.00	1.755	<1	1.5	C4
51	122.00	6.37	777.14	19.15	8.00	1500.00	12.30	0.0195	<1	1.5	C5
52	194.00	4.91	952.54	39.51	9.00	1200.00	6.19	0.078	<1	1.5	C5

4.4 Riparian Community Type

During the stream channel type inventory, forty-seven different plant species were identified within the greenline of the Pack River (Table 4). Mixes of coniferous species occur throughout the upper portion of the Pack River riparian areas, particularly in B type sub-reaches. These mixtures of coniferous species include Western redcedar, Douglas fir, western hemlock, Engelmann spruce, Western white pine, ponderosa pine, and grand fir. In the C type stream reaches, black cottonwood occurs. Sub-reaches containing conifers exist in the lower watershed, but to a lesser extent than in the upper watershed.

Understories in coniferous habitat in the B type stream reaches are comprised of Gray-leaved and Scouler willow, Sitka alder, red-osier dogwood, Rocky Mountain maple, and western seviceberry. In some areas that contain low numbers of conifers, these shrub species comprise the dominant vegetation.

In the C type reaches of the lower watershed, sandbar willow and red-osier dogwood occur in the moist riparian areas, while rose, snowberry, and spirea occur on the higher and drier terraces. Other shrub species listed in Table 4 occur in lesser amounts.

Graminoids, such as beaked sedge, bulrush, and smooth brome are more prevalent in the lower C type sub-reaches than in the upstream B type portions of the watershed, where forbs are more prevalent.

Five invasive species were identified in the riparian areas. The majority of these occurred in the lower watershed. Common tansy and Canada thistle were the most prevalent. In addition, reed canarygrass occurred throughout the lower watershed.

TABLE 4

Plant Species Observed in Pack River Riparian Areas

Common Name	Genus and species
Trees	
Western redcedar	*Thuja plicata*
Douglas-fir	*Pseudotsuga menziesii*
Engelmann spruce	*Picea engelmannii*
Western hemlock	*Tsuga heterophylla*
Western white pine	*Pinus monticola*
Ponderosa pine	*Pinus ponderosa*
Grand fir	*Abies grandis*
Black cottonwood	*Populus trichocarpa*
Shrubs	
Mountain-ash	*Sorbus sitchensis*
Pink spiraea	*Spiraea douglasii ssp.menziesii*
Hawthorn	*Crataegus douglasii*
Devil's club	*Oplopanax horridus*
Gray-leaved willow	*Salix*
Coyote (sandbar) willow	*Salix exigua*
Scouler willow	*Salix scouleriana*
Sitka alder	*Alnus sinuate*
Mountain alder	*Alnus incana*
Red-osier dogwood	*Cornus stolonifera*
Rocky Mountain maple	*Acer glabrum*
Western serviceberry	*Amelanchier alnifolia*
Western yew	*Taxus brevifolia*
Black huckleberry	*Vaccinium membranaceum*
Common snowberry	*Symphoricarpos albus*
Rose	*Rosa sp. (woodsii, nutkana)*
Black raspberry	*Rubus leucodermis*
Thimbleberry	*Rubus parviflorus*
Northern blackcurrant	*Ribes hudsonianum*
Twin-berry	*Lonicera involucrata*

Graminoids	
Beaked sedge	*Carex utriculata*
Small-flowered bulrush	*Scirpus microcarpus*
Bluejoint reedgrass	*Calamagrostis canadensis*
Reed canarygrass	*Phalaris arundinacea*
Smooth brome	*Bromus inermis*
Forbs	
Pearly-everlasting	*Anaphalis margaritacea*
Fireweed	*Epilobium angustifolium*
Common willow-herb	*Epilobium ciliatum*
Twisted stalk	*Streptopus amplexifolius*
Sweet-scented bedstraw	*Galium triflorum*
Arrowleaf groundsel	*Senecio triangularis*
Field mint	*Mentha arvense*
Field horsetail	*Equisetum arvense*
Bracken fern	*Pteridium aquilinum*
Invasive species	
Common tansy	*Tanacetum vulgare*
Spotted knapweed	*Centaurea maculosa*
Redtop	*Agrostis stolonifera*
Lambs quarter	*Chenopodium album*
Canada thistle	*Cirsium arvense*

Vegetated areas along the greenline were classified into twenty three community types. Of these community types, willow (including gray-leaf and sandbar willow types), western redcedar, and Sitka alder dominated the riparian communities. Detailed descriptions of the three major vegetation community types found on the Pack River are provided below from (Hansen et al., 1995). Successional stage and stability ratings were also assigned by interpretation from (Hansen et. al, 1995) or using professional judgement.

Western Redcedar Type

This type occurred mostly in the uppermost reaches, particularly in reaches A and B. It occurred much less in reaches D and E.

According to (Hansen et al., 1995), there are three main western redcedar community types. The western redcedar/devil's club community type is the wettest type. The western redcedar/lady fern community type, (lady fern) phase, and the western redcedar/oak fern community type occupy drier wetland sites. Because the Pack River sites are relatively disturbed and typical wetland forbs are not fully established, it was difficult to subdivide the community type further than western redcedar.

Western redcedar and western hemlock, either alone or as co-dominants, are the major tree species in this type. Both species occur either alone or together along the Pack River. The western redcedar type often supports large old growth trees. However, in the study area, the majority of trees are quite young ranging from sapling to mid-pole size with few fully developed trees.

Hansen et al., 1995) rates western redcedar as a species with medium erosion control potential because it is moderate in these aspects in established stands: aggressive growth, persistent plant structure, potential biomass, and/or soil binding root-rhizome-runner system. It is rated low in potential for short term revegetation, because it demonstrates slow growth and reproduction and poor cover. However, it is rated medium for long-term revegetation because it has fair growth, cover, reproduction, and stand maintenance over the long-term.

It is important to recognize that though this type is considered a late seral vegetation community type, on the Pack River the western redcedar occurs in young age classes, mostly as saplings and poles. As a result, though this report categorizes the western redcedar type as late seral with a high stability rating, it is presently functioning at a more limited level.

Sitka Alder Type

The Sitka alder type was prevalent in Reaches A and B, and less abundant in Reach C and the upstream portion of Reach D. In many of the sub-reaches where it is established type, is being gradually replaced by western redcedar. According to (Hansen et al., 1995), the Sitka alder community occurs at mid to high elevations. It typically forms long narrow riparian or wetland stringers along mountain streams but is also located on wet stream benches, overflow channels, and hillside seeps. Sitka alder is well known as a colonizer of disturbed soils and is highly resistant to flooding damage (Haeussler and Coates, 1986).

Cooper et al, 1991 considered wetlands dominated by the Sitka alder community to be long-lived mid-seral communities. (Hansen et al., 1995) describes the Sitka alder community type as characterized by a dense overstory of Sitka alder, with a diverse undergrowth of herbaceous species or other shrubs. The conditions in the Pack River study area fit this description. The community is characterized by relatively dense vegetation where it occurs.

Hansen et al., 1995) also describes the Sitka alder type as highly competitive and tending to establish at mid to high elevations along sites that are continually scoured and flooded, with high water tables, and following severe disturbance. Mueggler, 1965 found that broadcast burning favored the Sitka alder type in the cedar-hemlock zone of northern Idaho. Frequency and cover were increased on sites that had been repeatedly burned over a 30-year period. Thus, it this community type would be expected in the upper reaches of the Pack River that were disturbed by fire.

Willow Types

In general, the willow community type occurred in some form in almost all sub-reaches. The majority of the identified willows were gray-leaved willow and Scouler's willow in the upper reaches and coyote (or sandbar) willow along the lower river. The first two species are mid-seral type, while the latter is an early seral type. Willow communities occurred primarily in areas that were disturbed. In Reaches A and B, where fire had been the major recent disturbance, gray-leaf and/or Scouler's willow occurred as a subdominant to the Sitka alder type. Gray-leaf willow dominated in Reach C and coyote (sandbar) willow was the characteristic community in reaches D and E. These reaches are disturbed by erosion or flooding.

All willow types are rated by (Hansen et al., 1995) high for streambank erosion control potential because the of aggressive growth habits, persistent plant structure, high potential biomass, and/or good soil-binding root-rhizome-runner system in established stands. This type stabilizes soils adjacent to streams and forms overhanging banks, enhancing fisheries quality Hansen et al. 1995).

The herbaceous understory of the willow type aids in filtering out sediments during high flows contributing to the building of the streambanks. Hansen et al. (1995) also describes that the various willow species sprout vigorously following fire, especially in wetter stands. Quick, hot fires result in more willow sprouts than slower fires, which are potentially more damaging to the willows.

4.4.1 Reach A

Western redcedar community types, with secondary occurrences of Sitka alder and gray-leaved willow types dominated Reach A (Table 5a) All eight sub-reaches contained to some extent the western redcedar community type. Western redcedar ranged from 88 percent (Reach 5) to 22 percent coverage (Reach 8). Sub- reaches 2, 3, 5, and 6 had the highest percent cover of the western redcedar type, while reaches 7 and 8 had the lowest percentage of this type (42 and 22 percent, respectively). Sub-reaches 7 and 8 were dominated instead by the willow and Sitka alder community types, respectively. The second dominant type in Reach A was the Sitka alder community type with a range of 72 (Reach 8) to 11 percent (Reaches 1 and 2).

Sub-reaches 2 and 5 had the highest percentage of vegetation types in late seral stages (84 and 88 percent, respectively). These sub-reaches also had high stability ratings. Sub-reaches 7 and 8, in contrast, had the lowest percentage of late seral vegetation (42 and 24 percent). These sub-reaches also had the lowest stability ratings within Reach A.

TABLE 5a

Riparian Vegetation Characteristics of Reach A

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
1	Sitka alder	11%	E	7	0.77	
1	Western redcedar	67%	L	8	5.36	
1	Boulder	6%	L	10	0.6	
1	Gray-leaf willow	16%	E	7	1.12	
1 Total					7.85	73
2	Sitka alder	11%	E	7	0.77	
2	Western redcedar	84%	L	8	6.72	
2	Gray-leaf willow	5%	E	7	0.35	
2 Total					7.84	84
3	Sitka alder	24%	E	7	1.68	
3	Western redcedar	76%	L	8	6.08	
3 Total					7.76	76
4	Western redcedar	60%	L	8	4.8	
4	Mesic forb	6%	E	4	0.24	
4	Sitka alder	34%	E	7	2.38	
4 Total					7.42	60
5	Western redcedar	88%	L	8	7.04	
5	Sitka alder	12%	E	7	0.84	
5 Total					7.88	88
6	Western redcedar	79%	L	8	6.32	
6	Sitka alder	21%	E	7	1.47	
6 Total					7.79	79
7	Western redcedar	42%	L	8	3.36	
7	Gray-leaf willow	46%	E	7	3.22	
7	Sitka alder	12%	E	7	0.84	
7 Total					7.42	42
8	Sitka alder	72%	E	7	5.04	
8	Western redcedar	22%	L	8	1.76	
8	Horsetail	4%	E	3	0.12	
8	Boulder	2%	L	10	0.2	
8 Total					7.12	24

4.4.2 Reach B

Vegetation in Reach B is transitioning from conifer to shrub types. It is dominated by western redcedar, gray-leaved willow, and Sitka alder types (Table 5b).

Eight of the 13 sub-reaches in Reach B contained some extent the western redcedar community type. Three sub-reaches (9, 10, and 14) near the upstream end of Reach B were dominated by the Sitka alder type. Sub-reach 11 was dominated by a boulder/bedrock substrate. Four sub-reaches (12, 15, 16, and 21) were dominated by willow type. Western redcedar was the dominant type for four other sub-reaches (13, 17, 18, and 19). Western redcedar was also a codominant with Sitka alder in sub-reach 14. Sub-reach 20 was dominated by a water birch (*Betulus occidentalis*) type.

Sub-reaches 17, 18, 19 had the highest percentage that were in late seral vegetation stages (90, 100, and 93 percent, respectively. Sub-reaches 9, 12, and 15 had the lowest percentage of late seral vegetation (18, 26, and 21 percent). Reach 11 had the highest stability rating because of the prevalence of bedrock. Reach 15 had the lowest stability rating because of the mixture of community types, and it was 10 percent barren.

TABLE 5b

Riparian community characteristics of Reach B

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
9	Sitka alder	62%	E	7	4.34	
9	Western redcedar	11%	L	8	0.88	
9	Boulder	7%	L	10	0.7	
9	Willow	20%	E	7	1.4	
9 Total					7.32	18
10	Sitka alder	37%	E	7	2.59	
10	Black cottonwood/Red-osier dogwood	19%	L	8	1.52	
10	Spruce	14%	L	8	1.12	
10	Willow	11%	E	7	0.77	
10	Mountain alder	14%	L	8	1.12	
10	Red-osier dogwood	5%	E	7	0.4	
10 Total					7.52	47
11	Boulder/Bedrock Wall	46%	L	10	4.6	
11	Willow	32%	E	7	2.24	
11	Red-osier dogwood	6%	E	7	0.42	
11	Sitka alder	6%	E	7	0.42	
11	Unclassified riparian type	7%	E	6	0.42	
11	Western redcedar	3%	L	8	0.24	
11 Total					8.34	49
12	Red-osier dogwood	22%	E	7	1.54	
12	Willow	36%	E	7	2.52	
12	Boulder/Mesic Forb	1%	L	10	0.1	
12	Sitka alder	16%	E	7	1.12	
12	Unclassified riparian type (late seral)	18%	L	8	1.44	
12	Pseudotsuga menziesii/Cornus stolonifera	7%	L	8	0.48	
12 Total					7.2	26
13	Sitka alder	37%	E	7	2.59	
13	Willow	20%	E	7	1.4	
13	Western redcedar	43%	L	8	3.44	
13 Total					7.43	43

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
14	Willow	21%	E	7	1.47	
14	Sitka alder	40%	E	7	2.8	
14	Western redcedar	39%	L	8	3.12	
14 Total					7.39	39
15	Willow	46%	E	7	3.22	
15	Sitka alderCT	15%	E	7	1.05	
15	Mesic Forb	4%	E	4	0.16	
15	Unclassified riparian type (late seral)	3%	L	8	0.24	
15	Ponderosa pine/red-osier dogwood	18%	L	8	1.44	
15	Barren	10%	E	1	0.1	
15	Spirea	2%	E	6	0.12	
15	Upland Grass	2%	E	4	0.08	
15 Total					6.41	21
16	Willow	54%	E	7	3.78	
16	Ponderosa pine/red-osier dogwood	31%	L	8	2.48	
16	Mass Wasting/Barren/Mixed Shrubs	5%	E	3	0.15	
16	Mesic Forb/Barren	10%	E	3	0.3	
16 Total					6.71	31
17	Western redcedar	90%	L	8	7.2	
17	Willow	10%	E	7	0.7	
17 Total					7.9	90
18	Willow	20%	E	7	1.4	
18	Western redcedar	55%	L	8	4.4	
18	Bedrock/Sparse Riparian Mix	25%	L	10	2.5	
18 Total					8.3	80
19	Willow	32%	E	7	2.24	
19	Western redcedar	54%	L	8	4.32	
19	Barren	6%	E	1	0.06	
19	Sitka alder	5%	E	7	0.35	
19	Sparse willow/Upland Tanacetum vulgare~Centaurea maculosa	3%	E	4	0.12	
19 Total					7.09	54
20	Willow	29%	E	7	2.03	
20	Birch	45%	L	8	3.6	
20	Red-osier dogwood	4%	E	7	0.28	
20	Sitka alder	18%	E	7	1.26	
20	Unclassified riparian type	4%	E	5	0.2	
20 Total					7.37	45
21	Willow	44%	E	7	3.08	

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
21	Birch	7%	L	8	0.56	
21	Western redcedar	23%	L	8	1.84	
21	Spirea	12%	E	6	0.72	
21	Unclassified riparian type	14%	E	5	0.7	
21 Total					6.9	30

4.4.3 Reach C

The vegetation transitioned between Reach B to Reach C from a mix of conifer and shrub types to willow. This change to early seral species occurs where BB stream types transition to C or F stream types. Only three of the nine sub-reaches of Reach C contained to any extent the western redcedar community type, which did not dominate anywhere in this reach (Table 5c). Eight of the nine sub-reaches were dominated by willow type. Only sub-reach 22 was dominated by Sitka Alder type.

Sub-reach 25 had the highest percentage of vegetation types in late seral stages (14 %). Sub-reaches 24, 26, 27, 28, and 30, had the lowest percentage of late seral vegetation (0 %). All sub-reaches in Reach C had lower stability ratings than those found upstream in Reaches A and B. Reach 22 had the highest stability rating because of the dominate Sitka alder community. Reach 24 had the lowest stability rating because of the large amount of upland community types.

TABLE 5c

Riparian community characteristics of Reach C

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
22	Sitka alder	64%	E	7	4.48	
22	Unclassified riparian type	15%	E	6	0.9	
22	Spiraea	16%	E	6	0.96	
22	Western redcedar	5%	L	8	0.4	
22 Total					6.74	5
23	Willow	45%	E	7	3.15	
23	Barren	3%	E	1	0.03	
23	Sitka alder	17%	E	7	1.19	
23	Western redcedar	8%	L	8	0.64	
23	Spirea	27%	E	6	1.62	
23 Total					6.63	8
24	Sitka alder	16%	E	7	1.12	
24	Willow	44%	E	7	3.08	
24	Upland site	32%	E	3	0.96	
24	Unclassified riparian type	8%	E	3	0.24	
24 Total					5.4	0
25	Willow	59%	E	7	4.13	

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
25	Black cottonwood/red-osier dogwood	14%	L	8	1.12	
25	Spirea	6%	E	6	0.36	
25	Unclassified riparian type	3%	E	2	0.06	
25	Unclassified riparian type	7%	E	2	0.14	
25	Red-osier dogwood	3%	E	7	0.21	
25	Sitka alder	8%	E	7	0.56	
25 Total					6.58	14
26	Willow	45%	E	7	3.15	
26	Alder	33%	E	7	2.31	
26	Unclassified riparian type	22%	E	5	1.1	
26 Total					6.56	0
27	Willow	55%	E	7	3.85	
27	Unclassified riparian type	7%	E	3	0.21	
27	Sitka alder	16%	E	7	1.12	
27	Upland site	22%	E	3	0.66	
27 Total					5.84	0
28	Spirea	10%	E	6	0.6	
28	Willow	78%	E	7	5.46	
28	Upland site	13%	E	3	0.39	
28 Total					6.45	0
29	Willow	49%	E	7	3.43	
29	Spirea	2%	E	6	0.12	
29	Willow	5%	E	7	0.35	
29	Western redcedar	4%	L	8	0.32	
29	Upland site	30%	E	3	0.9	
29	Sitka alder	10%	E	7	0.7	
29 Total					5.82	4
30	Spirea	8%	E	6	0.48	
30	Upland site	7%	E	3	0.21	
30	Sitka alder	10%	E	7	0.7	
30	Willow	75%	E	7	5.25	
30 Total					6.64	0

4.4.4 Reach D

Reach D contains the willow, western redcedar, and upland community types (Table 5d). Six of the 9 sub-reaches in Reach D contained some amount of western redcedar community type, an increase from Reach C. In sub-reach 31, western redcedar was a dominant vegetation type. In addition, western redcedar was prevalent on the floodplain in the area just outside the greenline of the channel. Since it is outside the greenline in this area, the western redcedar was not considered the dominant type on the channel banks. Five of the 9 sub-reaches were dominated by willow type. Upland types dominated the remaining three sub-reaches that were in late seral stages (34 %). Sub-reach 33 also had the highest stability rating as it had a secondary layer of dogwood (*Cornus*) associated with the conifer and alder.

Sub-reach 37 and 38 had the lowest percentage of late seral vegetation (0 %). Upland community types and willow type dominated these sub-reaches. Sub-reach 37 also had the lowest stability rating as it was characterized by a large amount of herbaceous upland community types.

TABLE 5d

Riparian community characteristics of Reach D

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
31	Willow	15%	E	7	1.05	
31	Upland site	27%	E	3	0.81	
31	Western redcedar	33%	L	8	2.64	
31	Sitka alder	25%	E	7	1.75	
31 Total					6.25	33
32	Spirea	3%	E	6	0.18	
32	Unclassified riparian type	10%	E	6	0.6	
32	Willow	65%	E	7	4.55	
32	Western redcedar	22%	L	8	1.76	
32 Total					7.09	8
33	Mountain alder	27%	E	7	1.89	
33	Western redcedar	30%	L	8	2.4	
33	Black cottonwood/red-osier dogwood	4%	L	8	0.32	
33	Willow	39%	E	7	2.73	
33 Total					7.34	34
34	Willow	62%	E	7	4.34	
34	Upland site	20%	E	3	0.6	
34	Blackcottonwood/red-osier dogwood	18%	L	8	1.44	
34 Total					6.38	18
35	Spirea	14%	E	6	0.84	
35	Western redcedar	13%	L	8	1.04	
35	Willow	30%	E	7	2.1	
35	Upland site	43%	E	3	1.29	
35 Total					5.27	13
36	Spirea	7%	E	6	0.42	
36	Upland site	58%	E	3	1.74	
36	Western redcedar CT	12%	L	8	0.96	
36	Unclassified riparian type (late seral)	9%	L	8	0.72	
36	Willow	14%	E	7	0.98	
36 Total					4.82	21
37	Willow	34%	E	7	2.38	
37	Upland site	63%	E	3	1.89	
37	Mountain alder	3%	E	7	0.21	
37 Total					4.48	0
38	Willow	28%	E	7	1.96	
38	Willow (early)	30%	E	6	1.8	

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
38	Residential	19%	E	3	0.57	
38	Mountain alder	8%	E	7	0.56	
38	Upland site	15%	E	3	0.45	
38 Total					5.34	0
39	Western redcedar	8%	L	8	0.64	
39	Mountain alder	25%	E	7	1.75	
39	Spirea	7%	E	6	0.42	
39	Unclassified riparian type	6%	E	6	0.36	
39	Upland site	21%	E	3	0.63	
39	Willow	33%	E	7	2.31	
39 Total					6.11	8

4.4.5 Reach E

Reach E was dominated by the willow community type, but also had high percentages of reed canarygrass (*Phalaris arundinacea)* and upland community types within its sub-reaches (Table 5e). Two of the 13 sub-reaches contained to some extent the western redcedar community type; it was a dominant vegetation type in sub-reach 40. Six of the 13 sub-reaches were dominated by willow type. Two of the 13 sub-reaches were dominated by reed canarygrass type. Another two of the 13 sub-reaches were dominated by upland community type. The remaining two sub-reaches were dominated by a snowberry (*Symphiocarpus alba*) community type.

Sub-reach 40 had the highest percentage of late seral stages (44 %). Sub-reaches 44, 49, 50, and 52 had the lowest percentage of late seral vegetation (0 %). Upland and willow types dominated these reaches. Sub-reach 40 had the highest stability rating because of the dominant presence of western redcedar.

TABLE 5e

Riparian Community Characteristics of Reach E

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
40	Willow	28%	E	7	1.96	
40	Mountain alder	14%	E	7	0.98	
40	Snowberry	3%	E	6	0.18	
40	Western redcedar	44%	L	8	3.52	
40	Upland site	11%	E	3	0.33	
40 Total					6.97	44
41	Willow	53%	E	7	3.71	
41	Bulrush	8%	L	6	0.48	
41	Reed canarygrass	12%	L	6	0.72	
41	Hawthorne (douglasii)	8%	L	9	0.72	
41	Wood’s rose	5%	E	6	0.3	
41	Barren (Sand)	8%	E	1	0.08	

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
41	Sedge	6%	NA	NA	NA	
41 Total					6.01	28
42	Sedge	8%	NA	NA	NA	
42	Hawthorne (douglasii)	4%	L	9	0.36	
42	Mountain alder	27%	E	7	1.89	
42	Willow	23%	E	7	1.61	
42	Reed canarygrass	38%	L	6	2.28	
42 Total					6.14	42
43	Willow	33%	E	7	2.31	
43	Spirea	6%	E	6	0.36	
43	Sedge	12%	NA	NA	NA	
43	Reed canarygrass	8%	L	6	0.48	
43	Reed canarygrass	31%	E	3	0.93	
43	Upland site	6%	E	3	0.18	
43	Unclassified riparian type	4%	E	7	0.28	
43 Total					4.54	8
44	Willow(early)	6%	E	6	0.36	
44	Willow	46%	E	7	3.22	
44	Reed canarygrass	19%	E	3	0.57	
44	Upland site	29%	E	3	0.87	
44 Total					5.02	0
45	Snowberrry	28%	E	6	1.68	
45	Hawthorne (douglasii)	20%	E	6	1.2	
45	Reed canarygrass	21%	L	6	1.26	
45	Willow	20%	E	6	1.2	
45	Upland site	11%	E	3	0.33	
45 Total					5.67	21
46	Snowberry	76%	E	6	4.56	
46	Willow	13%	E	7	0.91	
46	Hawthorne (douglasii)	6%	E	6	0.36	
46	Western redcedar	5%	L	8	0.4	
46 Total					6.23	5
47	Willow (early)	21%	E	6	1.26	
47	Spirea	20%	E	6	1.2	
47	Reed canarygrass	9%	L	6	0.54	
47	Willow	50%	E	7	3.5	
47 Total					6.5	9
48	Willow	35%	E	7	2.45	
48	Blackcottonwood/red-osier dogwood	15%	L	8	1.2	
48	Snowberry	20%	E	6	1.2	
48	Smooth bromw	19%	E	4	0.76	
48	Hawthorne (douglasii)	11%	E	6	0.66	
48 Total					6.27	15
49	Woods rose	6%	E	6	0.36	

Sub-reach	Community Type or Dominant Species	Percent Composition	Successional Status	Stability Class	Stability Index	Percent Late Seral
49	Willow	45%	E	7	3.15	
49	Upland site	46%	E	3	1.38	
49	Hawthorne (douglasii)	3%	E	6	0.18	
49 Total					5.07	0
50	Willow	86%	E	7	6.02	
50	Hawthorne (douglasii)	8%	E	6	0.48	
50	Spruce	6%	E	6	0.36	
50 Total					6.86	0
51	Willow	52%	E	7	3.64	
51	Reed canarygrass	29%	L	6	1.74	
51	Sedge	14%	NA	NA	NA	
51	Willow (early)	5%	E	6	0.3	
51 Total					5.68	29
52	Willow	17%	E	7	1.19	
52	Sedge	33%	NA	NA	NA	
52	Upland site	42%	E	3	1.26	
52	Willow (early)	8%	E	6	0.48	
52 Total					2.93	0

4.5 Fish Habitat

Summaries of fish habitat characteristics and woody debris data are presented in this section. Data is represented in Appendix F.

4.5.1 Reach A

Reach A contained ten instream habitat types. Fast moving types were more prevalent than slow moving pool habitat. All sub-reaches contained some amount of slow habitat.

Sub-reaches 1 and 5 had the highest amount of pool area (58.2 and 60.9 percent. Sub-reaches 2, 6, and 8 had 20 to 23 percent pool area. Other sub-reaches had lesser amounts of pool area with the lowest amount in sub-reaches 3, 4, and 7.

One hundred and twenty three pieces of aggregated wood and 67 single pieces were counted in Reach A. There were 202 aggregate and 110 single pieces of wood per mile. Wood in Reach A occurred primarily in the smallest size classes and was mostly in the oldest decay class.

4.5.2 Reach B

Ten instream fish habitat types occurred within Reach B and the dominant types were glide and low gradient riffle. Slow moving pool habitat was largely absent from the reach. Seven sub-reaches had no pool habitat. Slow habitat comprised 11.6 percent of the habitat area measured in Reach B. Sub-reach 9 had the highest amount of pool area (57.9 percent). Sub-reaches 11 and 19 had 20 to 30 percent pool area. The remaining sub-reaches had little to no pool habitat.

Eighty-two aggregate and 67 single pieces of woody debris were found in this reach. There were 82 aggregate and 67 single pieces of wood per mile. The most wood occurred in sub-reaches 12 through 16. Wood in Reach B occurred primarily in the smallest size classes and in the oldest decay class.

4.5.3 Reach C

Eight different instream fish habitat types occurred in Reach C with glide and low gradient riffle as the dominant types. Slow moving pool habitat was largely absent from the reach.

Four sub-reaches had no pool habitat and slow habitat comprised 9.2 percent of the habitat area. Sub-reach 29 had the highest amount of pool area at 37.2 percent. The remaining sub-reaches had minimal to no pool habitat.

Reach C had a low amount of aggregate and single wood; 122 pieces aggregate and 45 single wood pieces were counted. There were 32 pieces of aggregated and 66 of single wood per mile. Sub-reaches 27-29 had the most amount of wood. Wood was primarily in the smallest size classes and in the oldest decay class.

4.5.4 Reach D

Reach D had six instream fish habitat types. The predominant types were fast habitat types, including glide and low gradient riffle. Slow moving pool habitat was present in a low amount in Reach D. Slow habitat comprised 17.3 percent of the habitat area, and three of the nine sub-reaches had no pool habitat. Sub-reaches 31, 36, and 39 had the highest amount of pool area with 38.7 , 38.5, and 34.6 percent, respectively. Sub-reaches 34 and 35 had nearly 20 percent slow habitat. Sub-reaches 32, 33, and 37 lacked of pool habitat completely.

Most of the wood in this reach occurred as aggregates. One hundred forty three aggregate and 34 single pieces were counted in this reach. There were 208 aggregate and 50 single pieces per mile. The most amount of wood occurred in sub-reaches 38 and 39. Woody debris pieces occurred predominantly in the smallest size classes and in the oldest decay class.

4.5.5 Reach E

Reach E contained seven instream habitat types with glide types dominant. Slow pool habitat comprised 20.7 percent. Sub-reaches 42, 43, and 49 had the highest amount of pool area with 50.8, 59.4, and 40.0 percent, respectively. Sub-reaches 40, 45, and 52 lacked pool habitat.

A total of 182 aggregate and 106 single pieces were documented within this reach. There were 192 aggregate and 111 single pieces per mile of stream. The most amount of wood occurred in sub-reaches 44 to 47. Woody debris pieces occurred predominantly in the smallest size classes and in the oldest decay class.

4.6 Reach F Results

4.6.1 Sub-reach 53

In Sub-reach 53, the river meanders through the Hidden Lakes Resort golf course and has a lentic character. The reach is characterized by low velocity and uniform morphology typical of a broad glide habitat. The flood-prone area extends at least 700 feet on each side of the river. The channel has a very low gradient of <0.05 percent and the valley floor is wide.

Approximately 0.5 miles of the right bank has little riparian vegetation because many of the outside meander bends are riprapped. There is an abrupt transition to grass as the golf course lawn extends to within a few feet of the riprapped bank. Occasional woody species (i.e., alders) grow in some places on the edge of the bank.

The riparian area, where it is not converted to golf course, appears healthy. The inside meander bends appear to be frequently flooded and wetland vegetation, alder, willow, dogwood and wetland sedges, predominates.. Aggressive invasive species, such as reed canarygrass and common tansy, dominate many areas. Structural diversity is good in this area, though species diversity is lower than it would be if native mesic forbs were more abundant. The old oxbows in this area produce palustrine wetlands that are excellent wildlife habitat.

There are many cottonwood trees on the floodplain located away from the bank of the river. Beaver-chewed cottonwood stumps were present, but there is a lack of large woody debris in the river. Several old conifer stumps are also present on the floodplain.

4.6.2 Sub-reach 54

This sub-reach is characterized by slow, deep meandering glide habitat with many wetlands formed by old oxbows. The area has good structural diversity of riparian and wetland vegetation, but invasive species have lowered complexity of vegetation in some areas.

Lentic wetlands in this area are bordered by cattails (*Typha)* and bulrush (*Scirpus)* with reed canarygrass on the outer extent of bulrush. Willows grow in the area upslope of the reed canarygrass. Mixed riparian shrubs, including alder, birch, red-osier dogwood, hawthorn, snowberry, rose, and spirea grow at the upper edge of the willows throughout the floodplain. Cottonwood and birch grow generally between the mixed shrubs and the mixed conifer, which are present in some small higher areas within the floodplain that appear are flooded regularly. Toward the downstream end of the sub-reach, cattails grow along the riverbanks. Several large old cedar stumps can be found within this reach standing in water.

The reservoir flooded much of the land that was historically hayland. The surface water and raised water table in the area resulted in an altered hydrology. The altered hydrology created an area with a more lentic nature. Hydrophytic vegetation such as bulrush and cattails dominate in the lower areas and cottonwoods occur at a distance from the lotic portion of the area.

5.0 DISCUSSION

A river is a dynamic, living system with complex physical and biological processes that are constantly undergoing change. A good understanding of these processes is crucial to sound river management. The three basic components of the system, geomorphic physical character, riparian zone and floodplain, and instream physical fish habitat, all interact to determine the structure and function of river ecosystems. Any changes to one of these elements can have significant impacts upon other parts of the system.

5.1 Reference Conditions

Desired conditions as indicated by reference locations provide a target for which private and public land managers to aim as they conduct resource management activities. Reference conditions for the Pack River were based on best - functioning sub-reaches identified during this survey and information gathered from available scientific literature on conditions of other unmanaged reference areas in northern Idaho. Reference Rosgen stream channel types were chosen as areas that exhibited a stable channel geometry and planform, and did not appear to change dramatically over time. Vegetation reference areas were those that had the most amount of late seral vegetation as defined in this survey. Fish habitat reference was a combination of the optimum conditions available on the Pack River and for other northern Idaho reference areas.

This section provides a comparison of current Pack River conditions to reference conditions by sub-reach for stream channel type, riparian vegetation, and fish habitat.

5.2 Stream Channel Type

All streams seek to establish a channel morphology in equilibrium with prevailing flow and sediment conditions. For most rivers, this is not a static state, but a form of relatively stable characteristics to which the channel returns after a disturbance. That equilibrium, however, can easily be upset by human activities and natural disturbance events that alter the sediment load and discharge characteristics of the river.

Over the last century, several natural and man-made disturbances have affected the Pack River watershed. As a result, the existing river channel is a sum of present and past influences. How each segment of the channel responds to disturbances within the watershed is affected by factors such as bank composition, bank vegetation and valley slope. As such, the locations, magnitude, rates, and extent of the Pack River channel responses to watershed changes are highly variable.

Tables 6a through d summarize current and desired stream types for the Pack River. Following each table is a discussion of the comparisons and factors contributing to current conditions, as well as any trends in conditions. In many instances, the stream morphological parameters fit into more than one stream type category (e.g., width/depth ratio and channel slope). However, more weight was given to those stream morphological categories that were diagnostic of stream types (e.g., entrenchment ratio in contrast to those categories that were relatively general (e.g., width/depth ratio). When two or more stream types are listed for a reach, the dominant type is listed first. For sub-reach locations refer to Figures 4a – 4h.

5.2.1 Reach A

The reference stream type in Reach A is sub-reach 6. Sub-reach 6 exhibited little change in geomorphology when historical aerial photographs from 1932 to present were reviewed. Sub-reach 6 is a B3a type stream channel (Table 6a).

TABLE 6a

Current and Reference Stream Type Conditions of Reach A

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient (%)	Channel Sinuosity	Stream Type
1	47.9	1.12	53.63	42.94	1.97	57.7	1.21	Bedrock	15	1.1	B1a
2	36.4	1.12	40.40	34.41	2.13	55.1	1.44	11.076	5.8	1.2	B2a
3	51.3	1.74	89.31	29.53	3.05	334.2	6.51	7.995	3.8	1.2	C2b
4	37.6	1.87	70.23	20.09	2.79	76.9	2.05	10.2765	4	1.1	B2a
5	31.5	1.54	48.49	20.43	4.13	72.8	2.31	6.4467	7	1.0	B3a
6*	**38.0**	**0.95**	**36.14**	**40.00**	**2.33**	**69.5**	**1.83**	**6.2673**	**4.5**	**1.3**	**B3a**
7	40.8	1.15	46.96	35.57	1.90	62	1.52	5.3937	1.7	1.3	B3c
8	36.4	1.28	46.60	28.46	2.72	52.2	1.43	4.992	3	1.3	F3b

* Reference sub-reach

Issues

The geomorphology of the upper Pack River is characteristic of glaciated watersheds with granitic parent geology. Due to the erosive nature of granite and the large sediment sources created by retreating glaciers, these types of systems transport a high volume of coarse and fine sediment. This high sediment transport is evident in the upper Pack River. It is also apparent, after reviewing aerial photographs that bedload transport increased considerably after the Sundance Fire. Loss of hillside and streambank vegetation, as a result of the fire, likely had a pronounced effect on the amount of bedload that moved through the system. Increased erosion on existing roads in the upper watershed is evident. Erosion on road slopes may be influencing large-scale mass failure erosions occurring in the upper watershed (Appendix A).

Several sources of sediment occur in Reach A. A large mass failure site exists at the upstream end of sub-reach 1 near the confluence of Zuni Creek. Three mass failure sites exist in the area of sub-reach 2. One large slope area (150 feet high by 240 feet wide) was actively eroding sand-sized outwash material into the stream. Erosion appears to be taking place due to the loss of vegetated cover and the low angle of repose for sand. Zuni Creek also experienced accelerated erosion due to loss of much of its riparian vegetation and heavy erosion from roads (USFS 2002; Appendix A). It is likely that this sediment load is being transported downstream and is having an immediate effect on sub-reach 3 as well as other downstream sub-reaches. Another area of hillslope mass failure occurs near sub-reach 7.

The general geomorphic stream type in Reach A is a stable Rosgen Ba type. In general, sub-reaches 1, 2, 4, 5, and 6 exhibited a stable B type channel morphology. These sub-reaches appear to be capable of transporting the high levels of sediment downstream. Slopes were very steep in sub-reaches 1 and 5. Channel sinuosity is relatively low and slopes ranged from 3 to 5 percent for sub-reaches 2, 4, and 6. As a result of these two factors, these sub-reaches appear effective at transporting a large bedload. Sub-reaches 3, 7, and 8 diverge from the Ba type as shown in the following paragraphs.

Sub-reach 3. Because channel morphology is based on sediment and discharge, large increases in sediment can alter the channel's shape. It is likely that sediment sources upstream from sub-reach 2 are affecting sub-reach 3. A wide valley bottom and gentler slope in sub-reach 3 also facilitates different channel morphology (C2b). This morphology differs from the desired condition of a B2a type. The width of the flood-prone area was relatively wide (334 feet). A moderate amount of scoured, overflow channels exists in the floodplain testifying to the fact that above-bankfull flows frequently access the floodplain. Substrate in the overflow channels consisted of coarse, cobble material in a sand matrix. Review of aerial photos from 1968 revealed that large-scale bedload transport affected the channel possibly as to the extent of the flood prone area width (USFS 2002; Appendix A).

The upper Pack River Road runs adjacent to the river at this point. A highly erosive side runs down to the stream edge in this sub-reach as well. It is likely that transport of the increased sediment load from upstream, as well as the additional erosion associated with the adjacent roads led to an increased sediment load to sub-reach 3.

Sub-reach 7. Sub-reach 7 was classified as a B3c stream type, as it has a reduced slope. This classification differed slightly from the desired condition of a B3a type. Channel characteristics in sub-reach 7 are trending toward that of a C channel, but the stream is still entrenched to a degree that it maintains B channel characteristics.

Sub-reach 7 exhibits a floodplain that is accessible by bankfull flows but does not have developed point bars. The slope is moderate, but the channel does not have a well-defined thalweg. The stream is relatively wide and shallow throughout this sub-reach. Review of the 1968 aerial photos (post-Sundance fire) reveals that the channel has undergone significant morphological change since the Sundance fire. The fire completely burned the forest in most of this reach. Bank erosion increased and width/depth ratios became very high. Numerous channels are visible in the floodplain. Roads are also numerous on the slopes directly adjacent to the river and in the floodplain. An overall aggrading of the channel through sub-reach 7 is evident in 1968 aerial photos (USFS 2002; Appendix A).

Aggradation in this sub-reach is a result of sediment supplied from upstream and a reduced slope. Lack of capacity to transport the bed material supplied, lack of competence to remove the size of material supplied, bank erosion, or a combination of these factors may be resulting in braiding of the stream in this sub-reach. Below the sub-reach 6/7 break, a main channel and a side-channel exist. At base flow, the surface flow is diverted into this side-channel and the main channel goes dry. The presence of some braiding within this stream channel indicates a channel state that is in disequilibrium.

Sub-reach 8. Sub-reach 8 was classified as B3. More roads exist on the landscape directly adjacent to the channel. These roads exhibit surface erosion and in some cases, particularly in sub-reach 7, large scale fill-slope failures (USFS 2002; Appendix A).

The biggest change in channel characteristics from sub-reach 7 to sub-reach 8 was the entrenchment ratio from 1.52 in 7 to 1.43 in 8. Channel confinement in this sub-reach restricted the channel widening in response to the larger sediment load. As a result, the channel appears to have undergone severe downcutting due to the degree of confinement through this reach. It is evident that the channel also widened its margins due to loss of bank stability, which accelerated lateral erosion (USFS 2002; Appendix A).

5.2.2 Reach B

Sub-reach 13 exhibited a B3 type stream morphology, a type that would be in equilibrium with its surrounding setting (Table 6b). Upon review of historical aerial photographs the channel morphology of this sub-reach appeared to remain fairly constant.

TABLE 6b

Current and Reference Stream Type Conditions of Reach B

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient (%)	Channel Sinuosity	Stream Type
9	64.6	3.18	205.43	20.31	4.00	195.30	3.02	7.02	4	1	C3b
10	55.6	2.10	116.76	26.48	3.80	170.80	3.07	9.984	3	1.1	C3b
11	47.0	2.39	112.33	19.67	4.10	52.60	1.12	19.968	6	1	F2b
12	61.4	1.81	111.13	33.92	3.00	73.50	1.20	9.984	4	1	F3b
13	**67.2**	**1.67**	**112.22**	**40.24**	**2.60**	**98.20**	**1.46**	**7.02**	**3**	**1.1**	**B3**
14	57.0	1.53	87.21	37.25	2.70	91.00	1.60	9.984	2	1.1	B3
15	130.0	1.98	257.40	65.66	3.25	255.00	1.96	4.992	2	1.2	B3
16	68.5	1.65	113.03	41.52	2.70	100.70	1.47	4.992	2	1.5	B3
17	57.5	2.64	151.80	21.78	4.40	143.70	2.50	9.984	4	1.1	C3b
18	74.5	2.96	220.52	25.17	4.50	165.50	2.22	9.984	3	1.2	C3b
19	70.7	2.29	161.90	30.87	3.40	155.80	2.20	9.984	3	1.1	C3b
20	100.8	1.79	180.43	56.31	3.10	143.40	1.42	7.02	2	1.1	B3
21	75.6	2.20	166.32	34.36	3.05	136.10	1.80	9.984	2	1.1	B3

Issues

Roughly half the sub-reaches (13, 14, 15, 16, 20, and 21) exhibit a stable channel morphology (B3-type) similar to the reference reach. These channels seem to generally be in balance with their geomorphic setting. These sub-reaches are B stream types, with low-to-moderate gradients, gentle sideslopes, and cobble/boulder-gravel substrates that aid in-channel stability. Though generally in overall balance with slope and sinuosity to the reference sub-reach, sub-reaches 15 and 20 may be functioning slightly at risk. Bankfull width/depth ratios for sub-reaches 15 and 20 are higher than expected from the reference sub-reach. The other sub-reaches within Reach B have channel morphologies that diverge from the desired type and are discussed below.

Sub-reaches 9, 10, 17, 18, and 19. These sub-reaches exhibit a channel morphology (C3b) that differs from the desired reference B-type stream. The valley morphology in these areas is wider than that of the upstream area and other parts of Reach B. With this attribute, the floodprone area of the channel is increased, resulting in higher entrenchment ratios. These sub-reaches also exhibit lower width/depth ratios, as the depth is increased from that of the reference sub-reach. This is likely a result of channel downcutting as the channel tries to degrade to adjust a slope that is too steep. All C-type sub-reaches within Reach B exhibit slopes that are higher than those of the B sub-reaches.

Sub-reaches 11 and 12. Sub-reaches 11 and 12 exhibit an F-type stream morphology. These sub-reaches are much higher in gradient and more entrenched than other sub-reaches in Reach B. This is primarily a result of significantly less flood-prone area than that of other sub-reaches. The main reason for the shift towards this F stream type is that in sub-reaches 11 and 12 the stream channel enters a narrower valley width with sides dominated by bedrock and large boulder boundary materials. This effect also resulted in a limited degree of downcutting as the stream attempts to adjust to the narrower valley width and greater slopes.

5.2.3 Reach C

In Reach C, the setting of the channel indicates a C stream type reference condition. Sub-reach 25 (C3 stream channel type) is the reference sub-reach selected for Reach C (Table 6c). In comparison to the 1968 aerial photos, sub-reach 25 exhibits a relatively stable channel morphology.

TABLE 6c

Current and Reference Stream Type Conditions of Reach C

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient (%)	Channel Sinuosity	Stream Type
22	84.50	2.24	189.28	37.72	2.60	101.00	1.20	4.992	1	1.1	F3 /D
23	140.50	1.50	210.75	93.67	2.90	435.00	3.10	3.51	2	1.4	C3
24	102.20	2.14	218.71	47.76	2.60	145.50	1.42	3.51	1	1.1	F3/C3
25	**76.50**	**2.45**	**187.43**	**31.22**	**3.80**	**244.40**	**3.19**	**3.51**	**1**	**1.1**	**C3**
26	100.30	2.53	253.76	39.64	3.70	490.00	4.89	2.496	1	1.1	C4
27	96.70	2.00	193.40	48.35	2.70	298.00	3.08	2.496	1	1.1	C4
28	93.40	1.48	138.23	63.11	3.45	1000.00	10.71	1.755	1	1.1	C4
29	81.20	2.13	172.96	38.12	3.40	330.00	4.06	1.755	1	1.3	C4
30	111.20	1.44	160.13	77.22	2.60	265.00	2.38	1.248	1	1.2	C4

Issues

Reach C of the river represents a decrease in gradient, and size of substrate from Reaches A and B. As a result, sub-reaches in Reach C changed morphology dramatically. Reach C sub-reaches exhibit unstable C- and F-type channel morphology for a variety of reasons as described below. Sub-reaches diverge from the reference condition completely (different channel type) or partially (same channel type, but significantly different characteristics).

Sub-reaches 22, 23, and 24. These sub-reaches are undergoing channel morphology changes as a result of a change in base-level at sub-reach 22. The gradient of the river changes from 2 percent above sub-reach 22 to 1 percent at and below sub-reach 22.

Sub-reach 22 represents the upstream point at which the Pack River has progressively shallowed its gradient across the alluvial plains as a result of upstream degradation and downstream aggradation. A rapid transition in bed material size from sub-reach 21 upstream is also evident in this area. Sub-reach 22 exhibits F-type stream characteristics with some D braiding characteristics. Also, sub-reach 22 is beginning to aggrade and transition from an F-type to a D-type due to the lack of capacity or competence to move stream sediment loads. This aggradation is the stream's attempt to increase channel gradient to transport sediment.

Sub-reach 23, a C-stream type, developed a large width/depth ratio as a result of the aggradation of material. The stream is attempting to increase gradient in order to transport the sediment load. Sub-reach 24 exhibits an unstable stream morphology (F) as the stream responds to the load and gradient changes.

Sub-reach 25. Sub-reach 25 exhibits a more stable stream geomorphic pattern, with an increased depth and decreased width/depth ratio compared to sub-reaches 22 to 24 upstream. Downcutting of the channel in this sub-reach has increased the average channel depth and decreased the width/depth ratio to a more efficient channel morphology.

Sub-reaches 26 through 30. Sub-reaches 26 through 30 are undergoing aggradation. The average depth in these sub-reaches is decreasing, the bankfull width has increased, and the width/depth ratio is increasing from that of sub-reach 25. A noticeably high amount of sediment enters the Pack River main channel from Caribou Creek. In addition, sediment being eroded in sub-reaches 22 through 24 is being transported to these sub-reaches. It is likely that due to this increased sediment load the stream is attempting to recover a balance in the main channel in its sediment discharge relationship. Major anthropogenic in-channel modifications are occurring in sub-reach 27 consisting of in-stream gravels being moved and piled within the channel. This area represents significant anthropogenic disturbance of the stream channel in this sub-reach.

5.2.4 Reach D

The stream type reference sub-reach for Reach D is a C-type stream channel and is characterized by sub-reach 36, which is a C4- stream type (Table 6d). The C4 type is a stream that is in equilibrium with its landscape setting in this area of the watershed.

TABLE 6d

Current and Reference Stream Type Conditions of Reach D

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrenchment Ratio	Channel Material Size (D50) (in)	Gradient (%)	Channel Sinuosity	Stream Type*
31	111.00	2.84	315.24	39.08	4.45	195.00	1.76	0.8814	1	1.2	F4/C4
32	74.60	1.97	146.96	37.87	3.05	137.00	1.84	0.8814	1	1.3	F4/C4
33	67.40	1.59	107.17	42.39	2.20	84.50	1.25	0.8814	1	1.3	F4
34	87.40	2.70	235.98	32.37	4.00	95.00	1.09	0.624	1	1.2	F4
35	106.90	1.53	163.56	69.87	3.10	117.00	1.09	0.624	1	1.4	F4
36	**91.40**	**3.74**	**341.84**	**24.44**	**4.45**	**1000.00**	**10.94**	**0.4407**	**1**	**1.4**	**C4**
37	114.00	2.96	337.44	38.51	3.75	1001.00	8.78	0.4407	1	1.3	C4
38	112.60	2.05	230.83	54.93	2.85	208.00	1.85	0.4407	1	1.5	F4/C4
39	97.50	1.99	194.03	48.99	2.95	140.50	1.44	0.4407	1	2	F4/C4

Issues

Reach D was consists primarily of unstable sub-reaches in the F and C stream channel types. Only sub-reaches 36 and 37, C4 types, appear to be in balance. They have extensive floodprone areas resulting in a high entrenchment ratio. These sub-reaches appear to have downcut over time as they have deeper mean bankfull depths than the other sub-reaches within Reach D. The width/depth of these sub-reaches is lower than the other sub-reaches as well. The remaining sub-reaches within Reach D have channel morphologies that also diverge from the reference condition as discussed below.

Sub-reaches 31-35. These sub-reaches exhibit mostly F4 characteristics, though in sub-reaches 31 and 32, they exhibit some C4 characteristics. It is likely that historically the channel in this area downcut in an attempt to redefine a slope that would transport a higher level of sediment. The stream appears to be beginning to rebalance its channel morphology and is evolving back more towards the C stream type. Channel material size has decreased to a finer material than that found in sub-reach C upstream. The F4 types are wide, entrenched and meandering. Floodflows in non-entrenched C4 streams normally spread out onto the surrounding floodplain. The stream in these F4 types, however, incised and abandoned its historic floodplain. The significance of this is that large flows, which would normally spread over a wide floodplain, are confined in the channel, exerting excess stream power on the bed and banks. This can cause additional bank erosion supplying excess sediment that creates depositional features resulting in more bank erosion downstream, thus generating more excess sediment. The stream will not return to equilibrium until it has moved enough sediment to create a new floodplain at the new lower base elevation.

Sub-reaches 38 and 39. Sub-reaches 38 and 39 exhibit F4 stream channel types with C4 characteristics. These sub-reaches have a significantly reduced floodprone area from that of the reference sub-reach 36. They are undergoing relatively high levels of aggradation of fine sediment material. A large sediment load being discharged from Colburn Creek. This large input of sediment resulted in aggradation as the stream cannot efficiently move the sediment due to the low slope. This is resulting in decreased minimum depths, though the bankfull width has not changed significantly. As a result, the width/depth ratios in these sub-reaches are out of balance compared to the reference sub-reach. These sub-reaches are also much more entrenched than the reference sub-reach.

5.2.5 Reach E

The reference sub-reach for the wide, alluvial, gentle valley of Reach E would be a C- type stream. However, much of Reach E exhibits channel morphology that appears to be unstable (Table 6e). Review of aerial photographs indicates changes in channel planform and morphology over time in most of the sub-reaches. Sub-reach 42, a C4 stream channel type, is considered the reference sub-reach for Reach E as it demonstrates the most stable geomorphology over time.

TABLE 6e

Current and Reference Stream Type Conditions of Reach E

Sub-reach	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Bankfull X-sect Area (ft2)	Width /Depth Ratio	Max Depth (ft)	Width of Flood-prone Area (ft)	Entrench-ment Ratio	Channel Material Size (D50) (in)	Gradient (%)	Channel Sinuosity	Stream Type
40	70.50	2.62	184.71	26.91	3.55	89.60	1.27	0.4407	1	1.4	F4
41	140.00	2.79	390.60	50.18	6.25	262.00	1.87	0.2223	1	1.3	F4/C4
42	**101.00**	**2.61**	**263.61**	**38.70**	**4.75**	**450.00**	**4.46**	**0.156**	**1**	**1.5**	**C4**
43	95.50	3.50	334.25	27.29	5.85	143.00	1.50	0.8814	0	1.5	F4/C4
44	105.50	3.15	332.33	33.49	4.40	111.50	1.06	0.078	1	1.2	F5
45	107.90	5.76	621.50	18.73	8.05	470.00	4.36	0.078	0	1.2	C5
46	115.00	5.63	647.45	20.43	8.25	775.00	6.74	0.039	0	1.5	C5
47	116.00	6.42	744.72	18.07	10.70	1150.00	9.91	0.0195	0	1.5	C5
48	122.00	7.30	890.60	16.71	9.60	1250.00	10.25	0.039	1	1.2	C5
49	106.20	6.23	661.63	17.05	8.00	1200.00	11.30	0.078	0	1.2	C5
50	150.00	4.38	657.00	34.25	7.00	750.00	5.00	1.755	0	1.5	C4
51	122.00	6.37	777.14	19.15	8.00	1500.00	12.30	0.0195	0	1.5	C5
52	194.00	4.91	952.54	39.51	9.00	1200.00	6.19	0.078	0	1.5	C5

Issues

Reach E is characterized primarily as a C type stream. The sub-reaches exhibit predominantly low gradient areas with moderate to high sinuosity, low to high entrenchment ratios, and moderate to high width/depth ratios (Table 6e). The dominant substrate in Reach E is fine gravel and sand. This is a finer particle size than all reaches described upstream. While only three sub-reaches exhibit channel types that deviated from the overall C reference type, many of the C-type sub-reaches exhibit characteristics that indicate a state of disequilibrium with their surroundings.

Most of Reach E experienced extensive channel migration over the past 60 years, cutting off meanders and drastically changing planform as a result of bank erosion. On most river systems, the dominant bank erosion processes resulting in lateral channel migration change from hydraulic action in upper reaches to mass bank failure in lower reaches. This is the type of erosion that is apparent on the outer meander bends in Reach E. This effect is because of decreasing stream power, and increasing cohesivity of bank materials and higher bank heights in lower reaches. Local site characteristics also influence the bank erosion, the most notable being bank material composition, flow distribution and channel geometry. Vegetation type and rooting depth can dramatically affect the rate of bank erosion as well.

There is extensive bar development and deposition of fine materials throughout Reach E. These bars are not well vegetated with perennial species indicating that sediment deposition is an active process. The streambanks of the reach exhibit active lateral migration of the channel. The low channel slope and its higher width/depth ratio reduced the stream energy in this reach from that of Reaches A through D. This reduction in stream energy allows the finer sediment particles input from disturbances in Reaches A through D to be deposited in Reach E.

Sub-reaches 40, 41, 43 and 44. These sub-reaches are F4- or F5-type reaches, some of which also exhibit C4 type characteristics. The stream appears to historically reacted to large sediment loads by downcutting and deepening the channel as it attempted to reach a gradient that could transport the received material. Presently, these sub-reaches and those downstream appear to be a settling and storage area for most of the sediment that has been transported from upstream. In addition, the stream appears to be reacting to a high sediment load from Sand Creek by increasing the channel depth. Late seral vegetation decreased sinuosity appear to contribute to a downcutting rather than lateral channel migration. In sub-reaches 41 and 43, it appears these channel types are evolving to resume more C-type stream characteristics.

Sub-reaches 45 through 47. These sub-reaches exhibit a stream channel type that is C4 or C5 and is similar to the reference stream type. However, they also exhibit specific channel characteristics that are divergent from the reference sub-reach. These characteristics include wider bankfull widths, deeper mean depths, lower width/depth ratios, and higher entrenchment ratios.

Sub-reaches 45 through 47 comprise a dynamic area of Reach E and is experiencing extensive disturbance. This area is primarily C5-type, though Reach 45 is an F5-type The changes appear to be predominantly channel adjustments in response to extensive sediment contributions from Grouse Creek, as well as additional sediment from upstream sources. The planform in this area changed dramatically from 1936 to 1996, undergoing extensive lateral channel migration. These areas have a high width/depth ratio and relatively higher entrenchment ratios and lower slopes. The migration rate in bends tends to reach a maximum where the ratio of the radius of curvature to channel width falls in the range of 2 to 3 (Nanson and Hickin, 1986). Such radius of curvatures is characteristic of many of these sub-reaches.

Sub-reach 45 has a planform that exhibits substantial meanders that are undergoing rapid streambank erosion. The channel meanders in this region are narrow and will likely cutoff in the near future. This excessive sinuosity is reducing the ability of the stream channel in this area to transport the high sediment load which appears to be from Grouse and Sand creeks and upstream sources. Excessive sinuosity lowers the channel gradient so that the stream cannot support the sediment supplied. Cutoffs can be regarded as a response to excessive sinuosity that will increase the channel gradient. While this will aid in sediment transport in the sub-reach, it will also result in increased channel instability downstream as the river reacts to the increased sediment resulting from the cut-off.

Sub-reaches 48 through 52. These sub-reaches are also characteristically divergent from the reference sub-reach though less so than sub-reaches 45 through 47. Aggradation is evident as extensive bar development, increased width/depth ratios, and lateral channel migration and streambank erosions. These areas are likely reacting to sediment inputs from Rapid Lightning Creek and upstream bank erosion.

5.2.6 Reach F

These sub-reaches were not typed and have more lentic, wetland characteristics due to inundation and flooding caused by increased water levels of Lake Pend Oreille. Observational information pertaining to these sub-reaches is presented in the Riparian Vegetation section which follows.

5.3 Riparian Vegetation

Riparian areas function as “three-dimensional zones of direct interaction between terrestrial and aquatic ecosystems” (Gregory et al. 1991). The riparian area includes the stream channel between low and high water levels, and extends outward from high water to the limits of flooding. The riparian zone also extends (and influenced by elevated water tables) and upward into the canopy of streamside vegetation (Kauffman et al. 2001; Naiman and Décamps, 1997).

Riparian areas play a variety of critical roles in the natural processes associated with streams. On the Pack River, sedimentation, streambank erosion, and high nutrient levels are issues of concern. Interception of sediment and debris by riparian areas reduces velocity of overland flow and consequently, reduces sediment input resulting from overland flow (Lee et al. 1999). Riparian buffers have varying degrees of ability to reduce sedimentation from overland flow depending upon buffer width and species composition. The input of nutrients bound to soil particles can also be reduced through the reduction of sedimentation inputs, in this manner. Plants with deep-binding root mass also maintain soil structure; physically restraining otherwise erodible soil and can have more stream stabilizing ability than shallower rooted vegetation (Castelle and Johnson, 2000).

A lack of large woody debris and elevated temperatures have also been considered as limiting factors for salmonids, particularly bull trout, in the Pack River. Riparian vegetation can directly affect stream temperature by blocking or reflecting solar radiation and reducing stream heating (IMST 2000). Contribution of size and type of large woody debris is directly related to the vegetation habitat type of the associated riparian area. Bisson et al., 1987 showed that (evergreen) coniferous forests produce more durable and long-lasting large woody debris than deciduous forests.

In a broad sense, the “health” of a riparian or wetland area may be defined as its ability to perform its normal functions. Some of these functions include sediment filtering, streambank stabilization, storing water, aquifer recharge, providing fish and wildlife habitat, and dissipating stream energy. Evaluating a stream’s health requires consideration of upstream and adjacent management.

The following sections summarize current and reference conditions for vegetation types within riparian areas. Results are based on a comparison of current and desired conditions within each of the surveyed stream sub-reaches.

5.3.1 Vegetation Reference Condition

The reference sub-reaches for riparian vegetation on the Pack River can be found in Reaches A and B (Tables 7a and b). Sub-reaches 5 and 17 both contain a high percentage of late-seral Western redcedar vegetation type (88 and 90 percent, respectively).

The locations of these sub-reaches within more confined portions of the valley appear to have limited their exposure to the Sundance fire effects. The riparian habitat is less disturbed in these sub-reaches than in others on the Pack River. Based on these reference sub-reaches, it is likely that more stable, larger substrate B-type streams have alder as a subdominate species (as in sub-reach 5), while the more dynamic C and F-type stream reaches are likely to contain willow as a subdominate species (as in sub-reach 17).

Sub-reach 5 likely represents the reference vegetation condition for B channel types within the watershed. Despite elevational differences between the lower and upper watershed, it is likely that sub-reach 17 is indicative of reference conditions for C and F channel types within Reaches C, D, and E of the watershed as indicated by the presence of Western redcedar trees and stumps.

5.3.2 Reach A

TABLE 7a

Vegetation Conditions of Reach A

Sub-reach	% Late Seral	Late-Seral Habitat Types	% Early Seral	Early-Seral Habitat Types	Stability Index
1	73	Western redcedar, boulder	27	Gray leaf willow, Sitka alder	7.85
2	84	Western redcedar	16	Sitka alder, Gray leaf willow	7.84
3	76	Western redcedar	24	Sitka alder	7.76
4	60	Western redcedar	40	Sitka alder, Mesic forb	7.42
5*	**88**	**Western redcedar**	**12**	**Sitka alder**	**7.88**
6	79	Western redcedar	21	Sitka alder	7.79
7	42	Western redcedar	58	Gray leaf willow, Sitka alder	7.42
8	24	Western redcedar, boulder	76	Sitka alder, Horsetail	7.12

* indicates reference sub-reach

Issues

Of all sub-reaches, those of Reach A have vegetation conditions most similar to that of the reference condition. In only two sub-reaches does the vegetation differ significantly from the reference state as discussed below.

Sub-reaches 1 through 6. Sub-reaches 1 through 6 have a high percentage of a late-seral habitat type (Western redcedar) resulting in high bank-stability index values. Despite the disturbance effect of the Sundance fire, portions of the pre-fire late-seral types remain within these sub-reaches (USFS 2002; Appendix A). While the Western redcedar type is dominant in these sub-reaches, more of the coverage is comprised of younger, smaller trees than would be expected at full potential. This is likely an effect of the re-establishment following logging. As the vegetation continues to mature, the full benefits of bank stability, shading, and large woody debris recruitment will be more fully realized.

In general, the stable stream types and boulder bank material work with the riparian vegetation in these sub-reaches to maintain a high degree of bank stability (USFS 2002; Appendix A). Naturally stable stream types (B types) and the dominance of late-seral species in sub-reaches 1, 2, 5, and 6, promote the associated high bank-stability values. The dominance of late-seral vegetation is a benefit to the unstable stream type (C type) in sub-reach 3. The effect of the Western redcedar type in sub-reach 3 will be more fully realized as the vegetation continues to age. The stable stream type (B type) of sub-reach 4 compensates for the somewhat reduced late seral vegetation types in that sub-reach.

These sub-reaches are generally experiencing an upward trend in vegetation condition as the trees continue to age. For these reasons, sub-reaches 1 through 6 are considered to be functioning appropriately for vegetation condition.

Sub-reaches 7 and 8. Sub-reaches 7 and 8 are comprised of significantly less late- seral habitat types than the reference reach. The sub-reaches are dominated by early-seral types, such as the Sitka alder type and the Gray-leaf willow type. As a result, bank stability indices for these two sub-reaches are less than those of the other sub-reaches in Reach A.

The higher percentages of early seral habitat types in sub-reaches 7 and 8 indicate a more severe disturbance to the riparian communities. Large cedar stumps throughout these sub-reaches indicate heavy historic logging with this effect most notable in sub-reach 7. The wide, open floodplain associated with sub-reach 7 would have provided easy access for removing trees during logging and is now characterized by a prevalence of old cedar stumps. The Sundance fire, however, is the most recent disturbance to which sub-reaches 7 and 8 are responding. It is likely that the fire burned more intensively in this area. Dramatic changes in riparian vegetation density were noted in pre-and post-fire aerial photographs reviewed by the USFS (USFS 2002; Appendix B). In sub-reaches 7 and 8, there are extensive burn effects on tree remnants in the area.

As a result of this combination of logging, fire effects, and channel movement, the riparian vegetation of sub-reaches 7 and 8 is still in an early- to mid-seral stage with alder and willow types currently dominant. Alder and willow types are rapid colonizers in areas that are burned and flooded. Though not as beneficial as a western redcedar or other late seral type, the Sitka alder and willow types are highly resistant to flooding effects and a high bank-stability index. The alder and willow types appear to be providing sufficient bank stabilizing to sub-reaches 7 and 8 at present. These habitat types, however, result in less shading potential and decreased size and amount of woody debris recruitment.

In general, the willow and alder types of these sub-reaches function as early- to mid-seral vegetation communities. If succession in these areas is allowed to proceed without disturbance, late seral species such as conifers will replace the shrubs.

5.3.3 Reach B

Table 7b

Vegetation Conditions of Reach B

Sub-reach	Percent Late Seral	Habitat Types	Percent Early Seral	Habitat Types	Stability Index
9	18	Western redcedar, boulder	82	Gray leaf willow, Sitka alder	7.32
10	47	Black cottonwood, Spruce, Mountain alder	53	Sitka alder, Gray leaf willow, Red-osier dogwood	7.52
11	49	Boulder/bedrock, Western redcedar	51	Willow, Red-osier dogwood, Sitka alder, Early-seral unclassified	8.34
12	26	Late-seral unclassified, Douglas fir, boulder	74	Willow, Red-osier dogwood, Sitka alder	7.2

Sub-reach	Percent Late Seral	Habitat Types	Percent Early Seral	Habitat Types	Stability Index
13	43	Western redcedar	57	Sitka alder, willow	7.43
14	39	Western redcedar	61	Sitka alder, willow	7.39
15	21	Ponderosa pine, Unclassified late- seral	79	Willow, Sitka alder, barren ground, other minor types	6.41
16	31	Ponderosa pine	69	Willow, Mesic forb, barren ground	6.71
17*	**90**	**Western redcedar**	**10**	**Willow**	**7.9**
18	80	Western redcedar, bedrock	20	Willow	8.3
19	54	Western redcedar	46	Willow, Sitka alder, barren ground, other minor types	7.09
20	45	Birch	55	Willow, Sitka alder, Red-osier dogwood, unclassified	7.37
21	30	Western redcedar, birch	70	Willow, Spirea, Early seral unclassified type	6.9

* indicates reference sub-reach

Issues

The sub-reaches of Reach B are still highly vegetated with bank stabilizing vegetation types (Table 7b). However, the sub-reaches have significantly less late-seral habitat than those of Reach A as discussed below.

Sub-reaches 17 and 18. Within Reach B, sub-reaches 17 and 18 appear to have been less affected by logging and fire. The high amounts of dominant late-seral habitat type (Western redcedar) result in high bank-stability index values. This is a direct benefit to maintaining river stability in these sub-reaches as the channel type (C type) is more sensitive to disturbance than many of the other sub-reaches in Reach B. Indeed, C stream types are generally characterized by deep-rooted species such as willow, alder, water birch, and red-osier dogwood. Often bank heights are associated with terraces on the outside of bends, requiring riparian species with greater rooting depths. The deeper rooted, woody species, adapted to such riparian sites, are critical to the bank stability of a C3, C4, C5, and C6 stream type (Rosgen 1996).

Though the vegetation in these two sub-reaches is more mature than Reach A, most of the vegetation is still comprised of younger, smaller trees than would be expected at full potential. Again, this is likely a result of replacement of trees removed by logging. The full benefits of bank stability, shading and large woody debris recruitment in these areas will be more fully realized as the vegetation continues to mature. These sub-reaches are generally experiencing an upward trend in vegetation condition as the trees continue to age. As a result, they are considered to be functioning appropriately for riparian vegetation.

Sub-reaches 9 through 16 and 19 through 21. These sub-reaches are composed of approximately one-quarter to one-half the amount of late-seral habitat types than found in the reference reach. Though the vegetation in these sub-reaches is primarily of the same species as found in the reference reach, these sub-reaches have significantly more early-seral (primarily Sitka alder and willow) vegetation than the reference condition.

Reach B were colonized by alder and willow habitat types after the Sundance fire. Evidence of burned vegetation is still prevalent throughout the sub-reaches. Generally, the alder and willow types provide sufficient bank stabilizing vegetation in these sub-reaches. Throughout many of the sub-reaches, the alder and willow types are well-established with a high density and do not provide much opportunity or space for late-seral types to develop in the greenline. As the alder and willow mature and increase in height, openings beneath them should allow for establishment of late-seral conifer species.

While the alder and willow-type vegetation likely provides sufficient bank stabilizing influence for both the B3 (sub-reaches 13, 14, 15, 16, 20, and 21) and C3b types (sub-reaches 9, 10, 17, 18 and 19), the larger amounts of early-seral types in these sub-reaches result in smaller amounts and size of woody debris while shading canopy cover is reduced due to the smaller shrub sizes.

Sub-reaches 15, 16, and 19 have portions of the bank that are barren. Barren areas of sub-reach 19, which is a more sensitive C3b type channel result in areas of instability and bank erosion. Barren areas in these three sub-reaches are generally a result of landslide loss of vegetation and fire effects sustained from the Sundance fire.

The low amount of late-seral vegetation in sub-reaches 11 and 12 could be an issue for these (F type) channels. However, the stability of the bedrock and constraints of the valley in sub-reaches 11 and 12, in combination with the alder and willow habitat types, seems to provide for sufficiently high bank stability.

5.3.4 Reach C

TABLE 7c

Vegetation Conditions of Reach C

Sub-reach	Percent Late Seral	Habitat Types	Percent Early Seral	Habitat Types	Stability Index
22	5	Western redcedar	95	Sitka alder, Spirea, Early seral unclassified type	6.74
23	8	Western redcedar	92	Willow, Spirea, Sitka alder, Barren	6.63
24	0	None	100	Willow, Upland type, Sitka alder	5.4
25	14	Black cottonwood	100	Willow, Spirea, Unclassified Riparian type, Sitka alder, Red-osier dogwood	6.58
26	0	None	100	Willow, Alder, Unclassified type	6.56
27	0	None	100	Willow, Upland type, Sitka alder, Unclassified type	5.84

Sub-reach	Percent Late Seral	Habitat Types	Percent Early Seral	Habitat Types	Stability Index
28	0	None	100	Willow, Upland type, Spirea.	6.45
29	4	Western redcedar	96	Willow, Upland type, Sitka alder, Spirea	5.82
30	0	None	100	Willow, Sitka alder, Spirea, Upland type	6.64

Issues

The sub-reaches of Reach C represent a much earlier stage of succession than those found in Reaches A and B. There is little to no late-seral vegetation, and early seral vegetation is dominated in all sub-reaches by willow. Much less of the alder type is represented in comparison to Reaches A and B. The dominance by willow in these sub-reaches indicates an even earlier level of succession than that of the alder dominated areas in Reach B.

Sub-reaches 22 through 30. Sub-reaches 22 through 30 experienced significant disturbance events resulting in riparian types that are degraded from the desired condition. The change in almost complete dominance to early-seral habitat types in the majority of sub-reaches in Reach C indicates a recent period of disturbance to the riparian communities.

As in Reaches A and B, logging and fire impacted the riparian area in sub-reaches 22 through 30. However, the driving disturbance to these sub-reaches is the change in-channel morphology from the B types upstream to C and F stream types. The active channel movement in this area creates a dynamic landscape that is a recurring disturbance to the riparian area. As bank collapse removes vegetation and deposits new alluvium downstream, the riparian area in sub-reaches 22 through 30 is continually reshaped. The resulting moist silt and sand bars represent ideal sites for the willow types that occur in Reach C. The more the river channel moves in this area, the banks are increasingly dominated by early-successional plant species. The presence of active lateral migration can be seen in these sub-reaches as landowners have placed rip-rap in many areas to slow bank retreat.

The C and F stream types in Reach C are also characterized by high stream banks. These higher, drier banks may limit the ability of some riparian vegetation to establish. C stream types are also more sensitive to disturbance than the B types, and benefit the most from the bank stabilizing effects of riparian vegetation with deep binding root mass. The sub-reaches in Reach C, however, have bank stabilizing vegetation types (willow and alder) that comprise only 50 to 75 percent of the riverbanks, a decline from Reaches A and B upstream.

Where present, willow and alder types provide bank stabilizing capabilities. However, in most sub-reaches are areas where bank heights appear to extend beyond the stabilizing capacity of the willow roots. Many of the sub-reaches, particularly sub-reaches 24, 27, 28 and 29, have high amounts of upland types. These provide much less bank stabilizing characteristics than the willow and alder types, which leads to further potential for bank collapse. All sub-reaches have bank stability indices much lower than the reference condition.

In addition to the bank stability issue, are other ecological effects of riparian vegetation. The willow type that dominates these sub-reaches has less shading capacity and woody debris recruitment potential than other late-seral conifer types. Given that the channel bankfull widths are wider in the C-type sub-reaches than the B types upstream, the effects of the willow as shading is more limited in sub-reaches 22-30 than would be upstream.

5.3.5 Reach D

TABLE 7d

Vegetation Conditions of Reach D

Sub-reach	Percent Late Seral	Habitat Types	Percent Early Seral	Habitat Types	Stability Index
31	33	Western redcedar	67	Sitka alder, upland type, willow	6.25
32	22	Western redcedar	78	Willow, Unclassified riparian type, Spirea	7.09
33	34	Western redcedar, Black cottonwood	66	Willow, Mountain alder	7.34
34	18	Black cottonwood	82	Willow, upland type	6.38
35	13	Western redcedar	87	Upland type, Willow, Spirea	5.27
36	21	Western redcedar, Unclassified riparian type (late)	79	Upland type, Willow, Spirea	4.82
37	0	None	100	Upland type, Willow, Mountain alder	4.48
38	0	None	100	Willow, Residential, Upland site, Mountain alder	5.34
39	8	Western redcedar	92	Willow, Mountain alder, Upland type, Spirea, Unclassified riparian type (early)	6.11

Issues

Reach D represents an improvement in vegetation condition over Reach C. Seven of the sub-reaches exhibited some amount of late-seral vegetation (predominantly Western redcedar). In addition, Western redcedar was prevalent on the floodplain in the area just outside the greenline of the channel in these sub-reaches. More late-seral vegetation occurs in these sub-reaches than Reach C. However, the sub-reaches of Reach D have significantly less late-seral habitat than the reference sub-reach. Logging, fire, channel morphology changes, and some residential development impacted these sub-reaches.

The F stream type characterizes the channel morphology in many of the sub-reaches. As a result of the entrenchment associated with this stream type, high banks have resulted and upland vegetation types occupy a large percentage of the riparian area.

Sub-reaches 32 and 33. Sub-reaches 32 and 33 appear to be less affected by disturbance and do not contain any upland habitat type. They contain the late-seral Western redcedar type in association with the willow type. The high amounts of dominant late-seral habitat type (Western redcedar) results in the high bank stability index values for these sub-reaches. Vegetation, however, has less effect on these stream sub-reaches because they are predominantly F types.

As typical along the Pack River, most of the late-seral vegetation is still comprised of younger, smaller trees than would be expected at full potential. Again, this is likely a result of logging. The full benefits of bank stability, shading and large woody debris recruitment in these areas will be more fully realized as the vegetation continues to mature.

Sub-reaches 31 and 34 through 39. These sub-reaches are generally characterized by early-seral willow type vegetation that reflects succession after the burn disturbance and some presence of upland type vegetation. For most of these sub-reaches, the upland type vegetation is a response to the channel downcutting to an F type, leaving no alluvial bars and high banks incapable of supporting the early seral-willow species that typically occur after fire disturbances. In sub-reach 38, a portion of the degraded riparian types is a result of riparian alteration and vegetation removal due to residential development.

Of all areas in Reach D, sub-reaches 35, 36, and 37 have the most upland vegetation (43 to 63 percent of channel length). This high amount of upland vegetation results in low bank stability indices, some of the lowest on the entire river. Because sub-reaches 36 and 37 represent C type channel morphology, the degraded upland type vegetation in these riparian areas poses the most significant threat to channel stability.

5.3.6 Reach E

TABLE 7e

Current and Reference Vegetation Conditions of Reach E

Sub-reach	Percent Late Seral	Habitat Types	Percent Early Seral	Habitat Types	Stability Index
40	44	Western redcedar	56	Willow, Mountain alder, Upland type, Snowberry	6.97
41	8	Western redcedar	92	Willow, Reed canarygrass[1],Barren, Sedge, Hawthorn, Rose, Scirpus	5.77[2]
42	4	Western redcedar	96	Willow, Mountain alder, Reed canarygrass[1], Hawthorn, Sedge	6.02[2]
43	0	None	100	Willow, Reed canarygrass, Sedge, Spirea, Upland type	4.54[2]
44	0	None	100	Willow, Upland type, Reed canarygrass, Sandbar willow	5.02
45	0	None	100	Snowberry, Reed canarygrass[1], Hawthorn, Willow, Upland type	5.67

Sub-reach	Percent Late Seral	Habitat Types	Percent Early Seral	Habitat Types	Stability Index
46	6	Western redcedar	94	Snowberry, Willow, Hawthorn	6.23
47	0	None	100	Willow, Sandbar willow, Spirea, Reed canarygrass[1]	6.5
48	15	Black cottonwood	85	Willow, Snowberry, Brome, Hawthorn	6.27
49	0	None	100	Upland site, Willow, Rose, Hawthorn	5.07
50	0	None	100	Willow, Hawthorn, Spruce	6.86
51	0	None	100	Willow, Reed canarygrass, Sedge, Sandbar willow	5.68[2]
52	0	None	100	Upland site, sedge, Willow, Sandbar willow	2.93[2]

[1]Indicates sub-reach in which reed canarygrass exhibited complete infiltration of a site and substantial bank stabilizing capabilities.

[2]Sedge species unknown, therefore, no successional status or stability index could be provided for this species. The stability indices for these sub-reaches are artificially lower as a result.

Issues

In Reach E, the Pack River is predominantly a low gradient, meandering river in a wide alluvial valley. In order to understand the reference vegetation condition in Reach E, it is important to comprehend the successional patterns in this portion of the watershed. Following disturbance, tall shrubs including willow and alder dominate for some time. The succession to black cottonwood would likely proceed in this reach of the river. Black cottonwoods in these habitats probably regenerate primarily after floods or fires, and decrease in importance as succession progresses. Western hemlock and western redcedar typically maintain co-dominance as stand development progresses because of the frequency of small-scale disturbances and the longevity of these species. Co-dominance of the western redcedar type with black cottonwood may occur in some areas depending on the frequency of disturbance.

Though not often represented on the greenline, the Western redcedar habitat type and black cottonwood habitat type occur throughout the lower Pack River. Since a high amount of western redcedar type is not present on the greenline in any sub-reach, sub-reach 17 in the upper watershed was selected for a reference. Despite elevational and channel type differences, it is likely that the conditions represented in sub-reach 17 are indicative of reference conditions for the lower watershed.

Reach E sub-reaches (40 through 52) are generally represented by early-seral species (willow types) with additional large areas dominated by upland types. The presence of the early-seral species indicates riparian vegetation adjustment to disturbance effects. Reach E was impacted historically by logging and fire. Both stumps and burned vegetation are visible in these sub-reaches. Removal of riparian vegetation due to other land uses such as agriculture and residential development in Reach E also impact riparian vegetation, more so than in other reaches of the Pack River. Use of riprap and other artificial bank stabilizing mechanisms throughout Reach E to slow lateral migration associated with the C stream types can limit areas of riparian vegetation as well. Changes in-channel morphology in some sub-reaches to a more entrenched (F type) stream system with high banks also impacted riparian vegetation.

In addition, a prevalence of invasive species, particularly common tansy and Canada thistle, were noted throughout the Reach E sub-reaches. This occurrence of invasive species degrades the health of the riparian habitat creating monocultures and limiting the presence and reproduction of native grasses and forbs. Their prevalence is likely the result of human-caused disturbance through various land uses such as residential development, pasture, and other agricultural uses.

Sub-reach 40. While sub-reach 40 does not have the same amount of late seral vegetation as the referenced reach, it does have the highest percentage of late-seral vegetation (Western redcedar type) of Reach E. It also exhibits the highest bank stability index as a result. As with all sub-reaches of the Pack River, the Western redcedar type in this area is functioning in a reduced capacity because the trees are not yet fully mature. This sub-reach is negatively affected by a portion of streambank (11 percent) comprised of upland vegetation. This upland vegetation occurs primarily on the high terrace banks of the outside meanders. As a result, very little stabilizing vegetation effect is provided to the streambanks in areas where the upland vegetation occurs.

Sub-reaches 41 through 45, 47, and 51. These sub-reaches are generally characterized by early seral willow habitat type and a significant percentage of reed canarygrass. Channel migration related to the C stream types in these sub-reaches creates alluvium that encourages willow development. However, on most areas of eroding streambanks in the C and F channel types of these sub-reaches, the willow type is incapable of providing full bank stability due to the height of the streambanks. This is most problematic for the C type stream channels (sub-reaches 43, 45, 47, and 51) than the F types.

The presence of the reed canarygrass habitat type in these sub-reaches is also problematic. According to Hansen (1986), this habitat type occurs at low to mid elevations, ranging from 2,100 to 4,100 feet. This vegetation type is located along streams, rivers, oxbows, lake and pond margins, ditches, irrigation channels, and in wet meadows. Although a native species, reed canarygrass was crossed with non-native strains making it more aggressive and is now considered an invasive species. It has been widely distributed as a forage species, and readily escapes from pastures into riparian or wetland areas, displacing more desirable native species. It is highly competitive with other riparian or wetland plants because of the heavy sod formed by its rhizome. Because of this, reed canarygrass forms areas of dense, highly productive monotypic stands that spread radially. Once established, reed canarygrass spreads rapidly and is extremely difficult to eliminate (Apfelbaum and Sams, 1987). As a result, in these sub-reaches, the presence of reed canarygrass is limiting the successional establishment of early-seral shrubs.

Sub-reaches 46, 48, and 50. These sub-reaches contain some amount of late-seral types (western redcedar or black cottonwood) or very dense coverage of early-seral willow species. As a result, these three sub-reaches have higher bank stability ratings than all but one of the other sub-reaches (sub-reach 40) in Reach E. These sub-reaches do not contain any areas of reed canarygrass or upland vegetation type. As a result, the vegetation in these sub-reaches has some capabilities of stabilizing the C stream types of these sub-reaches.

Sub-reaches 49 and 52. These two sub-reaches contain a significant amount (greater than 40 percent) of upland vegetation type within the greenline. This upland vegetation occurs primarily on high terraces along the outside meander bends of the streambanks. Lateral channel migration of these C-type channels occurs in areas in which riparian vegetation was reduced or removed due to a combination of agricultural land use and residential development. The upland vegetation provides little to no streambank stabilizing characteristics and as a result streambanks in these sub-reaches is actively eroding at an accelerated rate.

5.3.7 Reach F

Sub-reach 53. Approximately 0.5 miles of the right bank in this sub-reach has very little riparian vegetation because many of the outside meander bends are riprapped. An abrupt transition to grass is present because the golf course lawn extends to within a few feet of the riprapped bank. Occasional woody species (i.e., alders) grow in some places on the edge of the bank.

The riparian area, where it is not converted to golf course, appears relatively healthy. The inside meander bends appear to be frequently flooded and wetland vegetation predominates including alder, willow, dogwood, and wetland sedges. The exception to this is the presence of reed canarygrass and common tansy that dominate many areas. Structural diversity is good in this area, though species diversity is lower than it would be if native mesic forbs were more abundant. The old oxbows in this area produce palustrine wetlands that are excellent wildlife habitat.

Comment [JB1]:

Many cottonwood trees are present on this floodplain, but they are located a distance away from the bank of the river. While many beaver-chewed cottonwood stumps are present, there is an overall lack of large woody debris in the river. Several old conifer stumps from past logging are also present in the floodplain.

Sub-reach 54. This sub-reach is composed of a slow, deep, meandering glide habitat with many associated lentic wetlands associated with old oxbows. The area has good structural diversity of riparian and wetland vegetation, but invasive species have lowered the complexity of vegetation in some areas.

Lentic wetlands are bordered by cattails (Typha) and bulrush (Scirpus), with reed canarygrass on the outer edges of the bulrush. Willows grow in the area upslope of the reed canarygrass. Many of the same vegetation communities as observed upstream are here and in the same relationship to each other. Mixed riparian shrubs, including alder, birch, red-osier dogwood, hawthorn, snowberry, rose, and spirea, grow at the upper edge of the willows throughout the floodplain. Cottonwood and birch grow between the mixed shrubs and the mixed conifers, which are present at some small higher areas within the floodplain and appear to get flooded regularly. Toward the downstream end of the reach, cattails grow along the riverbanks in increasing numbers. Several large old cedar stumps standing in water can be found within this reach.

The reservoir has flooded much of the land that was historically hayland. The surface water and raised water table in the area results in an altered hydrology, which created an area with a more lentic character. Hydrophytic vegetation such as bulrush and cattails predominate in the lower areas and cottonwoods occur away from the lotic portion of the area.

5.4 Fish Habitat

Bull trout adult redd site selection is affected by substrate size and quality, hiding cover, streamflow, and groundwater sources (Spotts 1987, and Baxter et. al, 1999). Spawning sites are commonly found in association with groundwater seepage areas that mitigate severe winter temperatures and the formation of anchor ice. The long over-winter phase for incubation and development leaves bull trout vulnerable to increases in fine sediment, especially during snowmelt events, and degradation of water quality (Fraley and Shepard 1989).

Good hiding cover is also important to all life stages of all forms of bull trout. Juvenile bull trout, particularly young-of-the-year (YOY), have very specific habitat requirements. Bull trout fry less than 4 inches (100 mm) are primarily bottom-dwellers, often found on margins over fine depositions of detritus (J. Molesworth , USFS, pers. comm., 2000). They occupy positions just above, in contact with, or even within the substrate. Fry and juveniles can be found in pools or runs in close proximity with cover provided by boulders, cobble, or large woody debris. Age 1+ and older juveniles utilize use deeper, faster water than YOY, often in pools with shelter-providing large organic debris or clean cobble substrate. In large rivers, the highest abundance of juveniles can be found near rocks, along the stream margin, or in side channels.

Two of the more important characteristics affecting the life history of bull trout monitored in this survey included percentage of pool habitat and amount of large woody debris. Changes in the quality (volume and depth) and frequency of pool habitat has a negative influence on habitat carrying capacity and appears to influence the distribution of spawning bull trout. . Large woody debris is also important because pool habitat is generally formed by the presence of large woody debris blockages.

5.4.1 Pool Habitat Reference Condition

The Idaho Panhandle National Forests began typing undisturbed and disturbed watersheds in the Upper Spokane River ecosystem in 1991 (Cross and Everest 1995). Mean residual pool volume and residual pool depth from managed and reference watersheds were determined as a result of their efforts. Both managed and reference watersheds in that study had experienced stand-replacing fires in 1910. In these analyses, reference watersheds in the Coeur D'Alene River basin had pool habitat composition of approximately 10 percent. However, since this amount seems lower than that found on the Pack River, reference conditions from best-functioning Pack River reaches assessed in this survey were used for comparison. Sub-reaches of the Pack River with highest percentage of pool habitat had upwards of 60 % pool habitat. Summary tables of fish habitat data collected are presented in Appendix F .

5.4.2 Large Woody Debris Reference Condition

Large woody debris is severely limited throughout the Pack River system. As a result, an outside reference condition established by ICBEMP(1997) was used in the sub-reach comparisons. Large woody debris, as in conifer systems, is defined as being 20 inches in diameter on the small end and greater than 35 feet long (ICBEMP 1997). According to ICBEMP, for channels with a gradient of 2 to 4 percent, the 75th percentile for habitat includes large woody debris at a frequency of 0.08 for each mile of habitat by foot of riffle width. For channels with gradients of less than 2 percent, the frequency is .025 per foot of riffle width for each mile. The formula for desired numbers per mile = frequency x 5280/average riffle width in feet. If desired, another reference, INFISH (US Forest Service, 1995) lists the desirable LWD in forested systems as >20 pieces/mile (>12 inch diameter; >35 foot length). Since the ICBEMP reference incorporates more stream variability items it was utilized for this assessment.

Based on the large woody debris inventory that was used used only wood size class 7 meets the definition of large woody debris used in the ICBEMP (1997). Classes 1-3 (< 6 in. diam.), classes 1-6 (6-12 in. diam), and Class 8 (root wad). Table 8 provides a comparison of desired and current amounts of large woody debris.

TABLE 8

Current and Desired Large Woody Debris Conditions

Sub-reach	Desired amounts of LWD/mile (ICBEMP, 1997)	Current amount (LWD/mile)
1	15 – 20	0
2	15 – 20	35.2
3	15 – 20	52.8
4	15 – 20	0
5	15 – 20	0
6	15 – 20	26.4
7	15 – 20	0
8	15 – 20	8.8
9	10	0
10	10	0
11	10	0
12	10	13.2
13	10	0
14	10	26.4
15	10	13.2
16	10	0
17	10	0
18	10	0
19	10	0
20	10	13.2
21	10	0
22	3.5	0
23	3.5	26.4
24	3.5	0
25	3.5	0
26	3.5	0
27	3.5	39.6
28	3.5	26.4
29	3.5	13.2
30	3.5 – 4.5	0
31	3.5 – 4.5	0
32	3.5 – 4.5	0

Sub-reach	Desired amounts of LWD/mile (ICBEMP, 1997)	Current amount (LWD/mile)
33	3.5 - 4.5	0
34	3.5 - 4.5	0
35	3.5 – 4.5	0
36	3.5 – 4.5	0
37	3.5 -4.5	13.2
38	3.5 – 4.5	0
39	3.5 – 4.5	0
40	2 – 3.5	52.8
41	2 – 3.5	26.4
42	2 – 3.5	13.2
43	2 – 3.5	0
44	2 – 3.5	0
45	2 – 3.5	0
46	2 – 3.5	0
47	2 – 3.5	0
48	2 – 3.5	0
49	2 – 3.5	0
50	2 – 3.5	0
51	2 – 3.5	0
52	2 – 3.5	0

5.4.3 Reach A

The reference condition for pool habitat area in Reach A is in sub-reach 5, which had 60.9 percent of its habitat area as pools. Slow water habitat was higher in Reach A than in most of the other reaches on the river. In general, pools in Reach A were formed predominantly as a result of boulder scour areas and, to a lesser extent, large woody debris. Large boulders were the primary source of pool habitat because it did not have significantly more large woody debris than other reaches.

All sub-reaches contained some amount of slow moving habitat. Both sub-reaches 1 and 5 had over 50 percent slow moving habitat with the remaining reaches with less. In fact, slow moving habitat is one of the more limiting factors in fish habitat in the Pack River in general. Sub-reaches 3, 4, and 7 were particularly lacking in pool habitat in Reach A.

Based on riffle width in Reach A, sub-reaches should contain 15 to 20 pieces of large woody debris per mile of stream channel. Three of the eight reaches had more than the reference amount of large woody debris, while the other five had less. Much of the woody debris found within the sub-reaches of Reach A was of small diameter (<12 inches).

5.4.4 Reach B

Sub-reach 5 is the reference condition for pool habitat area in Reach B. Pool habitat was substantially decreased in Reach B as compared to Reach A. The significant decline in the presence of large boulders in Reach B resulted in significantly less pool habitat as well. Reach B also lacked significant large woody debris to create and sustain pool habitat.

Seven sub-reaches had no pool habitat. Sub-reach 9 had the highest amount of pool area at 57.9 percent. This was close to the reference amount of pool habitat. Sub-reaches 11 and 19 had 20 to 30 percent pool area, respectively. Other sub-reaches had lesser amounts of pool area. Sub-reaches 13 through 16, 18, 20, and 21 were severely limited by lack of pool habitat. This is likely a factor of many sub-reaches experiencing an aggrading condition, resulting in less pool habitat and increased riffle habitat.

Based on riffle width in Reach B, sub-reaches should contain approximately 10 pieces of large woody debris per mile of stream channel. Four sub-reaches had more than the reference amount of large woody debris. Overall, the amount of large woody debris found in the sub-reaches of Reach B was significantly less than the reference. Most of the woody debris found within the sub-reaches of Reach B was of small diameter (<12 inches). As a result, the woody debris in the channel is performing little habitat forming functions.

5.4.5 Reach C

Reach C is geomorphically an area with a C- or F-type stream channel. As such, sub-reach 31 represents the potential for available pool habitat (38.7 percent) within Reaches C and D of the Pack River. As in Reach B, lack of slow or pool habitat was a limiting feature in fish habitat in Reach C. Formative features for development of pool habitat, such as boulder scour areas or large woody debris, were generally not present in Reach C.

Four sub-reaches had no pool habitat within the area measured. Sub-reach 29 had the highest amount of pool area compared to the reference reach (37.2 percent). Sub-reaches 24, 27, 28, and 30 had minimal amount of pool area. Sub-reaches 22, 23, 25, and 26 were severely limited by a lack of pool habitat. As in Reach B, pool habitat was compromised in much of Reach C due to aggrading channel conditions that increased fast water habitat. Slow moving habitat, where it occurred, was generally a result of large woody debris obstructions. As a result of the overall lack of large woody debris throughout Reach C, the amount of pool habitat is reduced.

Based on riffle width and gradient in Reach C, sub-reaches should contain approximately 3.5 pieces of large woody debris per mile of stream channel. Four of the sub-reaches had more than the reference amount of large woody debris. Reaches 27 through 29 in particular had very high amounts of large woody debris compared to the reference condition.

5.4.6 Reach D

Sub-reach 31 continues to represent the reference condition for Reach D in terms of pool habitat. As in Reaches B and C, lack of slow habitat was a limiting feature in fish habitat in Reach D. However, there was more slow habitat present in Reach D than in both Reaches B and C. There were slightly increased amounts of pool-forming large woody debris obstructions in Reach D. Slow moving habitat was generally a result of these large woody debris obstructions.

Three of the nine sub-reaches had no pool habitat within the area measured. Three sub-reaches had pool areas similar to the amount in the reference condition. Sub-reaches 31, 36, and 39 had the highest amount of pool area (38.7, 38.5, and 34.6 percent, respectively). Sub-reaches 34 and 35 had close to 20 percent slow habitat. Sub-reaches 32, 33, and 37 were severely limited by a lack of pool habitat.

Based on riffle width and gradient in Reach D, sub-reaches should contain approximately 3.5 to 4.5 pieces of large woody debris per mile of stream channel. The amount of large woody debris found in the sub-reaches of Reach D was less than the reference in all but one case. As with all other reaches, most of the woody debris found within the sub-reaches of Reach D was of small diameter (< than 12 inches), was short (< than 6 feet) and did not qualify as large woody debris. The small woody debris is performing limited habitat function.

5.4.7 Reach E

Reach E represents a shallow gradient meandering C stream channel type. . This area would predominantly serve as migratory passage habitat for salmonids and is typified by broad expanses of alternating pool and riffle habitat. Thus, lack of deep, slow habitat was a limiting feature in fish habitat in Reach E. Where present, pools in these sub-reaches were generally a result of deep bed scour areas, and to a more limited extent, large woody debris. Sub-reach 43 represents the reference condition for Reach E pool habitat (59.4 percent). Three sub-reaches had pool areas similar to that of the reference sub-reach. Sub-reaches 42, 43, and 49 had the highest amount of pool area (50.8, 59.4, and 40.0 percent, respectively). Sub-reaches 41, 44, 47, 48, 50 and 51 have slow habitat to a lesser extent. Sub-reaches 40, 45, 46, and 52 had no pool habitat.

Based on riffle width and gradient, sub-reaches should contain approximately 2 to 3.5 pieces of large woody debris per mile. In general, the amount of large woody debris found in the sub-reaches of Reach E was less than the reference. In sub-reaches 40 through 42, the amount of large woody debris exceeded the reference condition. As with all other reaches, most of the woody debris found was of small diameter (< than 12 inches), was short (< than 6 feet) and did not qualify as large woody debris.

6.0 CONCLUSIONS

6.1 Natural Factors Influencing Pack River Condition

The Pack River is affected by several important and inherent characteristics that influence its natural channel form. These characteristics include:

- Arid climate and rain-on-snow, flashy hydrology;
- Geology and high erosivity of hillslope soils;
- Disturbance from fires;
- Steep, confined topography and high valley slope of the upper watershed; and
- Broad alluvial valley and gentle slope of the lower watershed.

The combination of these natural characteristics results in a dynamic system. Erosion and sediment discharge to the river can be naturally high because the soils and topography lead to a high tendency for mass slope failures and introduction of sediment. Much of the upper watershed is dominated by steep side slopes. Rapid-moving, shallow-seated landslides are common within this terrain. Thus, surface, and to a lesser extent subsurface, erosion of hillslopes naturally produce a large amount of sediment input to the river system.

The slope mass failure effect is exacerbated by storms associated with large rain-on-snow events. Watersheds in the Cabinet Mountains tend to be naturally prone to rapid runoff events, in-channel erosion, and occasional mass wasting (Pend Oreille Bull Trout Technical Advisory Team 1998). These Belt Series streams tend to have much less fine sediment than streams draining the granitic soils of the Selkirk Mountains.

The upper watershed tributaries and mainstem Pack River have high-energy gradients that transport cobbles, boulders, finer sediment, and large woody debris into the main river channel. The high stream power resulting from the steep slope of the upper Pack River readily flushes finer-textured sediments downstream. Historically, storage of sediment in the upper watershed would most likely have been much higher than it is today because sediment would have been trapped by large woody debris.

Finally, the area has a natural propensity for disturbance from fire effects and a hydrology resulting from rain-on-snow effects. These factors historically would have resulted in repeated disturbance events and dramatic changes in discharge and sediment load. As a result, the river channel would have undergone periods of adjustment following the disturbance events.

6.2 Human Caused Factors Affecting Pack River Condition

Though this investigation was not watershed-based, two general types of human induced changes were seen in the Pack River system. The first type includes changes due to direct modification of the channel itself. The second type is out-of-channel activity that likely modifies discharge and/or sediment load of the stream and ultimately results in stream channel response.

Likely human-caused factors affecting the current Pack River channel condition are listed below. Only factors that were documented in this investigation are included here.

- Increased human-caused sediment inputs resulting from road construction, mass failures associated with roads, and potential management issues associated with tributary watersheds;
- Reduction of / or changes in riparian vegetation through timber harvest, agricultural land uses, and residential developments; and
- Localized channel modifications with riprap or similar bank stabilization, and in- channel manipulation.

6.2.1 Sediment

In addition to the Pack River watershed's predisposition to naturally high sediment yields, erosion has likely increased as a result of a wide range of human activities that mobilize and supply sediment. It is apparent in some instances that these impacts have caused impaired channel types that do not correspond to the natural geologic setting, hydrologic regime, and sediment load. Moreover, some of the areas of the Pack River channel are now geomorphic stream types that are less efficient at transporting flood flows and sediment than the desired stream type.

Sediment inputs from road building throughout the upper watershed, coupled with the loss of vegetation due to timber harvest and fire, likely exacerbate the amount of natural sediment into the drainage to a high degree. Megahan and Kidd, 1972 emphasized the problems from road construction, and in particular, mass failures associated with roads in watersheds on a highly erosive granitic batholith. Sediment on a batholith also originates from road-cut slopes, where exposed granite weathers quickly. Megahan and Kidd, 1972 emphasized that roads constitute one of the primary sources of stream sediments on the granitic batholith. They reported sediment production rates from roads on a batholith 770 percent higher than rates in similar nearby watersheds that remain undisturbed. Of that increase, 30 percent was due to surface erosion from roads, and 70 percent was due to mass soil failures. Megahan and Kidd, 1972 also indicated that once logging ceased, sedimentation continued where roads had been cut through the soft, weathered granitic rocks. They also pointed out the need to treat surfaces of abandoned roads because the soft granite weathered easily without treatment and produced sediment for many years.

An examination of aerial photographs from the 1930s to the 1990s reveals that the miles and density of roads in the upper Pack River watershed increased dramatically. The Pack River Road and several intersecting smaller roads run adjacent to and cross the river and tributaries in several areas. In several instances, an eroding road runs to the river channel. In addition, several areas of mass failures associated with hillslopes and roads, and erosion of road cut-slopes were noted in the upper watershed during the inventory. No inventory was made of these failures or road densities, instead they were simply noted incidentally in areas. These mass failures appeared to be contributing large amounts of sediment into the stream channel.

6.2.2 Impacts to Vegetation

Land use in the watershed also contributes to channel-form adjustment through its influence on the vegetation cover. Reduction of / or changes in riparian vegetation, especially large western redcedars, appear to have compromised stream channel condition. The effect of removal of the large cedars and associated plant species and replacement in many areas with earlier-seral stage vegetation appears to have had a major effect on the system's structural integrity in many ways.

The number of remaining western redcedar stumps throughout the channel length provides some indication of the prevalence and function that this species historically had in the watershed.

Smith, 1976 found that bank soils with a root volume of 16 to18 percent were afforded 20,000 times more protection from erosion than comparable sediment without vegetation. Hey and Thorne, 1986 found that channels with grass banks were up to 1.8 times as wide as tree-lined banks. In addition to bank stabilizing effects, the large cedars that occurred in the riparian area of the Pack River historically likely provided a barrier to much of the high sediment input occurring naturally to the river and tributary channels.

The shading effect of the canopy of these large cedars also likely helped regulate stream temperature historically through reduction of stream heating. Large western redcedars also were critical to the structure and complexity of fish habitat in the Pack River as they provided a source of large slow-to-decay woody debris to the system. The large woody debris effectively added fish habitat diversity by developing much more pool habitat than is currently available and trapped sediment. A 6-year study (Megahan, 1982) concluded that logs were the most important type of obstruction in stream channels because of their longevity and the large volume of sediments trapped behind them. Megahan's study found only large stable obstructions remained in the channel during a high-flow year and 15 times more sediment was stored behind obstructions than was delivered to the drainage outlets. Larger old growth timbers such as the deadhead logs remain in the water as habitat during high flow periods. According to Bilby, 1984, number, area, and volume of pools decreased as a result of the removal of large woody debris

Human disturbance of riparian areas has also degraded the health of the habitat by increasing the presence of invasive species in Reach E. Invasive species can create monocultures and limit the presence and reproduction of native grasses and forbs. Invasive species such as tansy and Canada thistle rapidly colonize disturbed sites. Their prevalence can be caused by transport from one area to another and disturbance to the riparian areas from overgrazing, agricultural activities, and residential development among others

6.2.3 In-Channel Modifications

In-channel modifications are also limiting channel functioning in some areas. Placement of riprap, particularly in Reaches C and E, and in association with bridges and railroad trestles, can have a negative effect on fluvial and riparian processes. The placement of riprap reduces the amount of riparian vegetation and the ground may remain barren for extended periods of time (Brandt and Ringleberg, 1999). Alluvial channel patterns adjust by lateral channel migration and longitudinal profile changes through aggradation and degradation (Leopold et. al, 1964, Knighton and Nanson, 1983. However, riprap forces streams to maintain alignment and limit lateral channel adjustments. Thus, extensive riprap leads to straightening of stream reaches and increasing gradient (Simons and Richardson, 1966). Bridges and railroad trestles and associated riprap, can constrict stream channels and flows, affecting the reaches immediate downstream.

6.3 Reference Condition

The appropriate reference condition depends on the location within the river system. Reaches A and B are generally represented by a stable Rosgen B-type stream channel, while Reaches C, D, and E would be characterized by a stable C-type stream channel. Western redcedar vegetation type, with a subdominant alder or willow type (sub-reaches 5 and 17), would be the optimum reference conditions on the Pack River for Reaches A through D. Reference riparian vegetation for Reach E may have included sub-reaches that had both western redcedar and black cottonwood as co-dominant types with a sub-dominant understory of willow.

6.4 Current Stream Type Condition

In general, the Pack River system appears to have undergone large scale geomorphic changes resulting from increased sediment input and deposition in recent years. Increased sediment loading as a result of Sundance fire disturbance, followed by several periods of extreme flood events, coupled with additional human caused disturbances has resulted in a stream-channel morphology that is in disequilibrium in many areas.

6.5 Current Riparian Vegetation Condition

In general, riparian vegetation has been impacted by logging and fire in most sub-reaches of the river, by rural development in sub-reaches of Reaches C, D, and E, and by agricultural activities in sub-reaches of Reach E. Of all areas on the river, the sub-reaches of Reach A (sub-reaches 1-8) have vegetation conditions most similar to that of the late-seral western redcedar reference condition.

6.6 Current Fish Habitat Condition

The observed differences in relative abundance of habitat types such as pools, riffles, pocket water and run/glides in the Pack River suggest that sediment from the heavily roaded, burned and harvested headwater area is aggrading in many sub-reaches. Pools, critical to many portions of the life cycle of bull trout and other native fish such as the westslope cutthroat trout, appear to have a reduced volume and relative abundance throughout the river.

The amount and structure of large woody debris at present is a significant limiting factor in fish habitat. This is likely a result of direct and indirect effects of past and present land management activities in concert with natural disturbance events over the past century. Since pool habitat may be the last to recover in-channels in disequilibrium, maintenance of channels presently in equilibrium and recovery of stream channels in disequilibrium will be critical to the long-term survival and recovery of bull trout.

6.7 Recommendations

This section presents recommendations for enhancing the health and condition of the Pack River based on the results of this survey. Data collected in the survey were limited in extent and scope, and more detailed information on individual sub-reaches is likely necessary in order to make more site-specific recommendations. In addition, information on upland watershed characteristics and other studies as described below would enhance the ability to provide more directed management strategies for the Pack River.

- Anthropogenic sediment contributions should be controlled. While the river experiences naturally high sediment loads, human-caused sediment loads also appear to be affecting the channel morphology. The majority of channel type deviations from the reference condition occur in areas in which the channel appears to be responding or has responded to increased sediment loads. The control of anthropogenic sediment can be viewed in three phases: (1) Prevention – arresting original erosion or obstructing eroded sediment from leaving the site of its origin; (2) interdiction – capturing and retaining sediment between the site of origin and the stream, and (3) restoration - removing sediment from the stream to bring physical conditions back to their original state. It is greatly preferred to eliminate sediment at the source or the erosive action in the first place. Forestry control measures to prevent erosion from roads in the upper watershed are of paramount importance. Road miles should be progressively decreased through obliteration or permanent closures. In planning for access and travel management, priority should be given to obliteration of unnecessary roads within 300 feet of the stream channel and/or to those that have numerous stream crossings. The remaining roads should be properly drained to help reduce the amount of sediment reaching streams. A detailed road condition inventory would help to assess and prioritize roads as sediment sources in the upper watershed. An inventory of all roads within the analysis area could determine which roads are necessary for recreation, access, harvest, as well as to identify those unneeded or sub-standard roads for decommissioning.

- Several tributaries, including Caribou, Colburn, Sand, and Grouse creeks appear to be contributing a large amount of sediment to the Pack River. A sediment survey of these tributaries should be conducted and efforts made to reduce any sediment contributions.

- In the short-term, large woody debris can be added to areas with amounts below reference condition. Emphasis should be placed on Reaches B through D, in an upstream to downstream order. Additional large wood in the channel will enhance sediment retention, especially in the event of a catastrophic fire, and help improve water quality and aquatic habitat. Long-term solutions to lack of large woody debris recruitment can be achieved by leaving vegetated buffers of large trees.

- The percentage of pool habitat area can be increased throughout the river, specifically in Reaches B through D. Pool habitat in these areas will likely improve with the increased presence of large woody debris. In those reaches where large woody debris additions are recommended, the debris will help create additional pool habitat. Large wood will also make pools more complex increasing cover, depth, rearing habitat, cool water refugia, and over-wintering habitat. For large woody debris to effectively create a pool, the added pieces must be within the bankfull dimensions, preferably within the wetted channel.

- Efforts to control invasive species including reed canarygrass in Reach E, can be increased.

- Except where limited by topography, channel redesign of F stream types can be used to develop C channel types that are in balance with the landscape particularly in Reaches D and E. In general, efforts directed at restoration should occur after prevention of sediment sources has been accomplished.

- Channel redesign can also be used to rehabilitate stream channels that are similar to the reference type, but which exhibit other characteristics (such as high width/depths) that deviate from the reference condition.

- The results of this study should be used to plan stream rehabilitation efforts more effectively by stream type. Implementation of sporadic bank supports (such as rip rap) or bank restructuring should be discouraged, unless changes to the reference stream type and characteristics are considered. If structures are utilized to stabilize eroding meanders, they should only be placed when meander geometry (lateral erosion) is fully developed or when there is a risk of losing sinuosity. These actions will aid in maintaining or producing the desired stream types.

- Late-seral (Western redcedar habitat type) vegetation can be encouraged, preserved, and maintained. Management should cause "No Net Loss of Late-Seral Vegetation" (Eastside Forest Plan Amendment 1994). The amount of late-seral (Western redcedar habitat type) vegetation can be increased and/or maintained by allowing vegetation succession in reaches with C stream types. Many C stream types appear to be experiencing increased rates of lateral migration due to lack of deep binding, woody root mass in its riparian vegetation.

- Grazing management strategies can be promoted in Reach E to encourage the growth of willow and improve width/depth ratios along C stream types. Deferred rotation grazing strategies, or other types of grazing strategies that maintain or promote late-seral riparian plant communities and their associated high bank stability can be continued.

- A historic channel meander study can be conducted to determine the width of the lateral migration zone of the Pack River, particularly for Reach E. Increase of vegetation within this zone of lateral migration can be encouraged to slow rates of channel migration.

- The amount of late seral (Western redcedar habitat type) vegetation can be increased in areas in which bank height extends beyond the rooting capacity of current vegetation (bank re-shaping may be required in some areas to achieve this).

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FIGURES

APPENDIX A

PACK RIVER STREAM CHANNEL ASSESSMENT
(USFS 2002 REPORT)

APPENDIX B

GIS DATABASE WORK PRODUCT (CD)

APPENDIX C

PROTOCOLS FOR FIELD INVENTORY

APPENDIX D

GIS LOCATIONS OF SUB-REACH BOUNDARIES

APPENDIX E

PHOTOGRAPHS OF PACK RIVER SUB-REACHES

APPENDIX F

FISH HABITAT AND WOODY DEBRIS SUMMARY TABLES