RECLAMATION
Managing Water in the West

Bonanza Area Reach Assessment
Yankee Fork of the Salmon River,
Upper Salmon Subbasin

Custer County, Idaho

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Pacific Northwest Regional Office, Boise, Idaho

September 2012

U.S. DEPARTMENT OF THE INTERIOR

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

MISSION OF THE BUREAU OF RECLAMATION

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover Photo: View to the west looking upstream along the West Fork (upper channel) and Yankee Fork (lower channel), and their historic confluence area (upper right) – Bureau of Reclamation

Date: September 2, 2010 Photo by: David Walsh

RECLAMATION
Managing Water in the West

Bonanza Reach Assessment
Yankee Fork of the Salmon River, Upper Salmon Subbasin

Custer County, Idaho

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Pacific Northwest Regional Office, Boise, Idaho

September 2012

This page intentionally left blank

Acronyms and Abbreviations

BiOp	Biological Opinion
cfs	cubic feet per second
FCRPS	Federal Columbia River Power System
GIS	geographic information system
Hecla	Hecla Mining Company
HUC	hydrologic unit code
LiDAR	light detection and ranging
mi^2	square miles
mi/mi^2	miles per square mile
mm	millimeter
Reclamation	Bureau of Reclamation
REI	reach-scale ecosystem indicators
RM	river mile
RPA	Reasonable and Prudent Alternative
Tribes	Shoshone Bannock Tribes
Tributary Assessment	Yankee Fork of the Salmon River Tributary Assessment
TWA	total wetted area
USFS	U.S. Forest Service
West Fork	West Fork of the Yankee Fork Salmon River
Yankee Fork	Yankee Fork of the Salmon River

This page intentionally left blank

Table of Contents

List of Figures

List of Tables

ACKNOWLEDGEMENTS

We would like to thank members of the Yankee Fork Interdisciplinary Team for their input in the development of this Bonanza Area Reach Assessment and acknowledge them for their comments and suggestions on the draft report.

We would also like to acknowledge U.S. Bureau of Reclamation personnel, Richard Link, L.E.G., L.G., Program Manager for the Geology and River Systems Analysis Groups; and Terril Stevenson, L.G., Team Leader for the Geomorphology Section of the River Systems Analysis Group who were the peer reviewers and provided comments that helped further refine and clarify concepts presented in this report. Also, we would like to acknowledge Kristin Swoboda for her assistance in developing the geographic information system (GIS) database in support of this Reach Assessment. Finally, thanks to Kelly Vick, Natural Resources Technical Writer, for her thorough editorial work.

This page intentionally left blank

EXECUTIVE SUMMARY

The Yankee Fork of the Salmon River (Yankee Fork) is located in Custer County, Idaho and is one of the major tributaries to the Salmon River. The Yankee Fork drainage area covers about 122,000 acres and the river flows south about 28 miles from its headwaters in the Salmon-Challis National Forest to the Salmon River near river mile (RM) 368 near Sunbeam, Idaho.

The purposes of the Bonanza Area Reach Assessment (Reach Assessment) are to (1) complete a geomorphic analysis of the Yankee Fork, (2) document past, existing (baseline), and potential target physical conditions within the assessment area, and (3) indentify potential actions to achieve the target physical conditions and improve habitat-forming processes and classify each action’s ability to address the limiting factors.

The assessment area consists of a 2.3-mile portion of the Yankee Fork from its confluence with Jordan Creek (RM 9.1) to just below its confluence with West Fork of the Yankee Fork (West Fork) (RM 6.8) and the lower section of the West Fork between RM 0.8 and 0. The two principal species of concern are (1) spring/summer Chinook salmon (*Oncorhynchus tshawytscha*) that are part of the Snake River Evolutionary Significant Units and (2) summer steelhead (*Oncorhynchus mykiss*) that are part of the Snake River Basin Distinct Population Segment. Other fish species of interest are the Columbia River bull trout (*Salvelinus confluentus*) and Westslope cutthroat trout (*Oncorhynchus clarki lewisi*).

The primary limiting and causal factors for the Yankee Fork in the assessment area are (1) habitat fragmentation and connectivity due to mine tailings artificially constraining the stream and disconnecting historic floodplains and (2) habitat quantity and quality due to mining activities that have confined the channel, removed the vegetation, and disconnected off-channel habitat (Reclamation 2012).

Physical and ecological processes have been negatively impacted by gold dredging operations along the Yankee Fork and at the Yankee Fork/West Fork confluence area. The Yankee Fork is now slightly straighter and more confined than it was prior to the mining activity with reduced access to the limited floodplain areas that existed. This results in higher in-stream velocities and reduced access to floodplain and side channel areas. These changes impact fish by reducing juvenile rearing and refugia habitat, contributing to limited natural production of salmon and steelhead in the Yankee Fork. Historically, the Yankee Fork flowed through an alluvial valley with a valley gradient of about 1.1 percent and the depth to bedrock was relatively shallow, on the order of tens of feet, throughout the valley segment. There were two geomorphic channel reaches in this 2.3-mile section, (1) a moderately confined channel between Jordan Creek and Preachers Cove and (2) an unconfined channel between Preachers Cove and the West Fork. The moderately confined channel reach had a straight, free-formed alluvial channel with a plane-bed bedform and a low rate of lateral channel migration and low channel/floodplain dynamics based on 1945 aerial photographs and physical conditions observed in the field. The unconfined channel likely had a straight, free-formed alluvial channel with plane-bed to pool-riffle bedforms and a low rate of lateral channel migration and low to moderate rate of channel floodplain dynamics based on 1945 aerial photographs, 2010 light detection and ranging (LiDAR) topography, and geomorphic features (i.e., disconnected channels and floodplain) observed in the field.

Under existing conditions in the Bonanza reach, the Yankee Fork is moderately confined along its length by dredge tailings, bedrock, and alluvial and colluvial deposits. The channel pattern is a straight, free-formed alluvial channel with a plane-bed. Beechie et al. (2006) found that straight channels generally have a low rate of lateral channel migration and channel/floodplain dynamics as compared to meandering channels. Channel confinement has increased due to the dredge tailings. The channel confinement and loss of floodplains changes the geometry of the channel/floodplain cross-sectional area and results in increases in flow depth, flow velocities, and shear stress during high water events.

The long-term rehabilitation objectives for the Yankee Fork are to improve habitat-forming processes within the two historically distinctive channel reaches, RM 9.1 to 7.6 and RM 7.6 to 6.8 by the following:

1. Reconnecting the dynamic channel/floodplain interactions that once occurred in the Yankee Fork/West Fork confluence area will increase gravel retention, nutrient cycling, and availability of more diverse habitats.

2. Increasing dynamic channel/floodplain interactions by increasing the average floodplain patch size and connectivity will reduce and add variability to flow velocities, and improve nutrient cycling and sediment retention.

3. Improving riparian vegetation conditions will increase channel boundary and floodplain roughness, provide shading and cover, and improve nutrient cycling.

The West Fork historically flowed through an alluvial valley with a valley gradient of about 0.9 percent and the depth to bedrock was similar to the conditions described for the Yankee Fork. From Sawmill Creek to the 1945 Yankee Fork confluence, the West Fork had an unconfined channel reach that was evaluated during this assessment. The unconfined channel reach had a straight, free-formed alluvial channel with plane-bed to pool-riffle bedforms and a low to moderate rate of lateral channel migration and low to moderate channel/floodplain dynamics based on 1945 aerial photographs and 2010 LiDAR topography. In this plane-bed to pool-riffle channel, pools would be expected to occur sporadically, mainly in the few locations where meanders occurred (about five to eight total pools based on the 1945 aerial photo). The few unvegetated bars were most likely mobilized and secondary side channels activated during channel forming flows with a recurrence interval of about 1 to 2 years.

Under existing conditions, the West Fork has two geomorphic channel reaches, (1) an unconfined channel with a straight, free-formed alluvial channel with a plane-bed to pool-riffle bedforms from RM 0.8 to 0.2 (2011 West Fork river miles) and (2) a confined channel with a straight, free-formed alluvial channel with a plane-bed bedform from RM 0.2 to 0 that has been somewhat further confined by dredge tailings. The unconfined channel reach (RM 0.8 to 0.2) has remained similar to its historic conditions. Along the confined channel reach (RM 0.2 to 0); the channel is also similar to historic conditions with the following exceptions: (1) this channel was the mainstem Yankee Fork downstream from the West Fork confluence prior to disturbance, and (2) the channel has slightly higher energy and higher transport capacity due to the somewhat increased channel confinement by dredge tailings.

The objectives along the West Fork are to maintain habitat-forming processes and the potential actions to achieve those conditions include, but are not limited to, the following:

1. Monitoring and maintaining the habitat-forming processes currently occurring in the unconfined reach between RM 0.8 and 0.2 as it continues to recover from logging and other disturbances in the drainage.

2. Increasing dynamic channel/floodplain interactions in the confined reach by increasing the average floodplain patch size and connectivity which will reduce and add variability to flow velocities, and improve nutrient cycling and sediment retention.

3. Improving riparian vegetation conditions in the confined reach will increase channel boundary and floodplain roughness, provide shading and cover, and improve nutrient cycling.

The expected channel response in the confined channel reach will primarily benefit juvenile salmonids by (1) increasing availability of high-flow refugia, (2) improving variability in flow velocities, and (3) improving channel/floodplain interactions during flood events.

The findings in this Reach Assessment are intended to be used as one tool among many to guide rehabilitation and habitat improvements on the Yankee Fork and West Fork rivers. The actions outlined in this report represent appropriate actions based on physical and ecological processes for these riverine systems, but are not an exhaustive assessment of all possible actions that can be used to achieve habitat benefits.

This page intentionally left blank

INTRODUCTION

The Bureau of Reclamation (Reclamation) and Bonneville Power Administration contribute to the implementation of salmonid habitat improvement projects in the Upper Salmon subbasin to help meet commitments contained in the *2010 Supplemental Federal Columbia River Power System* (FCRPS) *Biological Opinion* (BiOp) (NOAA Fisheries 2010). This BiOp includes a Reasonable and Prudent Alternative (RPA), or a suite of actions, to protect salmon and steelhead listed under the Endangered Species Act across their life cycle. Habitat improvement projects in various Columbia River tributaries are one aspect of this RPA. Reclamation's contributions to habitat improvement are all meant to be within the framework of the FCRPS RPA or related commitments. The assessment described in this document provides scientific information on geomorphology and physical processes that can be used to help identify, prioritize, and implement sustainable fish habitat improvement projects and to help focus those projects on addressing key limiting factors to protect and improve survival of salmon and steelhead listed under the Endangered Species Act.

Tributary and reach assessments are first steps in a process aimed at focusing habitat improvement efforts toward the most beneficial actions in the most appropriate locations (Figure 1). Several project areas may be selected based on the assessment and feedback from local project partners and stakeholders. Each project area may undergo an Alternatives Development and Evaluation process to conceptually identify the project that best improves habitat while addressing local stakeholder needs. The preferred conceptual alternative is typically advanced through the design process. The final design incorporates feedback from several technical reviews provided by local and regional review teams and permitting agencies. With landowner approval and permits in place, the final design is advanced for construction. Following construction, Reclamation and other groups monitor the physical and biological performance of the project. Performance deficiencies may be remedied through adaptive management.

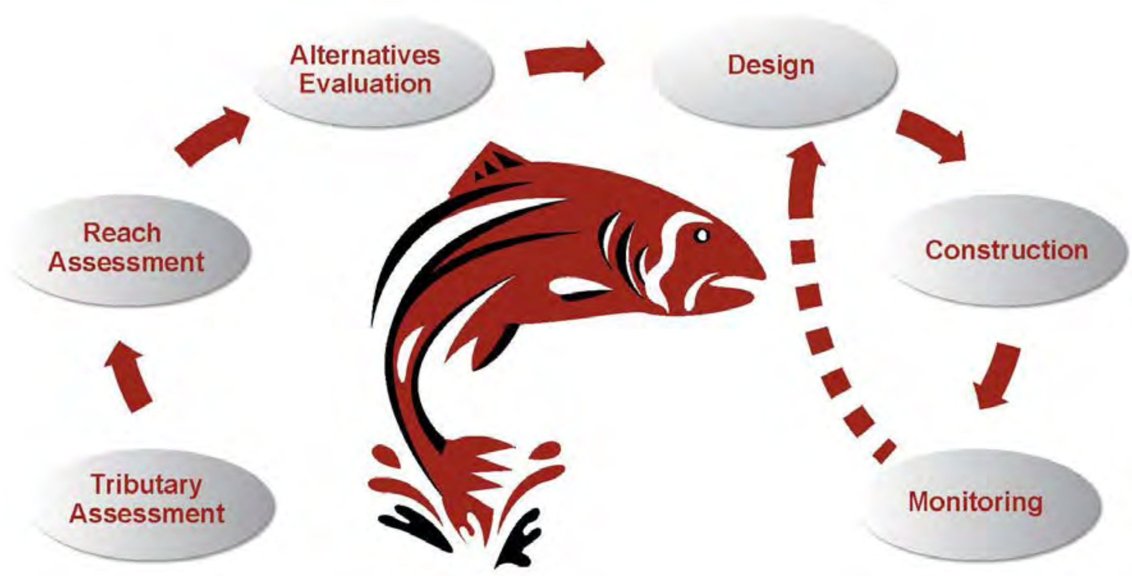


Figure 1. Flow chart illustrating typical steps in the approach to habitat improvement.

Purpose of this Reach Assessment

This Reach Assessment is a compilation report providing a range of scientific information relevant to habitat improvements for salmon and steelhead over a spatial scale fine enough to identify specific habitat improvement actions and coarse enough to support continuity between those actions. The purpose of this Reach Assessment is to assess and document reach-scale characteristics and how they have changed over time for the purpose of identifying suitable habitat improvement actions that address limiting and causal factors that are discussed in the Limiting and Causal Factors section of this report. The completed Reach Assessment can be used to guide future habitat rehabilitation, ensuring that specific projects are developed and advanced in a manner suitable to the geomorphic character and trends prevalent throughout the reach. In this way, a reach-scale approach to habitat improvement can be facilitated.

Reach Assessment Philosophy

This Reach Assessment represents a reach-scale refinement of data and analyses presented in existing watershed-scale reports such as the *Yankee Fork of the Salmon River Tributary Assessment, Upper Salmon Subbasin, Custer County, Idaho* (Tributary Assessment) (Reclamation 2012). Information in the Reach Assessment is not intended to duplicate previous efforts, rather it is intended to provide a summary of pertinent larger-scale background information and expand upon that information at the reach scale. The Reach Assessment area was delineated from the Tributary Assessment in which the Yankee Fork of the Salmon River (Yankee Fork) was divided into subwatersheds and then into unique valley segments and geomorphic (or channel) reaches based on changes in geomorphic character along the length of the channel and its floodplain.

The Yankee Fork is a 5th field Hydrologic Unit Code (HUC) watershed (HUC 1706020105) and covers about 190.2 square miles (mi^2) (USFS 2006). Principal tributaries to the Yankee Fork River are the West Fork of the Yankee Fork Salmon River (West Fork), Jordan Creek, Eightmile Creek, and McKay Creek. Smaller tributaries include Fourth of July Creek, Adair Creek, Slaughterhouse Creek, Ramey Creek, and Fivemile Creek.

Figure 2 shows the locations of the Yankee Fork subwatersheds that include:

- Upper Yankee Fork [6th field HUC 170602010501] that covers about 42.8 mi^2
- Middle Yankee Fork [6th field HUC 170602010502] that covers about 44.5 mi^2
- Jordan Creek [6th field HUC170602010503] that covers about 16.6 mi^2
- West Fork [6th field HUC 170602010504] that covers about 57.8 mi^2
- Lower Yankee Fork [6th field HUC 170602010505] that covers about 28.5 mi^2

Within the Lower Yankee Fork subwatershed, the Tributary Assessment delineated three separate geomorphic reaches (YF-3 through YF-1 from upstream to downstream) along the Yankee Fork based on reach-scale changes in valley characteristics, channel slopes, and channel types. This Reach Assessment focuses on the 2.3-mile portion of the Yankee Fork, Geomorphic Reach YF-3, from its confluence with Jordan Creek (river mile [RM] 9.1) to just below its confluence with West Fork (RM 6.8) and the lower section of the West Fork from Sawmill Creek (RM 0.8) to the Yankee Fork confluence (RM 0). This assessment area was identified in the Tributary Assessment as a high-priority area for habitat improvement.

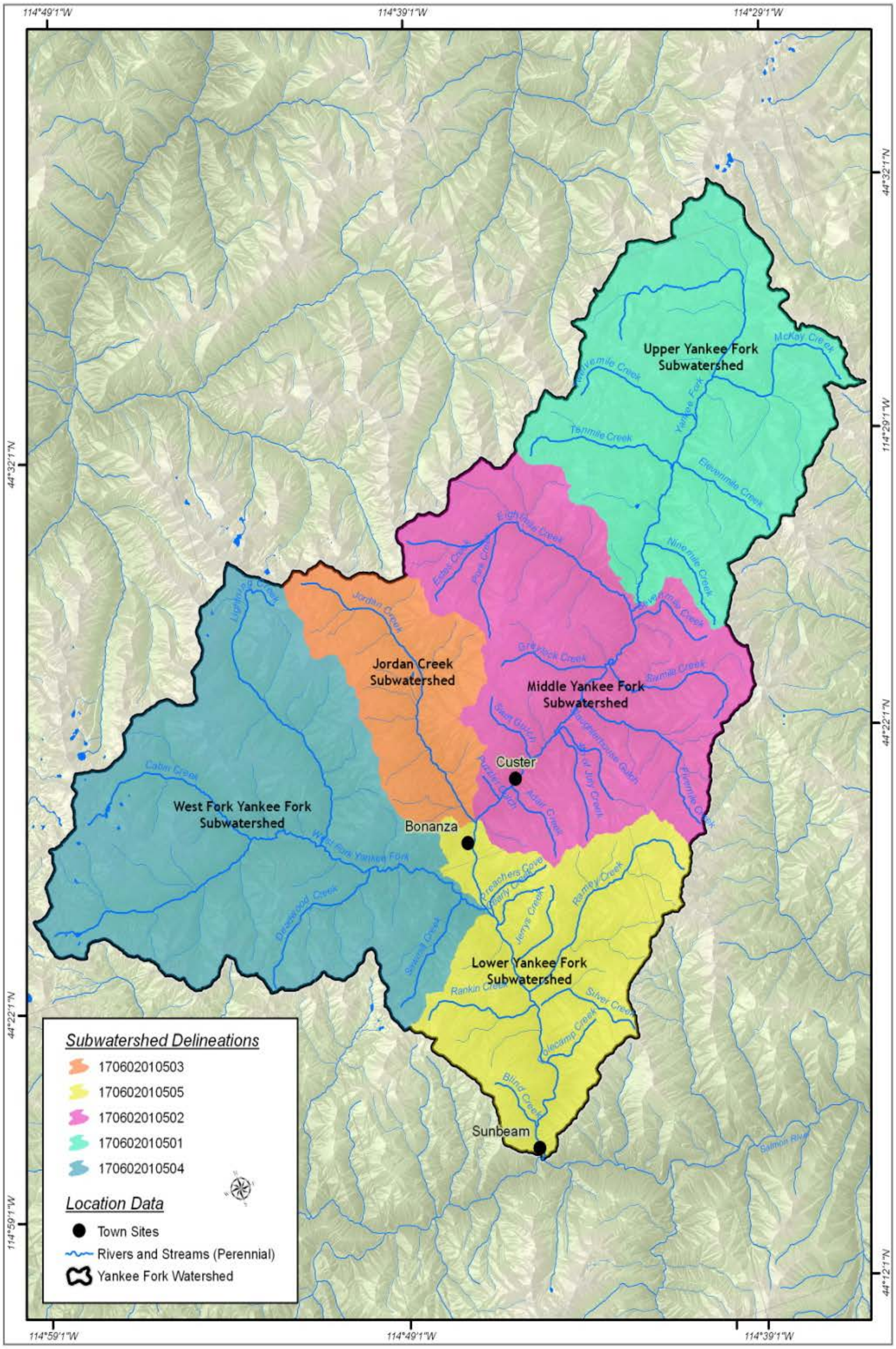


Figure 2. Yankee Fork subwatershed locations.

Reach Assessment Goals

There are two primary goals for this Reach Assessment:

1. Document past, existing (baseline), and potential target physical conditions within the assessment area.
2. Identify potential rehabilitation actions to achieve the potential target physical conditions that should improve reach-scale habitat-forming processes and increase the abundance and productivity potential for salmonids in this geomorphic reach.

Using this Document

This report is intended for the use of interdisciplinary scientists, engineers, and planners focusing on fish habitat improvement and rehabilitation. Conclusions from this Reach Assessment are intended to guide future project development as one tool among many others. The primary use of the Reach Assessment should be to guide habitat improvement actions toward those options that are most geomorphically appropriate for a given channel reach, while providing a means to begin prioritizing a variety of actions based on potential benefit to habitat. This document should not be used exclusively as the basis for habitat design. Detailed, site-specific analyses should be conducted to identify the most appropriate suite of actions, refine conceptual plans, and develop detailed designs for implementation.

This Reach Assessment was prepared by physical and biological scientists and engineers at Reclamation, with assistance and feedback from an interdisciplinary team of local and regional scientists familiar with the Yankee Fork. This document was prepared following a review of available background information, significant remote analysis using a Geographic Information System (GIS), and multiple site visits during high- and low-flow conditions. Focus was placed on reach-scale data since larger-scaled data were already documented in the Tributary Assessment. Finer-scaled data will likely be necessary for each project proposed in the future.

Information documented in this report is focused around habitat-forming processes and physical changes occurring in the Yankee Fork. Species such as Chinook salmon, steelhead, and other key species evolved with the physical environment of the Yankee Fork over thousands of years. Efforts to re-establish natural and appropriate physical and ecological conditions represent an improvement to habitat for these species.

Assessment Methods

At the reach scale, habitat-forming processes (or physical and ecological habitat dynamics) for surface water dominated systems are predominantly controlled by sediment, water and wood inputs, which drive channel/floodplain interactions, riparian processes, and formation of habitat features (Beechie et al. 2010). To understand how the riverine ecosystem dynamics are functioning, riparian processes and channel/floodplain interactions were analyzed using a matrix of reach-scale ecosystem indicators (REI) and other physical and ecological parameters. At the reach-scale, the thresholds in the REI were derived primarily from the Matrix of Pathways and Indicators (NOAA Fisheries 1996) and Matrix of Diagnostics/Pathways and Indicators (USFWS 1998). The criteria and thresholds are for a "Desired Future Condition" for low-gradient, unconstrained valley floor reaches, and are not absolute and should be adjusted to each unique subbasin as data becomes available (USFS 1994). When the criteria or thresholds are not applicable based on the geomorphology of the stream, a justification for the condition status is given in a narrative section.

The Bonanza Area Reach Assessment REI is provided in Appendix A of this report. The objectives of the REI analysis were to help identify root causes of degradation and the driving habitat-forming processes that create and maintain habitat conditions. Several of the condition rating thresholds are not applicable to some of the channel reaches because they were developed for an unconfined, meandering channel system and not for a moderately confined, straight channel system. However, the listed indicators and pathways are useful in evaluating habitat-forming processes. For example, vegetation composition and structure on the floodplain influences the delivery of wood to the channel, bank reinforcement, nutrient cycling, and thermal regimes. In addition, an appropriately functioning floodplain influences water quality, hyporheic interactions, and terrestrial connectivity.

The Reach Assessment analysis is provided in Appendix B of this report. It generally includes hierarchically nested subdivisions of the watershed, valley segments, channel reaches, and bedforms, falling in size between landscapes and watersheds, and individual point measurements made along the stream network (Frissell et al. 1986). In addition, photographic documentation (Appendix C), and available GIS data used in the analysis are provided in Appendix D.

Background Information

The Yankee Fork is located in Custer County, Idaho and is one of the major tributaries to the Salmon River. The Yankee Fork drainage area covers about 122,000 acres and the river flows south about 28 miles from its headwaters in the Salmon-Challis National Forest to the Salmon River near RM 368 near Sunbeam, Idaho.

The assessment area consists of a 2.3-mile portion of the Yankee Fork from its confluence with Jordan Creek (RM 9.1) to just below its confluence with West Fork (RM 6.8) and the lower section of the West Fork from Sawmill Creek (RM 0.8) to the Yankee Fork and West Fork confluence (RM 0) (Figure 3). The two principal species of concern are (1) spring/summer Chinook salmon (*Oncorhynchus tshawytscha*) that are part of the Snake River Evolutionary Significant Units and (2) summer steelhead (*Oncorhynchus mykiss*) that are part of the Snake River Basin Distinct Population Segment. Other fish species of interest are the Columbia River bull trout (*Salvelinus confluentus*), and Westslope cutthroat trout (*Oncorhynchus clarki lewisi*).

Physical and ecological processes have been negatively impacted by gold dredging operations along the Yankee Fork and at the West Fork/Yankee Fork confluence area. The Yankee Fork and the lower 0.8 miles of the West Fork channels are naturally (geologically) constrained within moderately confined and unconfined valley segments, but several channel reaches are anthropogenically confined by dredge tailings. Current channel configurations and location of channel convergence between the Yankee Fork and West Fork are now static and the dynamic hydraulic conditions that occurred prior to dredging no longer create and maintain a mosaic of habitat patches. The Yankee Fork is now slightly straighter and more confined than it was prior to the mining activity with reduced access to the limited floodplain areas that existed. This results in higher in-stream velocities, and reduced access to floodplain and side channel areas. These changes impact fish by reducing juvenile rearing and refugia habitats, contributing to limited natural production of salmon and steelhead in the Yankee Fork.

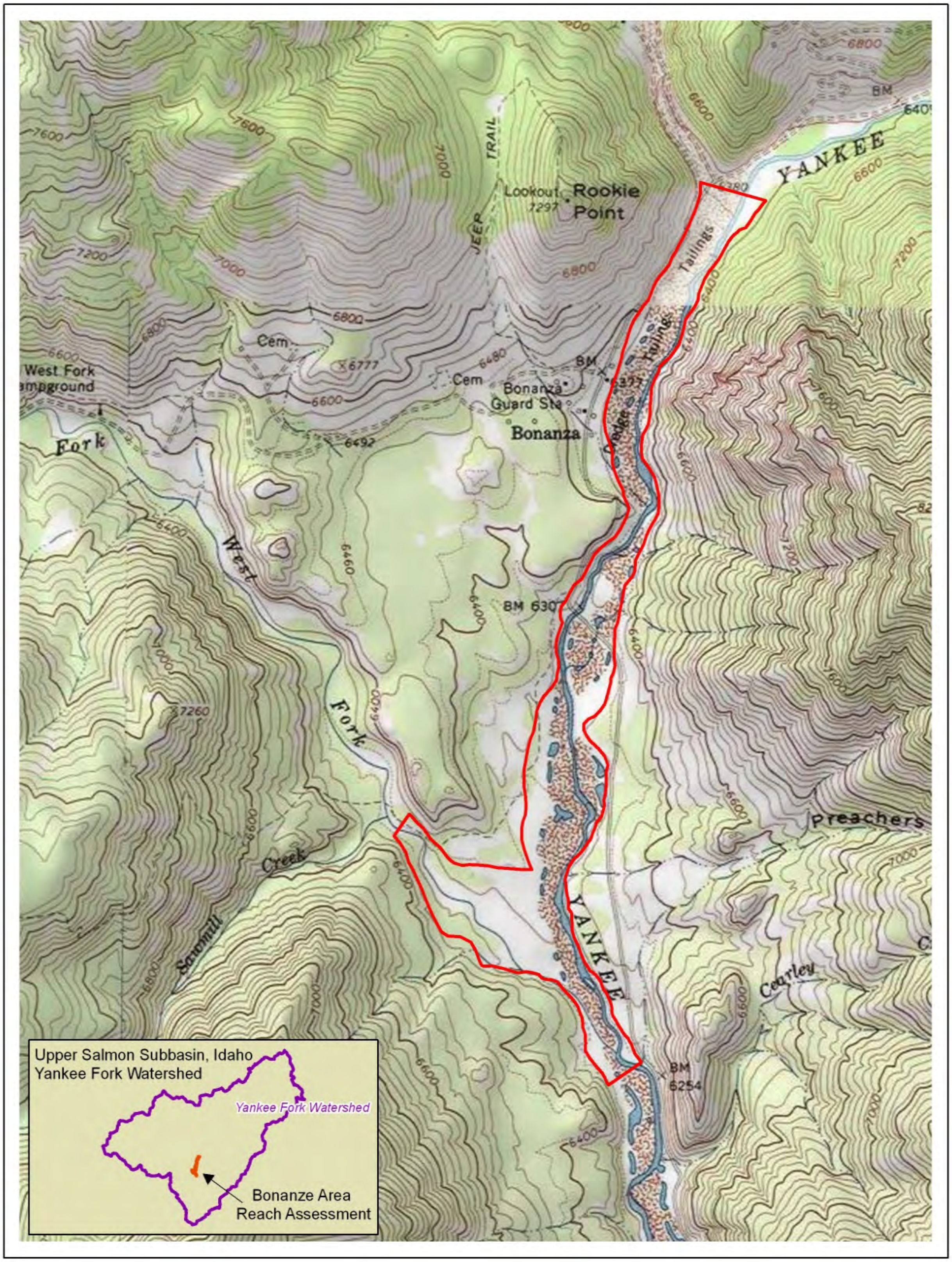


Figure 3. Bonanza Area Reach Assessment location.

Limiting and Causal Factors

Limiting factors are defined as those conditions or circumstances which limit the successful growth, reproduction, and/or survival of select species of concern. This report focuses primarily on physical conditions for spring/summer Chinook salmon and summer steelhead. Reach-scale limiting and causal factors identified in the Tributary Assessment are summarized in Table 1 in the order of most limiting to least limiting factors.

Currently, water quality does not negatively impact the fish species of concern (IDEQ 2011; SBT 2011; Reclamation 2012), but past and ongoing mining activities have impacted the system a great deal. These impacts have been most prominent in habitat disturbance and connectivity. Sediment geochemical surveys have shown that while there are areas of concern, generally there is a low risk associated from chemical contamination (Reclamation 2012).

Table 1. Summary table of reach-scale limiting factors and casual factors.

Limiting Factors	Causal Factors
Habitat fragmentation and connectivity	Relocated channels through the dredge tailings have resulted in a simplified channel configuration that confines flows within the channel and between dredge tailings with little or no channel/floodplain interactions. Historic floodplain areas along the Yankee Fork between Jordan Creek and West Fork have been disconnected by dredge tailings. These floodplain areas provided important high-water refugia and rearing habitat for juveniles during biologically significant flows.
Habitat quantity and quality	Placer mining (i.e., dredging) has altered the fluvial processes that create and maintain complex habitat units. The mining activities have resulted in the removal of riparian vegetation, simplification of the in-channel habitat, and relocation of the channel through dredge tailings. The most significantly impacted area is from Jordan Creek to the West Fork along the Yankee Fork.

Summary of Existing Reports

Sections of the Lower Yankee Fork subwatershed have been the subject of many reports and analyses that suggested the river has been severely impacted by anthropogenic alterations, resulting in the degradation of fish habitat. This assessment will show that while humans have impacted geomorphic processes in the Lower Yankee Fork subwatershed, the impact has largely been along the Yankee Fork between Jordan Creek and the West Fork, resulting in a loss of floodplains, and alterations of channel geometry, channel pattern, migration rates, and instream complexity.

Pertinent reach-scale information has been extracted from past work and used in this Reach Assessment. Specific broad-scale background information from existing reports and analyses has been summarized to help develop a better perspective regarding the reach-scale information to follow.

Regional Setting

The Yankee Fork watershed is within the Northern Rocky Mountains physiographic province which is characterized by a rugged, mountainous landscape that has been dissected by fluvial and glacial erosion (Fenneman 1931). Many of the taller peaks and higher elevation drainages were glaciated during the Pleistocene Epoch (Borgert, Lundeen, and Thackray 1999; Evenson, Cotter, and Clinch 1982).

Ecoregion classifications are (1) the Challis Volcanic section of the Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province (Bailey's classification) and (2) the Idaho batholith (Omernik's classification). Vegetation compositions are generally grand fir and Douglas-fir and at higher elevations Engelmann spruce and subalpine fir occur. Lodgepole pine, Ponderosa pine, shrubs, and grasses grow in deep canyons (www.nationalatlas.gov).

Climate is influenced by orographic uplift that occurs when air is forced to rise and cool due to mountainous terrain. The average annual precipitation locally exceeds 60 inches but decreases to 15 inches in "rain shadow" canyon bottoms. Snowfall is the dominant form of precipitation during the winter months (Reclamation 2012). Climate projections are that average mean-annual temperature will increase and that the mean-annual precipitation will not change significantly through the 21st Century. It is notable that the northern and higher elevations may experience net increases in snowpack, reflecting a general trend toward increasing total precipitation with the projected warming (Reclamation 2011).

Bedrock geology consists primarily of Tertiary volcanic and plutonic rocks, Cretaceous intrusive rocks, and Paleozoic and Precambrian sedimentary and metamorphic rocks (USGS 1995; Link and Janecke 1999). Many, if not all, of these rocks have been displaced by the northeast trending Trans-Challis fault system that cuts across Central Idaho and has had a controlling effect on the location of volcanic vents, dikes, faults, and zones of mineralization (McIntyre, Ekren, and Hardyman 1982; Kiilsgaard, Fisher, and Bennett 1986; Janecke 1992). Known active faults are associated with north-northwest to northwest trending Basin-and-Range type normal faults that have been grouped together as the Central Idaho Seismic Zone. Some earthquakes have produced strong ground motions (or shaking) that have triggered landslides and debris flows in the past (IBHS 2009).

Yankee Fork Watershed Physical Characteristics and Condition

The Yankee Fork watershed has a dendritic drainage pattern, draining about 190 mi^2 and has a drainage density of about 2.71 miles per square mile (mi/mi^2) which is a measure of the amount of stream network necessary to drain the basin. There is an estimated 223.6 miles of perennial streams and 291.3 miles of ephemeral streams within the basin (USFS 2006). Basin relief is about 4,407 feet with a maximum elevation of about 10,329 feet at The General peak and a minimum elevation of about 5,922 feet at the confluence with the Salmon River.

Hydrology is influenced by the accumulation and subsequent melting of snow in the upper watershed. Average annual air temperature generally ranges from -50^{o} F to 95^{o} F and freezing temperatures can occur throughout the year. Most precipitation comes in the form of snow in late fall to early spring, resulting in a hydrologic regime dominated by late spring and early summer snowmelt. Peak discharge is dominated by surface runoff, especially during rain-on-snow events. High intensity thunderstorms can occur during the spring and summer months. There are no large dams in the watershed capable of influencing the flow and sediment regimes.

Watershed conditions were analyzed in the Tributary Assessment using NOAA Fisheries' (1996) matrix of pathways and indicators which describes the functional condition pertaining to watershed-scale components. The matrix provides guidance on thresholds that should be considered and refined for the individual watersheds, to assess the condition ratings as properly functioning, at risk, or not properly functioning. Watershed conditions are applicable for most, if not all, riverine systems and are used to evaluate cause and effects of disturbances throughout the drainage area. The most significant impacts in the Yankee Fork watershed that affect physical and ecological processes were found to be from mining activities, particularly in the Lower Yankee Fork and Jordan Creek subwatersheds (Table 2).

Table 2. Watershed condition summary.

Watershed Pathway or Indicator	Condition Rating	Comments
Road density and location	At risk	The watershed appears to have a low road density (less than 2 mi/mi^2); but these calculations do not include mining access roads or all-terrain vehicle trails. There are several roads located on the valley bottoms and adjacent to waterways that encroach on channels and floodplains, redirect or impound overland flows, and provide fine sediment inputs through dust drift along the channel network.
Anthropogenic disturbance history	At risk	Mining activities primarily in the Lower Yankee Fork and Jordan Creek subwatersheds have negatively impacted riverine processes through ground disturbances (i.e., dredging, hydraulic mining, and open-pit mines) that redirect drainage networks, through surface and groundwater contamination (i.e., cyanide and mercury), and through past timber harvests to fuel the mills (i.e., loss of mature trees).
Riparian reserves	At risk	Riparian reserves are at or near natural levels throughout most of the watershed. The exceptions are in the dredged reaches in the Lower Yankee Fork and Jordan Creek subwatersheds.

Watershed Pathway or Indicator	Condition Rating	Comments
Water quality and quantity	Water quality – at risk Water quantity – properly functioning	There remains a threat to water quality and aquatic species due to potential chemical contaminants (i.e., cyanide, mercury, and selenium) associated with past and present mining activities.
Main Channel Physical Barriers (Yankee Fork mainstem)	Properly functioning	There are no man-made fish passage barriers along the mainstem Yankee Fork preventing fish migration into the watershed.

Yankee Fork Watershed Fish Usage and Density

Salmon and Steelhead Usage

Spring/summer Chinook salmon adults enter and ascend the Columbia River between March and July and reach the Upper Salmon River (about 850 miles upriver) in late July and August. Adult fish hold in deep pools within the main Salmon River and then move into the tributary streams like the Yankee Fork in late July and August to begin spawning (USFS 2006). Spawning occurs in August and September and the eggs remain in the gravel with winter and early spring water temperatures determining the actual time of emergence which typically occurs by mid-March to late April (USFS 2006). Young salmon emerge from redds in the spring and will rear in a variety of environments. Within one month of emergence (or release if planted) the fish generally remain within a localized reach from the point of emergence (or release) to roughly 0.5 to 1.0 mile downstream prior to outmigration (Richards and Cernera 1989). Juveniles will migrate from the Yankee Fork watershed to the Salmon River during fall and throughout the winter (Reiser and Ramey 1987), but the highest migration may be as young-of-the-year (age-0) and is done before spring (Gregory 2012). Juveniles spend about one year in freshwater before smolting and migrating to the Pacific Ocean between April and June (Reiser and Ramey 1987). The Yankee Fork salmon typically spend 1 to 3 years in the ocean before returning based on Shoshone-Bannock Tribes (Tribes) counts of returning fish (Gregory and Wood 2012).

Steelhead adult migration requirements are generally similar to those described for Chinook salmon. Steelhead enter and ascend the Columbia River in June and July, arriving near their spawning grounds several months prior to spawning (USFS 2006). However, adult holding takes place over a much longer period (from fall arrival in the Snake River drainage until spring spawning). Most adult steelhead have moved into tributary streams like the Yankee Fork by November. However, some adults hold in the Salmon River until February or March before moving into natal streams to spawn. Unlike Chinook salmon that return from the ocean to spawn and subsequently die, steelhead have the ability to migrate back to the ocean after spawning (kelting) and to return and spawn again. Juvenile rearing lasts up to about 3 years prior to ocean emigration (Rowe et al. 1989; NOAA Fisheries 2011).

Supplementation and habitat programs have been implemented in the Yankee Fork watershed by the Tribes in response to declining populations of Chinook salmon and steelhead. Their interest is to increase the viability and production of these species, increase harvest potential for members of the Tribes, increase knowledge of fishery management techniques, and facilitate adaptive management.

Chinook Salmon Fish Density

Summer densities of juvenile spring Chinook salmon were estimated by snorkeling riffle-pool sites between 1984 and 2008 (Tsosie, Bacon, and Wadsworth 2009). Mean density (number of fish/100 m^2) by sampling stratum was estimated by averaging the density of fish at each of the six sites per stratum. This information was then summarized on a subwatershed basis. Based on the average fish density per 100 m^2 shown in Figure 4, the Yankee Fork stock of naturally-producing spring Chinook salmon is severely depressed and well below the estimated carrying capacity of 425,000 smolts (Reclamation 2012).

Figure 4 also shows that the Middle Yankee Fork subwatershed had the highest fish densities for juvenile Chinook salmon followed by the West Fork and Lower Yankee Fork subwatersheds. The Lower Yankee Fork subwatershed had nearly three times lower fish densities than the Middle Yankee Fork subwatershed.

Interpretation of annual spawning ground surveys conducted by the Idaho Department of Fish and Game and the Tribes for spring Chinook salmon in the Yankee Fork drainage reflect depressed juvenile Chinook salmon numbers (Reclamation 2012). The Middle Yankee Fork subwatershed had the highest redd counts in the watershed followed by the West Fork. Survey data indicate that the Yankee Fork redd counts have ranged from 615 redds in 1968 to 0 redds in 1995 (Figure 5) and there has been a continuing decline of redds from 1969 through 2007, that has also been documented throughout the rest of the Salmon River drainage.

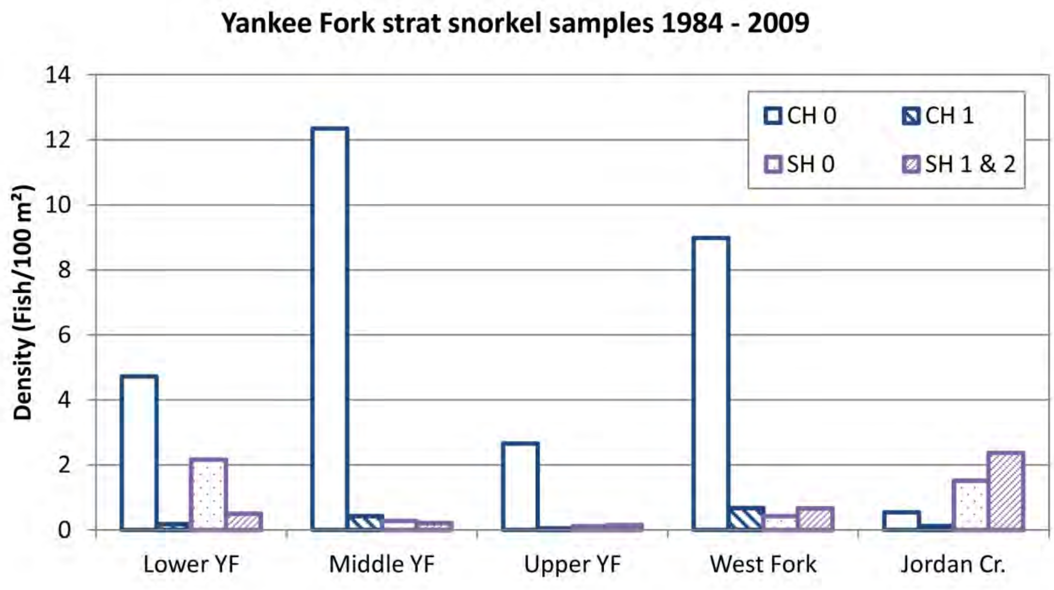


Figure 4. Yankee Fork stratified ("strat") snorkel survey samples from 1984 to 2009 by subwatershed based on data collected by the Tribes. *Chinook age classes: CH 0 = young of the year and CH 1 = one year old. Steelhead age classes: SH 0 = young of the year and SH 1 & 2 = one to two years old.*

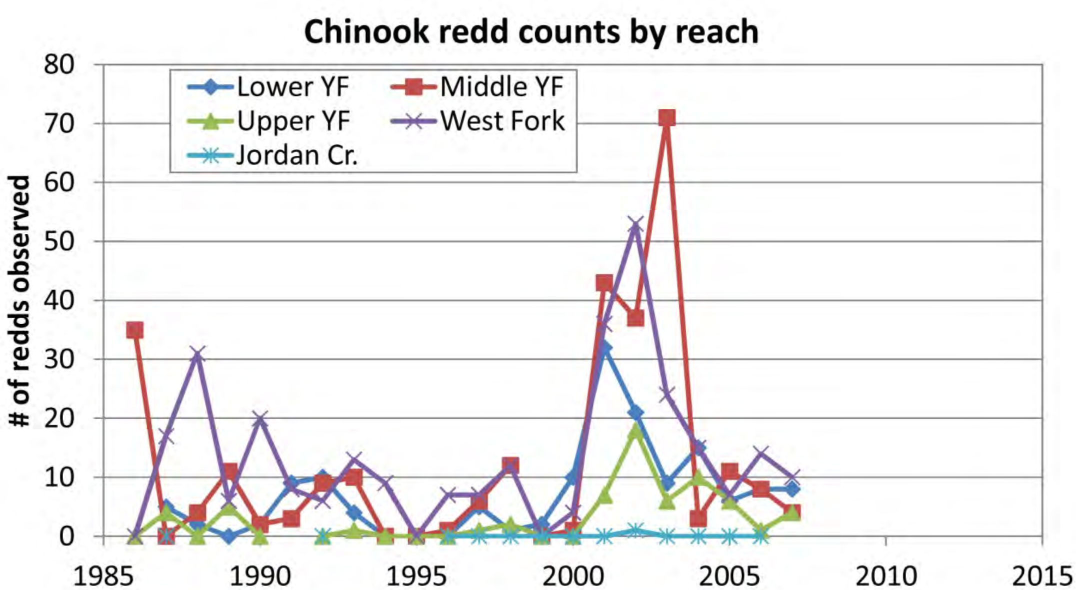


Figure 5. Yankee Fork redd counts by subwatershed based on data collected by the Tribes.

Lower Yankee Fork and West Fork Subwatersheds

Lower Yankee Fork Subwatershed

The Lower Yankee Fork drainage area is about 29 mi^2 and the drainage density is about 1.45 mi/mi^2. Bedrock geology consists predominantly of the Challis Volcanics except between RM 3 and the Yankee Fork/Salmon River confluence where the Idaho batholith crops out. The Yankee Fork valley segment generally has a north-south orientation except for the lower 3-mile section where it trends north-northeast downstream.

Anthropogenic disturbances that have significantly impaired riverine processes are primarily from mining activities. Prior to 1952, the mining practice of dredging left about 7.2 miles of unconsolidated and unvegetated dredge tailings along the Yankee Fork and Jordan Creek valley floors. These tailings are located along the Yankee Fork valley bottom for about 5.8 miles and along the Jordan Creek valley bottom for about 1.4 miles. Dredge tailing mounds have disconnected tributaries and floodplains and have altered channel processes and channel form. Impacts to habitat include the isolation of perennial drainages, loss of rearing habitat and high water refugia, alteration of hydraulic conditions that result in undesirable instream high-flow conditions and loss of instream habitat diversity.

West Fork Subwatershed

The West Fork drainage area is about 58 mi^2 which comprises about 30 percent of the total Yankee Fork watershed. The valley segment has a northwest orientation and elevations range from about 7800 feet in the headwater area to about 6200 feet at the confluence with the Yankee Fork. Drainage length from the headwaters to the Yankee Fork confluence is about 10.3 miles. The drainage density is about 2.5 mi/mi^2 with approximately 88.5 miles of perennial streams and 55.6 miles of intermittent streams (USFS 2006).

Bedrock geology consists predominantly of the Challis Volcanics with some outcrops of the Idaho batholith occurring in the headwater areas. Alpine glaciers during the Pleistocene Epoch sculpted the mountains and valleys throughout much of the drainage. Valley glaciers occurred along the West Fork, Cabin Creek, Lightning Creek, and Deadwood Creek based on the presence of glacial cirques and troughs. Glacial outwash terraces along the southern valley wall near the mouth of the West Fork suggest at least one of the valley glaciers made it to the Yankee Fork valley bottom.

The Salmon-Challis National Forest manages a majority of the land in the subwatershed. The West Fork is a major tributary to the Yankee Fork and contributes about 36 percent of the water in the Yankee Fork below the Yankee Fork/West Fork confluence. Channel forming discharge for the West Fork is about 247 cubic feet per second (cfs) with a recurrence interval of about 1.11 years, and probable peak flood discharge (100 year recurrence interval) is about 1395 cfs (Reclamation 2012).

Private lands bordering the stream are generally limited to the lower 0.9 miles and are referred to as the Yankee Fork Subdivision (USFS 2006). One mining operation, the Red Mountain Mine, is currently listed as active and is a lode exploration operation located on Red Mountain with a disturbance area of about 2 to 5 acres (USFS 2006). The road densities are low in the subwatershed with the majority of roads being confined to the Yankee Fork Subdivision. Wildland fires that have burned sections of the drainage include (1) the East Basin Fire (1985) that burned part of the Sawmill Creek drainage, (2) the Zane Fire (2006) burned a small ridge top area, and (3) the Potato Fire (2006) that burned the lower half of the West Fork and Deadwood Creek drainages, and about the lower third of the Lightning Creek drainage (Reclamation 2012). There are no physical mainstem barriers that impede fish passage along the West Fork channel.

Historical Timeline

Prior to Euro-American entry and settlement in the Yankee Fork watershed in the 1800s, the Shoshone and Bannock people resided in the Salmon River area and specifically hunted for fish, wildlife, and plants for subsistence. One historical reference identified that the Bannock people utilized a camp near the mouth of Ramey Creek, a tributary to the Yankee Fork near RM 4.6. After Euro-American settlement of the area, recorded historical events and activities occurring in the Yankee Fork watershed have impacted physical and ecological processes. Some significant historical events are summarized in Table 3. A more detailed historical timeline of the area is available in Appendices D and E of the Tributary Assessment (Reclamation 2012).

Table 3. Significant historical events impacting the Lower Yankee Fork subwatershed.

Year or Period	Significant Historical Event
1870s – early 1900s	Placer gold deposits found along Jordan Creek down to the Yankee Fork confluence which were mined using drag-line dredges and hydraulic monitors (cannons).
1875	First significant gold bearing quartz vein was found in Jordan Creek drainage which began the development of hard-rock mines in the area.
1877	Bonanza townsite built along the Yankee Fork upstream of West Fork/Yankee Fork confluence to serve the Charles Dickens Mine in the Jordan Creek drainage and other mines operating in the district.

Year or Period	Significant Historical Event
1879 - 1892	Custer townsite built (1879) to serve the General Custer Mine and Mill located along the Yankee Fork upstream of Jordan Creek/Yankee Fork confluence (Figure 6). The mill operated from 1881 to 1892 and gold recovery was by amalgamation and chlorination processing (USGS 2009). Waste from the milling process appears to have had a significant impact on salmonids based on a report from the Yankee Fork Herald (February 19, 1881), “the water in the Yankee Fork is of a deep red since the starting up of the Custer mill. No more fish need be looked for in that stream. Lovers of salmon will be compelled to go without their luxury or have them shipped in future”. Custer Mill operated from 1881 to 1892 and required over 300 cords of wood per month to fuel the steam engines (LOYF Historical Association 2005).
Late 1800s to Early 1900s	Hydraulic mining techniques were used in several tributary drainages to the Yankee Fork including Adair Creek, Jordan Creek, and mouth of the West Fork.
1906 -1911	Golden Sunbeam Mining Company developed the Golden Sunbeam Group mining claims about four miles up Jordan Creek. Sunbeam Hydroelectric Dam was constructed on the Salmon River above its confluence with the Yankee Fork to provide power to the Golden Sunbeam Mining Company. Entire Sunbeam enterprise including mine, mill, and dam abandoned in 1911.
By 1916	Most of the lumber used in building Custer and Bonanza was cut in Lavalle Creek (now Sawmill Creek), which enters West Fork near Bonanza. The 1916 Intensive Land Classification for the Challis National Forest says that along the Yankee Fork, “most of the good timber was taken out years ago for mining use and for cordwood” (USFS 2006).
1933 or 1934	Sunbeam Dam was breached by the Idaho State Game Department, presumably to improve upstream fish passage on the Salmon River.
1940 - 1952	Yankee Fork Gold Dredge operated along the valley bottom of the Yankee Fork from about Pole Flat Campground to Jordan Creek confluence (Figure 7).
1980 – 2004	U.S. Antimony Corporation’s subsidiary Yankee Fork Silver and Gold Company began processing dump material from Charles Dickens mine and mines on Estes Mountain using a vat leach cyanide mill at Preachers Cove in 1980 (Figure 8). There were some environmental problems at the mill site associated with soil and groundwater contamination from cyanide spills and heavy metals leaching from the tailing ponds. Supposedly by the end of 1993, over 90 percent of the chemicals had been neutralized (Mitchell 1997). In 1995, the U.S. Forest Service (USFS) discovered a cyanide leak at the processing facility. Approximately 20,000 gallons of cyanide solution from the tailing ponds leached into the ground about 650 feet from the Yankee Fork (High Country News 1995). No documented fish kill was associated with this release. U.S. Antimony completed the physical reclamation of the Preachers Cove mill in 2004.

Year or Period	Significant Historical Event
1993 - 2012	The following is a summary of the Grouse Creek Mine based on the *Removal Action Memorandum, Grouse Creek Mine Tailings Impoundment Closure*, initiated by the USFS in 1998. Construction of the Grouse Creek Mine in the Jordan Creek drainage by Hecla Mining Company (Hecla) began in 1993 and actual mining operations were from 1994 to 1997. The mine was a 536-acre open-pit mine and gold recovery used a carbon-in-pulp cyanide vat leach process which included a 105-acre tailings impoundment (Figure 9). In 1997, Hecla suspended mining operations due to unfavorable economic conditions. Beginning in 1997, water monitoring sites detected weak acid dissociable cyanide off-site, instream and downstream of the mine. In 1999, a USFS Technical Team concluded that cyanide was from the tailings impoundment. In October 2000, Hecla entered into an Administrative Order on Consent, under the Comprehensive Environmental Response Compensation and Liability Act, for a Time-Critical Removal Action with the USFS and the Environmental Protection Agency. In 2003, under an Action Memorandum, Hecla was allowed to discharge treated and untreated tailings impoundment water to the Yankee Fork via a pipe to Outfall 003 located downstream of the Yankee Fork/Jordan Creek confluence. No impacts to aquatic life in Jordan Creek were noted in the *Removal Action Memorandum*. Presently, Hecla has reclaimed about 80 percent and the final reclamation of the site with completion of the tailings impoundment closure is planned to be completed in 2012 **(http://www.hecla-mining.com/resposibility/resposibility_stewardship_reclamation.php)**.

Figure 6. General Custer Mill 1937 located along the Yankee Fork upstream of Custer (hht://www.fs.fed.us/r4/sc/yankeefork/generalcustermill_1.shtml).

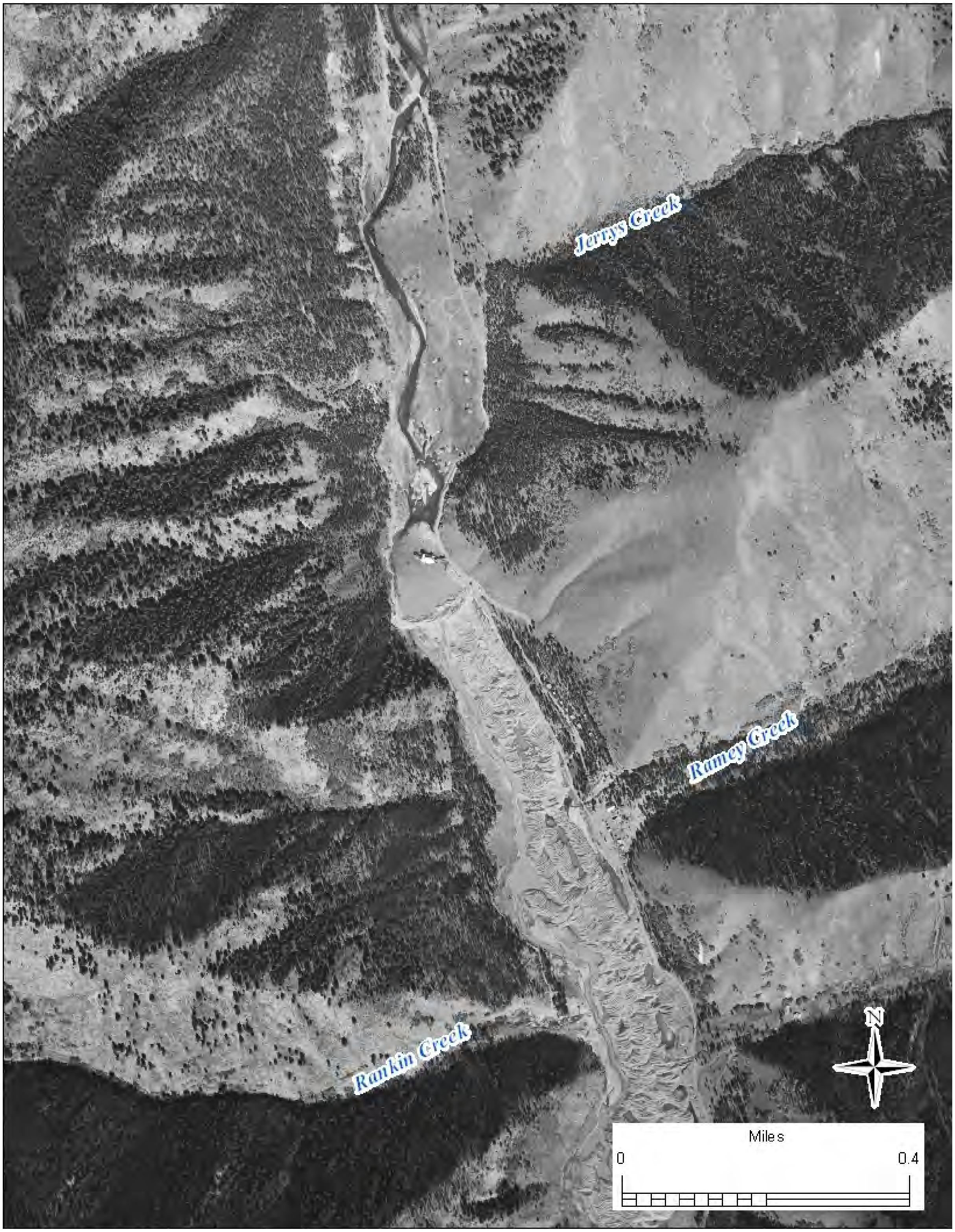


Figure 7. Yankee Fork Gold Dredge working between Rankin Creek and Jerrys Creek in 1945.

Figure 8. U.S. Antimony Corporation's vat leach cyanide mill at Preachers Cove in 1991.

Figure 9. Grouse Creek Mine that was operated by Hecla Mining along Jordan Creek in 2009.

Historic and Existing Conditions Comparison

In mountain drainage basins, valley segments define portions of the drainage network exhibiting similar valley-scale morphologies and governing geomorphic processes (Montgomery and Buffington 1998). Valley form and channel form are closely related and together can provide clues about how the system historically functioned, such as stream gradient, expected habitat unit types and characteristics, and the relationship of the stream to the riparian zone (ODFW 2010).

For this report, the historical conditions are defined as the unaltered or natural conditions representative of the assessment area prior to large-scale anthropogenic influences (i.e., Euro-American settlement). The existing conditions are the resultant processes following anthropogenic disturbances that currently shape the assessment area. It is the natural historical conditions in which the species of concern have evolved and will likely thrive in the future. As such, the historical conditions and the physical and ecological processes that created them can be used as a guide for developing the target conditions that can improve habitat-forming processes for the reach.

Valley segments, channel reaches, and bedforms are hierarchically nested subdivisions of the drainage network (similar to those proposed by Frissell et al. 1986) used in this report to document physical and ecological changes and interpret how habitat-forming processes have changed through time. A conscious effort was made to use published methodologies. However, some methodologies, particularly geomorphic measurements, had to be modified in order to capture temporal changes to the habitat-forming processes. Significant modifications to how geomorphic measurements were conducted are as follows:

1. Typically, valley bottom width measurements are conducted between side slopes of the surrounding hills or mountains (USFS 2010) or between constraining terraces (ODFW 2010). In this report, the valley bottom width measurements are conducted between geologic constraints (i.e., alluvial fans, bedrock, etc.) or anthropogenic constraints (i.e., dredge tailing mounds, levees, etc.) that physically restrict the stream's ability to migrate laterally across the valley bottom and are referred to as the constrained valley bottom width.

2. Valley length measurements are typically conducted along the midpoints between the geologic valley constraints and are used to calculate valley gradient and channel sinuosity. This report uses a similar method, but also includes the anthropogenic constraints in order to improve valley gradient and channel sinuosity estimates and are referred to as the constrained valley length.

3. Bankfull width or active channel width are measured in the field based on the width of active channel scour (USFS 2010; ODFW 2010). Historic field measurements of this type are rare, and accurate estimates are unattainable from aerial photography. Unvegetated channel width is used in this report as a surrogate because it should represent that portion of the channel that is inundated and frequently disturbed at times of high discharge when sediment transport or scour is initiated (Montgomery and MacDonald 2002; Rapp and Abbe 2003). The unvegetated channel width can be identified and measured from aerial photographs for analysis.

4. Channel confinement in this report is the ratio between the average constrained valley bottom width and the average unvegetated channel width. The degree of channel confinement adapted from Hillman (2006) is classified in this report as confined (less than 2:1), moderately confined (2:1 to 4:1), and unconfined (greater than 4:1).

5. Side channels can be categorized as secondary channels that are typically activated during channel forming flows, and tertiary channels that generally take discharges higher than a channel forming flow to activate (Rapp and Abbe 2003). Secondary channels can be further described as (1) split-flow channels, where the character of the mainstem and side channel are essentially the same, or (2) floodplain side channels, where a relatively small side channel has formed in the low-lying active floodplain. Tertiary channels can be further described as overflow channels, which are also important because some are groundwater fed and provide cooler water to the stream.

HISTORICAL CONDITIONS

Both the Yankee Fork and West Fork valley segments described in the following sections were shaped by alpine glaciers that carved U-shaped troughs during the Pleistocene Epoch between roughly 2.5 million and 10,000 years ago. At least two valley glaciers have occupied these valley segments based on the older, higher glacial terraces and the younger, inset glacial outwash plain. When these valley glaciers retreated, they released large volumes of sediment and high discharges that combined to fill the valley with coarse- to fine-grained alluvial deposits. Along the valley margins, accumulated debris flows and alluvial sediment transport processes have built alluvial fans that overlay glacial outwash deposits in many places.

Following the Pleistocene Epoch punctuated by multiple glacial periods, the climate in the Yankee Fork valley became warmer and drier during the Holocene Epoch (about 10,000 years ago to present). The glaciers essentially disappeared in the Yankee Fork watershed, and both discharge and sediment yield significantly decreased. The Yankee Fork and West Fork became “underfit” alluvial streams, defined as a relatively small stream flowing through a valley formed by and over sediment deposited from a much larger river.

Yankee Fork

The Yankee Fork flowed through an alluvial valley with a valley gradient of about 1.1 percent and the depth to bedrock was relatively shallow, on the order of tens of feet, throughout the valley segment. There were two channel reaches in the assessment area, (1) a moderately confined channel between Jordan Creek and Preachers Cove, and (2) an unconfined channel between Preachers Cove and the West Fork (Table 4).

Table 4. Valley and channel metrics.

Location	Year	Average Valley Length	Average Valley Width	Average Unvegetated Channel Width	Average Channel Confinement
Jordan Creek to Preachers Cove	1945	8,941 feet	182 feet	57 feet	Moderately Confined
Preachers Cove to 1945 Yankee Fork/West Fork Confluence	1945	1,451 feet	435 feet	81 feet	Unconfined

For the moderately confined channel reach between Jordan Creek and Preachers Cove, the channel patterns observed on the 1945 aerial photographs (Figure 10) were a straight, free-formed alluvial channel which indicates a relatively low rate of lateral channel migration and channel/floodplain dynamics. No distinct bedform patterns were visible which indicates a predominantly plane-bed channel with almost no bedform diversity. Few, if any, pools would be expected in this type of channel because plane-bed channels are typically threshold channels with an armored bed that require flows higher than the average 1.5- to 2-year recurrence interval flows to mobilize the bed. As these higher flows recede, the bed materials that were mobilized are redeposited across the channel, re-establishing the plane-bed bedform. Additionally, plane-bed channels are hydraulically rough due to the coarse and variable bed materials and stream energy is distributed fairly evenly across the bed. This decreases the likelihood that flows will converge in any one location to form scour conditions that might create a pool. Pools are typically non-existent in this channel type except in locations with channel-spanning structures or significant channel constrictions (Montgomery and Buffington 1997). Unvegetated bars and side channels were present. Bars were probably mobilized and side channels activated during channel forming flows with a recurrence interval of about 1 to 2 years for this channel type (Bisson, Buffington, and Montgomery 2006).

At the time the 1945 aerial photographs were taken, off-channel habitats were comprised predominantly of side channels. There were about 4,100 feet of secondary channels (unvegetated or wetted side channel paths) comprised of six split-flow and four floodplain-type side channels. The fair-to-good quality of the 1945 aerial photographs was not suitable for delineating tertiary, or overflow channels, with any confidence. However, the mosaic patches and arrangement of riparian vegetation (i.e., grasses, shrubs, and small trees) suggest tertiary channels significantly contributed to the availability of off-channel habitats during large floods (5- to 10-year recurrence interval) throughout this channel segment. The quantity of available side channels was more than would be expected for a plane-bed channel system. This may have been due to sediment pulses to the Yankee Fork from hydraulic mining in Jordan Creek and Adair Creek that occurred around the turn of the century, causing localized aggradation (i.e., braided channel) as the pulses moved through the system resulting in an abundance of side channels, unvegetated bars, and islands.

Vegetation composition in the watershed varies by elevation. Lower elevation, south-facing slopes supported patches of big sagebrush and forested habitats of the Douglas-fir series (USFS 1995). Vegetation most likely consisted of forested hillslopes of Douglas-fir with diverse shrub and grass riparian vegetation along stream channels and floodplains (Overton, Radko, and Wollrab 1999). The riparian vegetation influences on channel processes would have included marginal improvements in channel boundary and floodplain roughness, and bank stability.

Woody debris would have accumulated infrequently during and as a result of high-water events, with most wood lodging along the banks upstream or downstream of constriction points (i.e., vegetated bars). Woody debris would have been highly transient and accumulations likely did not build over time, rather they washed downstream during high-water events. Wood inputs were likely from upstream sources, debris flows entering the channel, and lateral recruitment through blow-down and mortality.

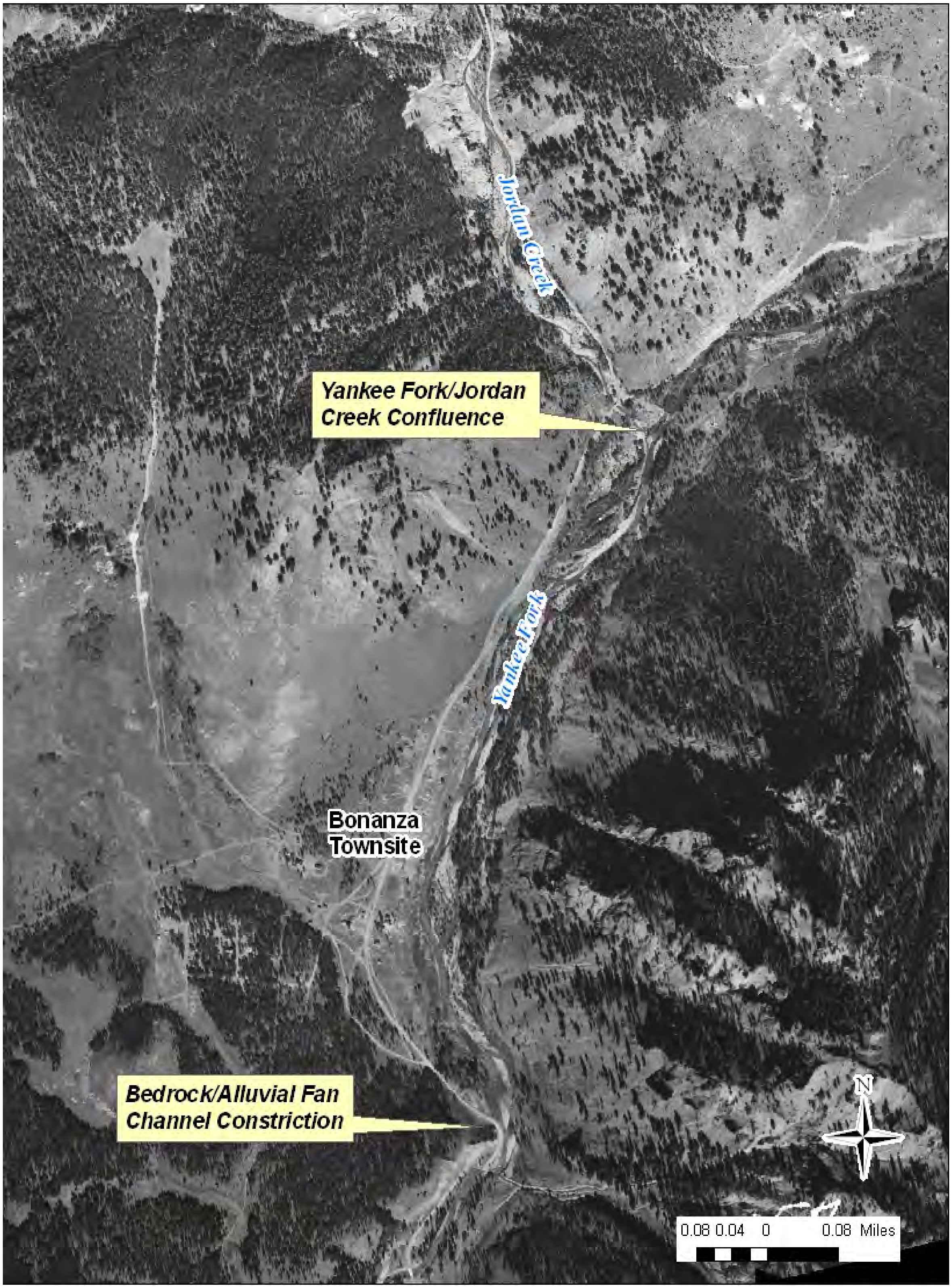


Figure 10. 1945 aerial photograph of the Yankee Fork from Jordan Creek downstream to bedrock/alluvial fan constriction above Preachers Cove.

For the unconfined channel reach between Preachers Cove and the West Fork, there was no distinctive bedform diversity (i.e., pools and riffles) visible in the 1945 aerial photographs and the channel pattern was a straight, free-formed alluvial channel with a relatively low rate of lateral channel migration and channel/floodplain dynamics. However, the 1945 aerial photographs represent a "snapshot" in time after there had been significant valley bottom and channel disturbances. Hydraulic mining during the late 1800s and early 1900s in Jordan Creek, Adair Creek, and West Fork increased sediment loads to the Yankee Fork channel which likely responded with alluvial aggradation and channel braiding in this low gradient, unconfined channel reach. Prior to these mining related disturbances, the channel most likely had a straight planform and predominantly plane-bed to pool-riffle bedforms indicating a relatively low to moderate rate of lateral channel migration and channel/floodplain dynamics.

Off-channel habitats were comprised predominantly of side channels based on interpretation of the 1945 aerial photographs. There were about 650 feet of secondary channels (unvegetated or wetted side channel paths) comprised of one split-flow and one floodplain-type side channels. The Yankee Fork had been channelized along the Preachers Cove alluvial fan by the 1945 aerial photographs and the quantity of available side channels was far less than would be expected for an unconfined, plane-bed to pool-riffle channel system. Unvegetated channel scrolls and arrangement of vegetation (i.e., shrubs and small trees) suggested secondary and tertiary channels significantly contributed to the availability of off-channel habitats during channel forming flows and large floods (5 to 10 year recurrence interval).

Vegetation along this channel reach consisted of forested hillslopes of Douglas-fir with patches of big sagebrush. Riparian vegetation along the stream channels and floodplain included diverse shrubs and grasses with patches of conifers (Overton, Radko, and Wollrab 1999). The riparian vegetation influences on channel processes would have included increased channel boundary and floodplain roughness, improved bank stability and sediment retention, improved wood recruitment and retention, and the creation and maintenance of diverse habitat patches.

Woody debris would have accumulated mainly along the few side channels and outside bends and high on transient gravel bars. The necessary wood sizes and volumes may have accumulated to form transient logjams as channel forming flows would dissipate energy over the floodplain. Wood inputs were likely from upstream sources, the West Fork, and recruitment through lateral inputs from blow-down and mortality.

The Yankee Fork appears to have been channelized by the time of the 1945 aerial photographs. Spoil piles had been placed on river right along the Preachers Cove alluvial fan creating a straight, plane-bed channel that was confined and disconnected from its floodplain (Figure 11). Observations from the U.S. Fish Bureau stream survey (USFB 1934) noted that the Yankee Fork between Jordan Creek and the West Fork was almost a continuous riffle (or plane-bed channel) with shallow pools that were defined as pools less than 25 square yards and less than 3 feet deep. The probable channel work could have been done as part of mining operations within the California Placer (unsurveyed) located in the broad floodplain area along river right, and in preparation to dredge the Iowa Group Placer Claim. One of the primary targets of the placer mining operation was an ancient channel that was created when the late Pleistocene-age valley glacier was retreating and releasing large volumes of sediment and high discharge. The ancient channel scars are visible in the 1945 aerial photographs (refer to Figure 10) and its alignment would have been along river right adjacent to the channelized section. The placer deposit was probably being worked as a small operation until the Yankee Fork gold dredge worked the area between 1945 and 1952.

Figure 11. 1945 aerial photograph of the Yankee Fork downstream of bedrock/alluvial fan constriction to Yankee Fork/West Fork confluence area.

West Fork

Downstream of Sawmill Creek, the West Fork had an unconfined channel and flowed through an alluvial valley with a valley gradient of about 0.9 percent (Table 5). The depth to bedrock was relatively shallow, on the order of tens of feet, with a bedrock/alluvial fan channel constriction downstream of the Yankee Fork/West Fork confluence that provided a vertical channel control. At the Yankee Fork/West Fork confluence area, there was a broad floodplain in which the unconfined West Fork and Yankee Fork channels dynamically interacted leading to varying hydraulic conditions that created and maintained a mosaic of habitat patches (Figure 12).

The channel observed on the 1945 aerial photographs has a straight planform with a sinuosity of about 1.2, which indicates a relatively low rate to moderate of lateral channel migration and channel/floodplain dynamics. There were distinctive bedform patterns that indicate a predominantly plane-bed with shorter pool-riffle segments. Pools would be expected less frequently in this plane-bed dominated system than in a pool-riffle dominated system. For example, pool frequency for a pool-riffle system would be about 12 to 17 pools per mile (or 1 pool every 5 to 7 channel widths) based on the interpreted 1945 average unvegetated channel width (Bisson, Buffington, and Montgomery 2006). Therefore, this plane-bed dominated system would be expected to be somewhat lower than the lower range of variance for pool frequency, or less than 12 pools per mile.

Table 5. Valley and channel metrics.

Location	Year	Average Valley Length	Average Valley Width	Average Unvegetated Channel Width	Average Channel Confinement
Below Sawmill Creek to 1945 Mouth	1945	2,224 feet	503 feet	64 feet	Unconfined

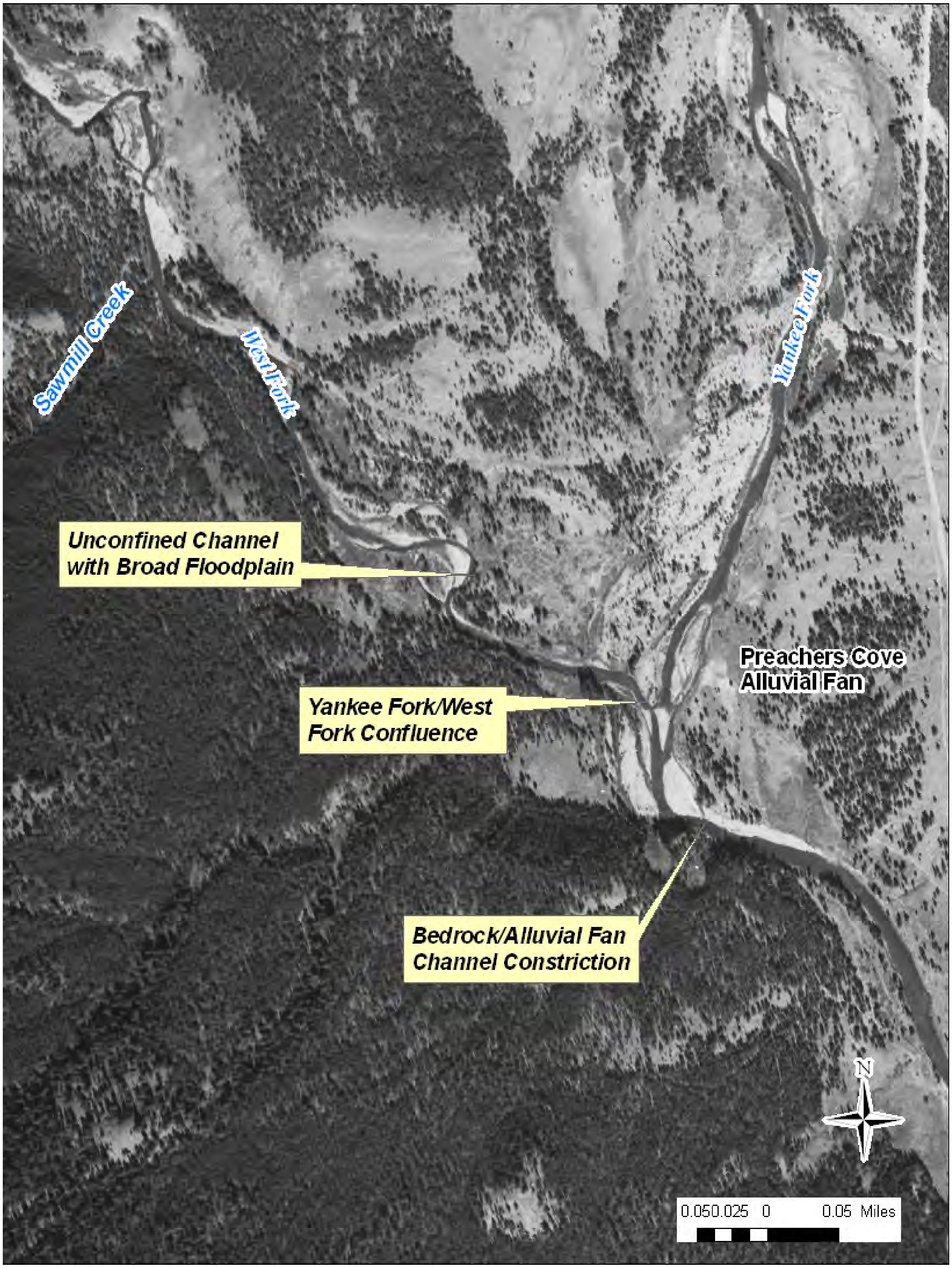


Figure 12. 1945 aerial photograph of the Yankee Fork downstream of bedrock/alluvial fan constriction to Yankee Fork/West Fork confluence area.

Prior to mining disturbances that included hydraulic mining and vegetation clearing, the floodplain would have had a higher density of riparian vegetation that provided channel boundary roughness and bank stability, and there would have been fewer unvegetated bars and more floodplain-type side channels. The unvegetated bars would have been mobilized and the side channels activated during channel forming flows, typically with a recurrence interval of about 1 to 2 years (Bisson, Buffington, and Montgomery 2006).

The oldest historic photograph found during this assessment was from 1911 (Figure 13). In the photograph taken downstream of Sawmill Creek looking toward the Yankee Fork confluence, timber harvests had removed almost all of the large trees (a sawmill was located in Sawmill Creek) and hydraulic mining had already introduced sediment pulses to the system (Sawmill Creek had been diverted for hydraulic mining purposes).

Figure 13. View downstream along the West Fork from about Sawmill Creek toward the confluence with the Yankee Fork (Smith 1911). Photograph taken by Maven Sawyer, winter of 1910**.**

Observations from the U.S. Fish Bureau stream survey (USFB 1934) noted that the lower 2.5 miles of the West Fork had a total of 35 pools or about 14 pools per mile which was in the range of variability expected for an undisturbed, pool-riffle channel. These pools were classified primarily as (1) less than 25 square yards and less than 3-feet deep and (2) 25-to-50 square yards and 3 to 6 feet deep. Boulders, log jams, and over-hanging banks were the primary forcing agents for scour pools. The survey also mentioned many backwater pools observed that were filled with plant and animal life, and a great number of fingerlings were observed in these pools. However, the surveyed section of the West Fork included the lowest reach at the confluence with the Yankee Fork, which was predominantly a depositional area with a combination pool-riffle and plane-bed channel form due to backwater effects from the Yankee Fork and the valley constriction at the confluence. This would indicate fewer pools existed in this 0.8 mile section than the 14 pools per mile average. Interpretation of the 1945 aerial photo suggests a range of five to eight pools may have existed in this channel reach.

Off-channel habitats were comprised predominantly of side channels and alcoves based on interpretation of the 1945 aerial photographs and 1934 stream inventory (USFB 1934). There were about 1,850 feet of secondary channels (unvegetated or wetted side channel paths) comprised of two split-flow and five floodplain-type side channels. Tertiary channels were not delineated due to the fair-to-good quality of the 1945 aerial photographs, but the 1934 stream inventory (USFB 1934) reported many backwater pools, or alcoves, that had an abundance of food and shelter.

Vegetation along the channel reach consisted of the Douglas-fir series of forested hillslopes on the north-facing slopes with patches of big sagebrush. On the south-facing slopes, big sagebrush was more dominant than the Douglas-fir series. Riparian vegetation along the channel and floodplain was comprised of diverse shrubs and grasses with patches of conifers (Overton, Radko, and Wollrab 1999). The riparian vegetation influences on channel processes would have included increased channel boundary and floodplain roughness, improved bank stability and sediment retention, improved wood recruitment and retention, and creation and maintenance of diverse habitat patches.

Woody debris would have accumulated sparsely in this channel reach, mainly along transient side channels and outside bends and on gravel bars. The necessary wood sizes and volumes may have accumulated to form logjams because channel forming flows would have been able to dissipate energy through channel roughness and over the floodplain during flood stages. Wood inputs were likely from upstream sources, debris flows entering the channel, and recruitment through lateral channel migration and inputs from blow-down and mortality.

EXISTING CONDITIONS

The existing conditions along the Yankee Fork and West Fork were assessed for the time period 2010 through 2011, giving a “snapshot” in time of the assessment area. Data collected to assess existing conditions included detailed light detecting and ranging (LiDAR) topography, aerial photographs, and field observations.

Yankee Fork

Channel Reach Characteristics

Channel reach types are identified in terms of channel morphology and observed processes. Transition zones between adjacent reaches may be gradual or sudden and exact upstream and downstream reach boundaries may be a matter of some judgment (Bisson, Buffington, and Montgomery 2006). Alluvial valleys typically exhibit varieties of alluvial channel reach types that are related to the supply and size of sediment and the streams ability to mobilize the streambed (Montgomery and Buffington 1998).

Under existing conditions in the assessment area, the Yankee Fork is moderately confined along its length by mine tailings, bedrock, and alluvial and colluvial deposits. The channel metrics (Table 6) and location map (Figure 14) are provided. The channel pattern is a straight, free-formed alluvial channel with a sinuosity of about 1.0 and a channel gradient of 1 percent which indicates a low rate of lateral channel migration and channel/floodplain dynamics. Depth to bedrock remains relatively shallow (tens of feet).

Table 6. Yankee Fork channel metrics (2010).

Metrics	RM 9.1 to 6.8
Average Constrained Valley Width	122 feet
Average Constrained Valley Length	12,104 feet
Average Channel Length	12,364 feet
Average Unvegetated Channel Width	48 feet
Channel Confinement	Moderately Confined (2.5)
Channel Gradient	1 percent
Sinuosity	1.02
Dominant Substrate	Cobble (2.5 to 10.1 inches; 64 to 256 mm)
Substrate Gradation (Approx.)	Cobble (45%); Boulder (25%); Gravel (20%); Sand (10%)
Bank Stability	Greater Than 90 Percent Stable
Bank Composition	Predominantly Cobble With Boulder, Gravel and Sand

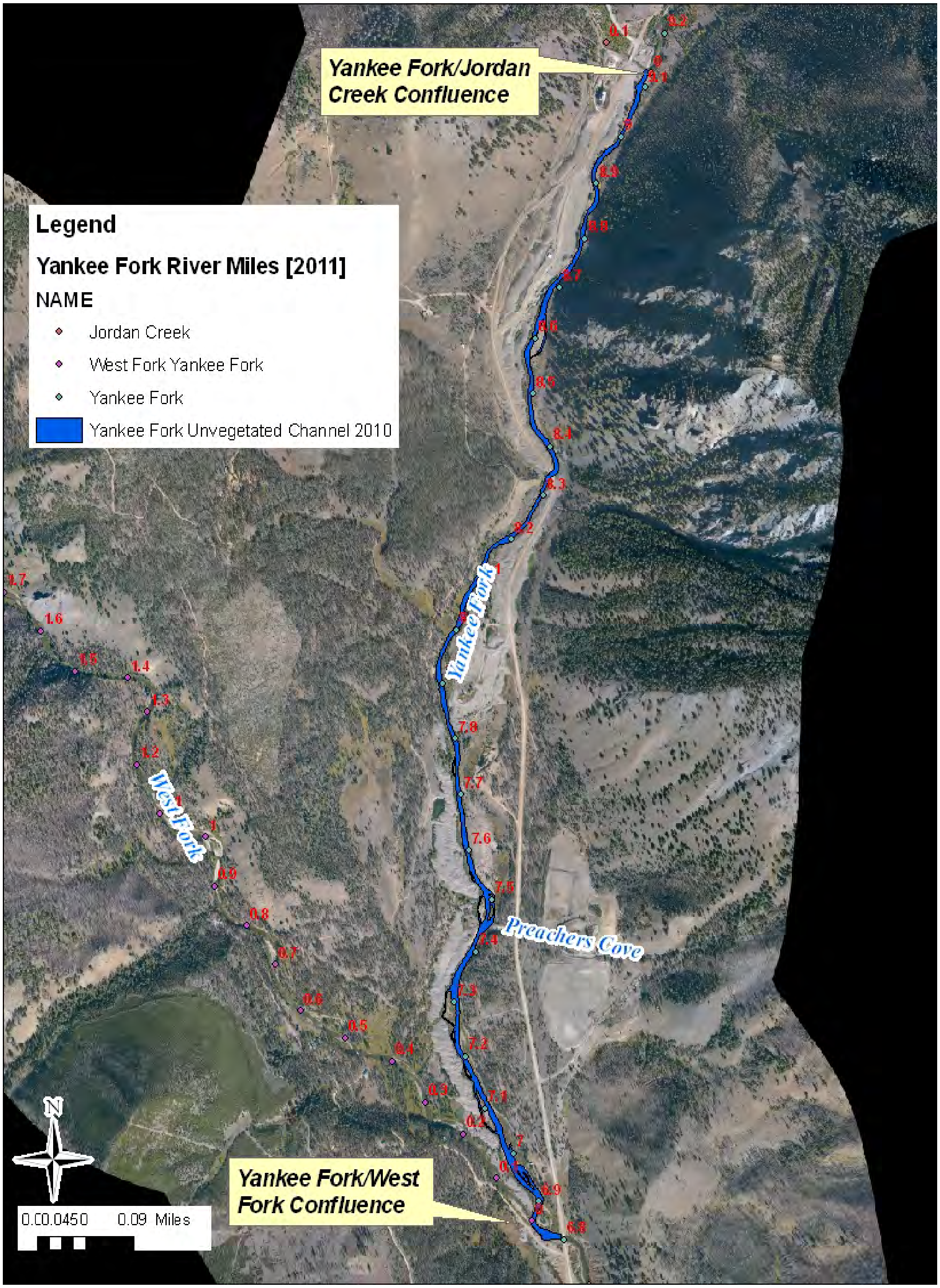


Figure 14. Map of the Yankee Fork (2010) in the assessment area.

Channel type is plane-bed with an average unvegetated channel width of about 48 feet within an average valley width of 122 feet (Figure 15). Channel confinement has increased due to the mine tailings that constrain lateral channel migration and limit floodplain development by about 28 percent from Jordan Creek to Preachers Cove, and about 54 percent from Preachers Cove to the Yankee Fork/West Fork confluence. Increased channel confinement and loss of floodplains changes the geometry of the channel/floodplain cross-sectional area. At high flows, the increased confinement results in deeper water and higher velocities in the more confined channel. The increased depths and velocities result in increased shear stress, and sediment mobilization and transport. The outcome is a wider, more uniform plane-bed channel that is often armored with only the larger sediment sizes due to the increased sediment transport. The armor layer inhibits pool development when flows are not sufficient to mobilize the armoring particles, or in the absence of channel-spanning structures or significant channel constrictions (Montgomery and Buffington 1997; Bisson, Buffington, and Montgomery 2006).

Figure 15. Yankee Fork plane-bed channel as viewed from the Bonanza Bridge.
Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation
Photograph by P. Drury, September 12, 2011.

Hydraulic modeling estimated the average shear stress in the main channel during the 2-year recurrence discharge at approximately 1.5 pounds per square feet, which indicates the river is capable of transporting gravel and small cobbles up to 3.9 inches (99 millimeters [mm]) in diameter (Reclamation 2012). The dominant substrate size found in the channel bed material, or armor layer, is cobble (2.5 to 10.1 inches; 64 to 256 mm). Wolman pebble counts indicated the gradation of the bed material included about 45 percent cobble with 25 percent boulder (10.1 to 161.3 inches; 256 to 4096 mm), 20 percent gravel (0.1 to 2.5 inches; 2 to 64 mm) and

10 percent sand (less than 0.1 inches or 2 mm) (USFS 2010). The hydraulic model results are supported by the channel bed material coarseness and increased channel confinement. The indication was that stream power is no longer being dissipated at its historical rate, resulting in a higher energy stream with more sediment transport capacity.

Along the mine tailings and alluvial deposits, bank materials have a similar gradation as the streambed materials based on field observations. The stream has been rerouted and confined between the mine tailings and alluvial deposits and, to a lesser degree, bedrock and colluvial deposits that have a higher percentage of boulders. Many of the banks do not have woody root reinforcement, primarily due to the lack of riparian vegetation and unconsolidated nature of the material, but still over 95 percent of the banks were found to be stable (USFS 2010). The bank stability along the mine tailings and alluvial deposits was because of the following: (1) banks tend to be “self-armoring” in that finer materials (i.e., fines to gravels) are eroded and coarser materials (i.e., cobbles to boulders) were deposited along the toe of the slope, thus protecting it from erosion, and (2) the size and volume of the material in these deposits inhibits the stream’s ability to erode and transport the sediment load. The coarse alluvial and colluvial materials and the bedrock sections indicate that this reach is naturally armored and laterally stable; however, the dredge tailings have increased the confinement and stability to some degree.

Bedforms and floodplain characteristics

Geomorphic bedforms are relatively homogeneous localized areas of the channel that differ in depth, velocity, and substrate characteristics from adjoining areas. Individual bedforms are created by hydraulic interactions between flow and roughness elements of the streambed, banks, and the channel planform. The frequency and location of bedform types can be affected by a variety of disturbances, including anthropogenic disturbances. This makes bedform mapping a useful tool for understanding the relationships between anthropogenically-induced habitat alterations and aquatic organisms (Bisson, Buffington, and Montgomery 2006).

In this plane-bed, free-formed alluvial channel there is little bedform diversity, except where local forcing agents are present that create flow convergence sufficient to mobilize the streambed. This channel reach is dominated by riffles (84 percent of total wetted area [TWA]) and lacks pools (6 percent TWA) because there are only a few forcing agents that provide sufficient flow convergence to scour the streambed. The forcing agents that were associated with pool scour are caused by flow convergence at tributaries (Jordan Creek and West Fork confluences), lateral scour forced by bedrock (Figure 16), boulders or riprap, along the outside of meanders with established riparian vegetation, and flow convergence (plunge) downstream of boulder clusters. Instream wood does not have a significant role in forcing flow convergence that would be sufficient to scour pools because the high energy flows move wood through this channel reach, and very large wood that could be retained is essentially not available from local or upstream sources.

Figure 16. Yankee Fork lateral scour pool forced by bedrock outcrop. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Off-channel habitats are comprised predominantly of side channels. There are about 3,800 linear feet of secondary channels comprised of four split-flow and ten floodplain-type side channels in this channel reach of the Yankee Fork (Figure 17). Four tertiary, or overflow channels, make available about 850 linear feet of additional off-channel habitat during large floods (5- to 10-year recurrence interval). In this channel reach, wood was generally transient, and was predominantly in the small- to medium-size class. Most of the wood that interacted with flood flows could be found on some vegetated bars where it contributes to the development of the floodplain-type side channels.

Figure 17. Yankee Fork floodplain-type side channel on far side of vegetated bar. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Vegetation Condition

Vegetation along the channel and in floodplains both influences and is influenced by channel processes. The vegetation condition within, along, and near channels can influence changes in channel geometry or sediment storage and transport. Root strength of vegetation growing along channel banks enhances bank stability, especially in noncohesive alluvial deposits (Montgomery and Buffington 1993). Vegetation also shades the channel, provides a source of wood that can be recruited by the channel, and enhances ecological processes.

The vegetation in the connected floodplain areas ranged from grasslands and forbs to small trees. Roughly 78 percent of vegetation was grassland/forb and sapling/pole. Riparian vegetation along the mine tailings adjacent to the channel was predominantly a narrow strip of sapling-to-pole sized alders and willows (Figure 18). This narrow strip of alders is almost continuous along the mine tailings throughout the channel reach. The alder and willow roots somewhat enhance bank stability along the unconsolidated mine tailings and provide some channel boundary roughness.

Figure 18. Yankee Fork riparian corridor along mine tailings and valley wall.
Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation
Photograph by P. Drury, September 12, 2011.

Active (connected) floodplain areas are generally vegetated with a mosaic of grassland/forbs, shrub/seedlings, and sapling poles. Alders, willows, grasses, and forbs were dominant in the lower areas where floods frequently disturbed the surface and the soil is wetter from seepage through the mine tailings (Figure 19). Grasses with dispersed lodgepole pines were dominant in the higher areas where floods less frequently disturb the surface and the soils tend to be drier. Most of the mine tailings adjacent to the stream are unvegetated and the vegetation along the channel shades less than 20 percent of the stream (USFS 2010).

Vegetation in the disconnected floodplain areas ranged from no vegetation to small trees. Nearly all the mine tailings that disconnect the floodplain areas are unvegetated. There are seeps through the mine tailings and springs that daylight on the valley floor and maintain patches of riparian vegetation. Other vegetation patches are comprised primarily of grass and lodgepole pines where the groundwater table is lower and the soil remains drier.

Figure 19. Yankee Fork riparian vegetation along connected floodplains.
Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation
Photograph by P. Drury, September 12, 2011.

Floodplain Connectivity

Much of the historic channel paths and floodplains in the moderately confined section between Jordan Creek and Preachers Cove had been thoroughly worked by the gold dredge based on the 1945 and 2010 aerial photographs. The channel had been rerouted around and through the mine tailings by 1966 as evidenced in aerial photographs from that year. Qualitatively, the overall historic channel and floodplain acreage upstream of Preachers Cove appears to be similar to existing conditions. However, much of the historic channel and floodplains were buried by mounds of mine tailings and, for this reason, the historic channel and floodplain areas in this channel reach are not included in the calculations discussed in the following paragraph.

The total acres of existing and historic channel paths that are visible on the 2010 LiDAR topography are about 18.4 acres, of which about 4.9 acres are Yankee Fork historic channel paths that have been disconnected by mine tailings (Figure 20). Total acres of existing and historic floodplains are about 34.5 acres of which 17.4 acres have been disconnected by mine tailings or embankments. There is also a gravel mining plant that could provide about 4.6 acres of artificial floodplain, but is disconnected by a levee. The re-routing of the Yankee Fork between Preachers Cove and the West Fork has resulted in an increase in channel confinement by about 54 percent, transforming the historically unconfined pool-riffle to plane-bed channel into a moderately confined plane-bed channel. The change in the cross-section geometry of the channel and floodplain has resulted in more flow being confined in the channel, and the loss of channel/floodplain interactions has resulted in higher flow velocities and increased shear stresses.

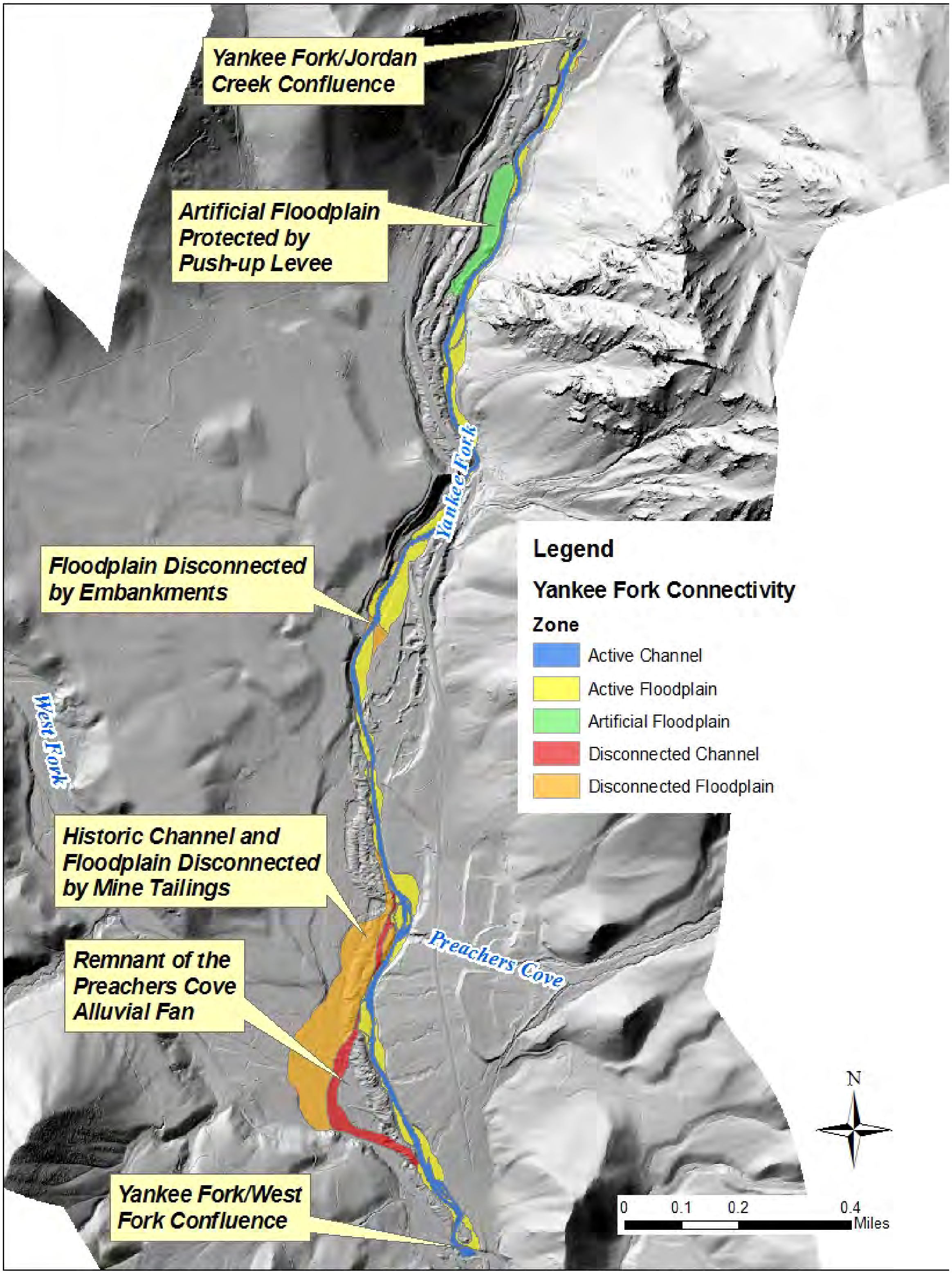


Figure 20. Map of Yankee Fork active and disconnected channels and floodplains, and artificial floodplain area (gravel mine) protected by levee. *The areas labeled "disconnected" are in reference to their connectivity to the Yankee Fork channel and floodplain areas only. Regarding the disconnected channel and floodplain areas near the bottom center of the map, these areas are active and connected to the West Fork, but not the Yankee Fork (see next section on West Fork).*

West Fork

Channel Characteristics

The West Fork is unconfined along its length from RM 0.8 to 0.2 and confined from RM 0.2 to its confluence with the Yankee Fork. In the unconfined channel reach, glacial and alluvial terraces define the valley width; whereas in the confined channel reach mine tailings, bedrock, and glacial terrace define the valley width. Channel metrics and location map are provided in Table 7 and Figure 21, respectively. The overall channel pattern is a straight, free-formed alluvial channel with a sinuosity of about 1.1 and a channel gradient of less than 1 percent which indicates a low rate of lateral channel migration and lateral channel/floodplain dynamics. Depth to bedrock is relatively shallow, on the order of tens of feet. A constriction between bedrock and Preachers Cove alluvial fan near RM 0.2 provides channel grade control for the West Fork.

Table 7. West Fork channel metrics (2010).

Metrics	RM 0.8 to 0.2	RM 0.2 to 0
Constrained Valley Width	475 feet	94 feet
Constrained Valley Length	2,677 feet	1,555 feet
Channel Length	2,813 feet	1,652 feet
Unvegetated Channel Width	47 feet	49 feet
Channel Confinement	Unconfined (10.1)	Confined (1.9)
Channel Gradient	0.8 percent	0.6 percent
Sinuosity	1.1	1.1
Dominant Substrate	Gravel	Gravel with Cobbles
Substrate Gradation (Approx.)	Gravel (60%); Sand (25%); Cobble (15%); Trace Fines	Gravel (50%); Cobble (30%); Sand (15%); Fines (5%)
Bank Stability	Greater Than 95%[1]	Greater Than 95%[1]
Bank Composition	Predominantly Gravel With Cobble, Sand and Boulders	Predominantly Cobble With Gravel, Sand and Boulders

[1]Estimated from R1/R4 Stream survey conducted by Yankee Fork Ranger District, Challis National Forest 2002

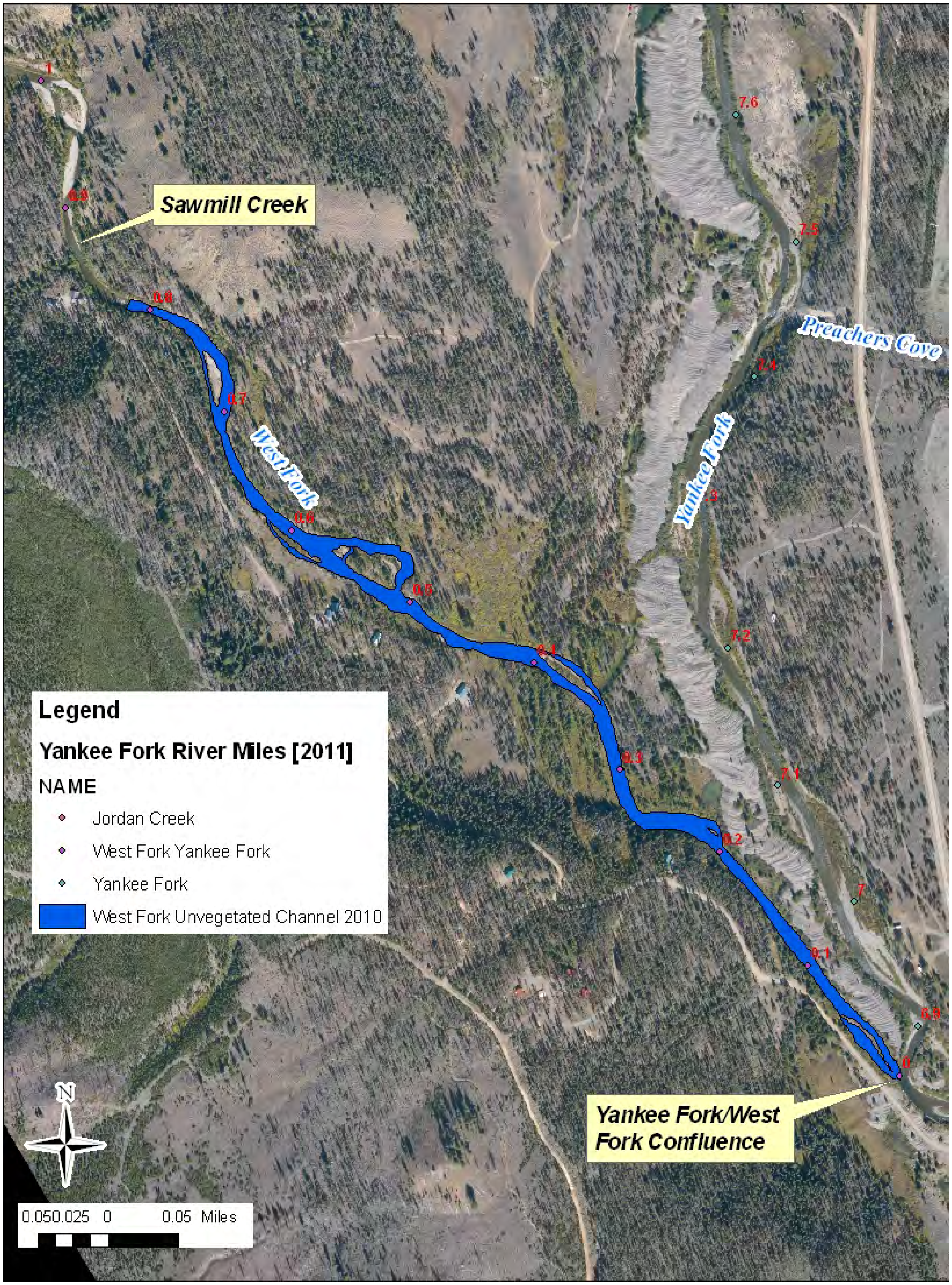


Figure 21. Map of the West Fork (2010) in the assessment area.

In the unconfined channel reach (RM 0.8 to 0.2), the channel has predominantly a plane-bed with some pool-riffle bedforms, and an average unvegetated channel width of 47 feet and average constrained valley width of 475 feet. In the confined channel reach (RM 0.2 to 0), the channel type is plane-bed with an average unvegetated channel width of 49 feet and average constrained valley width of 94 feet (Figure 22).

Prior to dredging in the 1940s, the West Fork/Yankee Fork confluence was in the unconfined channel reach near RM 0.4. After dredging, the Yankee Fork was routed between the Preachers Cove alluvial fan and mine tailings, and the West Fork remained in the former Yankee Fork channel between the valley wall and mine tailings from about West Fork RM 0.2 to the new confluence with the re-routed Yankee Fork.

Figure 22. Looking downstream along the West Fork where it becomes confined near RM 0.2. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

In the unconfined channel reach (RM 0.8 to 0.2), the dominant channel bed substrate size is gravel (2 to 64 mm); whereas, in the confined channel reach (RM 0.2 to 0) it is predominantly cobble (64 to 256 mm). Wolman pebble counts along bars showed the gradation of material being transported during channel forming flows in the unconfined channel reach included about 85 percent gravel and 15 percent cobble; versus the confined channel reach that was about 75 percent gravel and 25 percent cobble. The stream sediment transport capacity is lower in the unconfined channel reach as indicated by the smaller substrate size. This suggests that the channel flows can access floodplains and dissipate energy in the unconfined section; but sediment transport increases in the confined channel reach because the energy is maintained within the channel rather than dissipated across floodplains.

Bank materials in the unconfined channel reach are predominantly gravel with cobble, sand, and fines. In the confined channel reach, about 62 percent of the channel is constrained by mine tailings that are predominantly cobble with gravel, sand, and boulder based on field observations, and the remainder is bedrock and glacial outwash. The streambanks in the unconfined channel reach are well vegetated and the banks are reinforced by the vegetation. The confined channel reach is well vegetated along the alluvial deposits on river right, but only has a narrow strip of alders along the mine tailings on river left. Over 95 percent of the banks in the combined unconfined and confined sections of the West Fork reach are stable, and most of the active bank erosion occurs in the unconfined channel reach through lateral channel migration processes. In the confined channel reach, the banks are stable along the mine tailings because of the “armored” conditions.

Bedforms and Floodplain Characteristics

In the unconfined channel reach (RM 0.8 to 0.2), the channel is predominantly a plane-bed system with bedform diversity associated with local forcing agents that create flow convergence sufficient to mobilize the streambed. This channel reach is dominated by riffles (77 percent TWA) with runs (14 percent TWA) and pools (9 percent TWA). Pools are typically associated with flow convergence on the outside of bends where transient wood tends to accumulate and contribute to forcing lateral scour (Figure 23). A relatively small section of bank protection (about 200 linear feet of large cobbles and boulders) encroaches on the channel causing flow convergence and scouring a mid-channel pool. Instream wood appears to have a significant role by contributing to flow convergence that is sufficient enough to mobilize the bed load and scour pools.

Figure 23. West Fork pool-riffle bedforms influenced by wood and vegetated banks. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

In the confined channel reach (RM 0.2 to 0), the channel is a straight, plane-bed system comprised almost entirely of long (hundreds of feet) alternating runs and riffles. Instream wood does not have a significant role in forcing flow convergence that is sufficient enough to scour pools because of the plane-bed channel form, high sediment transport capacity, and channel confinement.

A majority (more than 75 percent) of the off-channel habitats are located within the unconfined channel reach. The off-channel habitats are comprised of groundwater channels, side channels, and a tailings pond. There are four groundwater channels that provide about 1,130 linear feet of off-channel habitat; one of these groundwater channels is shown in Figure 24. Secondary side channels that activate during channel forming flows are comprised of five split-flow type channels (about 1,100 linear feet) and four floodplain-type channels (about 1,400 linear feet). Tertiary side channels, or overflow channels, which are activated during relatively large (+ 5-year recurrence interval) flood events are comprised of eight channels that total about 2,680 linear feet. There is one tailings pond connected to the active channel that is influenced by groundwater and provides over 0.1 acres of pond habitat. Wood generally accumulates at the head, or apex, of vegetated bars where it interacts with channel forming flows to create flow divergence which contributes to the development and maintenance of floodplain side channels. Wood is temporarily stored on the outside channel bends, high on unvegetated bars and at the downstream end of side channels.

Figure 24. Groundwater channel charged by seepage through the mine tailings. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Vegetation Condition

The vegetation in the connected floodplain areas ranged from grassland/forb to large trees. Roughly 95 percent of vegetation was shrub/seedling to large trees. Riparian vegetation along the mine tailings adjacent to the channel was predominantly a narrow strip of sapling-to-pole sized alders. This narrow strip of alders is almost continuous along the mine tailings throughout the confined channel reach. The alder roots do provide some enhanced bank stability along the unconsolidated mine tailings, and improved channel boundary roughness.

Active floodplain areas generally have a mosaic of shrub/seedling and small-to-large trees. Alders, willows, grasses, and forbs were dominant in the lower areas where floods frequently disturbed the surface and the soil was wetter from seepage through the mine tailings (Figure 25). Shrubs and seedlings with dispersed lodgepole pines were dominant in the higher areas where floods less frequently disturb the surface and the soils tend to be drier. Much of the mine tailings adjacent to the stream are unvegetated, except for the narrow strip of alders.

Figure 25. West Fork riparian vegetation along connected floodplains. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Floodplain Connectivity

The West Fork is connected to its floodplain with 5.3 acres of active channel and 8.5 acres of active floodplain. There are about 16.7 acres of lowland areas (Figure 26) with channel swales that are available floodplain and delineate the extent of the potential channel migration zone. Nearly all active and available floodplain areas are located upstream of RM 0.2 in the unconfined channel reach above the bedrock/alluvial fan constriction.

There are narrow strips of floodplain in the confined channel reach between RM 0.2 to the mouth. Mine tailings restrict lateral channel migration at the confluence with the Yankee Fork, and the channel confluence configuration with the Yankee Fork is now static. The pre-dredging dynamic hydraulic conditions that created diverse habitat patches between the two channels when they converged upstream of the bedrock/alluvial fan constriction no longer exist. However, that section of what is now the West Fork, does still exhibit unconfined channel and floodplain interaction as described above, though possibly to a lesser degree due to the reduction in total sediment and flow in that location.

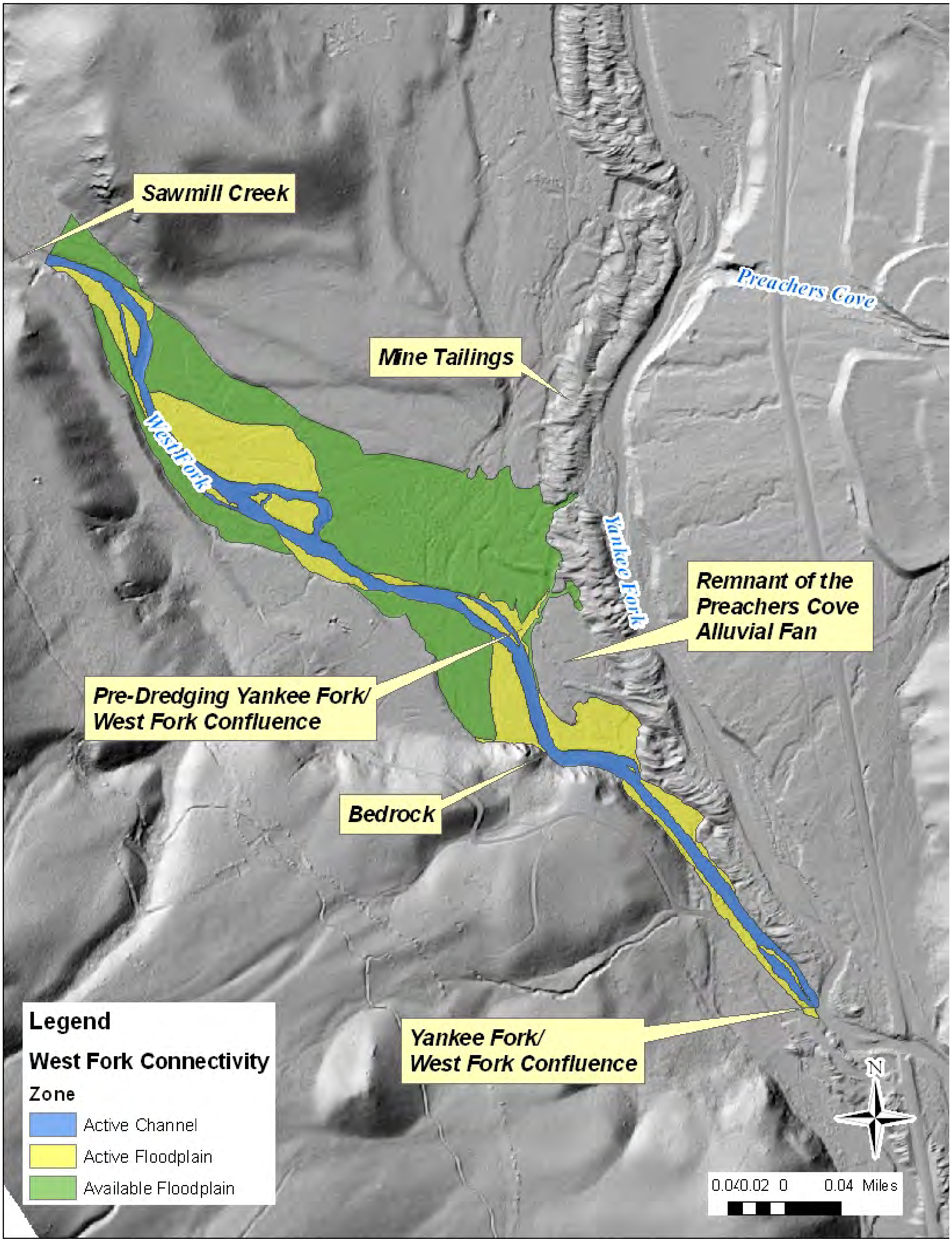


Figure 26. West Fork connectivity between the active channel and floodplain, and extent of available floodplain (lowland areas).

DEGREE OF IMPAIRMENT

Yankee Fork

The overall physical condition of the Yankee Fork has changed when comparing likely historical characteristics (prior to Euro-American settlement) to existing characteristics (Table 8). Channel confinement and planform, and substrate sizes have changed in localized areas. The most significant changes to channel character have resulted from channel relocation and confinement primarily from Preachers Cove downstream to the existing confluence with the West Fork, and the loss of some areas of available or accessible floodplains.

Primary limiting and causal factors for salmonids and their causes in the Reach Assessment area are (1) habitat fragmentation and connectivity due to mine tailings artificially constraining the stream and disconnecting historic floodplains and (2) habitat quantity and quality due to mining activities that have confined the channel, removed the vegetation, simplified the channel bedforms in localized areas, and disconnected off-channel habitat.

Left alone, the Yankee Fork will continue to function in predominantly the same manner it has since the channel was relocated after dredging operations ceased in the early 1950s. The straight, plane-bed channel type has a low rate of lateral channel migration and low channel/floodplain dynamics as compared to an unconfined, meandering channel with a pool-riffle bedform. In the case of the Yankee Fork, the confinement and armoring have been increased due to anthropogenic alterations. Without significant intervention, the physical and ecological processes will continue as they have for the last 60+ years and the system will remain static. The habitat-forming processes that create and maintain diverse habitat patches for anadromous fish, and other aquatic and terrestrial species, can be improved along this plane-bed channel with the appropriate interventions (discussed in the Potential Habitat Actions section of this report).

Table 8. Relative comparison along the Yankee Fork mainstem of historical and existing conditions and impaired processes. (Note: the parameters for the channel segment between Preachers Cove and the 2010 West Fork/Yankee Fork confluence are based on processes associated only with the Yankee Fork and that processes associated only with the West Fork are discussed in the West Fork section of this report).

Metrics	Location	Historical Condition	Existing Condition	Processes Impaired Resulting in the Change	Degree of Impairment Based on Limiting Factors (High, Medium, Low, None)
Constrained valley width	Jordan Creek to Preachers Cove	Moderately confined channel (3.2)[1]	Moderately confined channel (2.3)[1]	Change in the channel/floodplain cross-sectional geometry has increased sediment transport capacity due to increased flow velocities and shear stresses within the channel.	Low
	Preachers Cove to West Fork confluence[2]	Unconfined channel (5.4)[1]	Moderately confined channel (2.5)[1]		High
Channel pattern	Jordan Creek to Preachers Cove	Straight, free-formed alluvial channel	Straight, free-formed alluvial channel	Increased channel confinement resulted in very slight changes to the channel planform.	Low
	Preachers Cove to West Fork confluence[2]	Free-formed alluvial channel, predominantly straight with some meanders	Free-formed alluvial channel, straight	Increased channel confinement resulted in a straight, higher energy channel.	Medium
Channel bedform	Jordan Creek to Preachers Cove	Plane-bed	Plane-bed	Slight increase in sediment transport capacity resulted in coarsening of the bed and simplification of the bedform.	Low
	Preachers Cove to West Fork confluence[2]	Plane-bed to pool-riffle	Plane-bed	Moderate increase in sediment transport capacity resulted in channel bedform change and armored the bed.	Medium
Floodplain connectivity	Jordan Creek to Preachers Cove	Channel connected to isolated strips of floodplain	Channel partially relocated and connected to a narrower floodplain in some areas.	Estimated to be about 25 percent reduction in connected floodplain area resulting in a moderate increase in flow velocities.	Low
	Preachers Cove to West Fork confluence[2]	Channel connected to a broad floodplain	Channel relocated and connected to a narrow floodplain.	Estimated to be about 70 percent reduction in connected floodplain area resulting in a significant increase in flow velocities.	High

Metrics	Location	Historical Condition	Existing Condition	Processes Impaired Resulting in the Change	Degree of Impairment Based on Limiting Factors (High, Medium, Low, None)
Vegetation condition	Jordan Creek to Preachers Cove Preachers Cove to West Fork confluence[2]	Patches of mixed shrub/seedling and small-to-large trees	Patches of mixed grassland/forb to small trees, reduction in riparian buffer zone width due to mine tailings.	Reduction in vegetated cover, in conjunction with a reduction in available floodplain patches, has decreased effective channel boundary and floodplain roughness resulting in increased flow velocities and sediment transport capacity.	Medium
Off-channel habitat	Jordan Creek to Preachers Cove	About 4,100 linear feet of secondary side channels	About 1,750 linear feet of secondary side channels	Slightly increased channel confinement and decreased active floodplain patches.	Low
	Preachers Cove to West Fork confluence[2]	About 640 linear feet of secondary side channels visible in 1945 aerial photographs which is after channelization; unvegetated channel paths suggest multiple side channels were present prior to channelization.	About 2,050 linear feet of secondary side channels	Channel realigned and constructed through Preachers Cove alluvial fan; broad floodplain that was historically connected to the Yankee Fork is now disconnected by mine tailings thereby significantly reducing the potential for the stream to create and maintain diverse off-channel habitat patches.	High
Pools	Jordan Creek to Preachers Cove	Variable for plane-bed channels depending on the availability of forcing agents[3].	Variable for plane-bed channels depending on the availability of forcing agents[3].	Pool frequency is variable in plane-bed channels and are contigent on the number of constrictions and structures that force flow convergence sufficient enough to mobilize the armor layer	Low

Metrics	Location	Historical Condition	Existing Condition	Processes Impaired Resulting in the Change	Degree of Impairment Based on Limiting Factors (High, Medium, Low, None)
	Preachers Cove to West Fork confluence[2]	For a plane-bed to pool-riffle channel, pool frequency would generally be in the lower range of variability for a pool-riffle channel (i.e., a pool about every five unvegetated channel widths[3] or about nine pools per mile).	Variable for plane-bed channels depending on the availability of forcing agents[3].	Physical manipulation of the channel has increased channel confinement which has reduced the meander belt width and the channel's potential to develop meanders that force flow convergence and helical flow variability that scours the outside bend and deposits sediment along the inside bend.	Medium
Dominant roughness elements	Jordan Creek to Preachers Cove	Bedrock, boulders and cobbles, and to a minor extent vegetated banks for plane-bed channels.	Bedrock, boulders and cobbles, and to a minor extent vegetated banks for plane-bed channels.	Similar channel roughness processes are occurring, except the channel is slightly more confined with more sediment transport capacity.	Low
	Preachers Cove to West Fork confluence[2]	Bedforms, bedrock, boulders and cobbles, wood, sinuousity and vegetated banks for plane-bed to pool-riffle channels.	Bedrock, boulders and cobbles, and vegetated banks for plane-bed channels.	Channel manipulations have changed the plane-bed/pool-riffle system to a plane-bed system, and bedforms, channel sinuousity and wood no longer play a significant role in creating roughness or dissipating stream power.	Medium

[1]Ratio between the constrained valley bottom width and the unvegetated channel width, defined as confined for less than 2 channel widths, moderately confined for 2 to 4 channel widths, and unconfined for greater than 4 channel widths.

[2]The location of the 1945 Yankee Fork/West Fork confluence was significantly changed after dredging operations were completed.

[3]Montgomery and Buffington (1997)

West Fork

The overall physical condition of the West Fork has not significantly changed when comparing likely historical characteristics (prior to Euro-American settlement) to existing characteristics (Table 9). Channel confinement and planform, and substrate sizes have changed in localized areas. The most significant changes are (1) the relocation of the Yankee Fork channel through the Preachers Cove alluvial fan, which changed the location of the West Fork and Yankee Fork confluence from an unconfined channel reach with dynamic channel/floodplain interactions to a confined reach with static channel/floodplain interactions, (2) extensive logging in the watershed, particularly Sawmill Creek drainage and along the West Fork valley bottom downstream of West Fork/Sawmill Creek confluence, and (3) loss of sediment and flow inputs from the Yankee Fork along what is now the lower three-tenths of a mile of the West Fork.

The primary limiting factor for salmonids and its cause in the West Fork section of the assessment area is habitat quantity and quality due to localized sediment transport alterations, and removal of riparian and upland vegetation. Left alone, the West Fork between Sawmill Creek and the pre-dredging Yankee Fork/West Fork confluence will continue to improve as the vegetation continues to progress through successional stages. The area around the pre-dredging Yankee Fork/West Fork confluence will continue to function as a plane-bed system with a low rate of lateral channel migration and low channel/floodplain interactions. And finally, the confined lower three-tenths of mile channel reach will continue to function as a straight, plane-bed channel as it has since the Yankee Fork was rerouted and the West Fork was left to occupy the historic Yankee Fork channel.

Habitat-forming processes that create and maintain diverse habitat patches for anadromous fish, and other aquatic and terrestrial species, can be improved from about RM 0.4, the pre-dredging Yankee Fork/West Fork confluence to the existing Yankee Fork/West Fork confluence. Little can be done to improve habitat-forming processes along the West Fork between Sawmill Creek and the pre-dredging Yankee Fork/West Fork confluence as this area has not been significantly altered (physically), and continues to recover from past disturbances (i.e., logging and wildland fires). Table 9 summarizes the historical and existing conditions, and the degree to which processes are impaired. Discussions of potential habitat actions are included in the Potential Habitat Actions section of this report.

Table 9. Relative comparison along the West Fork mainstem of historical and existing conditions and impaired processes.

Metrics	Location	Historical Condition	Existing Condition	Processes Impaired Resulting in the Change	Degree of Impairment Based on Limiting Factors (High, Medium, Low, None)
Constrained valley width	Sawmill Creek to 1945 confluence[1]	Unconfined channel (7.9)[2]	Unconfined channel (10.1)[2]	None	None
	1945 confluence to existing Yankee Fork Confluence[1]	Confined channel (1.4)[2]	Confined channel (1.9)[2]	Flows confined within the former Yankee Fork channel resulting in “underfit” channel characterisics (i.e., sediment and flow about 40 percent of what existed in this reach historically).	Low
Channel pattern	Sawmill Creek to 1945 confluence[1]	Straight free-formed alluvial channel	Straight free-formed alluvial channel.	None	None
	1945 Mouth to existing Yankee Fork Confluence[1]	Straight, free-formed alluvial channel	Straight, free-formed alluvial channel.	None	None
Channel bedform	Sawmill Creek to 1945 confluence[1]	Plane-bed to pool-riffle	Plane-bed to pool-riffle	None	None
	1945 confluence to existing Yankee Fork Confluence[1]	Plane-bed	Plane-bed	None	None
Floodplain connectivity	Sawmill Creek to 1945 confluence[1]	Channel connected to a wide floodplain.	Channel connected to a wide floodplain.	Loss of dynamic interaction with Yankee Fork in the broad floodplain area that provided a mosaic of habitat patches.	Low

Metrics	Location	Historical Condition	Existing Condition	Processes Impaired Resulting in the Change	Degree of Impairment Based on Limiting Factors (High, Medium, Low, None)
	1945 confluence to existing Yankee Fork Confluence[1]	Channel confined by bedrock, glacial terraces and alluvial fan.	Channel confined along poorly vegetated mine tailings and bedrock/glacial terrace materials.	None	None
Vegetation condition	Sawmill Creek to 1945 confluence[1]	Shrubs and seedlings with dispersed patches of large trees; 100 feet buffer zone continuous.	Shrubs and seedlings with dispersed patches of large trees; 100 feet buffer zone continuous.	Vegetation condition and assemblage is recovering after being logged during the mining boom around the turn of the century.	Low
	1945 confluence to existing Yankee Fork Confluence[1]	Grasslands and forbs with dispersed patches of small trees.	Shrubs and seedlings with dispersed patches of medium trees.	Vegetation condition is improving in the floodplain patches, but areas along the mine tailings are immature, most likely due to flood disturbances.	Low
Off-channel habitat	Sawmill Creek to 1945 confluence[1]	Secondary side channels provided about 1,860 linear feet of habitat and backwater effects from Yankee Fork provided diverse habitat patches (1945).	About 1,320 linear feet of secondary side channels and no backwater effects (2010).	Reduction in backwater effects	Low
	1945 confluence to existing Yankee Fork Confluence[1]	Few lateral gravel bars that may have hosted secondary side channels visible in the 1945 aerial photographs.	About 1,170 linear feet of secondary side channels visible on the 2010 aerial photographs.	None	None
Pools	Sawmill Creek to 1945 confluence[1]	For a plane-bed to pool-riffle channel, pool frequency would generally be in the lower range of variability for a pool-riffle channel (i.e., about nine pools per mile).	Eight pools per mile	None	None

Metrics	Location	Historical Condition	Existing Condition	Processes Impaired Resulting in the Change	Degree of Impairment Based on Limiting Factors (High, Medium, Low, None)
	1945 confluence to existing Yankee Fork Confluence[1]	Due to the lack of forcing agents in this plane-bed channel, there were most likely no pools.	Due to the lack of forcing agents in this plane-bed channel, there were no pools.	None	None
Dominant roughness elements	Sawmill Creek to 1945 confluence[1]	Bedforms, coarse substrate and wood play a significant role in creating roughness or dissipating stream power.	Similar to historic conditions	None	None
	1945 confluence to existing Yankee Fork Confluence[1]	Bedrock, boulders and cobbles, and vegetated banks.	Similar to historic conditions	None	None

[1]The location of the 1945 Yankee Fork/West Fork confluence was significantly changed after dredging operations were completed.

[2]Ratio between the constrained valley bottom width and the unvegetated channel width, defined as confined for less than 2 channel widths, moderately confined for 2 to 4 channel widths, and unconfined for greater than 4 channel widths.

TARGET CONDITIONS

The approach used in this Reach Assessment describes reach-scale habitat-forming processes and identifies locations where these processes are impaired due to anthropogenic disturbance, and the specific rehabilitation actions that should be considered to re-create and maintain such processes. Target conditions represent the most appropriate physical and ecological characteristics for a given channel reach based on the habitat-forming processes that should be occurring. The difference between target conditions and historical conditions is that target conditions take into consideration existing conditions, constraints, and future trends. Critical to the development of target conditions is an understanding of the physical and ecological processes that create and maintain habitat. By better understanding this relationship, targeted conditions can be identified that will provide the appropriate habitat-forming processes for that particular riverine system.

Target conditions were determined by comparing historical and existing channel and floodplain metrics, where possible. Little consideration was given to socioeconomic constraints when determining the appropriate target conditions to rehabilitate habitat-forming processes. However, these socioeconomic constraints are considered in the potential habitat actions and will need to be mitigated accordingly at the project level.

Yankee Fork

The target conditions for the Yankee Fork are summarized and compared with existing conditions and the potential degree of improvement to habitat-forming processes in Table 10.

Table 10. Comparison of existing conditions, target conditions, and degree of improvement to habitat-forming processes along the Yankee Fork mainstem.

Metrics	Location	Existing Condition	Target Condition	Degree of Improvement to Habitat-forming Processes (High, Medium, Low, None)
Constrained valley width	RM 9.1 to 7.6	Moderately confined channel (2.3) with an average constrained valley width about 120 feet.	Moderately confined channel (3.0) with an average constrained valley width about 150 feet.	Low
	RM 7.6 to 7.3	Moderately confined channel (2.5) with an average constrained valley width about 120 feet.	Unconfined channel (9.5) with an average constrained valley width about 450 feet.	High
Channel pattern	RM 9.1 to 7.6	Straight, free-formed alluvial channel	Same	None
	RM 7.6 to 7.3	Straight, free-formed alluvial channel	Same, but with more sinuosity	Medium
Channel bedform	RM 9.1 to 7.6	Plane-bed	Same	None
	RM 7.6 to 7.3	Plane-bed	Plane-bed channel with pool-riffle sections	Medium
Floodplain connectivity	RM 9.1 to 7.3	About 17.7 acres of active floodplain with an average patch size of about 0.3 acres.	About 25 to 30 acres of active floodplain with an average patch size of about 1.5 to 2 acres.	Medium
Vegetation condition	RM 9.1 to 7.3	Mixed vegetation (e.g., grasslands and forbs with patches of small trees); fragmented riparian buffer zone due to unvegetated mine tailings.	Mixed vegetation (e.g., grasslands, shrubs and seedlings with patches of small to large trees); generally a continuous riparian buffer zone 30-feet wide or greater and vegetated floodplain patches where appropriate.	Medium
Off-channel habitat	RM 9.1 to 7.6	1,750 linear feet of secondary side channels	2,000 to 2,500 linear feet of secondary side channels	Low
	RM 7.6 to 7.3	Not applicable due to channel realignment	2,500 to 3,000 linear feet of secondary side channels	High

Metrics	Location	Existing Condition	Target Condition	Degree of Improvement to Habitat-forming Processes (High, Medium, Low, None)
Pools	RM 9.1 to 7.6	None to variable for plane-bed channels	Same	None
	RM 7.6 to 7.3	None to variable for plane-bed channels	Infrequent pools associated with channel constrictions and increased floodplain interactions.	Low
Dominant roughness elements	RM 9.1 to 7.6	Bedrock, boulders and cobbles	Same	None
	RM 7.6 to 7.3	Bedrock, boulders and cobbles, and vegetated banks	Vegetated banks	Low

The expected degree of improvement to habitat-forming processes from the existing conditions to the target conditions can be used to interpret the potential improvements to habitats required during varying salmonid life stages. Anticipated changes in the quantity and quality of habitat elements, such as channel confinement, floodplain connectivity, riparian vegetation, and flow velocities are qualitatively considered based on the expected channel response. For example, Richards and Cernera (1989) showed that hatchery-reared and naturally spawned juvenile Chinook salmon generally disperse and rear within a mile, primarily in the downstream direction, of their release or emergence site. Currently, the channel is confined to moderately confined along the dredged reaches with small floodplain patches. Flood flows are primarily confined to within the channel, thereby increasing flow velocities and sediment transport capacity with very limited channel/floodplain interactions. Such channel reaches can be rehabilitated by reducing channel confinement, and improving floodplain connectivity and roughness with the expected channel response being (1) an increase in instream flow variability, (2) an increase in the availability of off-channel habitats, and (3) potentially, an increase in spawning habitat. The actions described in this example would provide the necessary habitats for juvenile holding, rearing and migration for both released and emerging salmonids, and potentially increase the amount of available adult spawning habitat.

In general, when the diversity and quality of habitat patches increases, there is an overall improvement that affects several of the salmonid life stages. Table 11 and Table 12 summarize the expected overall improvements to salmonid habitats for the moderately confined (RM 9.1 to 7.6) and historically unconfined (RM 7.6 to 7.1) channel reaches.

Table 11. Yankee Fork from RM 9.1 to 7.6 list of stream metrics and their potential to improve varying salmonid habitats based on the target conditions (*X – large improvement; ♦ – small improvement).

Habitat Improvements	Channel Confinement	Channel Pattern	Channel Bedforms	Floodplain Connectivity	Vegetation Condition	Off-channel Habitat	Pool Frequency	Roughness Elements
Migration Habitat	X			X	♦			
Spawning Habitat			♦	♦				
Egg Incubation to Emergence Habitat	♦			♦				
Juvenile Rearing Habitat	♦		♦	♦	♦	♦		X
Adult Holding Habitat	♦						♦	

Table 12. Yankee Fork from RM 7.6 to 7.3 list of stream metrics and their potential to improve varying salmonid habitats based on the target conditions (X – large improvement; ♦ – small improvement).

Habitat Improvements	Channel Confinement	Channel Pattern	Channel Bedforms	Floodplain Connectivity	Vegetation Condition	Off-channel Habitat	Pool Frequency	Roughness Elements
Migration Habitat	♦	♦	♦				♦	
Spawning Habitat	X		♦					♦
Egg Incubation to Emergence Habitat	X		X	♦				
Juvenile Rearing Habitat	♦		X	♦	♦	♦	♦	X
Adult Holding Habitat	♦		X				♦	♦

West Fork

Table 13 summarizes and compares existing conditions and target conditions and the potential degree of improvement to habitat-forming processes.

Table 13. Comparison of existing conditions, target conditions, and degree of improvement to habitat-forming processes along the West Fork mainstem.

Metrics	Location	Existing Condition	Target Condition	Degree of Improvement to Habitat-forming Processes (High, Medium, Low, None)
Constrained valley width	RM 0.8 to 0.2	Unconfined channel (10.1) with an average constrained valley width of about 475 feet.	Same	None
	RM 0.2 to 0	Confined channel (1.9) with an average constrained valley width of about 95 feet.	Moderately confined channel (3.0) with an average constrained valley width of about 150 feet.	Low
Channel pattern	RM 0.8 to 0.2	Straight, free-formed alluvial channel	Same	None
	RM 0.2 to 0	Straight, free-formed alluvial channel	Same	None
Channel bedform	RM 0.8 to 0.2	Plane-bed with pool-riffle sections	Same	None
	RM 0.2 to 0	Plane-bed	Same	None
Floodplain connectivity	RM 0.8 to 0.2	About 6.1 acres of active floodplain with an average patch size of about 0.5 acres; available floodplain area in addition to active floodplain area is about 16.8 acres.	Same	None
	RM 0.2 to 0	About 2.4 acres of active floodplain area with an average patch size of about 0.5 acres.	About 4.5 acres of active floodplain area with an average patch size of about 1.5 to 2 acres.	Low
Vegetation condition	RM 0.8 to 0.2	Mixed vegetation (e.g., shrubs and seedlings with patches of small to large trees; broad, continuous riparian buffer zone.	Same	None
	RM 0.2 to 0	Mixed vegetation (e.g., grasslands and forbs with patches of small to large trees); narrow riparian buffer zone sections (about 15-feet wide) due to encroachment of mine tailings.	Mixed vegetation (e.g., grasslands, shrubs and seedlings with patches of small to large trees); generally 30-feet wide or greater, continuous riparian buffer zone.	Low
Off-channel habitat	RM 0.8 to 0.2	About 1,320 linear feet of secondary side channels.	1,200 to 1,500 linear feet of secondary side channels.	None
	RM 0.2 to 0	About 1,170 linear feet of secondary side channels; predominantly split-flow channels.	1,000 to 1,500 linear feet of secondary side channels.	None

Metrics	Location	Existing Condition	Target Condition	Degree of Improvement to Habitat-forming Processes (High, Medium, Low, None)
Pools	RM 0.8 to 0.2	About 8 pools per mile	Same	None
	RM 0.2 to 0	Variable for plane-bed channels which are dependant on the availability of forcing agents to scour pools.	Same	None
Dominant roughness elements	RM 0.8 to 0.2	Bedforms, bedrock, boulders and cobbles, wood, sinuousity and vegetated banks.	Same	None
	RM 0.2 to 0	Bedrock, boulders and cobbles, and vegetated banks.	Same	None

Table 14 and Table 15 summarize the expected overall improvements to salmonid habitats for the unconfined (RM 0.8 to 0.2) and confined (RM 0.2 to 0) channel reaches.

Table 14. West Fork from RM 0.8 to 0.2 list of stream metrics and their potential to improve varying salmonid habitats based on the target conditions (X – large improvement; ♦ – small improvement).

Habitat Improvements	Channel Confinement	Channel Pattern	Channel Bedforms	Floodplain Connectivity	Vegetation Condition	Off-channel Habitat	Pool Frequency	Roughness Elements
Migration Habitat								
Spawning Habitat								
Egg Incubation to Emergence Habitat								
Juvenile Rearing Habitat					♦			
Adult Holding Habitat					♦			

Table 15. West Fork from RM 0.2 to 0 list of stream metrics and their potential to improve varying salmonid habitats based on the target conditions (X – large improvement; ♦ – small improvement).

Habitat Improvements	Channel Confinement	Channel Pattern	Channel Bedforms	Floodplain Connectivity	Vegetation Condition	Off-channel Habitat	Pool Frequency	Roughness Elements
Migration Habitat	♦			♦	♦			
Spawning Habitat	♦							
Egg Incubation to Emergence Habitat								
Juvenile Rearing Habitat	♦			♦	♦			
Adult Holding Habitat	♦			♦				

POTENTIAL HABITAT ACTIONS

Yankee Fork

For channel reach RM 9.1 to 7.6, the target condition is to improve habitat-forming processes by (1) reducing channel confinement by increasing the average constrained valley bottom width to about 150 feet, (2) increasing average floodplain patch size to about 1.5 to 2 acres, (3) improving floodplain connectivity, and (4) improving the riparian vegetation buffer zone.

The objective is to dissipate stream energy during flood flows across a wider, more continuous floodplain. Expected results include the following:

- Decrease in flow velocities and shear stresses by changing the channel/floodplain cross sectional geometry to allow flows to access larger, more continuous floodplain patches.

- Increase in channel boundary and floodplain roughness to dissipate stream power during flood flows.

Potential habitat actions to meet the objectives include (1) removing and/or re-contouring sections of dredge tailings, embankments, and push-up levees to an elevation accessible to the stream during 2- to 5-year flood events, (2) connecting existing small (less than 0.5 acres), fragmented active floodplain patches to create larger (1.5 to 2 acres), more continuous active floodplains, and (3) planting appropriate vegetation in constructed floodplain and other cleared areas. Potential locations to implement these types of actions are shown in Figure 27.

Constraints to implementation of potential habitat actions are primarily (1) the need to maintain relatively “pristine” mine tailings as historical property and attraction, (2) active mining claims within the channel reach, (3) landowner and stakeholder cooperation and willingness, and (4) availability of funding.

The expected channel response will primarily benefit juvenile salmonid rearing habitat through (1) increased availability of high-flow refugia, (2) instream variability of flow velocities, and (3) decreased stream power and sediment transport capacity through increased floodplain connectivity and roughness during flood events.

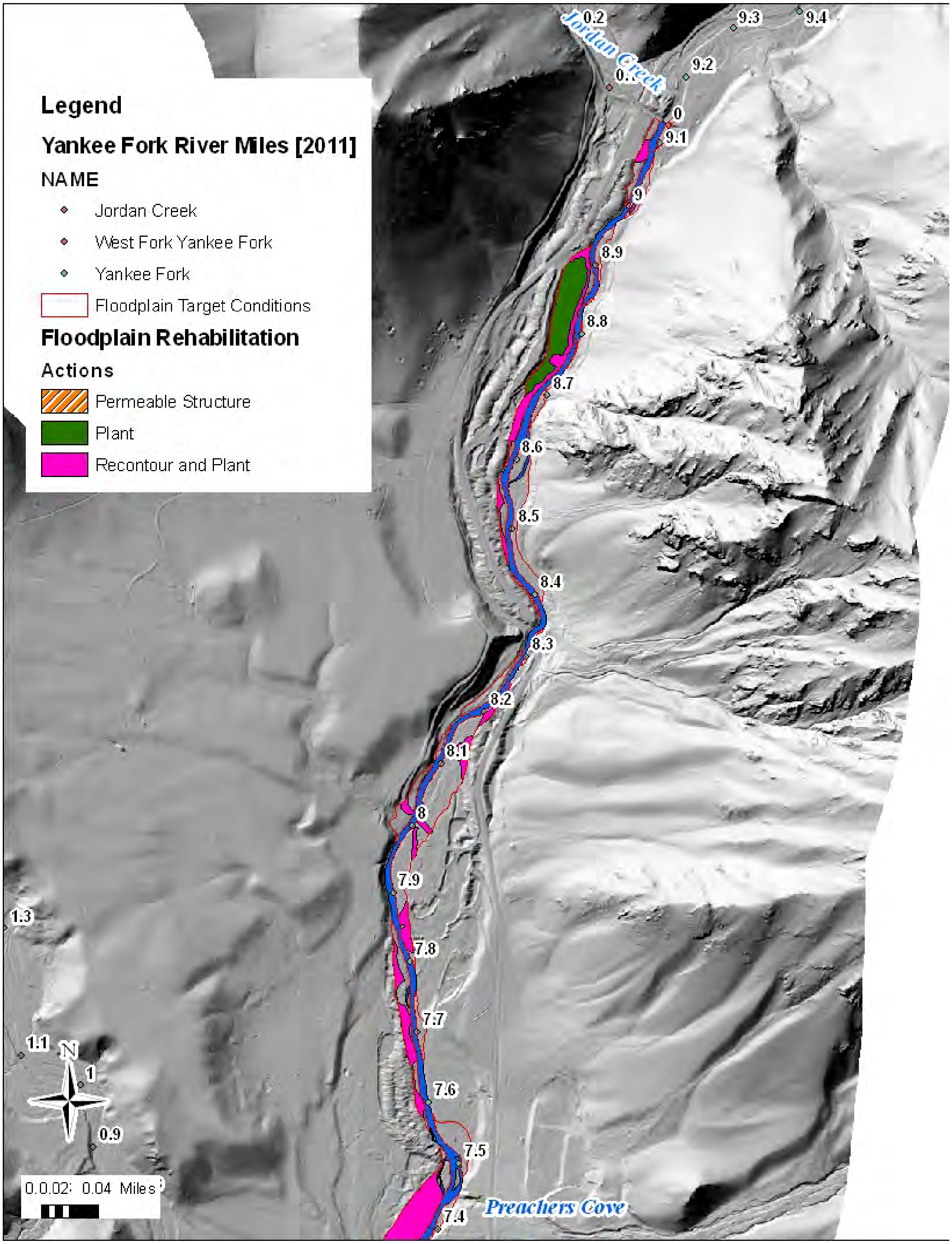


Figure 27. Potential areas to implement appropriate habitat actions. *The permeable structure (i.e., engineered wood complex) is not located in this channel segment and therefore does not show up on the map.*

For channel reach RM 7.6 to 6.8, the target condition is to improve habitat-forming processes by (1) re-establishing the dynamic hydraulic conditions that historically occurred at the confluence between the West Fork and the Yankee Fork, (2) allowing the channel to adjust and develop more diversified bedforms with an increase in the rate of lateral channel migration and channel/floodplain interactions, (3) increasing average patch size of available floodplain and improving floodplain connectivity, and (4) improving riparian vegetation condition and vitality.

The objectives are to dissipate stream energy across more continuous floodplain, allow unconstrained lateral channel migration, and allow the stream to dynamically interact with the West Fork. Expected results include the following:

- Decrease in flow velocities and shear stresses by changing the channel/floodplain cross-sectional geometry to allow flows to access a broad, continuous floodplain.
- Increase in channel roughness through increased development of bedform, instream wood, more dynamic channel planform, and vegetated banks to dissipate stream power during channel forming and flood flows.
- Unconstrained, lateral channel migration and dynamic interaction around the West Fork confluence area.

Potential habitat actions to meet the objectives include (1) removing and re-contouring some areas of dredge tailings to reconnect the stream to its historic channels and floodplain, (2) removing dredge tailings to accommodate the combined flows from the Yankee Fork and West Fork, and (3) developing alternatives for the channelized section across the Preachers Cove alluvial fan to provide “side channel” habitat and maintain a connection to Preachers Cove, if feasible. Figure 28 shows the potential locations and the maximum extent where these actions should be considered. In some locations, the extent of dredge tailings removal and re-contouring should be further evaluated during the project development phase based on cost versus benefits, and how to meet the intent of the objectives. For example, between RM 7.5 and 7.2, the intent is to breach the dredge tailings in order to create an unconfined channel that will dynamically interact with the West Fork and the floodplain. One of the alternatives to consider that meets the objectives would be to strategically construct an unconfined channel about 250 feet wide (average unvegetated channel width was about 50 feet wide) through the mine tailings that would cover about 2 acres, and place some type of control structure along the abandoned channel path to maintain side channel habitat.

Constraints to implementation of potential habitat actions are primarily (1) the need to maintain relatively “pristine” mine tailings as a historical property and attraction, (2) active mining claims within the channel reach, (3) landowner and stakeholder cooperation and willingness, and (4) availability of funding.

The expected channel response will benefit (1) juvenile salmonids through increased availability of rearing habitat and high-water refugia, (2) adult spawning through increased sorting and retention of gravel patches, and (3) egg incubation and emergence through increased hyporheic flow, due to the interactions between the West Fork and wetland areas. To a lesser degree, adult holding and migration will improve through the creation and maintenance of diverse bedforms with cover.

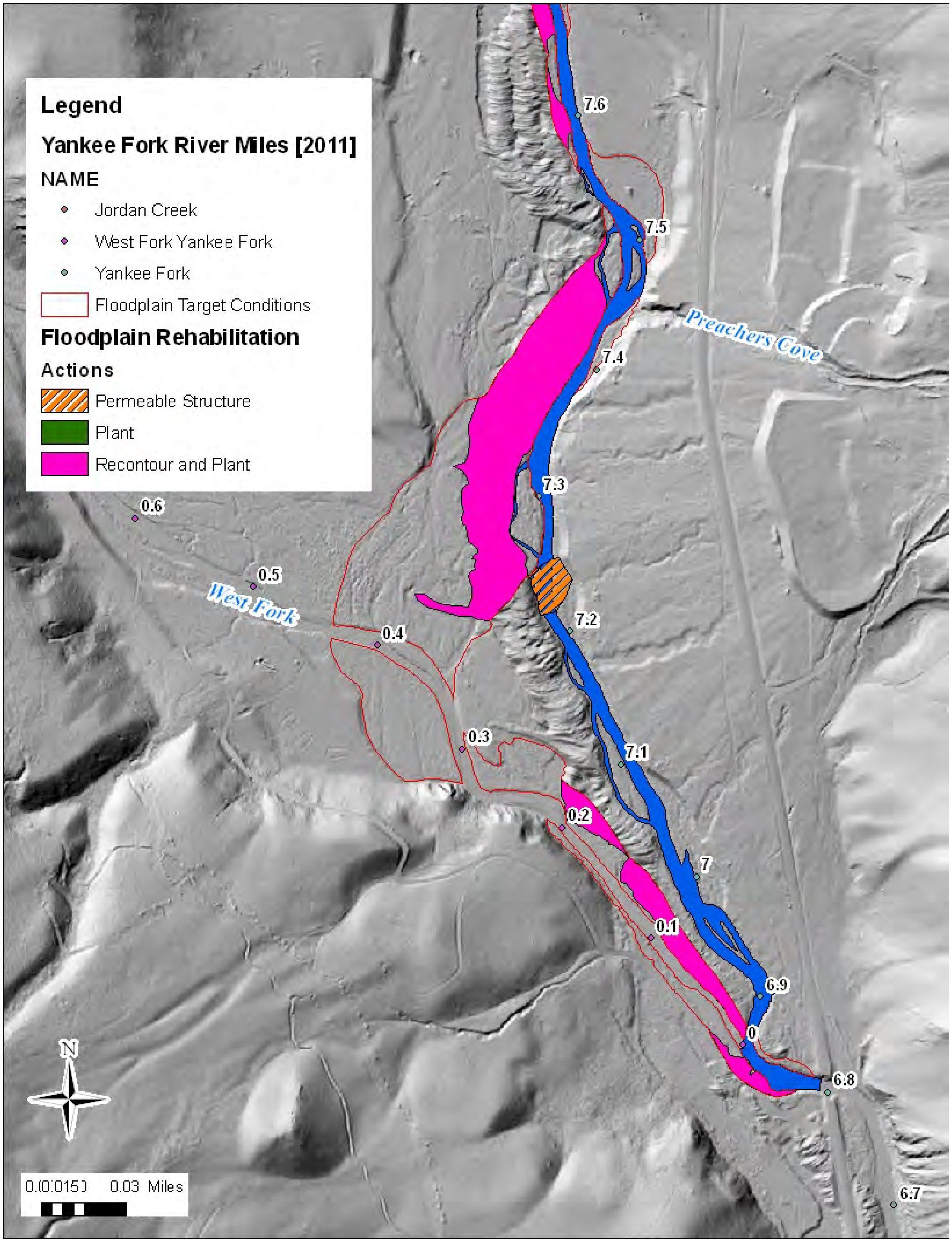


Figure 28. Potential areas to implement appropriate habitat actions.

West Fork

For the unconfined channel reach between RM 0.8 and 0.2, the target condition is to monitor and maintain the habitat-forming processes. The vegetation along the valley bottom and channel margins has been recovering from the extensive logging that took place in the late 1800s and early 1900s. Riparian and upland vegetation could be managed to improve vegetation growth and vitality, and reduce the risk of insect infestations.

In the confined channel reach between RM 0.2 and the Yankee Fork/West Fork confluence, the target conditions are to improve habitat forming processes by (1) reducing channel confinement by increasing the average constrained valley bottom width to about 150 feet, resulting in a moderately confined channel, (2) increasing average floodplain patch size to about 1.5 to 2 acres, and (3) improving the riparian vegetation buffer zone width (30 feet or greater width, if feasible). The objectives are to dissipate stream energy during channel forming and flood flows across a wider, more continuous floodplain. Average constrained valley bottom width needs to be sufficient (greater than two times the 1945 unvegetated channel width) to be able to pass the combined West Fork and Yankee Fork flows along a moderately confined channel, so as not to preclude the rehabilitation of the Yankee Fork. Expected results include the following:

- Decrease in flow velocities and shear stresses by changing the channel/floodplain cross-sectional geometry to allow flows to access larger, more continuous floodplain.

- Increase channel boundary and floodplain roughness to dissipate stream power during flood flows.

Potential habitat actions to meet the objectives include (1) removing and re-contouring about two acres of dredge tailings and embankments to increase the average constrained valley bottom width that can also accommodate the combined flows from the Yankee Fork and West Fork and (2) planting the area of disturbance to primarily improve floodplain roughness. Figure 29 shows the potential locations and the maximum extent where these actions should be considered.

Constraints to implementation of potential habitat actions are primarily (1) the need to maintain relatively “pristine” mine tailings as a historical property and attraction, (2) active mining claims within the channel reach, (3) landowner and stakeholder cooperation and willingness, and (4) availability of funding.

The expected channel response will benefit adult and juvenile salmonids primarily by increasing migration and holding habitat through the migratory corridor by increasing channel/floodplain interactions and improved instream flow variability.

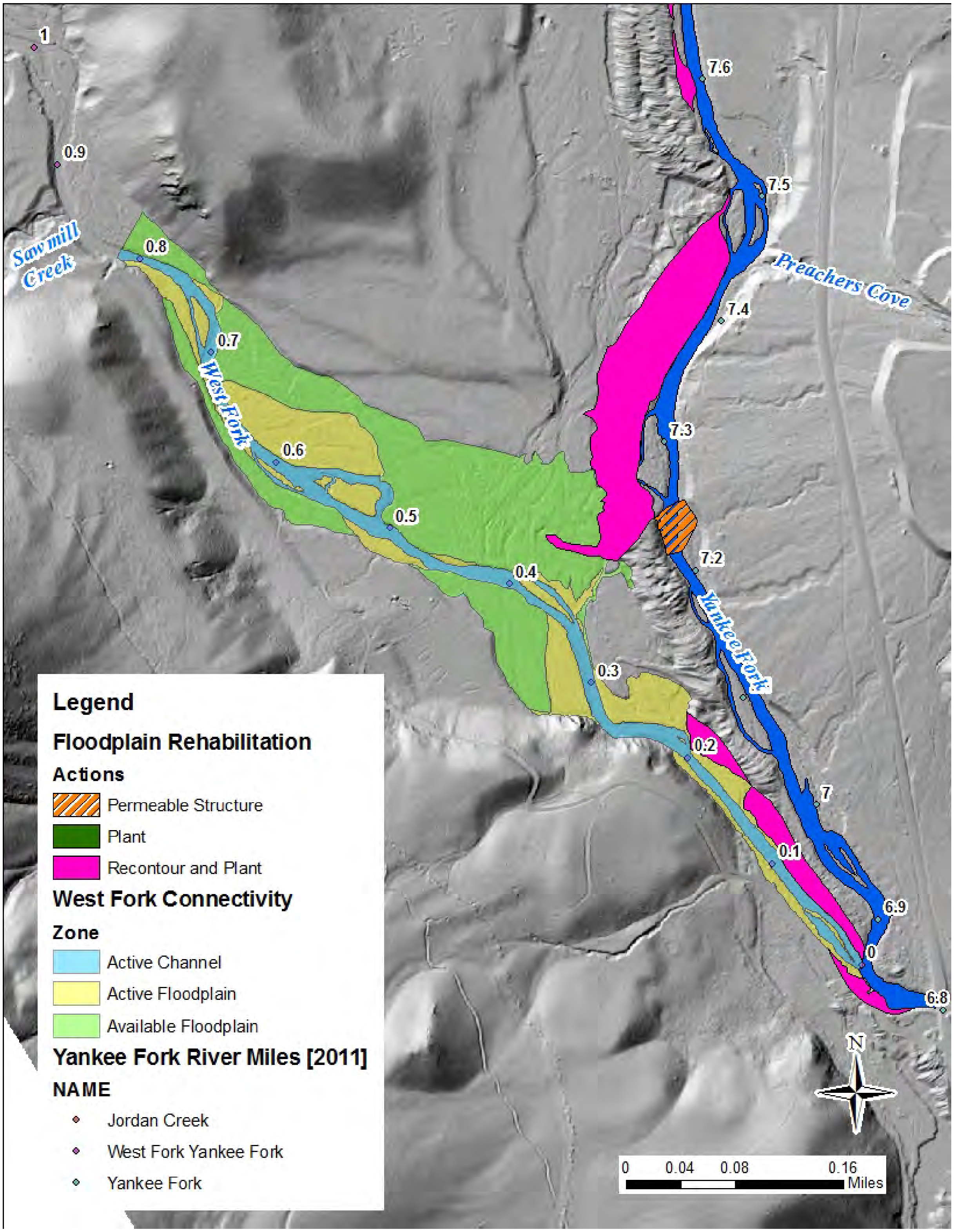


Figure 29. Potential areas to implement appropriate habitat actions.

SUMMARY

Historically in the assessment area, the Yankee Fork flowed through an alluvial valley with a valley gradient of about 1.1 percent and the depth to bedrock was relatively shallow, on the order of tens of feet, throughout the valley segment. Two geomorphic channel reaches were identified in the assessment area, (1) a moderately confined channel between Jordan Creek and Preachers Cove, and (2) an unconfined channel between Preachers Cove and the Yankee Fork/West Fork confluence. Based on interpretation of the 1945 aerial photographs and 2010 LiDAR topography, the moderately confined channel reach had a straight, free-formed alluvial channel with a plane-bed, and has a low rate of lateral channel migration and channel/floodplain dynamics. The unconfined channel reach had a relatively straight, free-formed alluvial channel with a predominantly plane-bed with pool-riffle sections, and has a low to moderate rate of lateral channel migration and channel floodplain dynamics.

Under existing conditions, the Yankee Fork is moderately confined along its length by mine tailings, bedrock, and alluvial and colluvial deposits. The channel pattern is a straight, free-formed alluvial channel with a plane-bed, and has a low rate of lateral channel migration and channel/floodplain dynamics. Channel confinement has increased due to the dredge tailings constraints that restrict lateral channel migration and limit floodplain development. The increased channel confinement and loss of floodplains changes the geometry of the channel/floodplain cross-sectional area which increases water depth, flow velocities, and shear stresses within the channel during high flows.

The primary limiting and causal factors for the Yankee Fork in the assessment area are (1) habitat fragmentation and connectivity due to mine tailings artificially constraining the stream and disconnecting historic floodplains and (2) habitat quantity and quality due to mining activities that have confined the channel, removed the vegetation, and disconnected off-channel habitat. The Yankee Fork is now straighter and more confined than it was prior to the mining activity with reduced access to the limited floodplain areas that existed. This results in higher in-stream velocities and reduced access to floodplain and side channel areas. These changes impact fish by reducing juvenile rearing and refugia habitat, contributing to limited natural production of salmon and steelhead in the Yankee Fork.

The objectives for the Yankee Fork are to improve habitat-forming processes within the two historically distinct channel reaches, RM 9.1 to 7.6 and RM 7.6 to 6.8. The potential actions to achieve those conditions include, but are not limited to, the following:

- Re-establishing the dynamic channel/floodplain interactions and hydraulic conditions that historically occurred at the Yankee Fork and West Fork confluence area which will increase channel complexity, improve nutrient cycling, and increase the availability of additional diverse habitats.

- Increasing dynamic channel/floodplain interactions by increasing the average floodplain patch size and connectivity which will reduce and add variability to flow velocities, and improve nutrient cycling and sediment retention.
- Improving riparian vegetation conditions will increase channel boundary and floodplain roughness, provide shading and cover, and improve nutrient cycling.

Expected channel response will primarily benefit salmonids through (1) increased availability of rearing habitat and high-flow refugia by increasing channel/floodplain interactions and improving variability in flow velocities, (2) adult spawning by increased sorting and retention of gravel patches, (3) adult and juvenile migration and holding by improving variability in flows velocities, and (4) egg incubation and emergence by improving hyporheic flow through spawning gravels, primarily in the historic Yankee Fork/West Fork confluence area.

In the West Fork assessment area, the stream historically flowed through an alluvial valley with a valley gradient of about 0.9 percent and the depth to bedrock that was similar to the conditions described for the Yankee Fork. One geomorphic channel reach was identified in the assessment area, an unconfined channel between Sawmill Creek and the 1945 West Fork and Yankee Fork confluence (near the existing West Fork RM 0.4). Based on interpretation of the 1945 aerial photographs and 2010 LiDAR topography, the unconfined channel had a straight, free-formed alluvial channel with predominantly a plane-bed with pool-riffle sections, and a had low to moderate rate of lateral channel migration and channel/floodplain dynamics. In this plane-bed to pool-riffle channel, pools would be expected to occur sporadically, mainly in the few locations where meanders occurred (about five to eight total pools, based on the 1945 aerial photo). The few unvegetated bars were probably mobilized and secondary side channels activated during channel forming flows with a recurrence interval of about 1 to 2 years.

Under existing conditions, the West Fork has two geomorphic channel reaches in the assessment area, (1) an unconfined channel with a straight, free-formed alluvial channel with predominantly a plane-bed with pool-riffle sections from RM 0.8 to 0.2 and (2) a confined channel that has been further constrained by dredge tailings with a straight, free-formed alluvial channel with a plane-bed bedform from RM 0.2 to 0. The unconfined channel reach (RM 0.8 to 0.2) has remained similar to its historic conditions. In the confined channel reach (RM 0.2 to 0), the channel has also remained similar to historic conditions with the exceptions that this channel used to be the main Yankee Fork downstream from the West Fork confluence. It now has a slightly higher energy and higher transport capacity reach due to increased confinement.

Objectives for the West Fork are to monitor and maintain existing habitat-forming processes occurring in the unconfined channel reach between RM 0.8 and 0.2 as it continues to recover from logging and other disturbances in the drainage. In the confined channel reach, the objectives are to improve habitat-forming processes and the potential actions to achieve those conditions include, but are not limited to, the following:

- Increasing dynamic channel/floodplain interactions by increasing the average floodplain patch size and connectivity, which will reduce and add variability to flow velocities, and improve nutrient cycling and sediment retention.
- Improving riparian vegetation conditions will increase channel boundary and floodplain roughness, provide shading and cover, and improve nutrient cycling.

Expected channel response will primarily benefit salmonids through improved adult and juvenile migration and holding habitats by increasing channel/floodplain interactions and improving variability in flow velocities.

NEXT STEPS

This Reach Assessment is intended to be used as one tool among many to guide rehabilitation and habitat improvement actions on the Yankee Fork and West Fork. The actions outlined in this report represent appropriate actions based on physical and ecological processes for these riverine systems, but are not an exhaustive assessment of all possible actions that can be used to achieve habitat benefits.

Within the overarching reach-scale goal to improve or re-establish habitat-forming processes, the potential habitat actions outlined and delineated in this report can be grouped in any number of ways or places to form projects. In some instances, only one course of action may be appropriate and project development is relatively simple. In other instances, multiple actions may be appropriate requiring prioritization based on collaboration amongst project stakeholders. In either case, evaluating the proposed action(s), based on the goals and objectives of the project stakeholders, will ensure the most appropriate suite of actions is developed. Throughout the project development, design, and implementation process, this Reach Assessment can be used as a reference to verify whether or not project components are appropriate for the geomorphic character and trends prevalent in the assessment area of the Yankee Fork and West Fork. Completed projects can be monitored and evaluated to determine the extent to which they helped achieve the identified objectives to improve or re-establish habitat-forming processes. Shortcomings can be addressed through adaptive management of the project and in future project designs.

LIST OF PREPARERS

Name	Organization	Contribution
Edward W. Lyon, Jr., L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Principal Author River Systems Analysis Group Geomorphologist
Rick Rieber	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Reviewer/Contributor Ecosystems Analysis Group
Terril Stevenson, L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Peer Reviewer River Systems Analysis Geomorphology Group Manager
Richard Link, L.E.G., L.G.	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Peer Reviewer Geology and River Systems Analysis Groups Program Manager
Kristin Swoboda	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	GIS Peer Reviewer Geographic Information System Geodatabase
Kelly Vick	Bureau of Reclamation Pacific Northwest Regional Office Boise, Idaho	Natural Resources Writer Liaison & Coordination Group

This page intentionally left blank

LITERATURE CITED

Parenthetical Reference	Bibliographic Citation
Beechie et al. 2006	Beechie, T., M. Liermann, M. Pollock, S. Baker, and J. Davies. 2006. Channel pattern and river-floodplain dynamics in forested mountain river systems: Geomorphology 78 (2006) p. 124-141.
Beechie et al. 2010	Beechie, T., D. Sear, J. Olden, G. Pess, J. Buffington, H. Moir, P. Roni, and M. Pollock. 2010. Process-based principles for restoring river ecosystems: BioScience 60 (2010) p. 209-222.
Bisson, Buffington, and Montgomery 2006	Bisson, P., J. Buffington, and D. Montgomery. 2006. *Valley segments, stream reaches, and channel units: in Methods in Stream Ecology*. Elsevier, p. 23-49.
Borgert, Lundeen, and Thackray 1999	Borgert, J., K. Lundeen, and G. Thackray. 1999. "Glacial geology of the southeastern Sawtooth Mountains" in hughes, S., and Thackray, C., eds., *Guidebook to the geology of Eastern Idaho*. Idaho Museum of Natural History, Pocatello, Idaho, p. 205-217.
Evenson, Cotter, and Clinch 1982	Evenson, E.B., J.F.P. Cotter, and J.M. Clinch. 1982. "Glaciation of the Pioneer Mountains, a proposed model for Idaho" in Bonnichsen B., and Breckenridge, R.M., eds., *Cenozoic Geology of Southern Idaho*. Idaho Bureau of Mines and Geology Bulletin, v. 26, p.653-665.
Fenneman 1931	Fenneman, N. 1931. *Physiography of the Western United States*. McGraw-Hill, New York, 534 p.
Frissell et al. 1986	Frissell, C., W. Liss, C. Warren, and M. Hurley. 1986. A hierarchial framework fir stream habitat classification: Viewing streams in a watershed context: Environmental Management 10 (1986) p. 199-214.
Gregory 2012	Gregory, J. 2012. Lost River Fish Ecology INC. Personal Communication. July 19, 2012.
Gregory and Wood 2012	Gregory, J. and C. Wood. 2012. Evaluation of juvenile anadromous fish populations in Pond Series 2 and Pond Series 3 and adjacent areas in the Yankee Fork drainage. Prepared for Bureau of Reclamation.
High Country News 1995	High Country News. 1995. "Festering Idaho mine to be cleaned; other remain" in the August 21, 1995 issue of High Country News. http://www.hcn.org/issues/41/1233.

Parenthetical Reference	Bibliographic Citation
Hillman 2006	Hillman, T. 2006. *Monitoring strategy for the Upper Columbia Basin, second draft report, August 2006*, prepared for the Upper Columbia Salmon Recovery Board, Bonneville Power Administration, and NOAA's National Marine Fisheries Service: BioAnalysts, Inc., Boise, Idaho. 98 pp.
IBHS 2009	Idaho Bureau of Homeland Security. 2009. *Putting down roots in earthquake country, your handbook for earthquakes in Idaho*. Idaho Bureau of Homeland Security, Boise, Idaho. 38 p.
IDEQ 2011	Idaho Department of Environmental Quality. 2011. *Idaho's 2010 Integrated Report*. Idaho Department of Environmental Quality, Boise, Idaho, 46 p. + Appendices.
Janecke 1992	Janecke, S. 1992. "Kinematics and timing of three superposed extensional systems, east central Idaho: Evidence for an Eocene tectonic transition." *Tectonics*, v. 11, p. 1121-1138.
Kiilsgaard, Fisher, and Bennett 1986	Kiilsgaard, T., F. Fisher, and E. Bennett. 1986. "The Trans-Challis fault system and associated precious metal deposits, Idaho." *Economic Geology*, v. 81, p. 721-724.
Link and Janecke 1999	Link, P. and S. Janecke. 1999. "Geology of East-Central Idaho: Geologic roadlogs for the Big and Little Lost River, Lemhi, and Salmon River valleys." Pages 295-334 in Hughes, S., and Thackray, G., eds., *Guidebook to the Geology of Eastern Idaho*: Idaho Museum of Natural History, Pocatello, Idaho
LOYF Historical Association 2005	Land of the Yankee Fork Historical Association. *Land of the Yankee Fork Historic Area in Words and Pictures.* Produced and Published by the Land of the Yankee Fork Interpretive Center and the Idaho Department of Parks and Recreation. 51 p.
McIntyre, Ekren, and Hardyman 1982	McIntyre, E., E. Ekren, and R. Hardyman. 1982. "Stratigraphic and structural framework of the Challis volcanics in the eastern half of the Challis 1º x 2º quadrangle, Idaho," in Bonnichsen, B., and Breckenridge, R., eds., Cenozoic geology of Idaho. Idaho Bureau of Mines and Geology Bulletin 26, p. 3-22.
Mitchell 1997	Mitchell, V. 1997. "History of the Sunbeam Mine, Custer County, Idaho." Idaho geological Survey Staff Report 97-18, 19 p.
Montgomery and Bolton 2003	Montgomery, D. and S. Bolton. 2003. "Hydrogeomorphic variability and river restoration" in R. C. Wissmar and P.A. Bisson, editors. Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and managed system: American Fisheries Society, Bethesda, Maryland, 39-79 pp.

Parenthetical Reference	Bibliographic Citation
Montgomery and Buffington 1993	Montgomery, D. and J. Buffington. 1993. "Channel classification, prediction of channel response, and assessment of channel condition." *Washington State Timber, Fish & Wild-life*: p.84 + figures
Montgomery and Buffington 1997	Montgomery, D. and J. Buffington. 1997. Channel reach morphology in mountain drainage basins: Geological Society of America Bulletin 109 (1997) p. 596-611.
Montgomery and Buffington 1998	Montgomery, D. and J. Buffington. 1998. *Channel processes, classification, and response: in River Ecology and Management*. Robert Naiman & Robert Bilby [editors]: Springer-Verlag New York, Inc., p. 13-39.
Montgomery and MacDonald 2002	Montgomery, D. and L. MacDonald. 2002. "Diagnostic approach to stream channel assessment and monitoring." *Journal of the American Water Resources Association 38: 1-16.*
NOAA Fisheries 1996	NOAA's National Marine Fisheries Service. 1996. *Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale* [Matrix of Pathways and Indicators]: NOAA's National Marine Fisheries Service, Northwest Region, Portland, Oregon.
NOAA Fisheries 2010	NOAA's National Marine Fisheries Service. 2010. *Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program*. May 20, 2010, F/NWR/2010/0209.
NOAA Fisheries 2011	NOAA's National Marine Fisheries Service. 2011. *Draft recovery plan for the Idaho Snake River spring/summer Chinook and steelhead populations in the Snake River spring/summer Chinook salmon evolutionary significant unit and Snake River steelhead distinct population segment.* National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Boise, Idaho.
ODFW 2010	Oregon Department of Fish and Wildlife. 2010. *Aquatic inventories project methods for stream habitat surveys*. Oregon Department of Fish and Wildlife, Aquatic Inventories Project, Conservation and Recovery Program, Corvallis, Oregon 70 p.
Overton, Radko, and Wollrab 1999	Overton, C., M. Radko, and S. Wollrab. 1999. *Watershed analysis approaches for Chinook salmon, Yankee Fork of the Salmon River, Idaho*. An example [draft]: U.S.D.A. Forest Service, Rocky Mountain Research Station, Boise, Idaho 47 p.

Parenthetical Reference	Bibliographic Citation
Rapp and Abbe 2003	Rapp, C. and T. Abbe. 2003. A framework for delineating channel migration zones: Washington State Department of Transportation, Ecology Publication #03-06-027 (Final Draft), 66 p.
Reclamation 2011	U.S. Department of the Interior, Bureau of Reclamation. 2011. *SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water 2011*. Prepared for: United States Congress. 226 p.
Reclamation 2012	Bureau of Reclamation. 2012. Yankee Fork Tributary Assessment, Upper Salmon Subbasin, Custer County, Idaho: Department of Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho, 153 p.
Reiser and Ramey 1987	Reiser, D.W. and M.P. Ramey. 1987. *Feasibility Plan For The Enhancement Of The Yankee Fork Of The Salmon River, Idaho*. Prepared for the Shoshone-Bannock Tribes Fisheries Department. Fort Hall, Idaho. BPA contract No. 83-359.
Richards and Cernera 1989	Richards, Carl and Phillip J. Cernera. 1989. “Dispersal and Abundance of Hatchery-Reared and Naturally Spawned Juvenile Chinook Salmon in an Idaho Stream.” North American Journal of Fisheries Management, p. 345-351.
Rowe et al. 1989	Rowe, M., S. Spaulding, J., Gunderman, and K. Bacon. 1989. *Salmon River habitat enhancement annual report 1989, subproject II: Yankee Fork Salmon River*. Prepared for the U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Project 83-359, Portland, Oregon.
SBT 2011	Shoshone Bannock Tribes. 2011. *Crystal Springs Fish Hatchery and programs for Snake River Chinook Salmon and Yellowstone Cutthroat Trout, Master Plan*. Shoshone Bannock Tribes, Fort Hall, Idaho, 198 p.
Smith 1911	Smith, G. 1911. “Field Notes of the Survey of the Mining Claim of Yankee Fork Placer Company, Ltd.” Mineral Survey No. 2406. Recorded in Custer County, Idaho, September 1, 1911.
Tsosie, Bacon, and Wadsworth 2009	Tsosie, T., K. Bacon, and P. Wadsworth. 2009. Salmon River Habitat Enhancement: Shoshone-Bannock Tribes, Fort Hall, Idaho.
USFB 1934	Bureau of Fisheries, 1934. West Fork of the Yankee Fork stream survey: U.S. Department of Commerce, Bureau of Fisheries.
USFS 1994	U.S. Department of Agriculture, Forest Service. 1994. Section 7 fish habitat monitoring protocol for the Upper Columbia River Basin: U.S. Department of Agriculture, Forest Service, Pacific Northwest, Intermountain, and Northern Regions 59 p.

Parenthetical Reference	**Bibliographic Citation**
USFS 1995	U.S. Department of Agriculture, Forest Service. 1995. Biological assessment for Chinook salmon in the Yankee Fork Section 7 watershed: Challis National Forest, 264 p.
USFS 2006	U.S. Department of Agriculture, Forest Service. 2006. *Biological assessment for the potential effects of managing the Salmon-Challis National Forest in the Yankee Fork Section 7 Watershed on Snake River Basin Spring/Summer Chinook Salmon, Snake River Steelhead, and Columbia River Bull Trout [Draft]*. U.S. Department of Agriculture, Salmon-Challis National Forest, Yankee Fork Ranger District, Clayton, Idaho. 126 p.
USFS 2010	U.S. Department of Agriculture, Forest Service. 2010. *Stream Inventory Handbook, Level I & II, Version 2.10*. Pacific Northwest Region, Region 6, Portland, Oregon.
USGS 1995	U. S. Geological Survey. 1995. "Geology and Mineral Resource Assessment of the Challis 1º X 2º Quadrangle." *Professional Paper 1525*. U.S. Geological Survey, U.S. Government Printing Office, Washington, 204 p. + maps.
USGS 2009	U.S. Geological Survey. 2009. "Stream-sediment geochemistry in mining-impacted drainages of the Yankee Fork of the Salmon River, Custer County, Idaho." *U.S. Geological Survey Scientific Investigation Report 2009-5115*. 49 p.
USFWS 1998	U.S. Fish and Wildlife Service, 1998. A framework to assist in making Endangered Species Act determinations of effect for individual or grouped actions at the Bull Trout subpopulation watershed scale: U.S. Fish and Wildlife Service, 49 p.

This page intentionally left blank

GLOSSARY

Some terms in the glossary appear in this Reach Assessment.

TERM	DEFINITION
action	Proposed protection and/or rehabilitation strategy to improve selected physical and ecological processes that may be limiting the productivity, abundance, spatial structure or diversity of the focal species. Examples include removing or modifying passage barriers to reconnect isolated habitat (i.e., tributaries), planting appropriate vegetation to re-establish or improve the riparian corridor along a stream that reconnects channel/floodplain processes, placement of large wood to improve habitat complexity, cover and increase biomass that reconnects isolated habitat units.
alluvial fan	An outspread, gently sloping mass of alluvium deposited by a stream, esp. in an arid or semiarid region where a stream issues from a narrow canyon onto a plain or valley floor. Viewed from above, it has the shape of an open fan, the apex being at the canyon mouth.
alluvium	A general term for detrital deposits made by streams on river beds, floodplains, and alluvial fans; esp. a deposit of silt or silty caly laid down during time of flood. The term applies to stream deposits of recent time. It does not include subaqueous sediments of seas and lakes.
anadromous fish	A fish, such as the Pacific salmon, that spawns and spends its early life in freshwater but moves into the ocean where it attains sexual maturity and spends most of its life span.
anthropogenic	Caused by human activities.
bank	The margins of a channel. Banks are called right or left as viewed facing in the direction of the flow.
baseflow	That part of the streamflow that is not attributable to direct runoff from precipitation or melting snow; it is usually sustained by groundwater discharge.
basin	The drainage area of a river and its tributaries.
bedrock	The solid rock that underlies gravel, soil or other superficial material and is generally resistant to fluvial erosion over a span of several decades, but may erode over longer time periods.
cfs	Cubic feet per second; a measure of water flows

TERM	DEFINITION
channel forming flow	Sometimes referred to as the effective flow or ordinary high water flow and often as the bankfull flow or discharge. For most streams, the channel forming flow is the flow that has a recurrence intermal of approximately 1.5 years in the annual flood series. Most channel forming discharges range between 1.0 and 1.8. In some areas it could be lower or higher than this range. It is the flow that transports the most sediment for the least amount of energy, mobilizes and redistributes the annually transient bedload, and maintains long-term channel form.
channel morphology	The physical dimension, shape, form, pattern, profile and structure of a stream channel.
channel planform	The two-dimensional longitudinal pattern of a river channel as viewed on the ground surface, aerial photograph or map.
channelization	The straightening and/or deepening of a stream channel, typically to permit the water to move faster, to reduce flooding, or to drain marshy acreage.
colluvial	A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity.
control	A natural or human feature that restrains a streams ability to move laterally and/or vertically.
degradation	Transition from a higher to lower level or quality. A general lowering of the earth's surface by erosion or transportation in running waters. Also refers to the quality (or loss) of functional elements within an ecosystem.
discharge	The volume per unit of time of streamflow at a given instant or for a given area. Discharge is often used interchangeably with streamflow.
diversity	Genetic and phenotypic (life history traits, behavior, and morphology) variation within a population. Also refers variations in physical conditions or habitat.
dredging	The various processes by which material is mined from a water body, often by large floating machines, or dredges, scoop up earth material at the bottom of a body of water, raise it to the surface, and discharge it back to the water body after removal of ore minerals.
ecosystem	An ecologic system, composed of organisms and their environment. It is the result of interaction between biological, geochemical, and geophysical systems.
erosion	Wearing away of the lands by running water, glaciers, winds, and waves.
floodplain	That portion of a river valley, adjacent to the channel, which is built of sediments deposited during the present regimen of the stream and is covered with water when the river overflows its banks at flood stages.
fluvial	Produced by the action of a river or stream. Also used to refer to something relating to or inhabiting a river or stream. Fish that migrate between rivers and streams are labeled "fluvial."

TERM	DEFINITION
fluvial process	A process related to the movement of flowing water that shape the surface of the earth through the erosion, transport, and deposition of sediment, soil particles, and organic debris.
geomorphic reach	An area containing the active channel and its floodplain bounded by vertical and/or lateral geologic controls, such as alluvial fans or bedrock outcrops, and frequently separated from other reaches by abrupt changes in channel slope and valley confinement. Within a geomorphic reach, similar fluvial processes govern channel planform and geometry resulting from streamflow and sediment transport.
geomorphology	The science that focuses on the general configuraion of the earth's surface; specif. the study of the classification, description, nature, origin and development of landforms and their relationships to underlying structures, and the history of geologic changes as recorded by these surface features.
GIS	Geographical information system. An organized collection of computer hardware, software, and geographic data designed to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.
gradient	Degree of inclination of a part of the earth's surface; steepness of slope. It may be expressed as a ratio (of vertical to horizontal), fraction, percentage, or angle.
groundwater	That part of the subsurface water that is in the saturated zone.
habitat unit	A segment of a stream which has a distinct set of characteristics.
headwaters	Streams at the source of a river.
hydraulics	The branch of fluid mechanics dealing with the flow of water in conduits and open channels.
hydrology	The applied science concerned with the waters of the earth, their occurrences, distribution, and circulation through the unending hydrologic cycle of: precipitation, consequent runoff, infiltration, and storage; eventual evaporation; and so forth. It is concerned with the physical and chemical reaction of water with the rest of the earth, and its relation to the life of the earth.
indicator	A variable used to forecast the value or change in the value of another variable; for example, using temperature, turbidity, and chemical contaminents or nutrients to measure water quality.
limiting factor	Any factor in the environment that limits a population from achieving complete viability with respect to any Viable Salmonid Population (VSP) parameter.
mainstem	The reach of a river/stream formed by the tributaries that flow into it.
perennial stream	A stream that flows all year round. Compare intermittent stream.
reach	A section between two specific points outlining a portion of the stream, or river.

TERM	DEFINITION
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
recurrence interval	The average amount of time between events of a given magnitude. For example, there is a 1 percent chance that a 100-year flood will occur in any given year.
redd	A nest built in gravel or small substrate materials by salmonids where eggs are deposited; the nest is excavated by the adult fish and the eggs are covered by the female after spawning.
riprap	Materials (typically large angular rocks) that are placed along a river bank to prevent or slow erosion.
river mile (RM)	Miles measured in the upstream direction beginning from the mouth of a river or its confluence with the next downstream river.
runoff	That part of precipitation that flows toward the streams on the surface of the ground or within the ground. Runoff is composed of baseflow and surface runoff.
shear stress	The combination of depth and velocity of water. It is a measure of the erosive energy associated with flowing water.
side channel	A distinct channel with its own defined banks that is not part of the main channel, but appears to convey water perennially or seasonally/ephemerally. May also be referred to as a secondary channel.
sinuosity	Ratio of the length of the channel or thalweg to the down-valley distance. Channels with sinuosities of 1.5 or more are called “meandering.”
smolt	A subadult salmonid that is migrating from freshwater to seawater; the physiological adaptation of a salmonid from living in freshwater to living in seawater.
spawning and rearing habitat	Stream reaches and the associated watershed areas that provide all habitat components necessary for adult spawning and juvenile rearing for a local salmonid population. Spawning and rearing habitat generally supports multiple year classes of juveniles of resident and migratory fish, and may also support subadults and adults from local populations.
subbasin	A subbasin represents the drainage area upslope of any point along a channel network (Montgomery and Bolton 2003). Downstream boundaries of subbasins are typically defined in this assessment at the location of a confluence between a tributary and mainstem channel.
terrace	A relatively level bench or steplike surface breaking the continuity of a slope. The term is applied to both the lower or front slope (the riser) and the flat surface (the tread).
tributary	Any stream that contributes water to another stream.

TERM	DEFINITION
valley segment	An area of river within a watershed sometimes referred to as a subwatershed that is comprised of smaller geomorphic reaches. Within a valley segment, multiple floodplain types exist and may range between wide, highly complex floodplains with frequently accessed side channels to narrow and minimally complex floodplains with no side channels. Typical scales of a valley segment are on the order of a few to tens of miles in longitudinal length.
viable salmonid population	An independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame. Viability at the independent population scale is evaluated based on the parameters of abundance, productivity, spatial structure, and diversity (ICBTRT 2007).
watershed	The area of land from which rainfall and/or snow melt drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins. Ridges of higher ground form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

This page intentionally left blank

APPENDICES

This page intentionally left blank

APPENDIX A

Reach-based Ecosystem Indicators

This page intentionally left blank

Appendix A

Reach-based Ecosystem Indicators (REI)

The reach-based ecosystem indicators table has been compiled from literature review, data contained in the *Yankee Fork Tributary Assessment, Upper Salmon Subbasin, Custer County, Idaho* (Reclamation 2012), and from new data collected for this assessment. The metrics used in this REI are for existing conditions (2011) based on anthropogenic constraints (i.e., mine tailings). At the reach-scale, the thresholds in the REI were derived primarily from the Matrix of Pathways and Indicators (NOAA Fisheries 1996) and Matrix of Diagnostics/Pathways and Indicators (USFWS 1998). The criteria and thresholds are for a "Desired Future Condition" for low-gradient, unconstrained valley floor reaches and are not absolute, and should be adjusted to each unique subbasin as data become available (USFS 1994: Endangered Species Act Section 7 Consultation).

General Regional Characteristics

At the regional spatial scale, characteristics are described by ecoregion, drainage basin, valley segments, and channel segments. This information informs planners and evaluators on the regional setting where the assessment occurred.

Watershed Characteristics

At the watershed/subwatershed spatial scales, several reach-based ecosystem indicators are evaluated as general indicators to inform planners and evaluators on how the geomorphic and ecologic processes are functioning. At this scale, an overall condition is evaluated to determine if deficiencies at the reach-scale are symptomatic of a larger (watershed scale) problem that should be addressed to reduce impact to the sustainability and effectiveness of planned habitat actions.

Reach Characteristics

At the reach spatial scale, individual reach-based ecosystem indicators are evaluated to inform planners and evaluators on the condition status of indicators that are responsive to reach scale impacts. The condition status, based on the geomorphology of the stream (i.e., valley confinement, channel type, gradient) is assigned as **adequate** for those that meet or exceed criteria and **at risk** or **unacceptable** for those that could use improvement. When the criteria are not applicable, based on geomorphology of the stream, a justification for the condition status is given in the narrative.

GENERAL REGIONAL CHARACTERISTICS

REGIONAL SETTING

Ecoregion	
Bailey's Classification	Challis Volcanic Section of the Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province (www.nationalatlas.gov)
Omernik Classification	Idaho Batholith (www.nationalatlas.gov)
Physiography	Northern Rocky Mountains physiographic province which is characterized by a rugged, mountainous landscape that has been dissected by fluvial and glacial erosion (Fenneman 1931)
Geology	Quaternary alluvium, Tertiary volcanic and plutonic rocks, Cretaceous intrusive rocks, and Paleozoic and Precambrian sedimentary and metamorphic rocks (USGS 1995)

DRAINAGE BASIN CHARACTERISTICS

Geomorphic Features	Yankee Fork Basin Area	Basin Relief	Drainage Density	Hydrologic Unit Code (5^{th} Field)	Strahler Stream Order	Land Ownership
	122,000 acres	4,407 feet (10,329-5,922 feet elevation)	2.71 mi/mi^2	1706020105	6	>99% public <1% private

VALLEY SEGMENT CHARACTERISTICS

Valley Characteristics	Valley Type	Valley Bottom Type	Average Valley Bottom Gradient	Average Constrained Valley Bottom Width[2]	Average Unvegetated Channel Width	Channel Confinement[3]
Yankee Fork (Jordan Creek, RM 9.1, to West Fork Confluence, RM 6.8[1])	Alluvial	Glaciated U-shaped valley	1.0%	122 feet	48 feet	Moderately Confined (2.5)
West Fork (Sawmill Creek, RM 0.8, to 1945 Yankee Fork Confluence area, RM 0.3[1])	Alluvial	Glaciated U-shaped valley	0.9%	475 feet	47 feet	Unconfined (10.1)
West Fork (1945 Yankee Fork Confluence area, RM 0.3, to 2010 Yankee Fork Confluence, RM 0[1])	Alluvial	Glaciated U-shaped valley	0.9%	94 feet	49 feet	Confined (1.9)

[1] 2011 Yankee Fork and West Fork river miles (RM)

[2] Average constrained valley bottom widths are based on geologic and/or geomorphic features that constrain the channel and floodplain, modified from the Oregon Department of Fish and Wildlife (ODFW) (2010) to include anthropogenic constraints (i.e., mine tailings and levees).

[3] Degree of channel confinement is classified as confined (average constrained valley bottom width less than 2 average unvegetated channel widths), moderately confined (average constrained valley bottom width is equal to 2-4 average unvegetated channel widths, or unconfined (average constrained valley bottom width is greater than 4 average unvegetated channel widths; adapted from Bisson and Montgomery 1996 to recognize changes due to geomorphic or anthropogenic channel constraints in highly disturbed systems.

CHANNEL REACH CHARACTERISTICS

Location	Channel Reach Type[1]	Bedform Type[1]	Channel Gradient	Sinuosity
Yankee Fork (RM 9.1-6.8)	Free-formed alluvial channel	Plane-bed	1.0 %	1.0
West Fork (RM 0.8-0.3)	Free-formed alluvial channel	Plane-bed to Pool-riffle	0.8%	1.1
West Fork (RM 0.3-0)	Free-formed alluvial channel	Plane-bed	0.6%	1.1

[1]Montgomery and Buffington (1998)

WATERSHED CHARACTERISTICS

GENERAL INDICATOR: EFFECTIVE DRAINAGE NETWORK AND WATERSHED ROAD DENSITY

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Effective Drainage Network and Watershed Road Density	Zero or minimum increases in active channel length correlated with human caused disturbance. And Road density <1 miles/miles^2.	Low to moderate increase in active channel length correlated with human caused disturbances. And Road density 1-2.4 miles/miles^2.	Greater than moderate increase in active channel length correlated with human caused disturbances. And Road density >2.4 miles/miles^2.

Narrative:

Road densities (0.85 mi/mi^2 excluding mining access roads and all-terrain vehicle trails) are low within the Yankee Fork watershed, there are several roads that are valley bottom roads and adjacent to waterways. The thresholds contained in the matrix of pathways and indicators for properly functioning are: (1) less than 2 mi/mi^2 of road and (2) no valley bottom roads. For **at risk**, the thresholds are: (1) 2 to 3 mi/mi^2 of road and (2) some valley bottom roads. Presently, this road density indicator is **at risk** based on roads being located on the valley bottoms and adjacent to fish-bearing streams. An analysis of all roads, including mining access roads and all-terrain vehicle trails, is needed to provide further clarification on the actual effects roads may have on waterways, erosion potential, and habitat quality (Reclamation 2012).

GENERAL INDICATOR: DISTURBANCE REGIME (NATURAL/HUMAN)

Criteria: The following criteria were modified from USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Disturbance Regime	Environmental disturbance is short lived; predictable hydrograph, high quality habitat and watershed complexity providing refuge and rearing space for all life stages or multiple life-history forms. Natural processes are stable.	Scour events, debris torrents, or catastrophic fires are localized events that occur in several minor parts of the watershed. Resiliency of habitat to recover from environmental disturbances is moderate.	Frequent flood or drought producing highly variable and unpredictable flows, scour events, debris torrents, or high probability of catastrophic fire exists throughout a major part of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.

Narrative:

Mining activities have resulted in the most significant anthropogenic disturbances in the watershed. The dredged area along the Yankee Fork valley bottom between Jordan Creek and Pole Flat Campground, and the lower 1.4-mile section of lower Jordan Creek are the most negatively affected areas based on physical and ecological processes. Valley bottoms were cleared of vegetation and are now predominantly barren mounds of dredge tailings with isolated patches of vegetation resulting in fragmentation of terrestrial and aquatic ecological interactions. The construction of the Yankee Fork channel and channelization of tributaries through the dredge tailings has further confined these channels and reduced channel/floodplain interactions, disconnected tributaries, and increased flow velocity and shear stress within the channel. Impacts to aquatic habitat include: (1) loss of juvenile rearing habitat and high water refugia; (2) reduction in spawning habitat; (3) isolation of tributaries that historically provided juvenile rearing habitat; and (4) increased flow velocities and basal stress in several channels.

Past livestock grazing and timber harvest practices impacted (1) channel form and function; (2) streambank stability; (3) sediment supply and delivery; (4) thermal regimes; and (5) ecological connectivity. Current USFS management practices preclude livestock grazing and timber harvest activities on their administered lands. The indication is that vegetation density and coverage along stream corridors and valley walls have been improving, except in areas where dredge tailings persist. The improving riparian and upland vegetation conditions have positively impacted sediment supply and delivery processes to the channel network by reducing erosion and providing streambank stability. In addition, as vegetation grows and progresses from small tree to mature tree successional stages, larger wood sizes will become increasingly more available to the channel networks.

The condition rating for anthropogenic disturbance history is **at risk** due to negative impacts from past and present mining activities (Reclamation 2012).

GENERAL INDICATOR: FLOW/HYDROLOGY

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Flow/hydrology	Magnitude, timing, duration and frequency of peak flows within a watershed are not altered relative to natural conditions of an undisturbed watershed of similar size, geology and geography.	Some evidence of altered magnitude, timing duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology and geography.	Pronounced changes in magnitude, timing, duration and/or frequency of peak flows relative to natural conditions of an undisturbed watershed of similar size, geology and geography.

Narrative:

The Yankee Fork is a snowmelt dominated system that is characterized by a spring snowmelt runoff with low summer and winter flows, except for occasional rain-on-snow events that typically occur in late fall (November and December) and late winter (January and February). The annual hydrograph (Figure 1) illustrates that annual peak flows occur during spring runoff from May through June and base flows of approximately 30 cfs can extend from September through March. Based on the flow exceedance curve, a flow rate of 200 cfs is equaled or exceeded 20 percent of the time and a flow rate of 500 cfs is equaled or exceeded 10 percent of the time. Peak flow statistics determined by the USGS are summarized in Table 1 (Reclamation 2012).

The flow/hydrology regime have been affected in the lower Yankee Fork subwatershed due to dredge tailings and the Custer Motorway that disconnect tributary surface water flows from reaching the mainstem Yankee Fork; thereby reducing the magnitude and timing of peak flows in the mainstem Yankee Fork. The disconnected tributaries do provide groundwater to the mainstem Yankee Fork through hyporheic flow, but the transmissivity of the sand to boulder size dredge materials increases the amount of time that it takes for such flows to reach the mainstem Yankee Fork which attenuates the amplitude of the hydrograph. Therefore, the flow/hydrology general indicator is **at risk**.

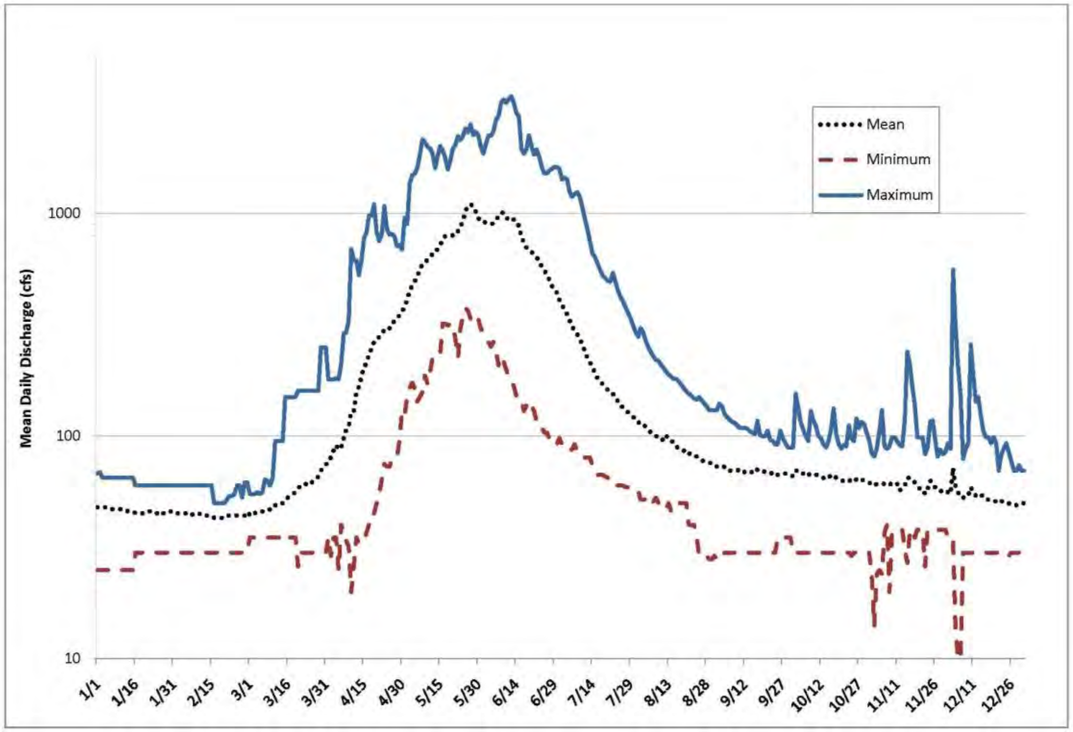


Figure 1. USGS 13296000 Gage Annual Hydrograph (Period of Record 1922-1949).

Table 1. USGS 13296000 Peak Flow Statistics Estimated by Berenbrock (2002) (Period of Record 1921-1949, 1974).

High Flow Statistic		Discharge, cfs
Recurrence Interval, years	Probability of Occurrence, %	
2	50	1,470
5	20	2,240
10	10	2,780
25	4	3,490
50	2	4,030
100	1	4,590
200	0.5	5,160
500	0.2	5,940

GENERAL INDICATOR: WATER QUANTITY AND QUALITY

Criteria: The following criteria were adapted and modified from the USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality and Quantity	Quantity/Temperature/Chemical Contamination/ Nutrients	Adequate instream flows for habitat, low levels of water quality impairments from landuse sources, no excessive nutrients, no CWA 303d designated reaches.	Inadequate instream flows for habitat, moderate levels of water quality impairments from landuse sources, some excess nutrients, CWA 303d designated reaches.	Inadequate instream flows for habitat, high levels of water quality impairments from landuse sources, high levels of excess nutrients, CWA 303d designated reaches.

Narrative:

Water quality presently meets IDEQ standards. Conditions were all found to be currently functioning properly although there was some variability for the fine sediment and surface water temperature indicators. Although the chemical contamination indicator is currently within the properly functioning threshold, there are some chemical contaminant sources related to past and present mining activities that may become available to the channel network through natural and anthropogenic disturbances; thereby, posing a threat to aquatic species. The ongoing mining activities and presence of elemental mercury from past mining in the watershed justifies a condition rating of **at risk** for chemical contamination (Reclamation 2012).

Instream flows (water quantity) are currently sufficient to maintain year-round access through the Yankee Fork mainstem to other fish-bearing tributaries (i.e., West Fork, Jordan Creek, Eightmile Creek, etc.). There are no dams regulating flows and there is no evidence showing a change in the hydrograph timing, peak flow, or base flow for the period of record. Therefore, based on current information, the water quantity indicator is **adequate** (Reclamation 2012).

GENERAL INDICATOR: MAIN CHANNEL PHYSICAL BARRIERS (NATURAL/HUMAN)

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Access	Main Channel Physical Barriers	Barriers (Natural/Human)	No manmade barriers present in the mainstem that limit upstream or downstream migration at any flow.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at some flows that are biologically significant.	Manmade barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

Narrative:

There are no man-made physical barriers present on the mainstem of the Yankee Fork that prevent fish passage (Reclamation 2012). Therefore, the habitat access general indication is **adequate**.

REACH CHARACTERISTICS

GENERAL INDICATOR: WATER TEMPERATURE

Criteria: The following criteria were developed by Hillman and Giorgi (2002) and USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Water Quality	Water Temperature	MWMT/ MDMT/ 7-DADMax	Bull Trout: Incubation: 2-5°C Rearing: 4-10°C Spawning: 1-9°C Salmon and Steelhead: Spawning: June-Sept 15°C Sept-May 12°C Rearing: 15°C Migration: 15°C Adult holding: 15°C	MWMT in reach during the following life history stages: Incubation: <2°C or 6°C Rearing: <4°C or 13-15°C Spawning: <4°C or 10°C Temperatures in areas used by adults during the local spawning migration sometimes exceed 15°C.	MWMT in reach during the following life history stages: Incubation: <1°C or >6°C Rearing: >15°C Spawning: <4°C or >10°C Temperatures in areas used by adults during the local spawning migration regularly exceed 15°C.

Narrative:

Table 2 and Table 3 summarize the water temperature thresholds used by the Salmon-Challis National Forest and IDEQ. Water temperature monitoring by the Salmon-Challis National Forest indicate that the maximum weekly (7-day average) maximum temperature at most water temperature monitoring stations along the mainstem Yankee Fork and West Fork exceeded the temperature limits set by the USFS. The 2001 Yankee Fork Watershed Analysis explains that water temperatures are generally less than 57º F within most reaches (USFS 2006). Water temperatures are warmer during the late summer period in the Yankee Fork below Jordan Creek and fish seek refugia in cooler tributary streams (i.e., West Fork where water temperatures are generally 37 to 41º F). Water temperature is not considered limiting in most surface waters, with the exception of the dredged area on the Yankee Fork below Jordan Creek (USFS 2006).

Table 2. USFS water temperature standards for salmonids (USFS 2006).

Use Metric	Salmonid Incubation	Salmonid Juvenile Rearing	Salmonid Spawning
MWMT[1]	36-41º F (2-5º C)	39-54º F (4-12º C)	39-48º F (4-9º C)

[1]MWMT = Maximum Weekly (7-day average) Maximum Temperature

Table 3. IDEQ water temperature standards for cold water use (http://www.deq.idaho.gov/water-quality/surface-water/temperature.aspx).

Use Metric	Cold Water	Salmonid Spawning	Bull Trout
MDMT[1]	72º F (22º C)	55º F (13º C)	N/A
MWMT[2]	N/A	N/A	55º F (13º C)
MDAT[3]	66º F (19º C)	48º F (9º C)	N/A

[1]MDMT = Maximum Daily Maximum Temperature
[2]MWMT = Maximum Weekly (7-day average) Maximum Temperature
[3]MDAT = Maximum Daily Average Temperature

Detailed thermal imaging was conducted in 2010 along the Yankee Fork between RM 16.4 and 3.4, Jordan Creek between RM 4 and 0, West Fork, and Rankin Creek in August 2010 (Watershed Sciences 2010). Complete analysis of the data and trends are included in Appendix J of the *Tributary Assessment* (Reclamation 2012).

Along the Yankee Fork mainstem between about RM 16.4 and 3.4, water temperatures generally ranged from 48 to 56º F. Eightmile Creek (RM 16.4) and Jordan Creek (RM 9.1) were noted to contribute warmer waters to the mainstem. The West Fork had an insignificant influence on water temperature in the Yankee Fork. Some tailing pond outlets contributed warmer waters, but most contributed cooler waters. Several smaller tributaries and springs contributed cooler waters and their locations were noted in the analysis.

In Jordan Creek between about RM 4 to the Yankee Fork confluence, water temperatures generally ranged from 49 to 60º F. Along the lower ½-mile of the creek, water temperatures exceeded 59º F. A mine discharge outlet near RM 4 contributed significantly warmer waters to Jordan Creek. Inflows from tributaries contributed predominantly cooler waters with only a few exceptions.

In general, warm water contributions to the Yankee Fork come from Jordan Creek and some tailing pond outlets. There are also several smaller tributaries, springs, and tailing ponds that contribute cooler waters to the Yankee Fork. Warm water temperatures and their effects on habitat quality are a concern primarily in the Yankee Fork downstream of Jordan Creek where unvegetated mine tailings covers the valley bottom. The Salmon-Challis National Forest considers the Yankee Fork watershed to be **at risk** for the water temperature indicator (Status of baseline conditions for Yankee Fork watershed, Salmon-Challis National Forest, updated December 12, 2011).

GENERAL INDICATOR: CHANNEL SUBSTRATE

Criteria: Performance standards for these criteria are from Hillman and Giorgi (2002).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Substrate	Dominant Substrate/ Fine Sediment	Gravels or small cobbles make-up >50% of the bed materials in spawning areas. Reach embeddedness in rearing areas <20%. <12% fines (<0.85mm) in spawning gravel or ≤12% surface fines of ≤6mm.	Gravels or small cobbles make-up 30-50% of the bed materials in spawning areas. Reach embeddedness in rearing areas 20-30%. 12-17% fines (<0.85mm) in spawning gravel or 12-20% surface fines of ≤6mm.	Gravels or small cobbles make-up <30% of the bed materials in spawning areas. Reach embeddedness in rearing areas >30%. >17% fines (<0.85mm) in spawning gravel or >20% surface fines of ≤6mm.

Narrative:

Channel confinement influences the stream's sediment transport capacity differently in each of the channel segments observed in this reach assessment. The Yankee Fork is artificially confined between RM 9.1 and 6.8 by mine tailings. Dominant substrate, or armor layer, is comprised of large cobble and boulder due to the high energy, high transport capacity within this channel segment. However, there are quite a few spawning patches that do have adequate substrate. Historically, the channel was moderately confined between Jordan Creek and Preachers Cove, and unconfined between Preachers Cove to the 1945 Yankee Fork/West Fork confluence. The thresholds listed for substrate do not apply to moderately confined, plane-bed channels, but they are applicable for unconfined, pool-riffle channels. The rerouting and artificial channel confinement have converted the stream from a plane-bed to pool-riffle combination channel to a plane-bed channel, thus the Yankee Fork is now functioning in an **at risk** condition for substrate.

The West Fork channel is unconfined between RM 0.8 and 0.3, and the thresholds listed for substrate do apply. There has been some manipulation of the channel around RM 0.4, but otherwise the channel has been able to migrate laterally throughout the rest of this channel segment. Dominant substrate is gravel with only a trace of fine sediment, and no embeddedness was observed. Therefore, this channel segment is in **adequate** condition.

From RM 0.3 to 0, the West Fork had been rerouted and artificially confined by mine tailings. Historically, the combined discharges from Yankee Fork and West Fork flowed in a moderately confined channel at this location. Changes to the West Fork in this channel segment have resulted in an artificially high energy, high transport capacity channel that has developed a coarse-grained armor layer. Due to rerouting of the West Fork and the relocation of the Yankee Fork, the sediment regime has changed with the loss of sediment input from the Yankee Fork. Thus, there has been a significant functional change to the system that places this channel segment in an **at risk** condition for substrate. Table 4 summarizes the substrate and condition rating by channel segment.

Table 4. Dominant substrate and approximate gradation.

Channel Segment	Dominant Substrate	Approximate Substrate Gradation	Condition Rating
Yankee Fork (RM 9.1-6.8)	Cobble (64-256 mm)	Cobble (45%); Boulder (25%); Gravel (20%); Sand (10%)	At Risk
West Fork (RM 0.8-0.3)	Gravel (2-64 mm)	Gravel (60%); Sand (25%); Cobble (15%); Trace Fines	Adequate
West Fork (RM 0.3-0)	Gravel with Cobble (2-256 mm)	Gravel (50%); Cobble (30%); Sand (15%); Fines (5%)	At Risk

GENERAL INDICATOR: CHEMICAL CONTAMINATION/NUTRIENTS

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Condition
Water Quality	Chemical Contamination/ Nutrients	Metals/ Pollutants, pH, DO, Nitrogen, Phosphorous	Low levels of chemical contamination from land use sources, no excessive nutrients, no CWA 303d designated reaches.	Moderate levels of chemical contamination from land use sources, some excess nutrients, one CWA 303d designated reach.	High levels of chemical contamination from land use sources, high levels of excess nutrients, more than one CWA 303d designated reach.

Narrative:

There remains a potential risk of chemical contamination from past and present mining activities (i.e., selenium, mercury, cyanide, etc.). Past mining activities are known to have had negative water quality impacts. For example, Rodeheffer (1935) reported "that creek (Jordan Creek) is so badly polluted by several small mines along its course that no fish or fish foods are found." Pollution control efforts have been implemented at the Grouse Creek Mine which is being reclaimed to control discharge of cyanide from leaking tailings ponds into Jordan Creek which flows into the Yankee Fork near RM 9.1, and the Preachers Cove ore processing site on the Yankee Fork near RM 7.3 has been reclaimed (IDEQ 2003). Presently, there are no chemical contaminants that are not within IDEQ standards, so the chemical contamination/nutrients indicator condition is **adequate**. However, some chemical contaminant sources related to past and present mining activities pose a risk that contaminants may become available to the channel network (Reclamation 2012).

GENERAL INDICATOR: HABITAT ACCESS

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Access	Physical Barriers	No manmade barriers present that inhibit salmonid access to tributaries and/or off-channel habitats.	Few manmade barriers present that prevent or inhibit salmonid access to tributaries and/or off-channel habitats.	Many manmade barriers present that prevent or inhibit salmonid access to tributaries and/or off-channel habitats.

Narrative:

Dredge tailings prevent access to off-channel habitats (i.e., connected floodplain patches) that were historically accessible to salmonids. These floodplains and associated floodplain-type side channels historically provided juvenile rearing and high water refugia habitats. Therefore, habitat access is **at risk** due to physical barriers (i.e., dredge tailings) disconnecting floodplain patches. In addition, further evaluation on a man-made structure on Jordan Creek near its confluence with the Yankee Fork is needed to determine if it inhibits upstream passage for juvenile salmonids during certain flows.

GENERAL INDICATOR: INSTREAM WOOD

Criteria: The following criteria were developed by USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Instream Wood	Pieces Per Mile at Bankfull	>20 pieces/mile >12" diameter >35 ft length; and adequate sources of woody debris available for both long- and short-term recruitment.	Currently levels are being maintained at minimum levels desired for "adequate", but potential sources for long-term woody debris recruitment is lacking to maintain these minimum values.	Current levels are not at those desired values for "adequate", and potential sources of woody debris for short- and/or long-term recruitment are lacking.

Narrative:

Channel confinement influences the stream's sediment transport capacity and its ability to transport or retain wood. The Yankee Fork is artificially confined between RM 9.1 and 6.8 by mine tailings. A stream inventory survey conducted by the Forest Service along this channel reach in 2010 determined the wood frequency was less than 1 piece per mile in the main channel (USFS 2010). Wood would not be expected to be retained in this high energy, high transport channel. However, historically the channel was moderately confined between Jordan Creek and Preachers Cove, and unconfined between Preachers Cove to the 1945 Yankee Fork/West Fork confluence. The listed thresholds do not apply to moderately confined plane-bed channels. However, they do provide some indication on the condition of the unconfined, plane-bed to pool-riffle channel segments that historically occurred between Preachers Cove and the 1945 Yankee Fork/West Fork confluence. The threshold for wood frequency should not be expected to be met in a plane-bed to pool-riffle channel due to the inherent higher transport capacity as compared with a pool-riffle channel. Dredge mining has led to the rerouting and artificial confinement of the channel which has changed the system from an unconfined, plane-bed to pool-riffle system to a moderately confined plane-bed channel. Thus, the Yankee Fork is now functioning in an unacceptable condition because it can no longer retain wood and there is an insufficient supply of wood available for recruitment by the stream.

The West Fork channel is unconfined between RM 0.8 and 0.3, and the thresholds listed for wood do apply. There has been some manipulation of the channel around RM 0.4, but otherwise the channel has been able to migrate laterally throughout the rest of this channel segment. An inventory of wood (size and frequency) was not conducted along this channel segment, nor could a stream inventory with wood counts be located. However, for this system, wood debris would be expected to accumulate at the head of vegetated islands, along side channels and outside bends, and on gravel bars. Wood can be observed on the 2010 aerial photographs in these types of locations and there are good sources of wood from upstream and adjacent to the channel. So qualitatively, instream and recruitable wood are **adequate**.

The West Fork was rerouted and artificially confined by mine tailings between RM 0.3 and its confluence with the Yankee Fork. Historically, the combined discharges from Yankee Fork and West Fork flowed in a moderately confined channel at this location, and the changes to the West Fork have resulted in an artificially high energy, high transport capacity channel. Instream wood would not be expected to be retained in this channel segment and there is a lack of wood available to the channel for recruitment. With these functional changes to this system, the instream wood indicator condition is **at risk**.

GENERAL INDICATOR: POOLS

Criteria: The following criteria were adapted from USFWS (1998) and Montgomery and Buffington (1993).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Pools	Pool Frequency and Quality Large Pools (in adult holding, juvenile rearing, and over-wintering reaches where streams are >3 m in wetted width at base flow)	Pool frequency: Channel width — No. pools/mile 0.5 ft — 39 5-10 ft — 60 10-15 ft — 48 15-20 ft — 39 20-30 ft — 23 30-35 ft — 18 35-40 ft — 10 40-65 ft — 9 65-100 ft — 4 For channel widths greater than 100 feet, pool spacing for an alluvial valley type that are moderately confined to unconfined with a channel slope <2% is generally a pool for every 5-7 channel widths (Montgomery and Buffington (1993). Pools have good cover and cool water and only minor reduction of pool volume by fine sediment. Each reach has many large pools >1 m deep with good fish cover.	Pool frequency is similar to values in "functioning adequately", but pools have inadequate cover/temperature, and/or there has been a moderate reduction of pool volume by fine sediment. Reaches have few large pools (>1 m) present with good fish cover.	Pool frequency is considerably lower than values for "functioning adequately", also cover/temperature is inadequate, and there has been a major reduction of pool volume by fine sediment. Reaches have no deep pools (>1 m) with good fish cover.

Narrative:

From RM 9.1 to 6.8, the Yankee Fork has a moderately confined, plane-bed channel. In this type of channel, flow velocities and basal shear stresses tend to armor the bed which inhibits pool development when flows are not sufficient to mobilize the armoring particles. Historically, the channel was moderately confined between Jordan Creek and Preachers Cove, and unconfined between Preachers Cove to the 1945 Yankee Fork/West Fork confluence. The listed thresholds do not apply to moderately confined plane-bed channels. However, they do provide some indication on the condition of the unconfined, plane-bed to pool-riffle channel segments that historically occurred between Preachers Cove and the 1945 Yankee Fork/West Fork confluence. The threshold for pool frequency would expected to be in the lower range of variability for pool frequency due to the inherent higher transport capacity and bed armoring as compared with a pool-riffle channel. The dredge mining has led to the rerouting and artificial confinement of the channel which has changed the system from an unconfined, plane-bed to pool-riffle system to a moderately confined plane-bed channel. This channel reach is now dominated by riffles (84 percent of total wetted area [TWA]) and lacks pools (6 percent TWA) because there are only a few forcing agents that provide sufficient flow convergence to scour the streambed. Thus, the Yankee Fork is now functioning in an **unacceptable** condition because it no longer has the ability to migrate laterally and pool development is limited.

The West Fork channel is unconfined between RM 0.8 and 0.3, and has a plane-bed to pool-riffle channel. The listed thresholds do provide an indication on the condition of this channel reach, and the threshold for pool frequency would be expected to be in the lower range of variability for pool frequency due to the inherent higher transport capacity and bed armoring as compared with a pool-riffle channel. Lateral channel migration has been occurring along most of this channel segment. Channel units are dominated by riffles (77 percent total wetted area [TWA]) with runs (14 percent TWA) and pools (9 percent TWA). The forcing agents associated with pool scour are helical flow and wood along outside bends causing flow convergence and lateral scour, and bank protection that encroaches on the channel causing mid-channel scour. Instream wood does have a significant role in forcing flow convergence sufficient to mobilize the armor layer and scour pools. The expected range of pool habitat is between 14 and 20 percent of the TWA (or a pool every 5 to 7 unvegetated channel widths). Although the West Fork appears to be somewhat lacking in the amount of pool habitat available, it is close to the expected range of variability and is in an **adequate** condition. With the rerouting of the West Fork between RM 0.3 and 0, and the loss of sediment inputs from the Yankee Fork (1945 Yankee Fork/West Fork confluence), the section between RM 0.5 and 0.4 may have become somewhat entrenched due to past channelization efforts and/or lowering the base level (i.e. minor incision on the order of one or two feet).

The West Fork was rerouted and artificially confined by mine tailings between RM 0.3 and its confluence with the Yankee Fork. Historically, the combined discharges from Yankee Fork and West Fork flowed in a moderately confined channel at this location, and the changes to the West Fork have resulted in an artificially high energy, high transport capacity channel. The listed thresholds do not apply to moderately confined plane-bed channels because flow velocities and basal shear stresses tend to armor the bed which inhibits pool development when flows are not sufficient to mobilize the armoring particles. Thus, the West Fork is now functioning in an **at risk** condition because it is no longer moderately confined with the ability to adjust laterally to develop more diverse bedforms.

GENERAL INDICATOR: OFF-CHANNEL HABITAT

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Off-channel Habitat	Connectivity with Main Channel	Reach has many ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are low energy areas. No manmade barriers present along the mainstem that prevent access to off-channel areas.	Reach has some ponds, oxbows, backwaters, and other off-channel areas with cover, and side channels are generally high energy areas. Manmade barriers present that prevent access to off-channel habitat at some flows that are biologically significant.	Reach has few or no ponds, oxbows, backwaters, and other off-channel areas. Manmade barriers present that prevent access to off-channel habitat at multiple or all flows.

Narrative:

The Yankee Fork between RM 9.1 and 6.8 has a moderately confined, plane-bed channel and the listed thresholds are not applicable to this channel type. However, historically the channel was moderately confined between Jordan Creek and Preachers Cove, and unconfined between Preachers Cove to the 1945 Yankee Fork/West Fork confluence. Although the listed thresholds do not apply to moderately confined plane-bed channels, they indicate the unconfined, plane-bed to pool-riffle channel segments that historically occurred between Preachers Cove and the 1945 Yankee Fork/West Fork confluence would have met the lower range of providing off-channel habitat patches as compared with a pool-riffle channel. The dredge mining has led to the rerouting and artificial confinement of the channel which has changed the system from an unconfined, plane-bed to pool-riffle system to a moderately confined plane-bed channel resulting in a net loss of off-channel habitat patches (i.e., floodplain-type habitats). Thus, the Yankee Fork is now functioning in an **unacceptable** condition because the ability to migrate laterally across its historic floodplain to create and maintain off-channel habitats has been reduced.

Between RM 0.8 and 0.3, the West Fork has an unconfined, pool-riffle channel and the thresholds listed for off-channel habitat do apply. Lateral channel migration has been occurring along most of this channel segment and there are good channel/floodplain interactions, except between RM 0.5 and 0.4 where the channel may be entrenched. Available off-channel habitats are primarily floodplain type side channels and wetland areas, and are similar in length and area in the 1945 and 2010 aerial photographs. The exception is near the 1945 West Fork/Yankee Fork confluence area where the West Fork appears to have become entrenched due to channelization and loss of sediment inputs from the Yankee Fork. The West Fork is now functioning in an **adequate** condition, but off-channel habitat could be increased with re-routing the Yankee Fork back to its former channel and floodplain.

The listed thresholds for off-channel habitat are not applicable to the confined West Fork between RM 0.3 and its confluence with the Yankee Fork. Historically, the combined discharges from Yankee Fork and West Fork flowed in a moderately confined channel at this location with a wider floodplain area that provided some off-channel habitat. The changes to the West Fork have resulted in a confined high energy channel that lacks floodplain areas. Thus, the West Fork is now functioning in an **at risk** condition because it is no longer moderately confined with the ability to adjust laterally to develop and maintain a floodplain in which off-channel habitat could be created.

SPECIFIC INDICATOR: FLOODPLAIN CONNECTIVITY

Criteria: The following criteria have been modified from USFWS (1998).

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel Condition	Channel Dynamics	Floodplain Connectivity	Floodplain areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function, riparian vegetation/succession.	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly.

Narrative:

Much of the historic channel paths and floodplains along the Yankee Fork between Jordan Creek and Preachers Cove have been obliterated by dredging activities based on the 1945 and 2010 aerial photographs. The channel had been rerouted around and through the mine tailings by the 1966 aerial photographs and most of the historic channel and floodplains were buried by mounds of mine tailings. Presently, the total acres of existing and historic channel paths (visible on the 2010 LiDAR topography) is about 18.9 acres, of which about 9 percent (5.4 acres) of historic channel paths have been disconnected by mine tailings. Total acres of existing and historic floodplains are about 39.2 acres of which 37 percent (21.5 acres) have been disconnected by mine tailings, embankments, or a push-up levee. The loss of channel and floodplain areas between Preacher Cove and the West Fork has resulted in an increase in channel confinement by about 54 percent, transforming the historically unconfined plane-bed to pool-riffle channel into a moderately confined plane-bed channel. Therefore, floodplain connectivity along this channel segment is **unacceptable**.

The West Fork between RM 0.8 and 0.3 is connected to its floodplain with 8.5 acres of active floodplain and about 16.7 acres of lowland areas with channel swales that are “available floodplain” and delineate the extent that lateral channel migration could be expected to occur. Nearly all the active and available floodplain areas are upstream of the bedrock/alluvial fan constriction (RM 0.3), and are hydraulically connected and in an **adequate** condition.

From RM 0.3 to the mouth, the West Fork has narrow strips of floodplain from RM 0.3 to the mouth due to mine tailings confining the channel. The mine tailings constrain lateral channel migration and restrict the channel from developing a wider floodplain (3 times the unvegetated channel width). Prior to dredging operations, the combined discharges from Yankee Fork and West Fork flowed in a moderately confined channel with a wider, connected floodplain. The changes to the West Fork have resulted in a confined high energy channel that lacks a sufficient floodplain to dissipate streampower. Thus, the West Fork is now functioning **at risk** because it is now confined and has lost the ability to adjust laterally to develop and maintain a floodplain.

SPECIFIC INDICATOR: BANK STABILITY/CHANNEL MIGRATION

Criteria: The criteria for bank stability/channel migration are a relative condition of the specific indicator developed by Reclamation.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel Condition	Channel Dynamics	Bank Stability/ Channel Migration	Channel is migrating at or near natural rates.	Limited amount of channel migration is occurring at a faster/slower rate relative to natural rates, but significant change in channel width or planform is not detectable.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain; or channel migration is occurring at an accelerated rate such that channel width has at least doubled, possibly resulting in a channel planform change, and sediment supply has noticeably increased from bank erosion.

Narrative:

The Yankee Fork between RM 9.1 and 6.8 is constrained by mine tailings. The stream has been rerouted and confined between the mine tailings and alluvial deposits, and to a lesser degree bedrock and colluvial deposits which have a higher percentage of boulders. Many of the banks do not have woody root reinforcement, primarily due to the lack of riparian vegetation and unconsolidated nature of the mine tailings, but remain very stable (over 95 percent of the banks are stable). This bank stability along the mine tailings and alluvial deposits is because (1) they tend to be "self-armoring" in that finer materials (i.e., fines, sands, and gravels) are eroded and coarser materials (i.e., cobbles and boulders) are deposited along the toe of the slope, thus protecting it from erosion, and (2) the sheer size and volume of the material in these deposits overwhelm the stream's ability to erode and transport the sediment. Little channel migration (e.g., lack of bank erosion) has been occurring along this channel reach. Historically, this channel was moderately confined between Jordan Creek and Preachers Cove, and unconfined between Preachers Cove to the 1945 Yankee Fork/West Fork confluence. The rerouting and artificial channel confinement may have modified the channel from an unconfined plane-bed to pool-riffle system with a low to moderate rate of lateral channel migration to a moderately confined plane-bed channel with a low rate of lateral channel migration. Thus, the Yankee Fork is now functioning in an **unacceptable** condition because the stream is constrained by erosion resistant bank materials and can no longer migrate laterally across its historic floodplain.

Bank materials along the West Fork in the unconfined channel segment between RM 0.8 and 0.3 are alluvial deposits comprised primarily of gravel with cobble, sand, and fines. In the confined channel segment between RM 0.3 and 0, the banks are mine tailings comprised primarily cobble with gravel, sand, and boulders based on field observations. The streambanks along the unconfined channel segment are well vegetated and the banks are reinforced by their root system. Whereas, the confined channel segment is well vegetated along the alluvial deposit on river right and has a narrow strip of predominantly alders along the mine tailing on river left. Over 95 percent of the banks are stable throughout the channel reach with most of the active bank erosion occurring in the unconfined channel segment through lateral channel migration processes which is in an **adequate** condition. In the confined channel segment, bank stability along the dredge tailings tend to be "self-armoring" in that finer materials (i.e., fines, sands, and gravels) are eroded and coarser materials (i.e., cobbles and boulders) are deposited along the toe of the slope, thus protecting it from erosion, and the sheer size and volume of the material in these deposits overwhelm the stream's ability to erode and transport the sediment. Thus, the banks are very stable and restrict lateral channel migration processes similar to bank protection (i.e., riprap) that indicates an unacceptable condition.

SPECIFIC INDICATOR: VERTICAL CHANNEL STABILITY

Criteria: The criteria for bank stability/channel migration are a relative condition of the specific indicator developed by Reclamation.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Channel Condition	Channel Dynamics	Vertical Channel Stability	No measurable or observable trend of aggradation or incision and no visible change in channel planform.	Measurable or observable trend of aggradation or incision that has the potential to, but not yet caused, disconnect the floodplain or a visible change in channel planform (e.g. single thread to braided).	Enough incision that the floodplain and off-channel habitat areas have been disconnected; or, enough aggradation that a visible change in channel planform has occurred (e.g. single thread to braided).

Narrative:

Bedrock is shallow (tens of feet) along the Yankee Fork, and crops out along and in the channel in some locations. These bedrock outcrops provide grade controls along the channel channels, limiting the depth to which the channel can incise. There is no observable trend of incision or aggradation, so the vertical channel stability is **adequate**.

SPECIFIC INDICATOR: VEGETATION CONDITION – DISTURBANCE

Criteria: The criteria for riparian vegetation disturbance are a "relative" indication to the functionality of the specific indicator.

General Characteristics	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Riparian/Upland Vegetation	Vegetation Condition	Vegetation Disturbance (Natural/Human)	>80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; <20% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); <2 mi/mi^2 road density in the floodplain.	50-80% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; 20-50% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); 2-3 mi/mi^2 road density in the floodplain.	<50% mature trees (medium-large) in the riparian buffer zone (defined as a 30 m belt along each bank) that are available for recruitment by the river via channel migration; >50% disturbance in the floodplain (e.g., agriculture, residential, roads, etc.); >3 mi/mi^2 road density in the floodplain.

Narrative:

Along the Yankee Fork, the vegetation successional stages in the connected floodplain areas ranged from grassland/forb to small trees condition. Roughly, 78 percent of vegetation was in a grassland/forb to sapling/pole condition. On the active floodplain, the vegetation is generally comprised of a mosaic of grassland/forb, shrub/seedling and sapling/pole conditions. Alders, grasses, and forbs were dominant in the lower areas where floods frequently disturbed the surface and the soil is wetter from seepage through the mine tailings. Grasses with dispersed lodgepole pines were dominant in the higher areas where floods less frequently disturb the surface and the soils tend to be drier. Most of the mine tailings adjacent to the stream are unvegetated with the exception of a narrow strip of sapling-to-pole sized alders that tend to grow along the high-water line. In the disconnected floodplain areas, vegetation successional stages generally range from no vegetation to small trees condition, with nearly all the mine tailings having no vegetation. Based on this qualitative analysis, the vegetation disturbance history associated with dredging the valley bottom has removed mature trees thereby changing the vegetation structure and reduced the riparian buffer width leaving the vegetation in an **unacceptable** condition.

Along the West Fork, the vegetation successional stages in the connected floodplain areas ranged from grassland/forb to large trees condition. Roughly, 95 percent of vegetation was in a shrub/seedling to large trees condition. On the active floodplain, the vegetation is generally comprised of a mosaic of shrub/seedling and small to large trees. Alders, willows, grasses, and forbs were dominant in the lower areas where floods frequently disturbed the surface and the soil was wetter from seepage through the mine tailings. Shrubs and seedlings with dispersed lodgepole pines were dominant in the higher areas where floods less frequently disturb the surface and the soils tend to be drier. Most of the mine tailings adjacent to the stream are unvegetated, except for the narrow strip of sapling-to-pole sized alders that tend to grow along the high-water line. Based on this qualitative analysis, the vegetation in the unconfined channel segment (RM 0.8-0.3) is **adequate**, but in the confined channel segment (RM 0.3-0), the vegetation disturbance associated with dredging the valley bottom has removed mature trees thereby changing the vegetation structure and reduced the riparian buffer width leaving the vegetation in an **unacceptable** condition.

REFERENCES

Parenthetical Reference	Bibliographic Citation
Berenbrock 2002	Berenbrock, C. 2002. "Estimating the magnitude of peak flows at selected recurrence intervals for streams in Idaho." U.S. Geological Survey Water-Resources Investigation Report 02-4170, 59 p.
Bisson and Montgomery 1996	Bisson, P., and Montgomery, D. 1996. Valley segments, stream reaches, and channel units: in Hauer, F.R. and Lamberti, G.A., eds. Methods in stream ecology. San Diego, CA: Academic Press: p. 23-52.
Fenneman 1931	Fenneman, N. 1931. *Physiography of the Western United States*. McGraw-Hill, New York, 534 p.
Hillman and Giorgi 2002	Hillman, T., and Giorgi, A. 2002. *Monitoring protocols: effectiveness monitoring of physical/environmental indicators in tributary habitats*, prepared for the Bonneville Power Administration: BioAnalysts, Inc., Boise, Idaho. 104 pp.
IDEQ 2003	Idaho Department of Environmental Quality. 2003. *Upper Salmon River subbasin assessment and TMDL*: Idaho Department of Environmental Quality, Boise, Idaho, 217 p.
Montgomery and Buffington 1993	Montgomery, D., and Buffington, J. 1993. "Channel classification, prediction of channel response, and assessment of channel condition." *Washington State Timber, Fish & Wild-life*: p.84 + figures
Montgomery and Buffington 1998	Montgomery, D., and Buffington, J. 1998. *Channel processes, classification, and response: in River Ecology and Management*. Robert Naiman & Robert Bilby [editors]: Springer-Verlag New York, Inc., p. 13-39.
NOAA Fisheries 1996	NOAA's National Marine Fisheries Service. 1996. *Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale* [Matrix of Pathways and Indicators]: NOAA's National Marine Fisheries Service, Northwest Region, Portland, Oregon.
ODFW 2010	Oregon Department of Fish and Wildlife. 2010. *Aquatic inventories project methods for stream habitat surveys*. Oregon Department of Fish and Wildlife, Aquatic Inventories Project, Conservation and Recovery Program, Corvallis, Oregon 70 p.
Reclamation 2012	U.S. Department of the Interior, Bureau of Reclamation. 2012. *Yankee Fork Tributary Assessment, Upper Salmon Subbasin, Custer County, Idaho.* Pacific Northwest Region, Boise, Idaho. 153 p.

Parenthetical Reference	Bibliographic Citation
Rodeheffer 1935	Rodeheffer, I.A. 1935. *A Survey of the Waters of the Challis National Forest, Idaho*. Department of Commerce, Bureau of Fisheries. Washington.
USFS 1994	U.S. Department of Agriculture, Forest Service. 1994. Section 7 fish habitat monitoring protocol for the Upper Columbia River Basin. Pacific Northwest, Intermountain, and Northern Regions. 59 p.
USFS 2006	U.S. Department of Agriculture, Forest Service. 2006. *Biological assessment for the potential effects of managing the Salmon-Challis National Forest in the Yankee Fork Section 7 Watershed on Snake River Basin Spring/Summer Chinook Salmon, Snake River Steelhead, and Columbia River Bull Trout [Draft]*. U.S. Department of Agriculture, Salmon-Challis National Forest, Yankee Fork Ranger District, Clayton, Idaho. 126 p.
USFS 2010	U.S. Department of Agriculture, Forest Service. 2010. *Yankee Fork of the Salmon River, 2010 Stream Survey Report*. Salmon-Challis National Forest, Yankee Fork Ranger District. Prepared by La Grande Ranger District, Wallowa-Whitman National Forest, La Grande, Oregon. 37 p.
USFWS 1998	U.S. Fish and Wildlife Service. 1998. *A framework to assist in making Endangered Species Act determinations of effect for individual or grouped actions at the Bull Trout subpopulation watershed scale*. 49 p.
USGS 1995	U. S. Geological Survey. 1995. "Geology and Mineral Resource Assessment of the Challis 1º X 2º Quadrangle." *Professional Paper 1525*. U.S. Geological Survey, U.S. Government Printing Office, Washington, 204 p. + maps.
Watershed Sciences 2010	Watershed Sciences. 2010. *Airborne Thermal Infrared Remote Sensing, Yankee Fork River Basin, Idaho*. September 27, 2010.

This page intentionally left blank

APPENDIX B

Reach Assessment Analysis

This page intentionally left blank

Appendix B

Overview

In this analysis and report, valley segments, channel reaches, and channel units are described using the following methodology:

1. Valley shape is described based on Naiman et al. (1992) classification of valley bottom types.

2. Valley confinement, defined as the degree that geologic or geomorphic features constrain the lateral migration of the stream, are described as confined (valley floor width less than 2 channel widths), moderately confined (valley floor width equal to 2 to 4 channel widths), or unconfined (valley floor width greater than 4 channel widths).

3. Valley types are classified as colluvial, alluvial, or bedrock as described in Buffington and Montgomery (1997).

4. Channel reaches are classified based on specific types of channel units and specific ranges of channel characteristics as described in Montgomery and Buffington (1998) and Bisson, Buffington, and Montgomery (2006).

5. Channel patterns are classified as (1) straight, (2) meandering, (3) island braided, and (4) braided channels, and can be used to interpret river-floodplain dynamics (Beechie et al. 2006).

6. Channel units, sometimes referred to as habitat units, are relatively homogeneous localized areas of the channel that differ in depth, velocity, and strata characteristics from adjoining areas (Bisson, Buffington, and Montgomery 2006).

7. The floodplain, for this assessment, is divided into the (1) active floodplains defined as those areas that have evidence of relatively recent disturbance (on the order of 5 to 10 years) by the stream such as vegetated bars and overbank deposits, (2) available floodplains defined as those low lying areas that would likely be inundated during the 100-year flood event and provide room for lateral channel migration, and (3) disconnected floodplains that are historic floodplains that are hydraulically disconnected from the channel due to anthropogenic disturbances such as mine tailing or embankments.

8. The channel is divided into (1) active channels that are unvegetated due to frequent flow disturbances that inhibit vegetation growth and approximates the area where channel forming flows occur, and (2) disconnected channels that are historic

channels that are hydraulically disconnected from the channel due to anthropogenic disturbances.

9. Vegetation analysis included a predominantly qualitative analysis of vegetation successional stages based on relative height classification (USFS 2010) interpreted from 2010 aerial photographs and ground photographs.

Valley Segments and Channel Confinement

Yankee Fork

The Yankee Fork valley segment (Geomorphic Reach YF-3 in the Tributary Assessment) was shaped by alpine glaciers that carved a U-shaped trough during the Pleistocene Epoch between roughly 2.5 million and 10,000 years ago. Tables 1 and 2 summarize the historical and existing valley and channel metrics.

Table 1. Yankee Fork historical (1945) valley and channel metrics.

Location	Year	Constrained Valley Length	Average Constrained Valley Width	Average Unvegetated Channel Width	Channel Confinement
Jordan Creek to Preachers Cove	1945	8,941 feet	182 feet	57 feet	Moderately Confined
Preachers Cove to 1945 Yankee Fork/West Fork Confluence	1945	1,451 feet	435 feet	81 feet	Unconfined

Table 2. Yankee Fork existing (2010) valley and channel metrics.

Metrics	RM 9.1 to 6.8
Constrained Valley Width	122 feet
Constrained Valley Length	12,104 feet
Channel Length	12,364 feet
Unvegetated Channel Width	48 feet
Channel Confinement	Moderately Confined (2.5)
Channel Gradient	1 percent
Sinuosity	1.02
Average Width/Depth Ratio	30.2 (USFS 2010)
Dominant Substrate	Cobble (64-256 mm)
Substrate Gradiation (Approx.)	Cobble (45%); Boulder (25%); Gravel (20%); Sand (10%)
Bank Stability	Greater Than 90 Percent Stable
Bank Composition	Predominantly Cobble With Boulder, Gravel and Sand

West Fork

The West Fork valley segment from downstream of Sawmill Creek to the Yankee Fork confluence was shaped by alpine glaciers that carved a U-shaped trough during the Pleistocene Epoch. Tables 3 and 4 summarize the historical and existing valley and channel metrics.

Table 3. West Fork historical (1945) valley and channel metrics.

Location	Year	Constrained Valley Length	Average Constrained Valley Width	Average Unvegetated Channel Width	Channel Confinement
Below Sawmill Creek to 1945 Mouth	1945	2,224 feet	503 feet	64 feet	Unconfined

Table 4. West Fork existing (2010) valley and channel metrics.

Metrics	RM 0.8 to 0.3	RM 0.3 to 0
Constrained Valley Width	475 feet	94 feet
Constrained Valley Length	2,677 feet	1,555 feet
Channel Length	2,813 feet	1,652 feet
Unvegetated Channel Width	47 feet	49 feet
Channel Confinement	Unconfined (10.1)	Confined (1.9)
Channel Gradient	0.8 percent	0.6 percent
Sinuosity	1.1	1.1
Average Width/Depth Ratio	54[1]	54[1]
Dominant Substrate	Gravel	Gravel with Cobbles
Substrate Gradiation (Approx.)	60% Gravel; 25% Sand; 15% Cobble; Trace Fines	50% Gravel; 30% Cobble; 15% Sand; 5% Fines
Bank Stability	Greater Than 95%[1]	Greater Than 95%[1]
Bank Composition	Predominantly Gravel With Cobble, Sand and Boulders	Predominantly Cobble With Gravel, Sand and Boulders

[1]Estimated from R1/R4 Stream survey conducted by Yankee Fork Ranger District, Challis National Forest 2002

Channel Reaches

Yankee Fork

Two historical (pre-dredging) channel reaches and one existing (post-dredging) channel reach where identified along the Yankee Fork from (1) Jordan Creek to Preachers Cove and (2) Preachers Cove to West Fork. These channel reaches are defined in Table 5.

Table 5. Location of identified pre-dredging and post-dredging channel reaches.

Channel Reach	Average Constrained Valley Width	Channel Confinement
Jordan Creek to Preachers Cove (Pre-dredging)	182 feet	Moderately Confined
Preachers Cove to West Fork (Pre-dredging)	475 feet	Unconfined
Jordan Creek to West Fork (Post-dredging)	94 feet	Moderately Confined

West Fork

One historical (pre-dredging) channel reach and two existing (post-dredgine) channel reaches where identified along the West Fork from (1) Sawmill Creek to 1945 Yankee Fork confluence and (2) 1945 Yankee Fork confluence to 2012 Yankee Fork confluence. These channel reaches are defined in Table 6.

Table 6. Location of identified pre-dredging and post-dredging channel reaches.

Channel Reach	Average Constrained Valley Width	Channel Confinement
Sawmill Creek to 1945 Yankee Fork Confluence (Pre-dredging)	182 feet	Unconfined
Sawmill Creek to 1945 Yankee Fork Confluence (Post-dredging)	435 feet	Unconfined
1945 Yankee Fork Confluence to 2010 Yankee Fork Confluence (Post-dredging)	122 feet	Confined

Channel Units

The channel units used in this report are based on the classification system proposed by Hawkins et al. (1993) and are typically identified during low flow discharge which often makes them indistinguishable from each other during higher discharges due to a change in the hydraulic properties (Bisson, Buffington and Montgomery 2006).

Unvegetated bars, vegetated bars, secondary side channels, and tertiary side channels were added to the analysis based on Washington State Department of Ecology Publication #03-06-027: A Framework for Delineating Channel Migration Zones (WSDOE 2003).

Yankee Fork

Table 7 summarizes the channel and bar units delineated along the Yankee Fork between Jordan Creek and 2010 West Fork confluence based on field observations and 2010 aerial photographs. Figures 1 through 6 show the delineated channel and bar units.

Table 7. Yankee Fork summary of channel and bar units.

Type	Count[1]	Area[2]	Average Size
Pool	7	0.6 acres	0.09 acres
Riffle	25	9.0 acres	0.36 acres
Run	9	0.9 acres	0.19 acres
Rapid	7	0.2 acres	0.03 acres
Secondary Channel	13	1.2 acres	0.09 acres
Tertiary Channel	5	0.3 acres	0.06 acres
Unvegetated Bar	39	1.3 acres	0.03 acres
Vegetated Bar	12	2.3 acres	0.19 acres
Totals	**117**	**15.8 acres**	**0.14 acres**

[1]Must be over 0.01 acres to be counted
[2]Rounded to the nearest tenth of an acre

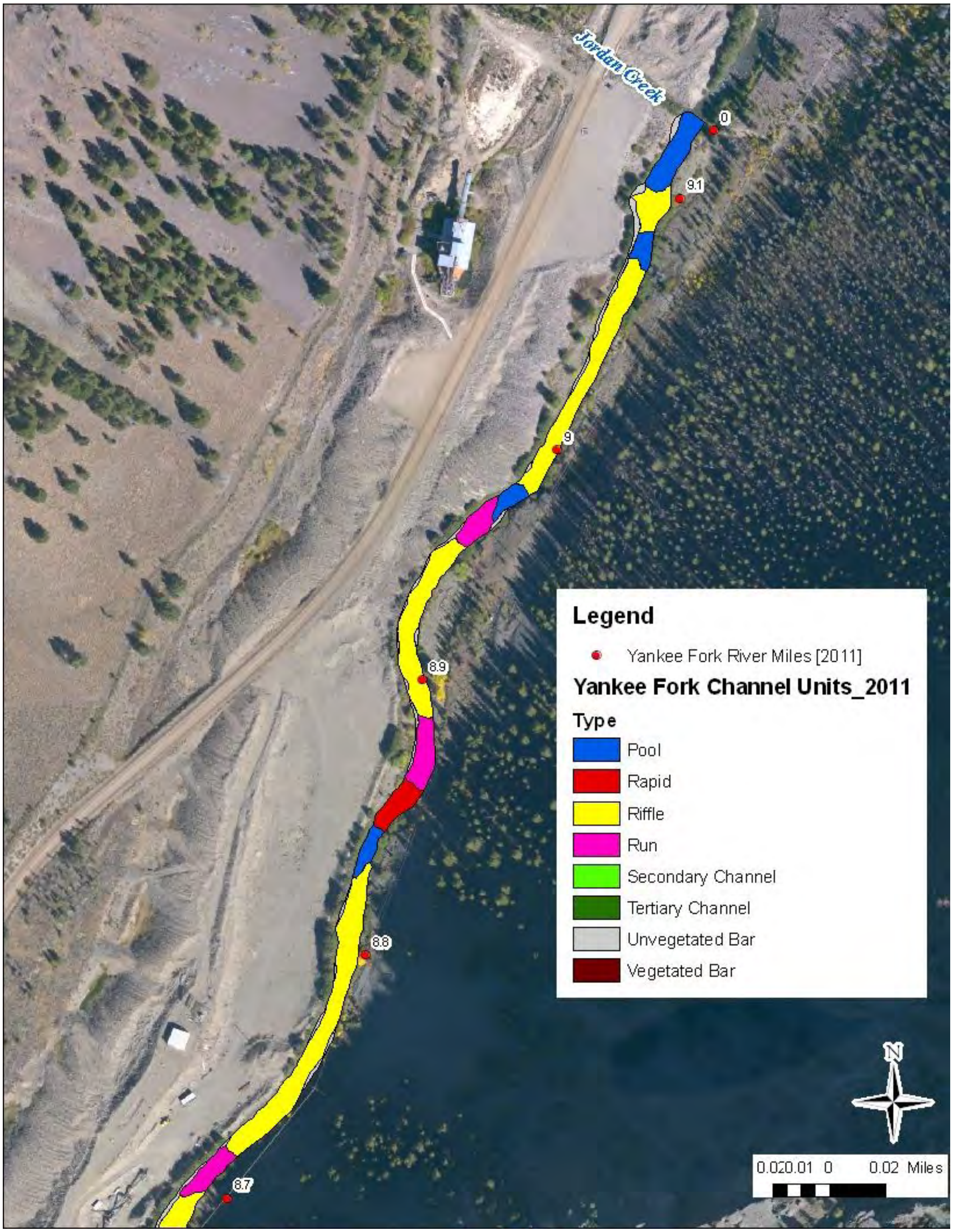


Figure 1. Channel and bar units delineated between RM 9.1 and 8.7.

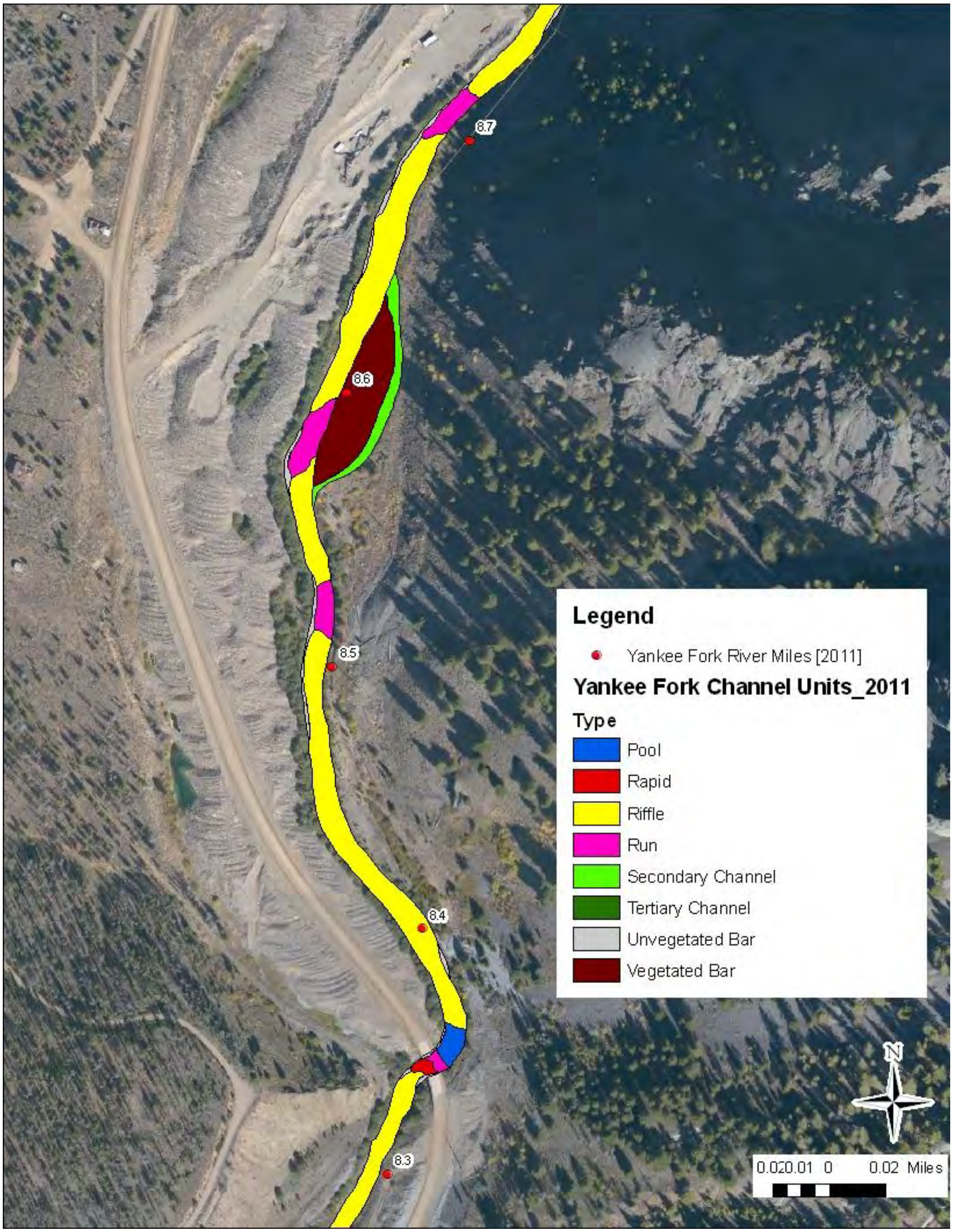


Figure 2. Channel and bar units delineated between RM 8.7 and 8.3.

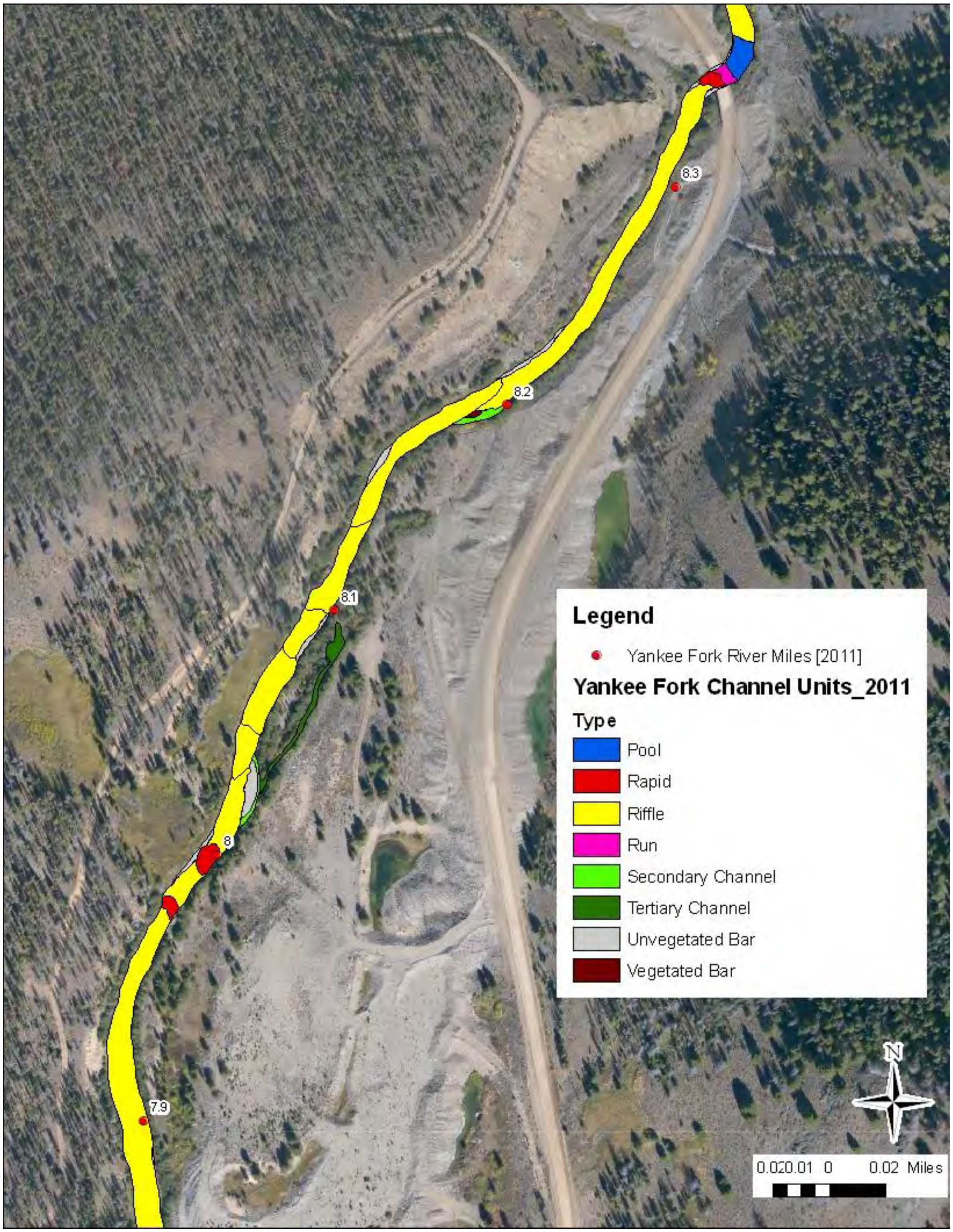


Figure 3. Channel and bar units delineated between RM 8.3 and 7.9.

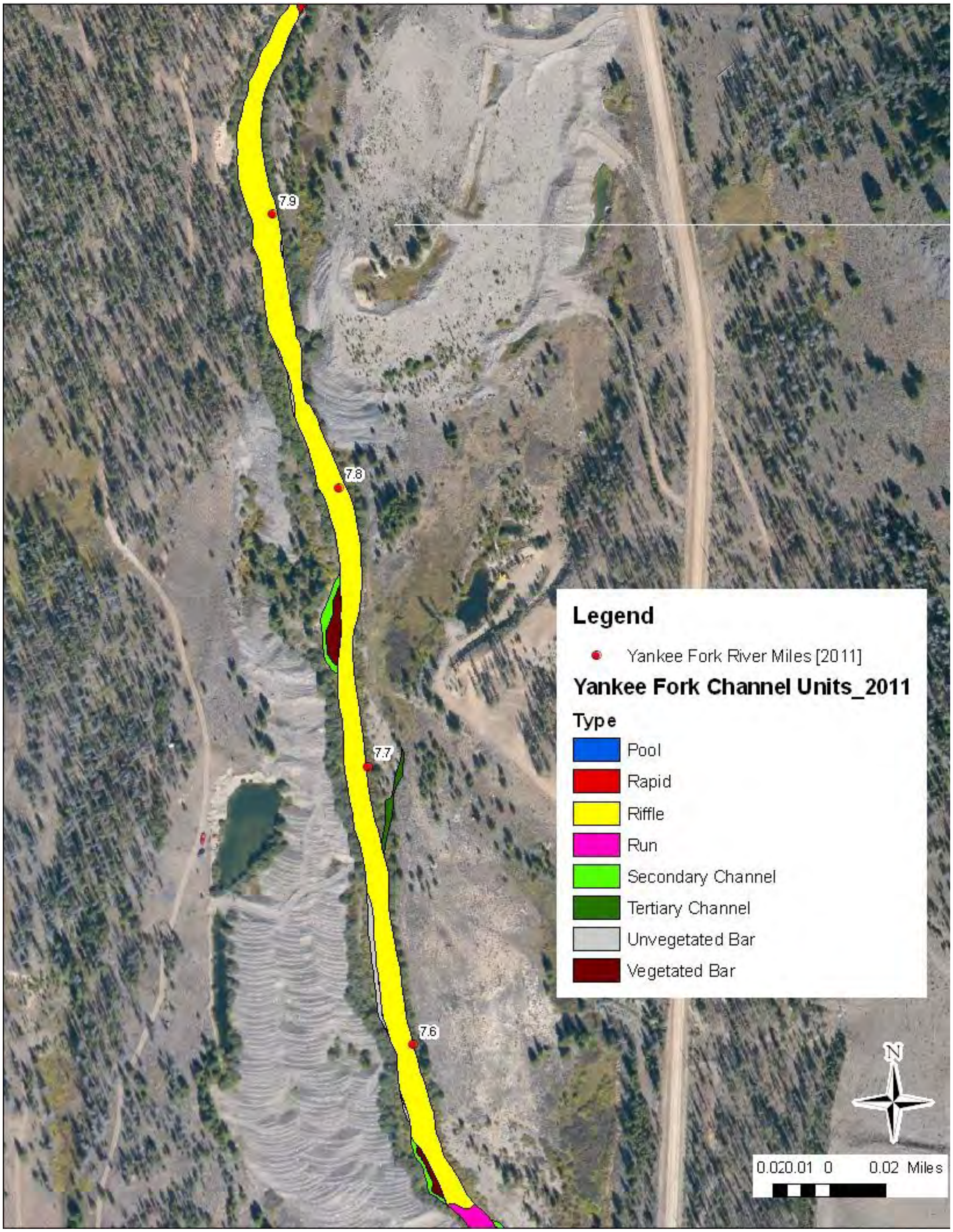


Figure 4. Channel and bar units delineated between RM 7.9 and 7.6.

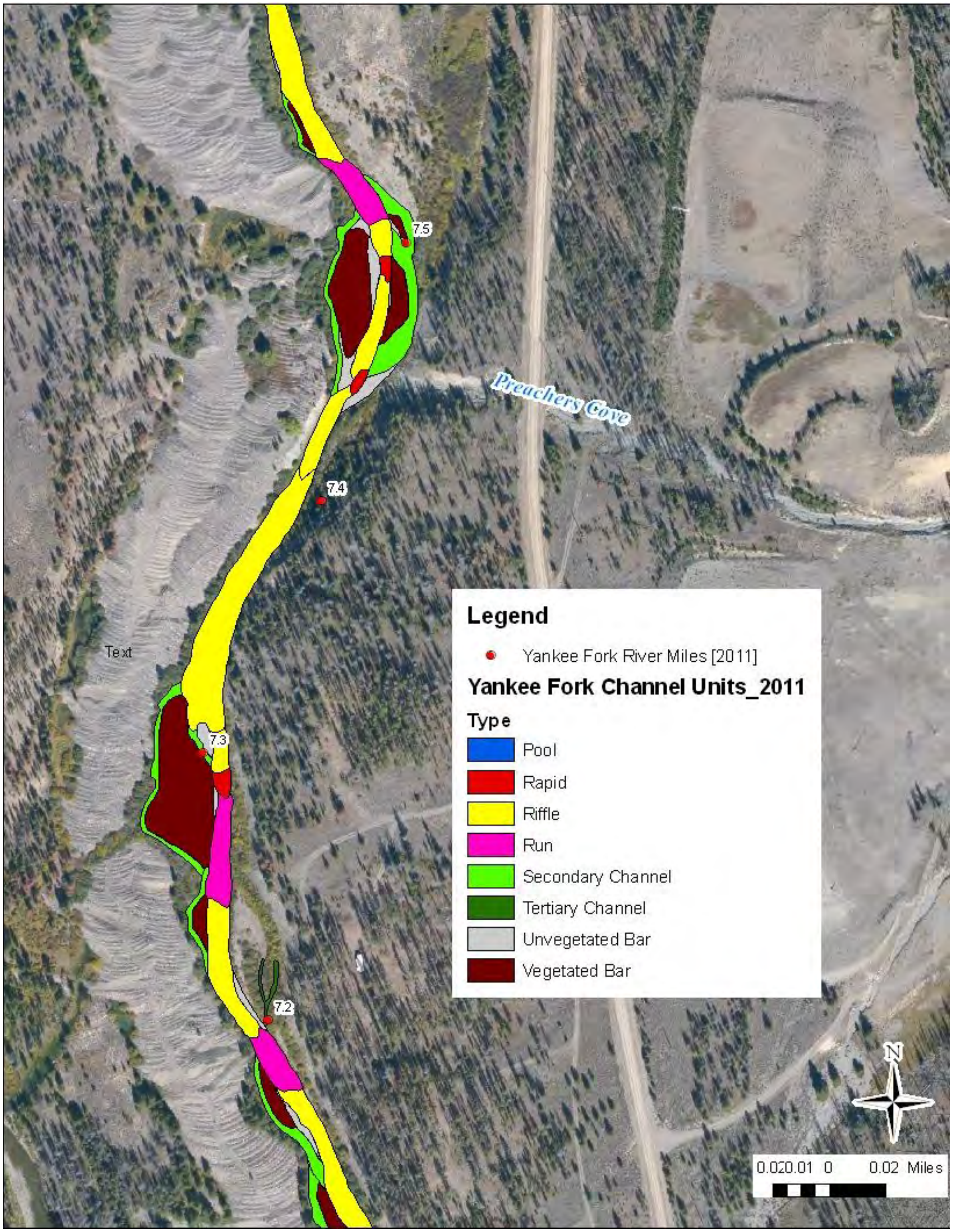


Figure 5. Channel and bar units delineated between RM 7.6 and 7.2.

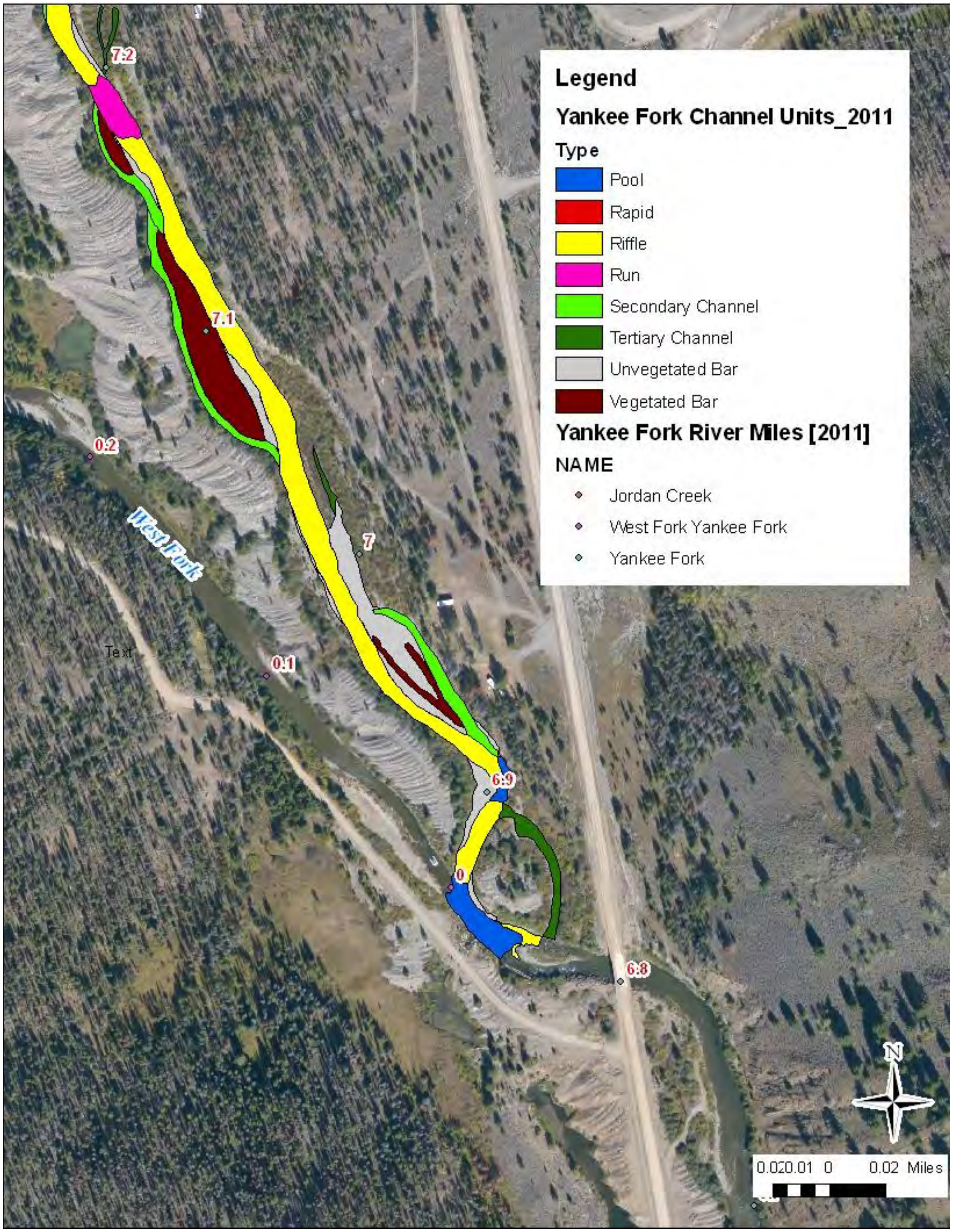


Figure 6. Channel and bar units delineated between RM 7.2 and 6.8.

West Fork

Table 8 summarizes the channel and bar units delineated along the West Fork between Sawmill Creek and 2010 West Fork confluence based on field observations and 2010 aerial photographs. Figures 7 through 9 show the delineated channel and bar units.

Table 8. West Fork summary of channel and bar units.

Type	Count[1]	Area[2]	Average Size
Pool	5	0.3 acres	0.06 acres
Riffle	11	2.4 acres	0.22 acres
Run	9	1.0 acres	0.11 acres
Rapid	1	---	---
Secondary Channel	6	0.9 acres	0.15 acres
Tertiary Channel	3	0.2 acres	0.07 acres
Tailings Pond	1	0.1 acres	0.1 acres
Unvegetated Bar	12	0.8 acres	0.07 acres
Vegetated Bar	11	1.4 acres	0.13 acres
Totals	**59**	**7.1 acres**	**0.12 acres**

[1]Must be over 0.01 acres to be counted
[2]Rounded to the nearest tenth of an acre

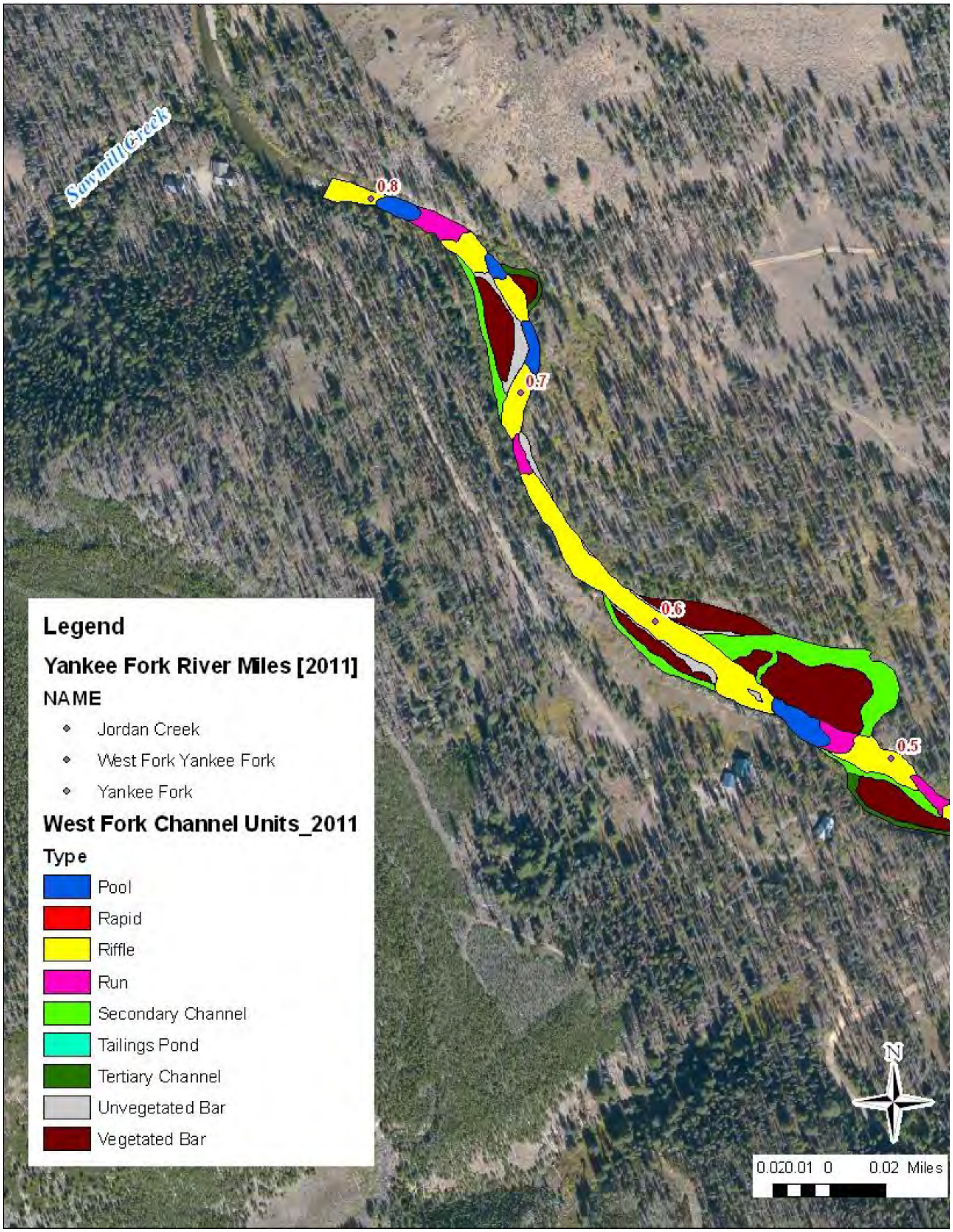


Figure 7. Channel and bar units delineated between RM 0.8 and 0.5.

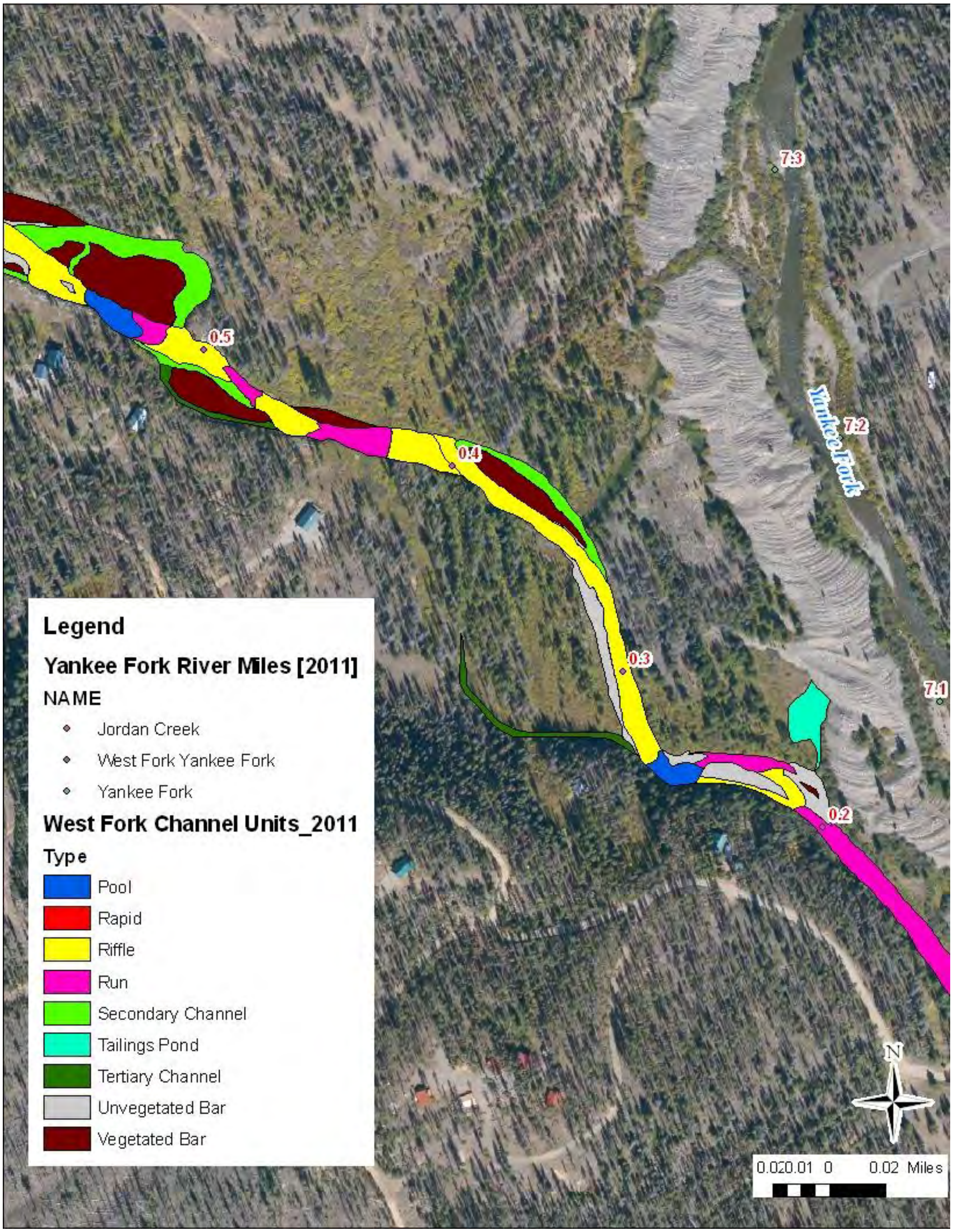


Figure 8. Channel and bar units delineated between RM 0.5 and 0.2.

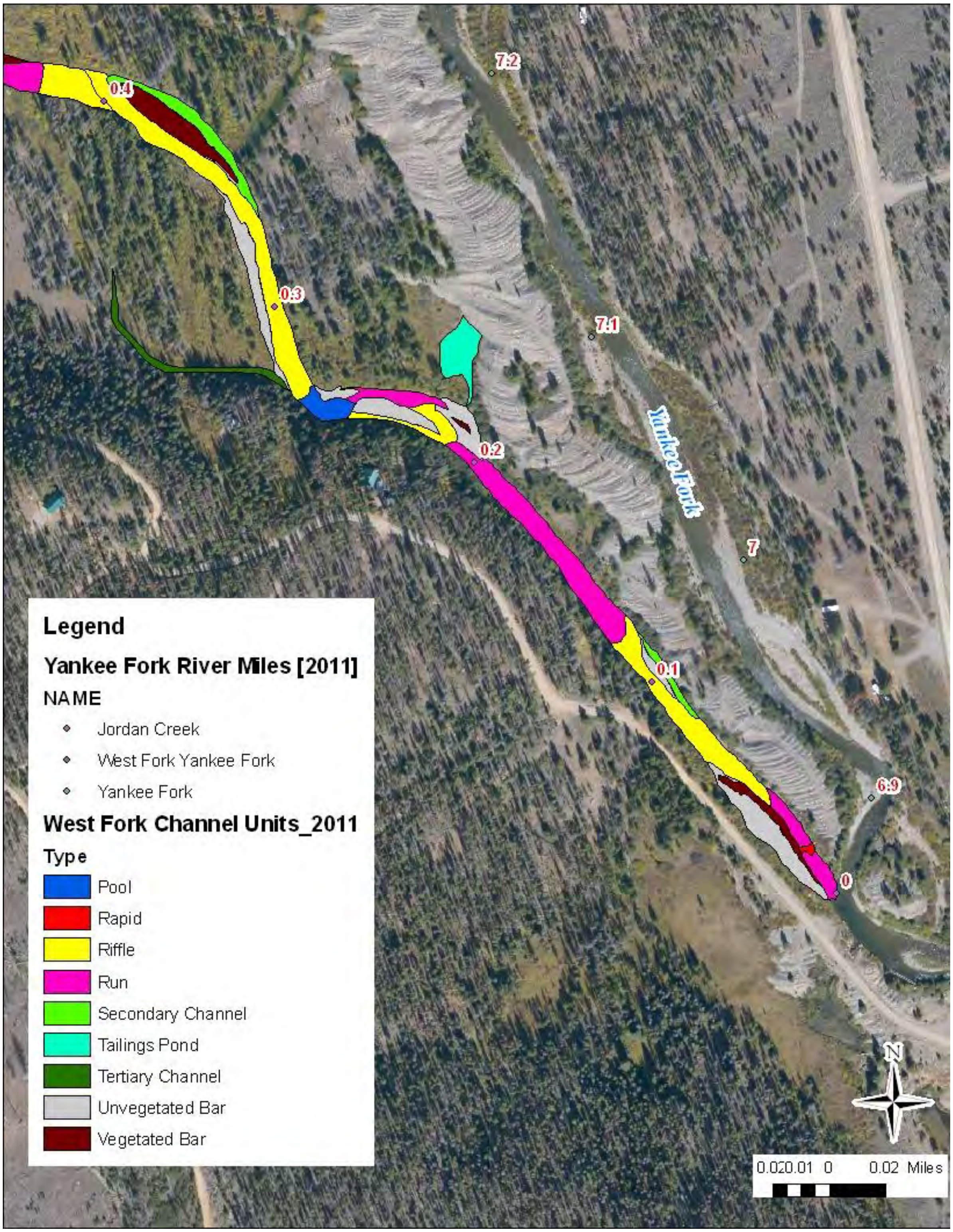


Figure 9. Channel and bar units delineated between RM 0.4 and 0.

Off-channel Habitat

Lengths of secondary side channels and tertiary side channels were added to the analysis based on Washington State Department of Ecology Publication #03-06-027: A Framework for Delineating Channel Migration Zones (WSDOE 2003).

Yankee Fork

Table 9 summarizes the side channel types, number of side channels, and lengths (in feet) of side channels, the primarily off-channel habitat in this channel segment. Figures 10 through 12 show the locations of the delineated side channels.

Table 9. Yankee Fork summary of side channels.

Side Channel Type	Activation	Count	Length	Average Length
Split-Flow	Secondary	4	1,089 feet	272 feet
Floodplain	Secondary	10	2,717 feet	272 feet
Overflow	Tertiary	4	854 feet	214 feet

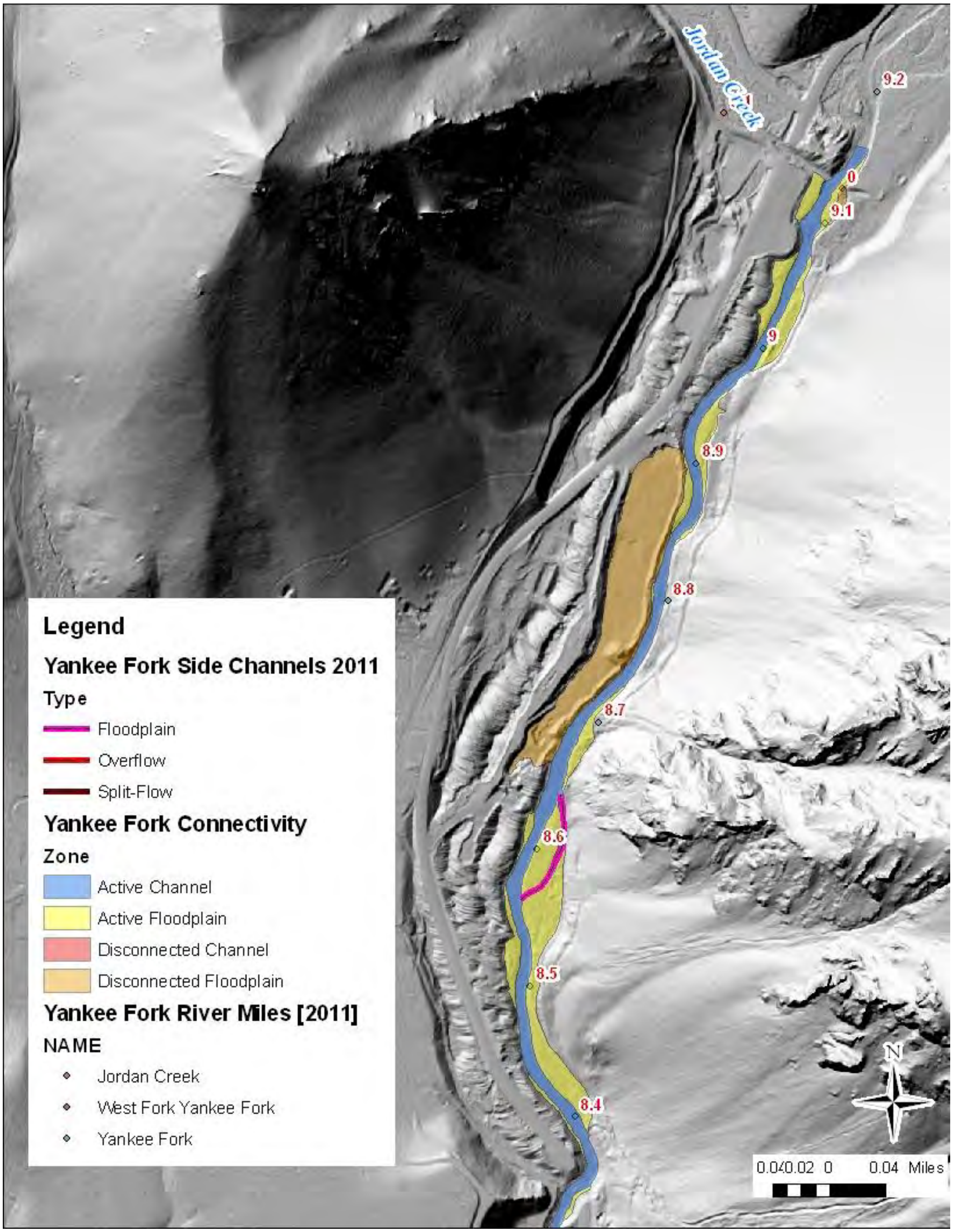


Figure 10. Side channel locations in reference to the channel and floodplain from RM 9.1 to 8.4.

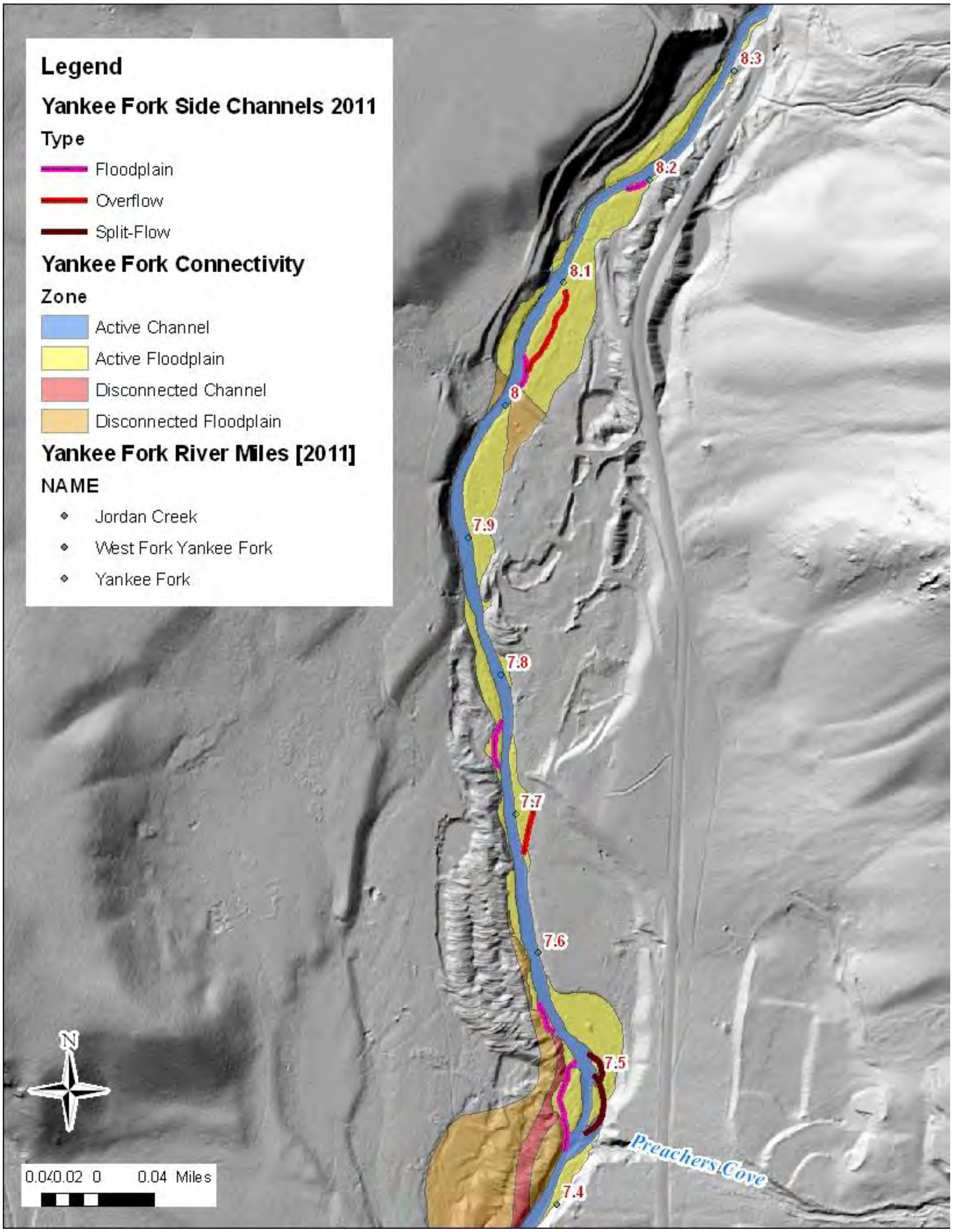


Figure 11. Side channel locations in reference to the channel and floodplain from RM 8.3 to 7.5.

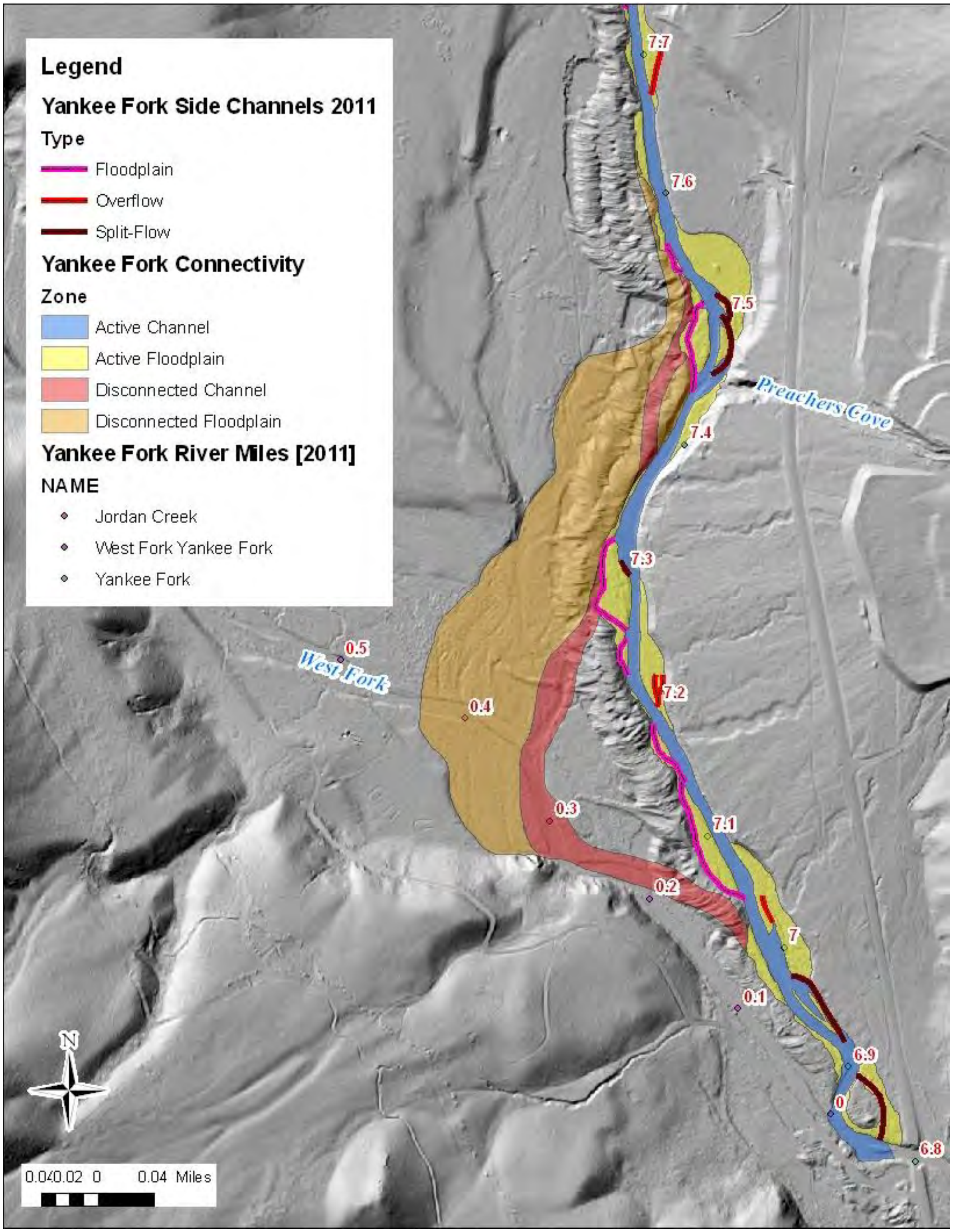


Figure 12. Side channel locations in reference to the channel and floodplain from RM 7.7 to 6.8.

West Fork

Table 10 summarizes the side channel types, number of side channels, and lengths (in feet) of side channels, the primarily off-channel habitat in this channel segment. Figures 13 through 15 show the locations of the delineated side channels.

Table 10. West Fork summary of groundwater and side channels.

Side Channel Type	Activation	Count	Length	Average Length
Groundwater	Primary	4	1,133 feet	283 feet
Split-Flow	Secondary	5	1,098 feet	220 feet
Floodplain	Secondary	4	1,398 feet	350 feet
Overflow	Tertiary	8	2,684 feet	336 feet

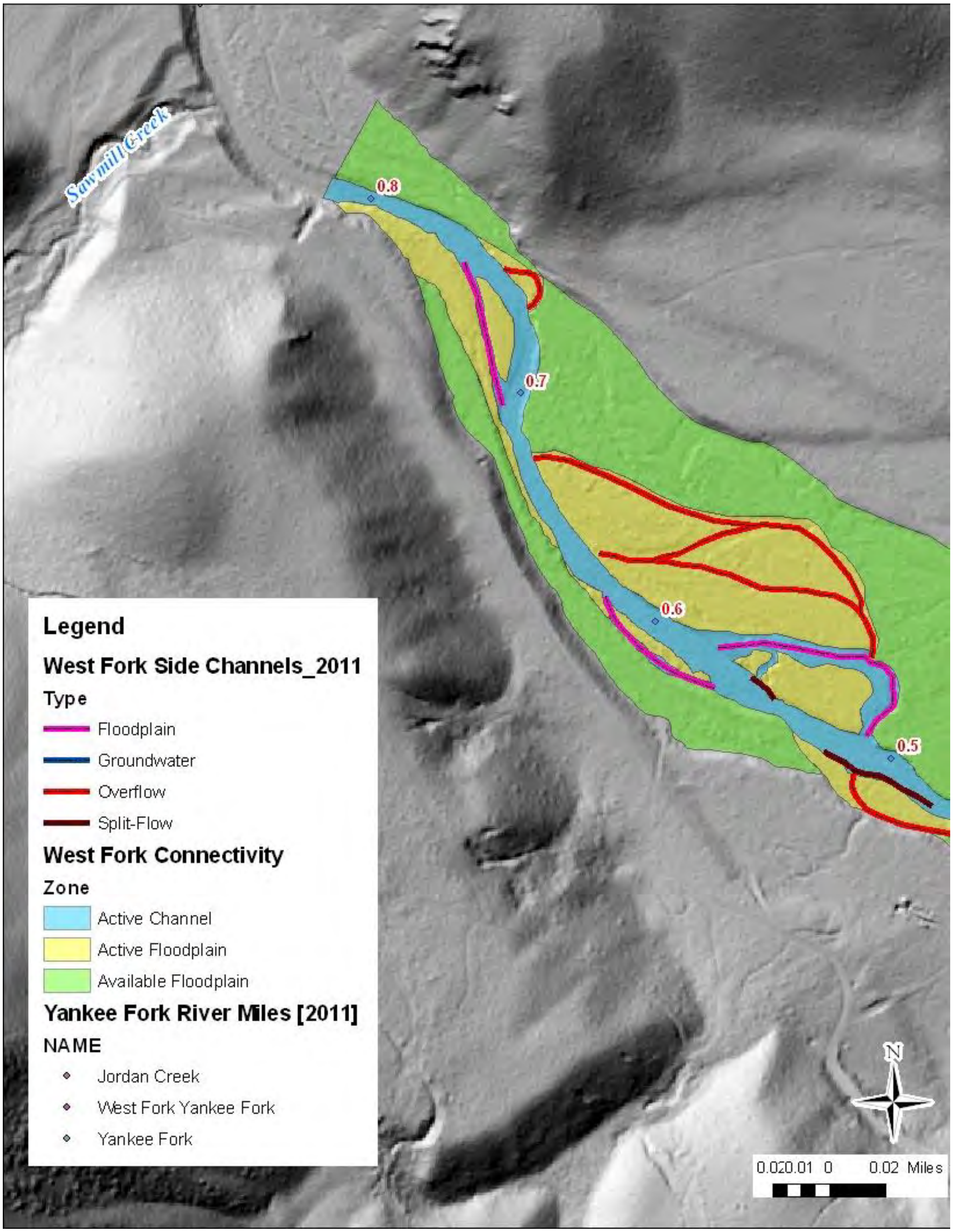


Figure 13. Side channel locations in reference to the channel and floodplain from RM 0.8 to 0.5.

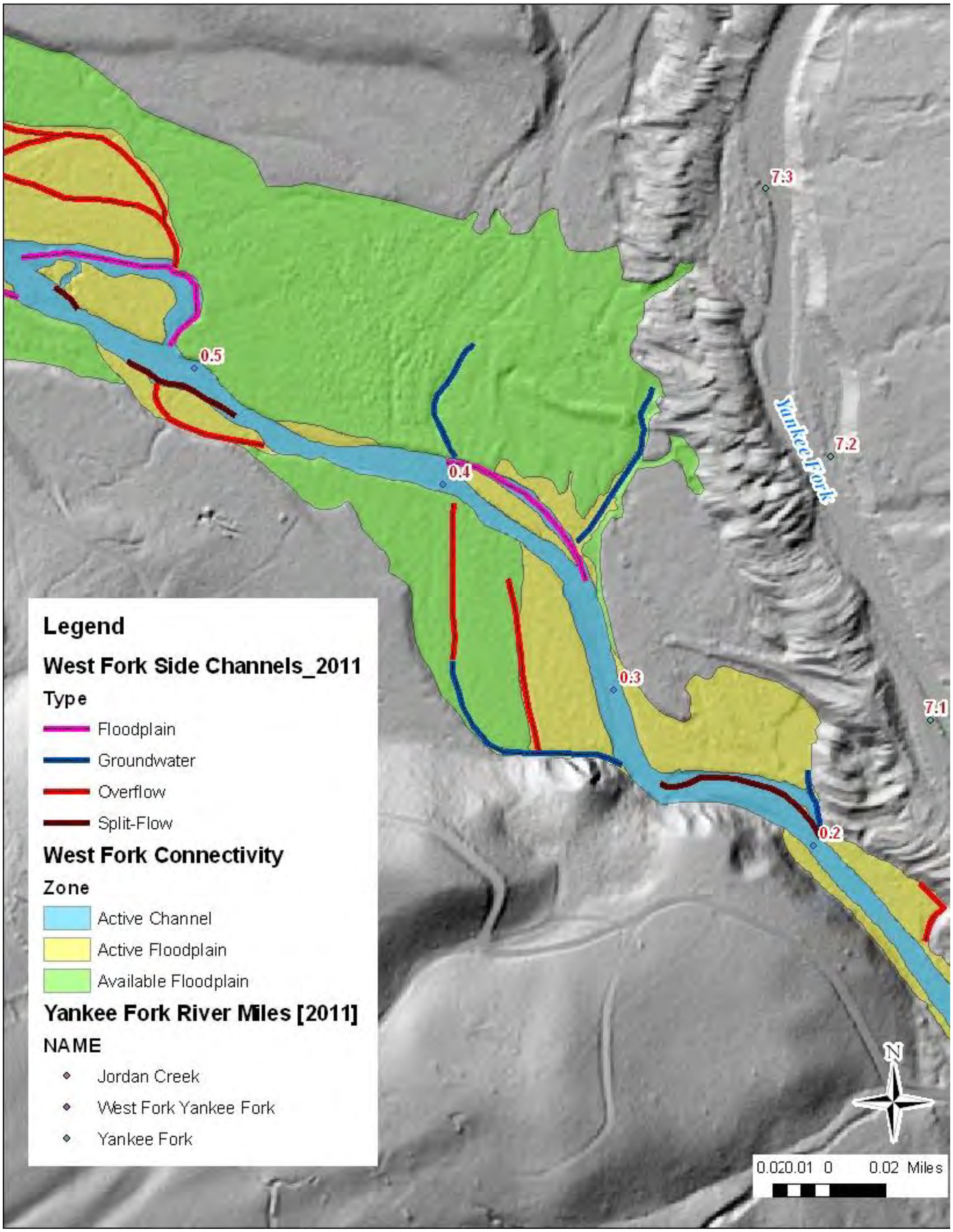


Figure 14. Side channel locations in reference to the channel and floodplain from RM 0.5 to 0.2.

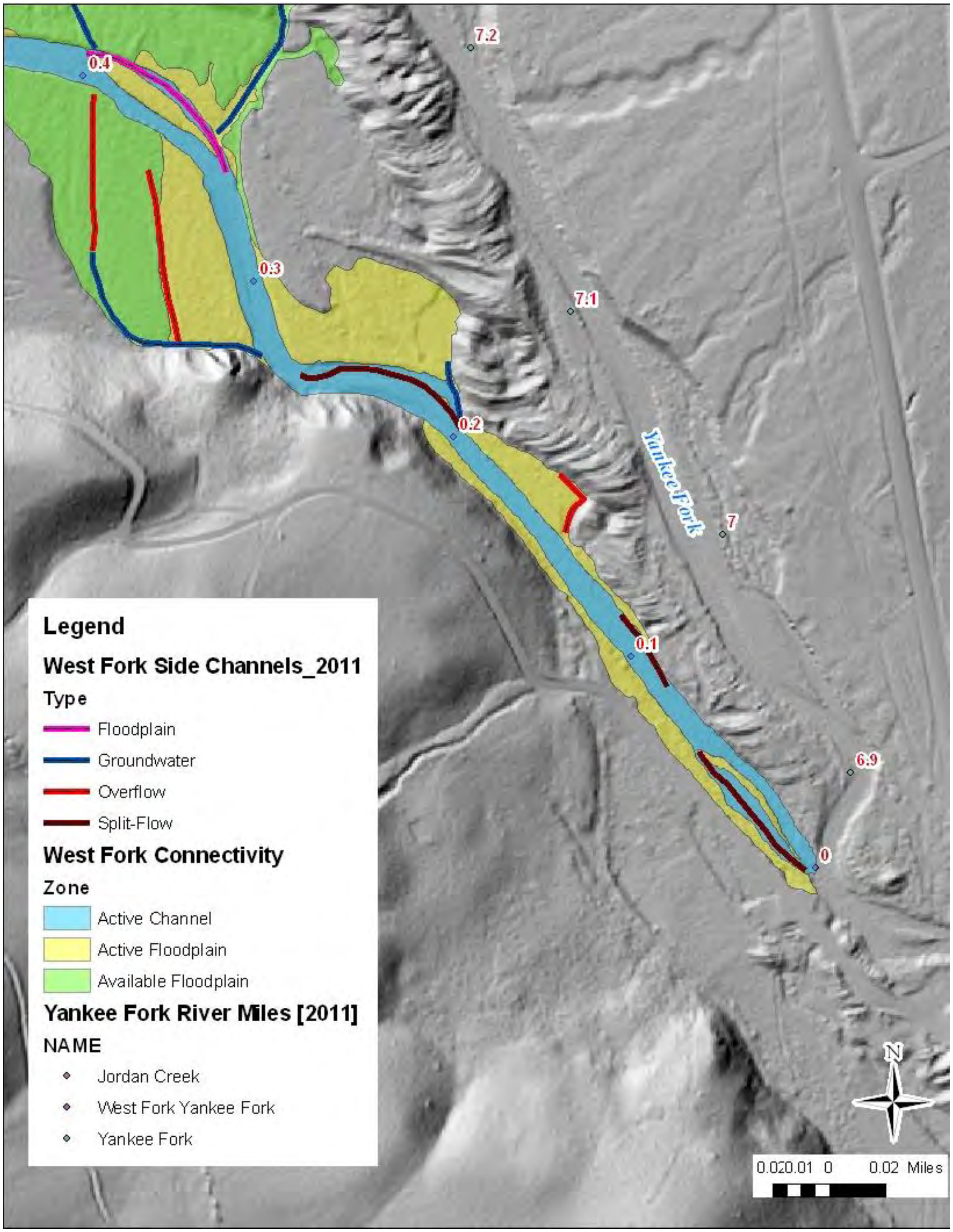


Figure 15. Side channel locations in reference to the channel and floodplain from RM 0.4 to 0.

Wolman Pebble Count Analysis

Wolman pebble counts were conducted on the Yankee Fork below and above the Yankee Fork/West Fork confluence, and on the West Fork in the unconfined channel segment (RM 0.8 and 0.3) and in the confined channel segment (RM 0.3 to 0). The pebble counts were conducted by Edward W. Lyon, Jr. (Geomorphologist) and Paul Drury (Hydraulic Engineer), Bureau of Reclamation, Pacific Northwest Regional Office, Boise, Idaho on September 15, 2011.

Depositional features along the channel system (i.e. bars) provide an indication of the size of material that is being transported by the stream as bedload during channel forming flows. Unvegetated areas of bars were chosen where particles were imbricated, indicating the particles were being transported during channel forming flows. The purpose was to quantify the particle sizes being transported by the stream within the following channel segments: (1) moderately confined section of the Yankee Fork between Jordan Creek and West Fork, (2) below the Yankee Fork/West Fork confluence, (3) unconfined channel segment on the West Fork, and (4) confined channel segment on the West Fork.

Figure 16 shows the locations where the Wolman pebble counts were conducted. Photographs and gradation results follow the location map and are included for each of the pebble count locations.

Figure 16. Map showing the locations of pebble counts and photographs.

Pebble Count (PC-1) Yankee Fork near RM 7.00

Location: Bar near head of secondary, split-flow channel near RM 7.00 on the Yankee Fork

Classification: Coarse Gravel with Cobble

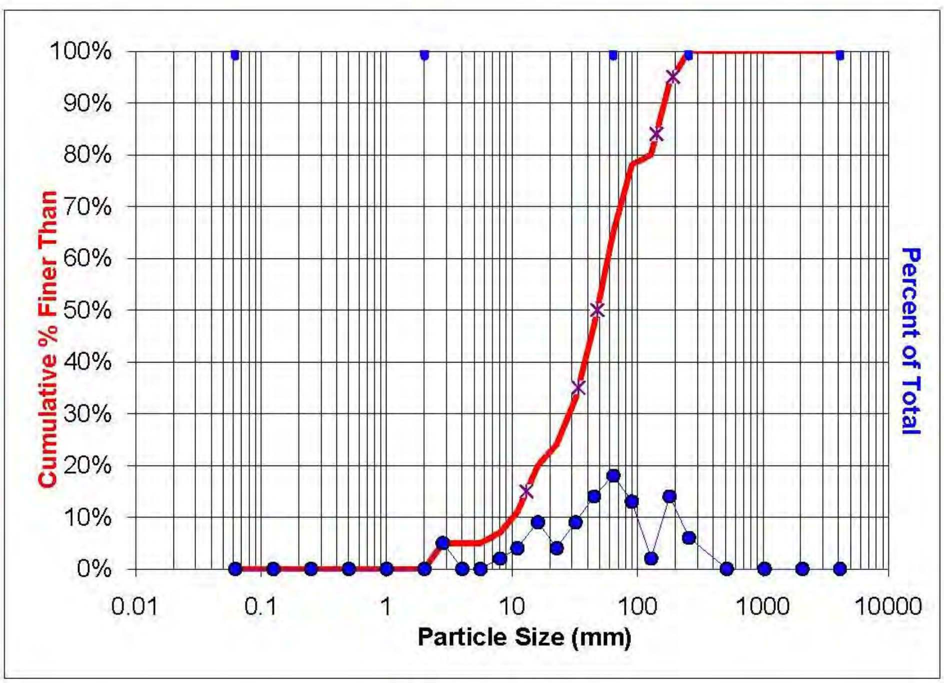
Visual Gradation: 40% Cobble, 25% Gravel, 20% Sand/Fines, 15% boulders

Pebble Count Tally:

Size Range Worksheet

Size Range (mm)	Classification	Total Count
0.062 - 2.0	Sand	0
2 - 8	Fine Gravel	7
8 - 16	Medium Gravel	13
16 - 64	Coarse Gravel	45
64 - 256	Cobble	35
256 - 4096	Boulder	0

Pebble Count Gradation:



Particle Size Distribution:

Particle Size	D15	D35	D50	D84	D95
Distribution (mm)	13.0	33.6	47.7	141.1	190.9

Photograph No. 1. Zoomed in photograph of bar material near Yankee Fork RM 7.00. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 15, 2011.

Photograph No. 2. Zoomed out photograph looking upstream at bar near Yankee Fork RM 7.00. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 15, 2011.

Pebble Count (PC-2) West Fork near RM 0.70

Location: Point bar in unconfined channel segment near RM 0.70 on the West Fork

Classification: Coarse Gravel with Medium Gravel

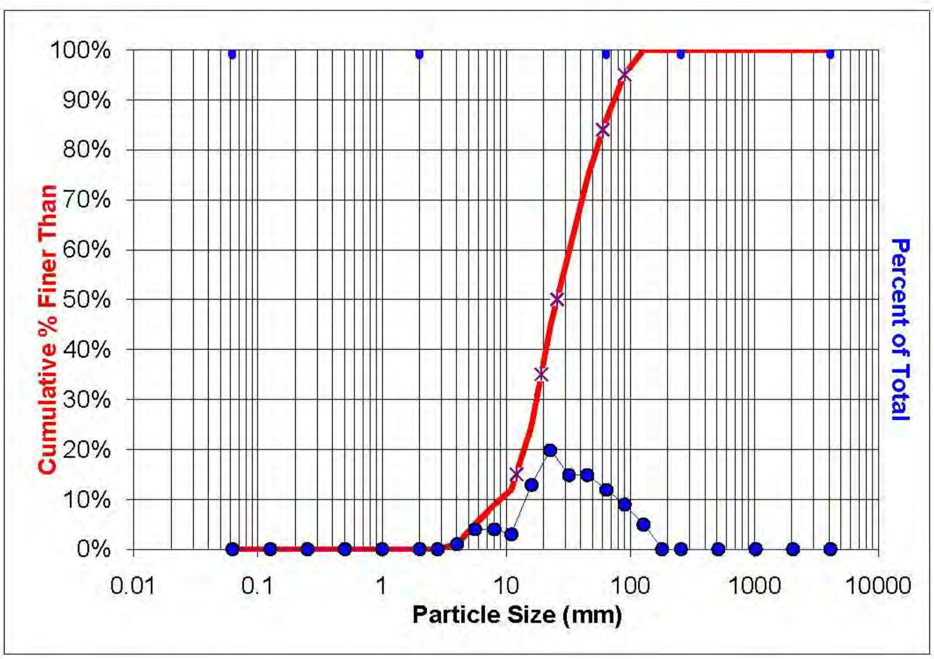
Visual Gradation: 60% Gravel, 25% Sand, 15% Cobble, Trace of Fines

Pebble Count Tally:

Size Range Worksheet

Size Range (mm)	Classification	Total Count
0.062 - 2.0	Sand	0
2 - 8	Fine Gravel	9
8 - 16	Medium Gravel	16
16 - 64	Coarse Gravel	62
64 - 256	Cobble	14
256 - 4096	Boulder	0

Pebble Count Gradation:



Particle Size Distribution:

Particle Size	D15	D35	D50	D84	D95
Distribution (mm)	12.0	19.1	25.7	60.1	89.8

Photograph No. 3. Zoomed in photograph of bar material near West Fork RM 0.70. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 15, 2011.

Photograph No. 4. Zoomed out photograph looking downstream at bar near West Fork RM 0.70. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 15, 2011.

Pebble Count (PC-3) Yankee Fork near RM 6.85
Location: Bar at apex of vegetated island directly downstream of the Yankee Fork/West Fork confluence near RM 6.85 on the Yankee Fork

Classification: Cobble and Coarse Gravel

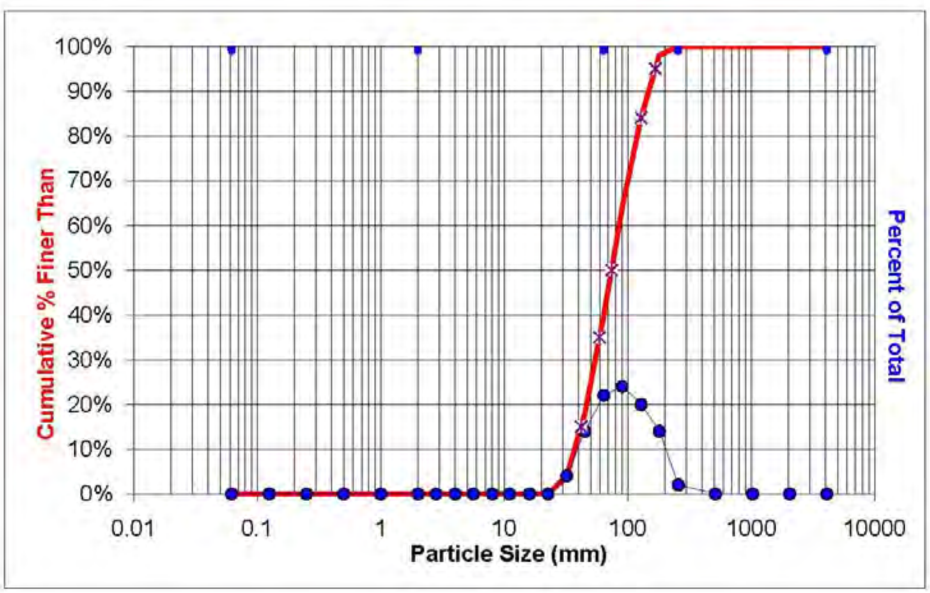
Visual Gradation: 60% Cobble, 25% Gravel, 10% Boulder, 5% Sand/Fines

Pebble Count Tally:

Size Range Worksheet

Size Range (mm)	Classification	Total Count
0.062 - 2.0	Sand	0
2 - 8	Fine Gravel	0
8 - 16	Medium Gravel	0
16 - 64	Coarse Gravel	40
64 - 256	Cobble	60
256 - 4096	Boulder	0

Pebble Count Gradation:



Particle Size Distribution:

Particle Size	D15	D35	D50	D84	D95
Distribution (mm)	41.8	59.1	73.8	128.0	167.3

Photograph No. 5. Zoomed in photograph of bar material near Yankee Fork/West Fork confluence at Yankee Fork RM 6.85. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 15, 2011.

Photograph No. 6. Zoomed out photograph looking downstream at bar near Yankee Fork/West Fork confluence near Yankee Fork RM 6.85. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 15, 2011.

Pebble Count (PC-4) West Fork near RM 0.10

Location: Bar near head of secondary, split-flow channel near RM 0.10 on the West Fork

Classification: Coarse Gravel with Cobble

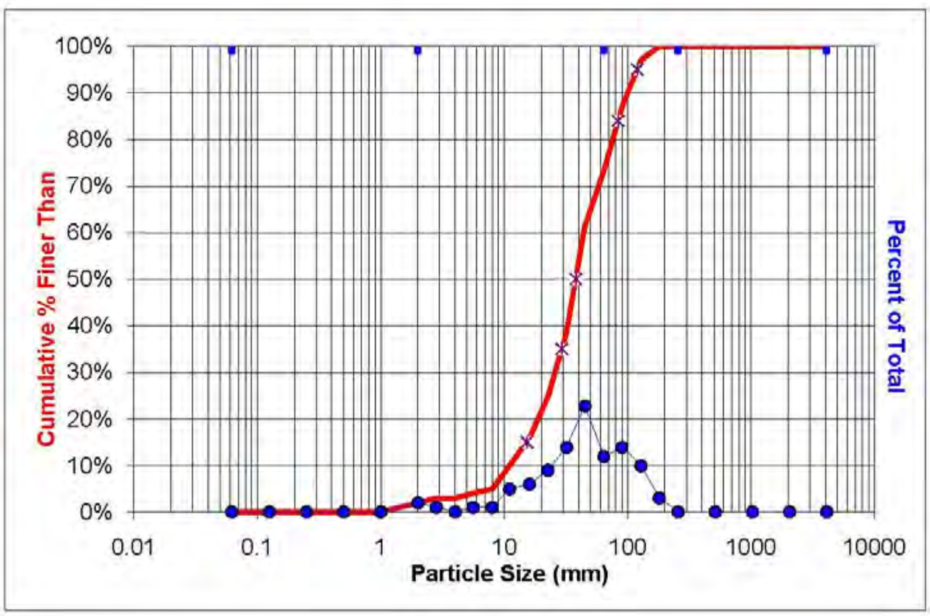
Visual Gradation: 50% Gravel, 30% Cobble, 15% Sand, 5% Fines

Pebble Count Tally:

Size Range Worksheet

Size Range (mm)	Classification	Total Count
0.062 - 2.0	Sand	2
2 - 8	Fine Gravel	3
8 - 16	Medium Gravel	11
16 - 64	Coarse Gravel	58
64 - 256	Cobble	27
256 - 4096	Boulder	0

Pebble Count Gradation:



Particle Size Distribution:

Particle Size	D15	D35	D50	D84	D95
Distribution (mm)	15.2	29.2	37.9	83.3	119.1

Photograph No. 7. Zoomed in photograph of bar material near West Fork RM 0.10. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 15, 2011.

Photograph No. 8. Zoomed out photograph looking upstream at bar near West Fork RM 0.10. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 15, 2011.

REFERENCES

Parenthetical Reference	Bibliographic Citation
Beechie et al. 2006	Beechie, T., Liermann, M., Pollock, M., Baker, S., and Davies, J., 2006. Channel pattern and river-floodplain dynamics in forested mountain river systems: Geomorphology 78 (2006) p. 124-141.
Bisson, Buffington, and Montgomery 2006	Bisson, P., Buffington, J., and Montgomery, D. 2006. *Valley segments, stream reaches, and channel units: in Methods in Stream Ecology*. Elsevier, p. 23-49.
Hawkins et al. 1993	Hawkins, C., Kershner, J., Bisson, P., Bryant, M., Decker, L., Gregory, S., McCullough, D., Overton, C., Reeves, G., Steedman, R., and Young, M. 1993. A hierarchical approach to classifying stream habitat features: Fisheries 18: 3-12.
Montgomery and Buffington 1997	Buffington, J.M. and D.R. Montgomery. 1997. "A Systematic Analysis of Eight Decades of Incipient Motion Studies, With Special Reference to Gravel-Bedded Rivers." *Water Resources Research, Vol. 33, No. 8*, Pages 1993-2029.
Montgomery and Buffington 1998	Montgomery, D., and Buffington, J. 1998. *Channel processes, classification, and response: in River Ecology and Management*. Robert Naiman & Robert Bilby [editors]: Springer-Verlag New York, Inc., p. 13-39.
Naiman et al. 1992	Naiman, R.J., Lonzarich, D.G., Beechie, T.J., and Ralph, S.C. 1992. "General principles of classification and the assessment of conservation potential in rivers." Pages 93-123 in: P.J. Boon, P. Calow, and G.E. Petts, editors. River conservation and management. John Wiley and Sons, New York, NY.
USFS 2010	U.S. Department of Agriculture, Forest Service. 2010. *Yankee Fork of the Salmon River, 2010 Stream Survey Report.* Salmon-Challis National Forest, Yankee Fork Ranger District. Prepared by La Grande Ranger District, Wallowa-Whitman National Forest, La Grande, Oregon. 37 p.
WSDOE 2003	Washington State Department of Ecology. 2003. A framework for delineating channel migration zones; Ecology Publication #03-06-027: Washington State Department of Ecology, Olympia, Washington 66 p.

APPENDIX C

Photographic Documentation

This page intentionally left blank

Appendix C

Bonanza Area Reach Photographic Log

Photographic documentation of the Bonanza area reach was completed during the fall 2011 in support of the document, *Bonanza Area Reach Assessment, Yankee Fork of the Salmon River, Custer County, Idaho*. Photographs were taken in the field and their location and direction were noted on aerial photographs. The photopoints were then mapped using GIS and are provided as Figures 1 through 3. Each photograph was captioned with the direction of the photograph, subject matter, and date, and provided as Photographs 1 through 80 in this appendix.

PHOTOGRAPH LOCATION DOCUMENTATION

Aerial photographs showing photograph locations for the Yankee Fork and West Fork are provided in Figures 1 through 3.

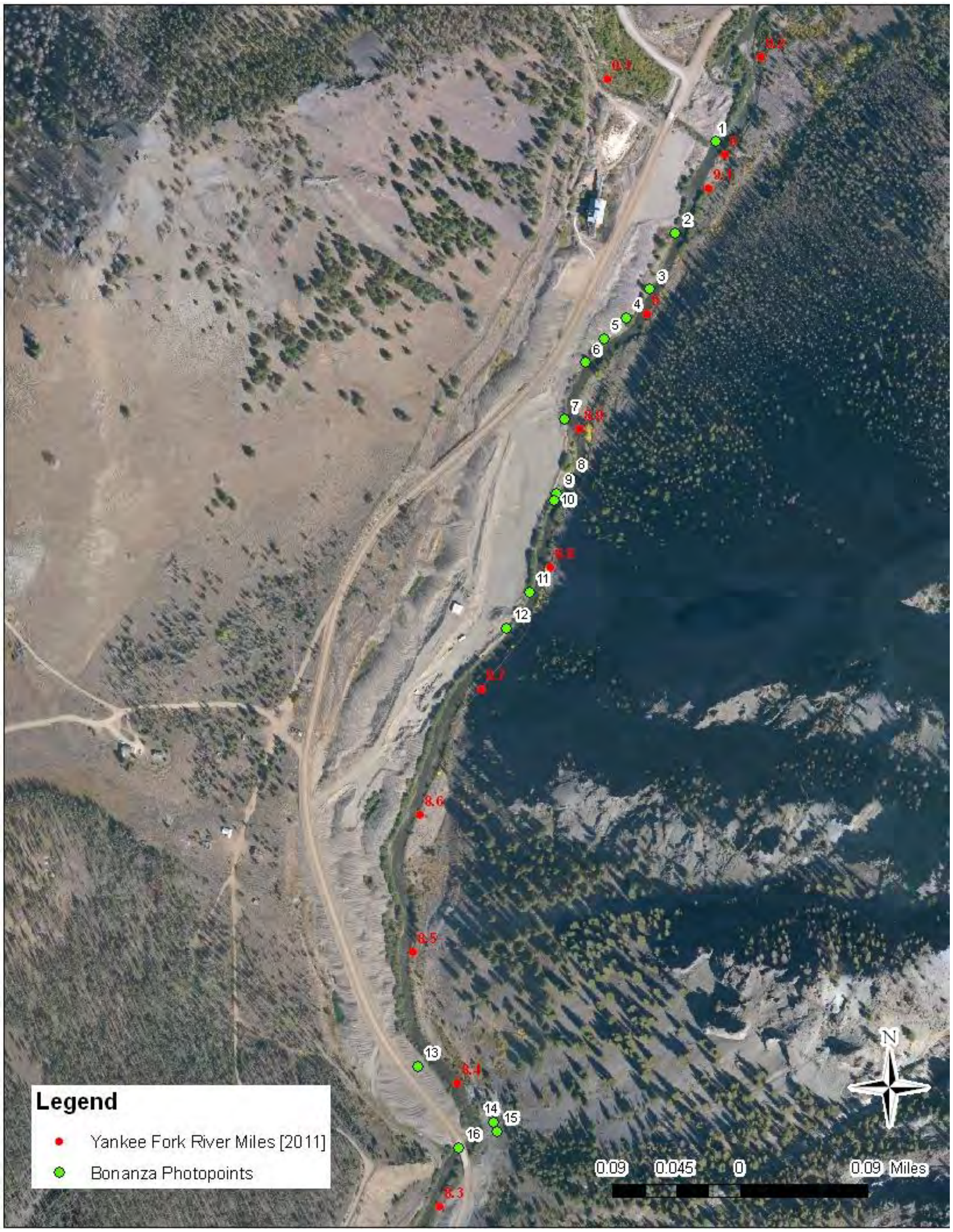


Figure 1. Photographic locations along the Yankee Fork between river miles (RM) 9.1 and 8.3.

Figure 2. Photographic locations along the Yankee Fork between RM 8.3 and 7.6.

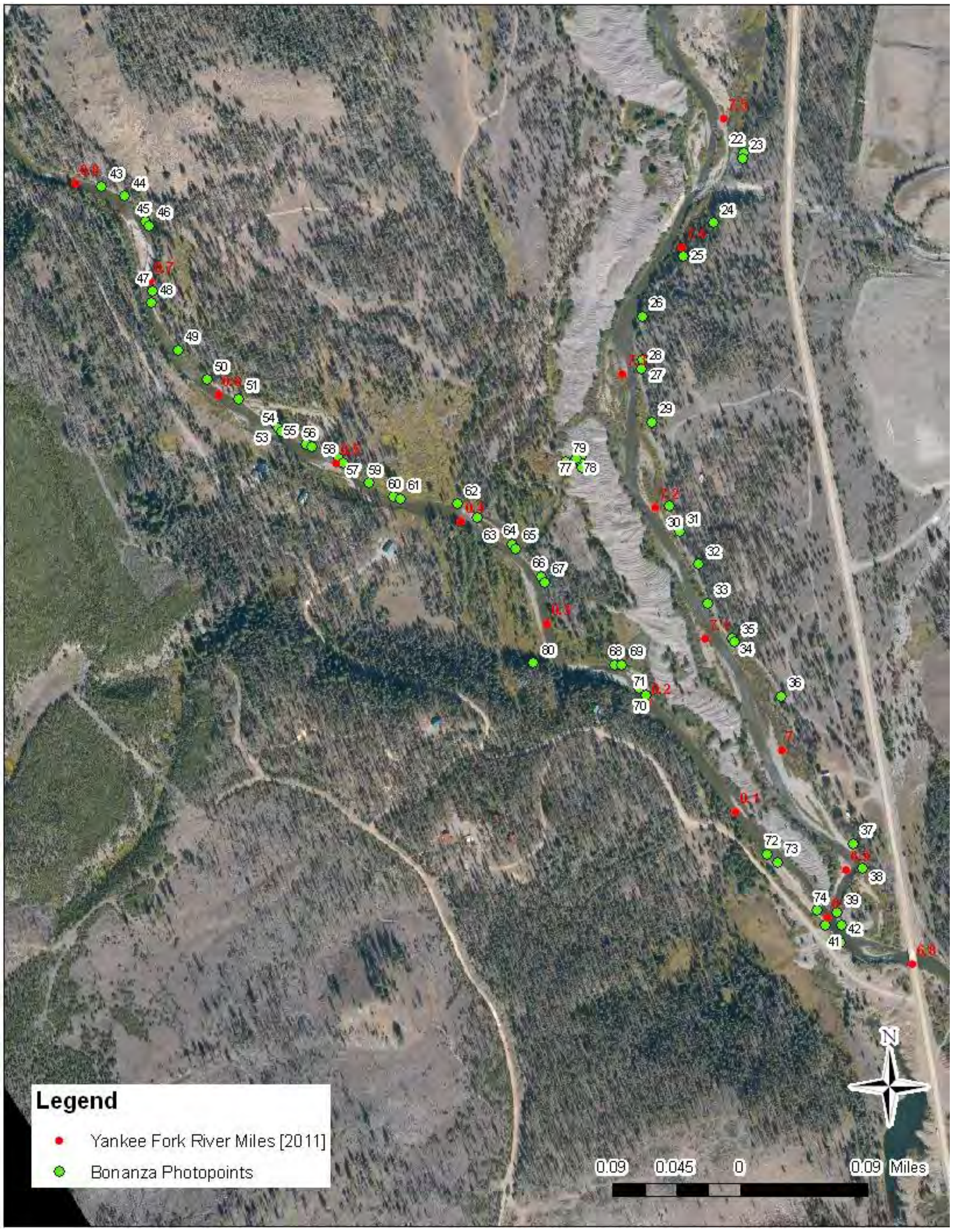


Figure 3. Photographic locations along the Yankee Fork between RM 7.5 and 6.8, and along the West Fork between RM 0.8 and mouth.

PHOTOGRAPHIC DOCUMENTATION

Captioned photographs that correlate to the location maps in the previous section are provided as Photographs 1 through 80.

Photograph No. 1. View to the south looking downstream at pool scoured at confluence of Yankee Fork and Jordan Creek. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 2. View to the south looking downstream at riffle habitat. The boulders provide hydraulic diversity and provide resting areas for migrating fish. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011**.**

Photograph No. 3. View to the south looking downstream at bedrock outcrop that prevents lateral channel migration and forces lateral scour. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 4. View to the southwest looking downstream at run habitat downstream of bedrock forced lateral scour pool. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 5. View to the east looking upstream at bedrock outcrop along river left and in the channel. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 6. View to the south looking downstream at a gravel/cobble dominated plane-bed channel. In the upper left corner of photograph note the large wood deposited high on a poorly vegetated gravel bar. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 7. View to the south looking downstream at a levee along river right that has been push-up to protect a gravel processing plant from floods. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 8. View to the south looking downstream at a concentration of boulders along river left where the stream has been eroding the toe of an alluvial fan deposit. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 9. View to the east looking across the channel at wood being recruited through bank erosion. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 10. View to the south looking downstream at a lateral scour pool along river right. Note the riparian cooridor that provides bank stability, channel boundary roughness and canopy cover. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 11. View to the south looking downstream at a concentration of boulders derived from a colluvial deposit along river left. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 12. View to the southwest looking downstream along a levee that has been pushed-up to protect a gravel processing operation along river right. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 13. View to the north looking upstream at a plane-bed channel that is constrained by dredge tailing piles along river right. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 14. View to the southwest looking downstream at a Custer Motorway bridge (Bonanaza Bridge) crossing the Yankee Fork where the channel was constructed through dredge tailings in an area where the channel was naturally constricted by bedrock and colluvial depostis. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 15. View to the north looking upstream at a plane-bed channel that is confined between dredge tailings (river right) and colluvial deposits (river left). Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 16. View to the south-southwest looking downstream from the Bonanaza Bridge at a plane-bed channel that is constrained by a bedrock outcrop along river right and dredge tailings along river left. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 17. View to the south-southwest looking downstream at bedrock that provides channel grade control. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 18. View to the north looking upstream at bedrock that provides channel grade control. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 19. View to the east looking at a "low spot" between dredge tailings. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 20. View to the south looking downstream at a seepage area that flows into the Yankee Fork. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 21. View to the south looking downstream at the active floodplain and riparian corridor. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 22. View to the northwest looking upstream at the active floodplain and side channel. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 23. View to the southwest looking downstream along a side channel where Preachers Cove enters the Yankee Fork. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 12, 2011.

Photograph No. 24. View to the north looking at the active floodplain and side channel near Preachers Cove. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 25. View to the southwest looking downstream where the Preachers Cove alluvial fan and dredge tailings confine the channel. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 26. View to the south-southwest looking downstream at the active floodplain along river right. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 27. View to the southwest looking across the channel at the active floodplain.
Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 28. View to the south looking downstream at the active floodplain on river right.
Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 29. View to the southwest looking at a side channel along river right and the active floodplain. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 30. View to the southwest looking across the channel at a side channel and active floodplain. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 31. View to the south looking downstream at outlet of side channel along river right. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 32. View to the northwest looking upstream at active floodplain and riparian corridor. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 33. View to the south looking downstream at active floodplain and riparian corridor. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 34. View to the southwest looking across the channel at active floodplain and riparian corridor. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 35. View to the south-southeast looking downstream at active floodplain and riparian corridor. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 36. View to the south looking downstream at side channel along river left and riparian corridor. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 37. View to the south-southeast looking downstream at lateral scour pool that is forced by boulders and cohesive clays along river left. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 38. View to the northwest looking upstream at lateral scour pool in the forefront and side channel outlet in upper center. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 39. View to the northeast looking upstream at a cobble/boulder dominated riffle, active floodplain along river right, and bank erosion along river left in the distance. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 40. View to the northwest looking upstream at the Yankee Fork/West Fork confluence. Note the screw-trap in upper left on the West Fork. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 41. View to the northwest looking at a scour pool created by flow convergence between the Yankee Fork and West Fork. Note screw-trap on the West Fork. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 42. View to the southwest looking downstream at the inlet of pond series three. Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, October 25, 2011.

Photograph No. 43. View to the southeast looking downstream along the West Fork where channel confinement transitions from moderately confined to unconfined. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 44. View to the west looking upstream along the West Fork where the channel transitions from moderately confined to unconfined. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 45. View to the northwest looking upstream at a lateral scour pool along river left (center) and riffle tail-out (foreground). West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 46. View to the south looking downstream at wood being recruited by lateral channel migration along river left. Note lateral scour pool downstream of point bar (left of center). West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 47. View to the north looking upstream at lateral scour pool along river right that is forced by wood and riparian vegetation along the outside meander. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 48. View to the southeast looking downstream at a run that transitions into a riffle downstream. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 49. View to the southeast looking downstream at a rock revetment (left of center) that was placed at the head of a side channel. An overflow channel has developed just left of the revetment. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 50. View to the southeast looking downstream at a cobble dominated riffle and vegetated bar along river right. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 51. View to the southeast looking downstream at a cobble/boulder dominated riffle and bank armoring along river right (upper center). West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 52. View to the west-northwest looking upstream from the head of a flow split channel along river left. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 53. View to southwest looking across the channel at bank armoring placed along river right and lateral scour pool. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 54. View to the southeast looking downstream at a mid-channel scour pool. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 55. View to the west looking upstream at the mid-channel scour pool (left front), cobble/boulder dominated riffle and bar (left of center) and flow-split channel (near center). West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 56. View to the southeast looking downstream at a cobble/boulder dominated riffle and unvegetated bar. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 57. View to the west looking upstream at the low-flow channel flowing around unvegetated bar. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 58. View to the southeast looking downstream at wood recruited by the channel through lateral channel migration. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 59. View to the southwest looking across the channel at a side channel outlet along river right. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 60. View to the west looking upstream at side channel outlet and bank erosion undermining trees along river right. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 61. View to east looking downstream at run/riffle sequence and active floodplain on river left. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 62. View to the southeast looking downstream at the head of a side channel along river left and vegetated bar that splits the flows. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 63. View to the west looking upstream from a vegetated bar that splits flows and the active floodplain upstream. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 64. View to the west-northwest looking upstream from vegetated bar. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 65. View to the south-southeast looking downstream from vegetated bar at riffle habitat and active floodplain. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 66. View to the northwest looking upstream at side channel outlet along river left that is also charged by a seep through the dredge tailings and pond. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 67. View to the south looking downstream from a remnant of the Preachers Cove alluvial fan at riffle habitat and active floodplain on river right. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 68. View to the west looking upstream at a bedrock outcrop that restricts lateral channel migration. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 69. View to the southeast looking downstream where flows split around a small vegetated bar. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 70. View to the northwest looking upstream at a split flow and where seepage through the dredge tailings and ponds enter the channel along river left. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 71. View to the southeast looking downstream where the channel becomes begins to be confined by dredge tailings. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 72. View to the southeast looking downstream at a vegetated bar along river right. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 73. View to the northwest looking upstream at the straight, confined section of lower West Fork. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 74. View to the southeast looking downstream at the West Fork/Yankee Fork confluence. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 75. View to the north looking at a narrow exaction through the dredge tailings. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 76. View to the west looking at vegetation along the 1945 Yankee Fork channel alignment. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 77. View to the southwest looking along the edge of the dredge tailings where the 1945 Yankee Fork channel probably flowed. Note the road embankment that bisects part of the historic floodplain (right of center). West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 78. View to the northwest looking at the historic (pre-dredging) Yankee Fork floodplain. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 79. View to the south-southwest looking downstream along a seep from the dredge tailings that flows into the West Fork. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by P. Drury, September 13, 2011.

Photograph No. 80. View to the north looking upstream from a bedrock outcrop that overlooks where the historic (pre-dredging) West Fork/Yankee Fork confluence was located. Note the green, young evergreens and riparian vegetation near the center and foreground in the photograph. West Fork of the Yankee Fork of the Salmon River, Yankee Fork Subbasin, Idaho – Bureau of Reclamation Photograph by E. Lyon, September 30, 2011.

APPENDIX D

GIS Databases

This page intentionally left blank

Appendix D

Bonanza Area Reach Geodatabase

Introduction

The Bonanza Area Reach GIS (Geographic Information System) File Geodatabase was produced in support of the document, *Bonanza Area Reach Assessment,Yankee Fork of the Salmon River, Upper Salmon Subbasin, Custer County, Idaho*. More file geodatabases at the tributary spatial scale are contained in the *Yankee Fork Tributary Assessment,Upper Salmon Subbasin, Custer County, Idaho(Reclamation 2012).*

Metadata for GIS-based mapping are provided in the related GIS files available for the *Reach Assessment* report. For more information or to request a copy of the *Bonanza Area Reach Assessment* geodatabase and other pertinent geographic information system data on DVD, contact Geographic Information System (GIS) Group at the Reclamation's Pacific Northwest Regional Office, 1150 North Curtis Road Suite 100, Boise, Idaho 83706.

GIS Data Sources and Citations

Bonanza Area Reach Assessment – U.S. Bureau of Reclamation; displays the area of focus for the *Reach Assessment*

Surficial Geology – U.S. Bureau of Reclamation; displays the surficial geology and geomorphic features analyzed from 1 meter LiDAR surface models.

Valley Length – U.S. Bureau of Reclamation; displays the locations of where the valley length was determined based on geomorphic and geologic constraints.

Valley Width – U.S. Bureau of Reclamation; displays the locations of where the valley widths were determined based on geomorphic and geologic constraints.

Channel Lengths – U.S. Bureau of Reclamation; displays the 1945 and 2010 channel alignment delineations for the Yankee Fork and West Fork.

Unvegetated Channel Widths – U.S. Bureau of Reclamation; displays the locations where the 1945 and 2010 unvegetated channel widths were determined.

Bonanza Photopoints – U.S. Bureau of Reclamation; displays the locations where photographs were taken to document 2011 baseline conditions (Appendix C of this report).

Pebble Count Photos – U.S. Bureau of Reclamation; displays the locations where Wolman pebble counts were conducted and photographic documentation.

Yankee Fork Connectivity – U.S. Bureau of Reclamation; displays connected and disconnected channels and floodplain areas along the Yankee Fork.

Yankee Fork Unvegetated Channel_1945 – U.S. Bureau of Reclamation; displays the unvegetated channel delineated from the 1945 aerial photographs.

Yankee Fork Unvegetated Channel 2010 – U.S. Bureau of Reclamation; displays the unvegetated channel delineated from the 2010 aerial photographs.

Yankee Fork Channel Units_2011 – U.S. Bureau of Reclamation; displays geomorphic channel units, side channels, and vegetated and unvegetated bars based on USFS (2010) stream inventory survey handbook and WDOE (2003) framework for delineating channel migration zones.

Yankee Fork Side Channels 1945 – U.S. Bureau of Reclamation; displays location of side channels and includes type and lengths in attribute table.

Yankee Fork Side Channels 2010 – U.S. Bureau of Reclamation; displays location of side channels and includes type and lengths in attribute table.

West Fork Connectivity – U.S. Bureau of Reclamation; displays connected channels and floodplain areas along the West Fork.

West Fork Unvegetated Channel_1945 – U.S. Bureau of Reclamation; displays the unvegetated channel delineated from the 2010 aerial photographs.

West Fork Unvegetated Channel 2010 – U.S. Bureau of Reclamation; displays the unvegetated channel delineated from the 2010 aerial photographs.

West Fork Channel Units_2011 – U.S. Bureau of Reclamation; displays displays geomorphic channel units, side channels, and vegetated and unvegetated bars based on USFS (2010) stream inventory survey handbook and WDOE (2003) framework for delineating channel migration zones.

West Fork Side Channels_1945 – U.S. Bureau of Reclamation; displays location of side channels and includes type and lengths in attribute table.

West Fork Side Channels_2010 – U.S. Bureau of Reclamation; displays location of side channels and includes type and lengths in attribute table.

Floodplain Target – U.S. Bureau of Reclamation; displays the floodplain target conditions to create connected floodplain patches to improve habitat-forming processes for the appropriate channel type.

Valley Width Target – U.S. Bureau of Reclamation; displays the locations of where the desired valley widths were determined based on geomorphic and geologic constraints.

Floodplain Rehabilitation – U.S. Bureau of Reclamation; displays the locations where mine tailings, embankments or levee could potentially be removed and/or recontoured to obtain the desired floodplain and valley widths to reach target conditions.