

LOWER CHEWUCH RIVER REACH ASSESSMENT



Methow Salmon Recovery Foundation

December 2025



Cover Photo: Upstream view of the Chewuch River at the downstream end of Chewuch Pearrygin 3 Reach. Credit: C. Byrne (USBR).

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List of Acronyms

7-DADM	7-Day Average Daily Maximum (temperature)
AU	Assessment Unit
CW	Channel Width
CTCR	Confederated Tribes of the Colville Reservation
CWP	Cold Water Patch
eDNA	Environmental DNA
EDT	Ecosystem Diagnostic and Treatment (model)
ELS	Engineered Log Structure
ELJ	Engineered Log Jam
ESA	Endangered Species Act
FMO	Feeding, Migration, and Overwintering (habitat)
GIS	Geographic Information System
HUC	Hydrologic Unit Code
LCRA	Lower Chewuch River Reach Assessment
lidar	Light Detection and Ranging
LW	Large Wood
MIF	Minimum Instream Flow
MSRF	Methow Salmon Recovery Foundation
NHD	National Hydrography Dataset
NSD	Natural Systems Design
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
PIT	Passive Integrated Transponder
PWI	Pacific Watershed Institute
REI	Reach-based Ecosystem Indicators
RSI	Relative Suitability Index
TIR	Thermal Infrared
UC RTT	Upper Columbia Regional Technical Team
UCSRB	Upper Columbia Salmon Recovery Board
USBR	U.S. Department of the Interior, Bureau of Reclamation
USFS	United States Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
VSP	Viable Salmonid Populations
WA Ecology	Washington Department of Ecology
WDFW	Washington Department of Fish and Wildlife
WQI	Water Quality Index
WWR	Wolf Water Resources
YN	Yakama Nation

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Executive Summary

The Lower Chewuch Reach Assessment (LCRA) has been developed to assist in the recovery of ESA-listed bull trout, spring-run Chinook Salmon, and steelhead in the Methow River watershed. The overarching goal of this assessment is to develop an aquatic-based strategy for improving habitat to benefit these threatened and endangered fish as well as other aquatic and riparian dependent species. This assessment is a follow-up to the 2010 Lower Chewuch Reach Assessment (Yakama Nation 2010) and provides updated information that can be incorporated into regional planning efforts such as the Upper Columbia Prioritization Strategy. The assessment identifies the lower Chewuch River reach as the 20 miles of stream channel and floodplain between Twentymile Creek and the confluence with the Methow River.

Specific objectives of the LCRA include:

- Describe current fish use within the reach.
- Develop a comprehensive inventory and assessment of the hydrologic, geomorphic, and aquatic habitat conditions including past, present, and future trends.
- Identify and evaluate the habitat related changes that have occurred since the 2010 Chewuch River Reach Assessment.
- Prioritize strategies and actions that address identified aquatic habitat impairments that are believed to limit the abundance and productivity of ESA-listed Spring Chinook, Bull Trout, and Steelhead.
- Prioritize strategies and actions that protect and restore the ecological form and function of the lower Chewuch River.
- Initiate contact and coordination between landowners, resource managers, and other stakeholders to set the foundation for the development of collaborative efforts that contribute to the implementation and success of restoration strategies presented in the assessment.
- Provide data resources for stakeholders engaging in implementation of the LCRA habitat improvement strategy.

Beginning in the early homesteading period, anthropogenic development and land use practices have diminished the extent, quality, availability, and connectivity of instream and riparian habitat within the LCRA area and surrounding watersheds. These changes have combined to reduce both the quality and quantity of habitat vital to fish production and contribute to the population declines observed in these species. The flood of 1948 and subsequent channel clearing and straightening activities resulted in a wider active channel in many areas which has contributed to changes in connectivity with off-channel habitats, channel incision, and diminished riparian habitat.

More recently, the LCRA has been significantly impacted by wildfire over the past 20 years and climate change effects are likely contributing to shifts in observed flow regimes including earlier onset of spring runoff, higher peak flows, and an earlier onset of low flows. Channel migration rates over the past few decades have been minimal which may be contributing to a reduced potential for some channel forming processes (e.g., avulsions, off-channel habitat development) to occur.

Two key limiting factors in the LCRA are instream flow and stream temperature both of which exceed Washington State standards (i.e., low flows in summer and fall, high temperatures in summer) each year. Both of these habitat attributes are critical to fish and, if not addressed, may continue to limit productivity of target species in the Chewuch River. Other pervasive limiting factors that should be addressed include large wood, riparian condition, fine sediment, instream complexity, and off-channel habitat connectivity.

Since the 1990's, over 30 habitat restoration and protection projects have been implemented in the LCRA area and these efforts have contributed to improvements in habitat conditions including increased instream flow, improved fish passage, increased instream complexity and off-channel habitat availability. However, key habitat attributes for fish production, such as pool quantity and quality and naturally-derived large wood density, remain well below target levels. Currently, only 25% of the projects identified in the 2010 reach assessment have been implemented so there remains significant potential to implement more projects to further improve habitat conditions in the LCRA area.

The LCRA identifies 8 potential habitat improvement areas that encompass nearly half of the assessment area where actions could be taken to benefit listed fish within the Lower Chewuch River. These project areas were identified for their potential to directly address the identified habitat deficiencies and all should be viewed as high priorities for implementation. Identified projects included reconnecting and invigorating side channels and floodplain surfaces, increasing instream complexity, and enhancing riparian vegetation. It is assumed that some level of habitat protection could help ensure long-term protection of restoration actions and facilitate implementation.

Implementation of the identified projects will increase habitat quality and quantity to improve conditions that support the growth and survival of ESA-listed fish species. Nevertheless, it is recognized that not all projects identified in this analysis will be feasible for implementation. Several factors contribute to project feasibility, including landowner acceptance, actual and perceived risk, and project costs. Each of these factors may influence the ability to implement individual projects or project elements which could reduce overall habitat benefits.

Securing landowner support and willingness—especially that of private landowners is critical to achieving the level of implementation necessary to meaningfully influence recovery. Landowner support and engagement during all phases of project development is recommended. For this reason, the habitat improvement projects and project types presented in the LCRA must be considered only as potential projects until the support and willingness of the landowners who reside on or near the project sites has been established. For this reason, landowner outreach and engagement is an important initial step in the development of each project identified in this reach assessment.

Other factors that contribute to the likelihood that an identified project will be implemented include project location, design and construction effort, site access, site management, regulatory requirements, and risk to public safety and infrastructure. Each of these factors can impact the ability to obtain project goals and objectives. Finally, the level of effort that is required to overcome one or more of these factors may shift the project cost to value ratio to the point where project sponsors and funders determine that some projects will not be feasible to develop and implement.

1 Introduction

1.1 Assessment Goals and Objectives

The goal of the Lower Chewuch River Reach Assessment (LCRA) is to develop a scientifically and aquatically-based habitat improvement strategy that addresses identified habitat limiting factors and other habitat impairments in the lower 20 miles of the Chewuch River in order to assist the recovery of Endangered Species Act (ESA)-listed Bull Trout, Upper Columbia Spring Chinook, and Upper Columbia Summer Steelhead.

Specific objectives of the LCRA include:

1. Describe current fish use within the reach.
2. Develop a comprehensive inventory and assessment of the hydrologic, geomorphic, and aquatic habitat conditions including past, present, and future trends.
3. Identify and evaluate the habitat related changes that have occurred since the 2010 Chewuch River Reach Assessment.
4. Prioritize strategies and actions that address identified aquatic habitat impairments that are believed to limit the abundance and productivity of ESA-listed Spring Chinook, Bull Trout, and Steelhead.
5. Prioritize strategies and actions that protect and restore the ecological form and function of the lower Chewuch River.
6. Initiate contact and coordination between landowners, resource managers, and other stakeholders to set the foundation for the development of collaborative efforts that contribute to the implementation and success of restoration strategies presented in the assessment.
7. Provide data resources for stakeholders engaging in implementation of the LCRA habitat improvement strategy.

1.2 Assessment Area Description

The Chewuch River watershed, a subbasin within the larger Methow River watershed, is located in Okanogan County in north-central Washington along the eastern slope of the North Cascades mountain range (Figure 1.2.1). The southerly flowing Chewuch River drains an approximately 525 mile² (336,000 acre) watershed and flows for approximately 36 river miles downstream to its confluence with the Methow River near Winthrop, WA. The watershed, which lies just south of the Canadian border, is comprised of two HUC 10 watersheds including the Upper Chewuch River (HUC 1702000803, area = 299 mi²) and the Lower Chewuch River (HUC 1702000804, area = 226 mi²). The watershed is contained entirely within the North Cascades Level III ecoregion as defined by Omernik et al. (2014).

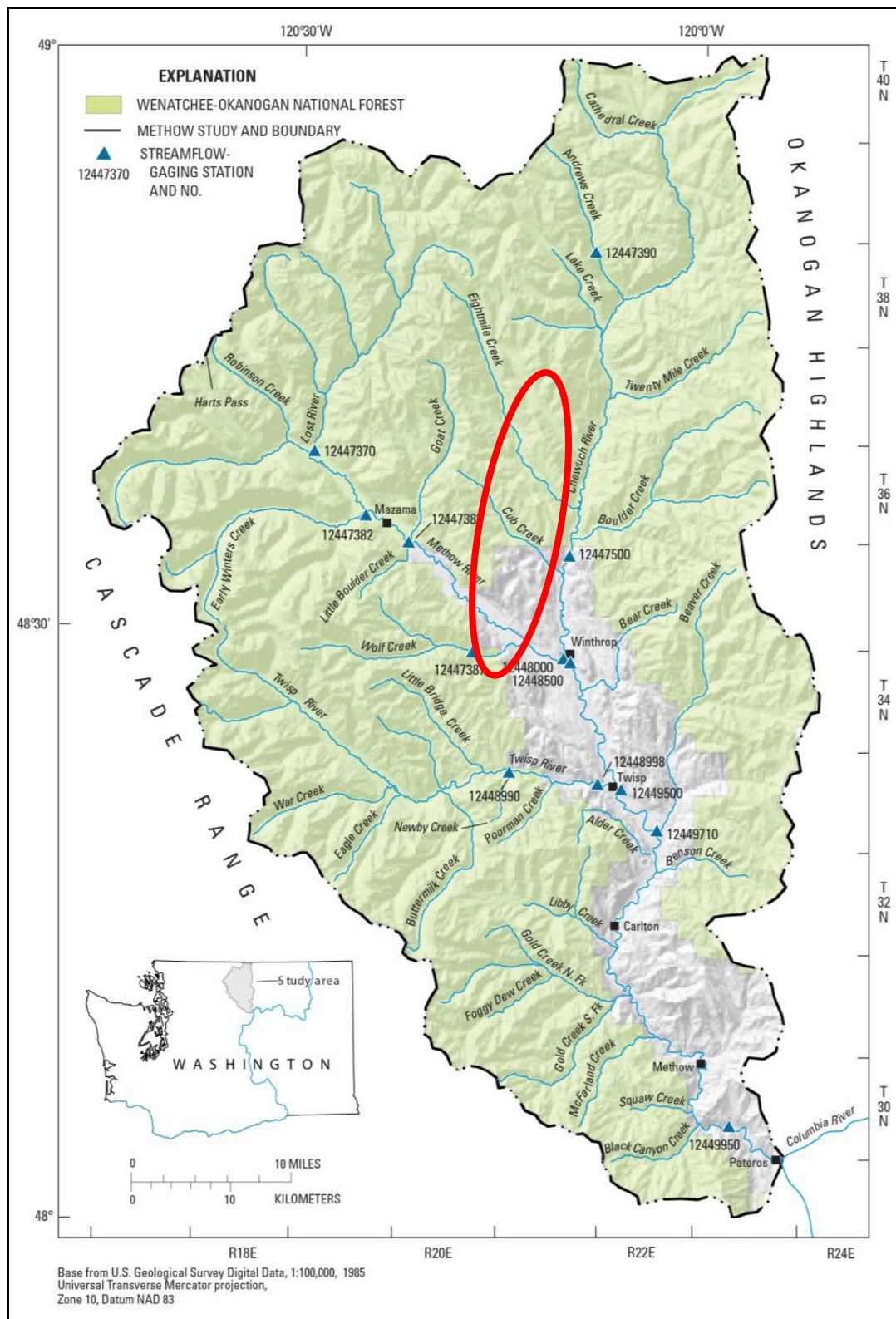


Figure 1.2.1. Map of the Methow River watershed. The lower Chewuch River reach assessment area is identified within the red oval. Map source: USGS, 2003.

Major tributary subbasins to the Chewuch River include the following: Cathedral Creek, Tungsten Creek, Andrews Creek, Lake Creek, Twentymile Creek, Doe Creek, Falls Creek, Eightmile Creek, Boulder Creek, and Cub Creek. The LCRA area includes the mainstem Chewuch river downstream of Twentymile Creek to the confluence with the Methow River.

The Chewuch River watershed originates at elevations in excess of 8,000 feet in mountainous alpine and subalpine terrain and flows through coniferous and riparian forestlands down to an elevation of approximately 2,500' where shrub steppe and ponderosa pine vegetation communities dominate the landscape down to the confluence with the Methow River at an elevation of 1700'. Generally, the western half of the watershed is of higher elevation and is wetter compared to the drier eastern half that borders the plateau landscape of the Okanogan Highlands.

The Chewuch River watershed lies in the rain shadow of the North Cascades Mountains and experiences extremes of climate in a northern temperate location. Winters are long with persistent snowpack on the valley floors from December through March and low temperatures reaching -30 °F during cold snaps. Summers are warm and July-August average temperatures average 86 °F. During summer heat waves temperatures commonly exceed 103 °F.

Mean annual precipitation in the Chewuch River watershed varies from approximately 30"-35"/year in the high elevation mountainous areas to 15"-20"/year in the low elevation shrub-steppe hills surrounding Winthrop (NPCC 2004). Although the Chewuch River drains a larger area than the Methow River upstream of Winthrop, its annual discharge is appreciably less relative to the upper Methow River owing primarily to its lower overall precipitation (Watters and Nassar 1974).

Land ownership within the watershed includes approximately 320,000 acres of federal lands (including 212,000 acres of the Okanogan-Wenatchee National Forest and 108,000 acres within the Pasayten Wilderness), 5,000 acres of Washington State lands (WDFW and DNR), and 15,000 acres of private land. Recently, The Confederated Tribes of the Colville Reservation acquired ownership of several hundred acres in the vicinity of Ramsey Creek.

1.2.1 LCRA Area Description

The LCRA area is comprised of two assessment units (AUs): Chewuch-Pearrygin and Chewuch-Doe (Figures 1.2.2 and 1.2.3). These AUs were delineated as components of the *Habitat Action Prioritization Within the Upper Columbia River Basin (Prioritization; UCSRB 2021)*. Both AUs are approximately 25,000 acres in size and combined they occupy approximately 15% of the total Chewuch River watershed area (Table 1.2.1). The two AUs differ markedly in land ownership. Chewuch-Doe AU is nearly all federal land (>98%) within Okanogan-Wenatchee National Forest while Chewuch-Pearrygin AU is a mix of federal (43%), WA state (including both WDFW and DNR) lands (23%), and privately-owned lands (34%).

Table 1.2.1. Land area and ownership within the LCRA area.

Assessment Unit	Total Acres	Private (%)	Federal (%)	WA State (%)
Chewuch - Pearrygin	25,754	8,789 (34.1)	11,041 (42.9)	5,924 (23.0)
Chewuch - Doe	25,078	91 (0.4)	24,757 (98.7)	230 (0.9)
TOTAL	50,832	8,880 (17.5)	35,798 (70.4)	6,154 (12.1)

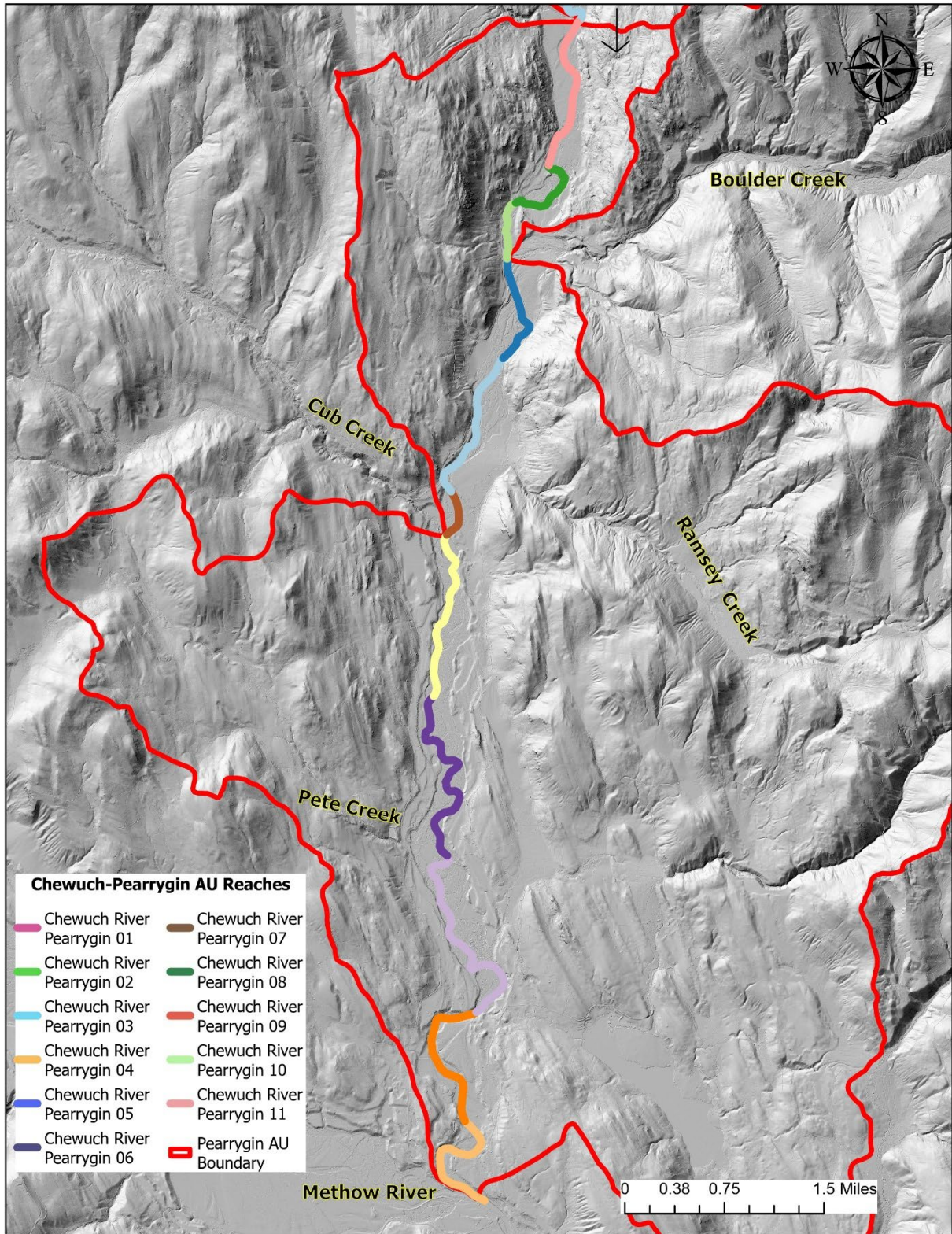


Figure 1.2.2. Chewuch-Pearrygin assessment unit boundary and reaches. Data source: UCSRB.

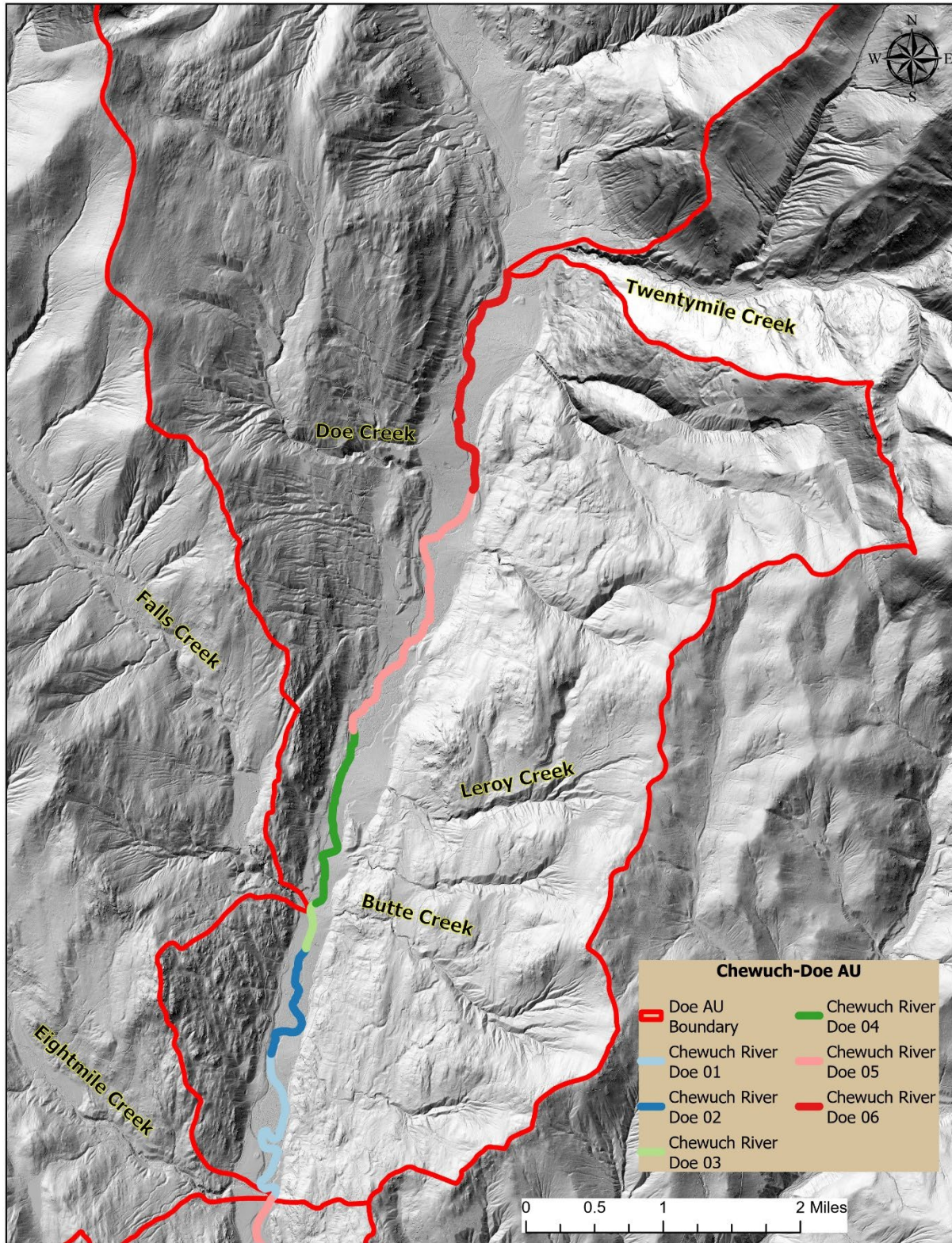


Figure 1.2.3. Chewuch-Doe assessment unit boundary and reaches. Data source: UCSRB.

In terms of Chewuch River length within the LCRA area, Chewuch-Pearrygin AU is 11.9 river miles and Chewuch-Doe AU is 8.4 river miles long for a total assessment reach of 20.3 miles. Chewuch-Pearrygin AU extends from the confluence with the Methow River upstream to the Eightmile Creek confluence, and Chewuch-Doe extends from that point upstream to the Twentymile Creek confluence.

Within the AUs, *Prioritization* delineated mainstem channel reaches based primarily on channel and valley characteristics (e.g., gradient, confinement). The LCRA area included all 11 reaches in the Chewuch-Pearrygin AU and the downstream 6 reaches in the Chewuch-Doe AU (Table 1.2.2). The reaches varied in number of characteristics (e.g., length, gradient, floodplain area) and were used in a suite of geomorphic and habitat related analyses. Specific reach details are presented in Section 3.6.

Table 1.2.2. LCRA reach length information and relation to previous assessments.

Prioritization Reach	RM Start	RM End	Reach Length (miles)	USFS Reach (2008)	2010 Reach Assessment Reach	EDT Reach
Pearrygin 1	0	1.1	1.1	Sub-reach 1	C1	C1a
Pearrygin 2	1.1	2.3	1.2	Sub-reach 1	C1	C1b
Pearrygin 3	2.3	4.1	1.8	Sub-reach 2	C2a	C2a.1
Pearrygin 4	4.1	5.7	1.6	Sub-reach 2	C2a	C2a.2
Pearrygin 5	5.7	7.1	1.4	Sub-reach 3	C2b	C2b
Pearrygin 6	7.1	7.4	0.3	Sub-reach 4	C3a	C2c
Pearrygin 7	7.4	8.6	1.2	Sub-reach 4/5	C3a	C3a
Pearrygin 8	8.6	9.5	0.9	Sub-reach 5	C3b	C3b
Pearrygin 9	9.5	10.0	0.5	Reach 2	C4a	C4a
Pearrygin 10	10.0	10.6	0.6	Reach 2	C4b	C4b
Pearrygin 11	10.6	11.9	1.3	Reach 2	C4c	C4c
Doe 1	11.9	13.4	1.5	Reach 3	C5a	C5a
Doe 2	13.4	14.4	1.0	Reach 3	C5b	C5b
Doe 3	14.4	14.8	0.4	Reach 3/4	C6	C6
Doe 4	14.8	16.2	1.4	Reach 4/5	C7	C7
Doe 5	16.2	18.4	2.2	Reach 5	C8	C8
Doe 6	18.4	20.3	1.9	Reach 6	C9 (partial)	C9a

Previous stream habitat assessments in the Chewuch River watershed also used a reach-based approach similar to *Prioritization*, but, for the most part, the reach breaks differed to varying degrees in location (i.e., length) which confounded 1:1 reach comparisons for some analyses such as reach habitat change over time.

1.3 Recovery Planning Context

1.3.1 Upper Columbia Salmon Recovery Plan

The Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (Recovery Plan; UCSRB 2007) was completed in 2007 with a mission “to restore viable and sustainable populations of salmon, steelhead, and other at-risk species through collaborative, economically sensitive efforts, combined resources, and wise resource management of the Upper Columbia

region.” Plan implementation and continued refinement is overseen by the Upper Columbia Salmon Recovery Board (UCSRB) and a supporting group of tribal, federal, state, county, and non-profit organizations.

Since its inception, the *Recovery Plan* has guided efforts throughout the Upper Columbia to recover three ESA-listed salmonids: Upper Columbia Spring Chinook (listed as *endangered* on March 24, 1999), Upper Columbia Steelhead (listed as *endangered* on August 18, 1997; reclassified as *threatened* on January 5, 2006; reinstated to *endangered* status on June 13, 2007; reclassified as *threatened* on August 24, 2009), and Bull Trout (listed as *threatened* on November 1, 1999). The LCRA supports recovery of these imperiled species through development of a strategy that, when implemented, will improve the quality and quantity of aquatic habitat in the lower Chewuch River thereby assisting regional fish recovery in the Upper Columbia.

The primary goal of the *Recovery Plan* is secure the long-term persistence of self-sustaining, naturally produced, and complex populations of Spring Chinook, Steelhead, and Bull Trout in their native ranges in the Upper Columbia. It recognizes that recovery requires 1) reducing or eliminating threats to the long-term persistence of fish populations, 2) maintaining widely distributed and connected fish populations across diverse habitats of their native ranges, and 3) preserving genetic diversity and life-history characteristics. These requirements are derived from recognition of the tenants of Viable Salmonid Populations (VSP) including abundance, productivity, spatial structure, and diversity, which are a key component of ESA fish recovery throughout the Columbia River Basin (McElhany et al. 2000). To this end, the *Recovery Plan* identifies several recovery objectives for Spring Chinook, Steelhead, and Bull Trout in the Upper Columbia including the following (summarized from UCSRB 2007):

- Increase the abundance of naturally produced adults within each population [Ecologically Significant Unit (Spring Chinook), Distinct Population Segment (Steelhead), and Core Area (Bull Trout)] to levels considered viable and/or self-sustaining.
- Increase the productivity of naturally produced Spring Chinook, Steelhead, and Bull Trout to levels that result in low risk of extinction.
- Increase, restore, or maintain the distribution and population connectivity of naturally produced Spring Chinook, Steelhead, and Bull Trout throughout their native range.
- Allow natural patterns of genetic and phenotypic diversity to be expressed.

The *Recovery Plan* follows a holistic approach to species recovery that includes recovery related actions across the “four Hs” of Harvest, Hatcheries, Hydropower, and Habitat (UCSRB 2007). The four Hs represent broad categories of anthropogenic impacts that exert influence over fish populations and their habitat. It is recognized that impacts from the four Hs have been major contributors to the declines in fish populations and aquatic habitat degradation in the Upper Columbia.

The LCRA is focused on identification of aquatic habitat improvement and management actions in the lower 20 miles of the Chewuch River. It does not address, nor attempt to identify or remedy any of the influences of the other Hs present within this reach, such as the influence of hatchery-derived salmonids.

1.3.2 Reach Assessments in the Upper Columbia

The *Reach Assessment Guidance for the Upper Columbia* document (UCSRB 2022) provides guidance for the development of reach assessments in the Upper Columbia and this approach has been integrated into the development of the LCRA. According to the guidance, reach assessments should:

- Identify pertinent watershed-scale characteristics including dominant geomorphic forms and processes, ecological interactions, and land use history with an emphasis on the characteristics that influence salmonid habitat and fluvial geomorphic processes.
- Identify systemic habitat-limiting factors and their causes.
- Identify past, existing, and future trends or watershed, stream, and riparian processes and potential target conditions.
- Identify specific areas where salmonid habitat can be protected and/or enhanced.

At their foundation, reach assessments should provide pertinent information to help inform and guide decision making around salmon recovery efforts. Reach assessments should identify the locations and types of projects, including habitat restoration and/or protection, and land management actions that will improve habitat conditions to support recovery.

It is recommended that reach assessments be updated after 10 years since previous assessments in the same reach, and the LCRA represents a “re-assessment” of the lower Chewuch River. The initial reach assessment was published in 2010 (Yakama Nation 2010) and was based largely on habitat information that was collected in 2008 and earlier. Thus, it has been over 15 years since habitat related information has been updated and synthesized for this reach. Since the 2010 assessment, a number of significant changes have been observed within the assessment area including large-scale wildfire, significant flood and debris flow events, and the implementation of a number of habitat restoration projects. These occurrences have influenced the stream and riparian habitat within the LCRA area and are a central focus of the analyses contained in this assessment.

1.3.3 Habitat Action Prioritization in the Upper Columbia

1.3.3.1 Prioritization

Currently, habitat restoration, protection and management activities intended to benefit ESA-listed fish in the Upper Columbia follow guidance and information from *Prioritization*. This planning framework was developed through the UCSRB with significant input from the Upper Columbia Regional Technical Team (UC RTT), the UCSRB’s scientific advisory board. The guidance from *Prioritization* is a foundational component of the restoration and protection strategy developed through the LCRA. The information developed through the LCRA provides updated information that should be incorporated into *Prioritization* as it represents the most up-to-date data and analyses for the LCRA area and will result in changes to limiting factor conditions. To date, LCRA information has not been incorporated into *Prioritization*.

Prioritization is an important component of the Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region (Biological Strategy; UC RTT 2021). A key principle of the Biological Strategy is the identification of habitat limiting factors and habitat restoration and protection actions, many identified by reach assessments, that can be implemented to support recovery. The Biological Strategy, and by extension *Prioritization*,

emphasizes habitat-related improvements that support natural watershed processes that influence habitat form and function at relevant spatial and temporal scales. This approach will result in long-term improvements to watershed processes at levels meaningful to target species.

The approach of *Prioritization* is to define and rank AUs, reaches, target fish life stages, and habitat restoration and protection project types to determine priorities for funding and implementation. Through the identification and prioritization of limiting factors, *Prioritization* also identifies reach specific features of aquatic and riparian habitat that exert a direct influence on the abundance, productivity, and spatial structure of target fish populations – the key building blocks of ESA-fish recovery in the Columbia River Basin.

Prioritization identified fish-life stage priorities for Chewuch-Pearrygin and Chewuch-Doe AUs in the LCRA area (Table 1.3.1). Life stages were ranked either low, medium, or high based on several criteria including restoration potential and importance of the reach to the broader population persistence and productivity. High and medium ranks represent those life stages that hold the greatest potential to contribute to recovery and the habitat attributes they rely on the target of habitat restoration and protection actions.

Table 1.3.1. Life stage ranks for ESA-listed fish species in the LCRA area. LSNS = life stage not supported

Life Stage	Chewuch - Pearrygin			Chewuch - Doe		
	Spring Chinook	Steelhead	Bull Trout	Spring Chinook	Steelhead	Bull Trout
Adult Migration	Low	Low	Med	Low	Low	Low
Adult Holding	Med	LSNS	LSNS	Med	LSNS	LSNS
Spawning	Med	Med	LSNS	Low	Med	LSNS
Fry Colonization	Med	Med		Med	Low	
Summer Rearing	High	Med		Med	Med	
Winter Rearing	High	Med		Med	Med	
Smolt Emigration	Low	Low		Low	Low	
Natal Rearing			LSNS			LSNS
Adult Non-Spawning			Low			LSNS
Subadult Rearing			Med			Low

Using life-stage ranks and other information including life-stage habitat needs and reach geomorphic potential, *Prioritization* generated reach-based rankings to prioritize actions within reaches that contained the highest potential to affect target fish survival and productivity.

The LCRA area contains a mix of rank 1, rank 2, and rank 3 reaches (Table 1-4). Reaches Pearrygin 6, 7, 8, 10 and 11, and Doe 2 and 3, were the highest priority reaches and combined cover 6.2 river miles representing nearly one-third of the LCRA length. Rank 2 reaches covered 9.5 miles (47%) and rank 3 4.7 miles (23%).

Limiting factors identified in at-risk and unacceptable condition, as well as the potential habitat restoration and protection actions that could address them, identified for the LCRA are presented in Table 1.3.2.

Table 1.3.2. Prioritization reaches, ranks, and reach-based unacceptable and at-risk habitat limiting factors and related action categories (adapted from UCSRB 2021). **Note:** A re-assessment of these *Prioritization* results using LCRA derived information may result in some changes to *Prioritization* reach ranks and conditions. This analysis was not completed by the LCRA which relied on the existing *Prioritization* results for reach priorities, see Section 5 for more details.

Stream Reach	Reach Rank	Unacceptable Condition	At-Risk Condition	Action Categories
Pearrygin 1	3	Riparian Canopy Cover, Temperature-Rearing, Wood	Coarse Substrate, Summer Base Flow, Riparian, Fines, Embeddedness	Bank Restoration, Channel Complexity, Channel Modification, Fine Sediment Management, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat, Upland Management, Water Quality
Pearrygin 2	3	Riparian Canopy Cover, Temperature-Rearing, Wood	Coarse Substrate, Summer Base Flow, Riparian, Fines, Embeddedness	Bank Restoration, Channel Complexity, Channel Modification, Fine Sediment Management, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat, Upland Management, Water Quality
Pearrygin 3	2	Riparian Canopy Cover, Temperature-Rearing, Wood	Summer Base Flow, Floodplain Connectivity, Off/Side Channels, Riparian	Bank Restoration, Channel Complexity, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat, Upland Management, Water Quality
Pearrygin 4	2	Riparian Canopy Cover, Temperature-Rearing, Wood	Summer Base Flow, Floodplain Connectivity, Off/Side Channels, Riparian	Bank Restoration, Channel Complexity Restoration, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality
Pearrygin 5	1	Temperature- Rearing, Wood	Bank Stability, Summer Base Flow, Floodplain Connectivity, Off/Side-Channels, Riparian Canopy Cover	Bank Restoration, Channel Complexity Restoration, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement
Pearrygin 6	1	Temperature- Rearing, Wood	Bank Stability, Summer Base Flow, Floodplain Connectivity, Off/Side Channels, Riparian Canopy Cover	Bank Restoration, Channel Complexity Restoration, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement
Pearrygin 7	1	Floodplain Connectivity, Riparian Canopy Cover, Temperature- Rearing, Wood	Bank Stability, Summer Base Flow, Off/Side Channels, Riparian	Bank Restoration, Channel Complexity Restoration, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement
Pearrygin 8	2	Temperature- Rearing, Wood	Summer Base Flow, Riparian Canopy Cover	Channel Complexity Restoration, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement

Stream Reach	Reach Rank	Unacceptable Condition	At-Risk Condition	Action Categories
Pearrygin 9	3	Floodplain Connectivity, Riparian Canopy Cover, Temperature- Rearing, Wood	Bank Stability, Summer Base Flow, Off/Side Channels, Riparian	Bank Restoration, Channel Complexity, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat, Upland Management, Water Quality
Pearrygin 10	1	Floodplain Connectivity, Riparian Canopy Cover, Temperature- Rearing, Wood	Bank Stability, Summer Base Flow, Off/Side Channels, Riparian	Bank Restoration, Channel Complexity, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat, Upland Management, Water Quality
Pearrygin 11	1	Floodplain Connectivity, Riparian Canopy Cover, Temperature- Rearing, Wood	Bank Stability, Summer Base Flow, Off/Side Channels, Riparian	Bank Restoration, Channel Complexity, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat, Upland Management, Water Quality
Doe 1	2	Temperature- Rearing, Wood	Coarse Substrate, Summer Base Flow, Floodplain Connectivity, Riparian Canopy Cover	Channel Complexity Restoration, Channel Modification, Fine Sediment Management, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement
Doe 2	1	Temperature- Rearing, Wood	Coarse Substrate, Summer Base Flow, Floodplain Connectivity, Riparian Canopy Cover	Channel Complexity Restoration, Channel Modification, Fine Sediment Management, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement
Doe 3	1	Temperature- Rearing, Wood	Coarse Substrate, Summer Base Flow, Floodplain Connectivity, Riparian Canopy Cover	Channel Complexity Restoration, Channel Modification, Fine Sediment Management, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement
Doe 4	2	Temperature- Rearing, Wood	Summer Base Flow, Pool Quantity and Quality, Riparian Canopy Cover	Channel Complexity Restoration, Channel Modification, Fine Sediment Management, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement
Doe 5	2	Riparian Canopy Cover, Temperature- Rearing, Wood	Summer Base Flow, Riparian	Bank Restoration, Channel Complexity Restoration, Channel Modification, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement
Doe 6	3	Riparian Canopy Cover, Temperature- Rearing, Wood	Summer Base Flow, Pool Quantity and Quality, Riparian	Bank Restoration, Channel Complexity Restoration, Channel Modification, Fine Sediment Management, Floodplain Reconnection, Instream Flow Enhancement, Riparian Restoration and Management, Side Channel and Off-Channel Habitat Restoration, Upland Management, Water Quality Improvement

Pervasive limiting factors in both Chewuch-Pearrygin and Chewuch-Doe AUs assessed by *Prioritization* to be in unacceptable condition include riparian canopy cover, temperature, large wood, and floodplain connectivity. Other prominent at-risk limiting factors include off/side channels, summer base flows, bank stability, and substrate.

Results from the LCRA largely support the existing *Prioritization* designations, but additional analyses are needed to integrate LCRA results into *Prioritization* in order to develop a revised set of reach conditions and ranks. See Section 5 (Restoration Strategy) for additional details, including Table 5.4.2 which provides a revised limiting factor summary based on information developed through the LCRA. Several limiting factors including fines, pool quality and quantity, and riparian conditions generally increased in severity to mostly At-Risk and Unacceptable condition.

1.3.3.2 *Ecosystem Diagnosis and Treatment*

An Ecosystem Diagnostic and Treatment (EDT) model was developed for the Methow subbasin in 2017 and updated in 2020 (<https://ecosystems.azurewebsites.net/hstr-methow/>). EDT is a conceptual framework that employs an analytical model to examine the relationships between environmental attributes and biological performance over varying spatial and temporal scales.

EDT theory states that observed changes in fish population abundance and productivity over time (with accompanying changes in habitat condition) are a reflection of the conditions experienced by the target species over the course of their life cycle. EDT model results can be used to gauge how changes in habitat condition influence target species productivity. EDT uses a hypothetical “template” condition to describe “historical” conditions on which to base change over time from other conditions (e.g., a particular year) which rely more on measured field conditions.

EDT results were not directly incorporated into LCRA Restoration Strategy or REI analyses and are presented herein to provide context to information that is available and relevant to restoration potential for the lower Chewuch River. Similar to *Prioritization*, LCRA results and analyses should be incorporated in future EDT model analyses.

For the Methow, EDT was run using spring Chinook and steelhead as the diagnostic species. Similar to *Prioritization*, the LCRA area was divided into two assessment units (similarly encompassing 17 shorter reaches) including Chewuch-Pearrygin and Chewuch-Doe, which occupied the same 20.3-mile reach. Of the 49 AUs prioritized, Chewuch-Doe ranked 5th and Chewuch-Pearrygin ranked as 19th in terms of their restoration priority within the larger Methow River subbasin.

A summary of EDT results for the trend comparison between the template (i.e., historic) conditions and 2020 conditions for the LCRA area is presented in Table 1-5. Model results indicate that habitat in the LCRA area is presently functioning in a condition more suitable to steelhead compared to spring Chinook. Modeled 2020 habitat for steelhead is functioning at 99% and 75% of historic capacity in Chewuch-Pearrygin and Chewuch-Doe AUs, respectively, while it is only 40% and 25% in those two AUs for spring Chinook.

The EDT survival factors, which are analogous to *Prioritization* limiting factors, define the relative contribution of a suite of habitat attributes to fish mortality. One key difference between

the two approaches is that EDT, in addition to habitat factors, incorporates a suite of biological attributes that reflect interactions between target species and their biological community.

The relative weights (e.g., strength of their influence within the AU but not necessarily relative to other AUs) of the five top ranking survival factors, and the underlying habitat attributes that comprise them, varied to some degree amongst the two assessment units and species (Table 1.3.3). Nevertheless, there were similarities as to the overall conditions influencing fish productivity within the LCRA EDT assessment units. Cover and complexity and competition with hatchery fish were observed as a factor in all four model outputs (two species x two AUs), while temperature and channel stability were identified in three of four outputs. Other survival factors identified included channel constraints and flow variability (Chewuch-Pearrygin AU only) and fish pathogens and predation (Chewuch-Doe AU only).

EDT also generated outputs related to trends (between historic “template” and 2020 conditions) in habitat composition within the LCRA area (Table 1-5). Results indicate that several types of habitat types that are important for fish, including pooltails and backwater pools, have decreased in overall area in both AUs. Beaver pond availability decreased to 0% of habitat in 2020 in Chewuch-Pearrygin AU and was not identified as a habitat type in Chewuch-Doe AU.

Historically, scour pools and riffle habitats comprised the majority (approximately 75%) available habitat in both Chewuch-Pearrygin AU and Chewuch-Doe AU. By 2020, these habitat types still comprised a majority habitat but declined slightly to 72% in Chewuch-Pearrygin AU and 73% in Chewuch-Doe AU. The largest shift in both AUs was the increase in glide habitat which increased to 15-18% - up from 1.4% and 4.4% in Chewuch-Pearrygin AU and Chewuch-Doe AU, respectively. Pooltail habitat in 2020 decreased from historic levels by approximately 6% in both AUs.

Table 1.3.3. Summary of 2020 Ecosystem Diagnosis and Treatment (EDT) results for the Lower Chewuch Reach Assessment area.

Assessment Unit	Habitat Composition Proportion of Total Area (Template%/2020%)	% gain/loss	Steelhead Priority Habitat Attributes (AU Factor Weight)	Spring Chinook Priority Habitat Attributes (AU Factor Weight)
Chewuch - Pearrygin (RM 0-11.9) AU Rank = 19 of 49 STH performance = 99% SPC performance = 40%	1. Scour Pools (29.7%/33.2%)	+3.5	1. Temperature (10.0) 2. Channel stability (2.2) 3. Cover and complexity (1.8) 4. Competition w/ hatchery fish (1.8) 5. Flow variability (1.3)	1. Cover and complexity (7.4) 2. Temperature (6.2) 3. Channel stability (4.2) 4. Channel constraints (3.5) 5. Competition w/ hatchery fish (1.0)
	2. Small Cobble Riffles (28.2%/27.8%)	- 0.4		
	3. Large Cobble Riffles (17.5%/10.5%)	-7.0		
	4. Pooltails (13.8%/8.3%)	-5.5		
	5. Backwater Pools (7.2%/0.4%)	-6.8		
	6. Beaver Ponds (2.3%/0%)	-2.3		
	7. Glides (1.4%/19.8%)	+18.4		
Chewuch - Doe (RM 11.9 – 20.3) AU Rank = 5 of 49 STH performance = 75% SPC performance = 25%	1. Small Cobble Riffles (31.7%/19.3%)	-12.4	1. Temperature (7.5) 2. Competition w/ hatchery fish (1.0) 3. Pathogens (0.9) 4. Cover and complexity (0.5) 5. Predation (0.5)	1. Pathogens (1.2) 2. Cover and complexity (1.0) 3. Competition w/ hatchery fish (0.9) 4. Channel stability (0.6) 5. Predation (0.4)
	2. Scour Pools (23.2%/23.0%)	-0.2		
	3. Large Cobble Riffles (21.1%/30.9%)	+9.8		
	4. Pooltails (11.9%/5.8%)	-6.1		
	5. Backwater Pools (7.7%/1.3%)	-6.4		
	6. Glides (4.4%/19.8%)	+15.4		

2 Lower Chewuch River Fish Use Summary

Owing to its size, location, tributary network, and quality of habitat, the lower Chewuch River provides habitat essential to the long-term viability of the three ESA-listed fish species in the Methow River subbasin. It also supports a diverse aquatic-based food web on which the production of the ESA-species, and other imperiled species such as Pacific Lamprey and Westslope Cutthroat Trout, depend. Describing fish use within the assessment area provides important context for the development of the habitat restoration and protection strategy that addresses the habitat attributes that influence fish production, distribution, and diversity.

From time immemorial, fish from the Chewuch River provided the mətʃˈwu/Methow People of the Methow Valley with a dependable and valuable food source. The Chewuch River was an important harvest location for several species of fish, including salmon and steelhead, and fishing camps were present at several locations within the LCRA area (USFS 1994). Bryan and Parkhurst (1950) reported that the Chewuch was “an excellent producing area for chinook salmon in the early days and supported large runs of that species.” While the abundance of several species in the Chewuch River has diminished greatly over the past 150 years, it remains an important stream for the overall production of spring Chinook Salmon, steelhead, and Bull Trout in the Methow River subbasin.

Additional information for key species is presented in the descriptions below. Species information was gathered from a variety of data sources including redd surveys, WDFW rotary screw trap catch, PIT tag detections, snorkel surveys, and discussions with local fisheries experts.

2.1 Target (ESA-Listed) Fish Species in the LCRA

Spring Chinook Salmon, Summer Steelhead, and Bull Trout all use the lower Chewuch River, and there is year-round use by all three species for one or more life stages. The assessment reach provides well-documented spawning and rearing habitat for both Spring Chinook and steelhead and serves as a migration corridor and subadult rearing habitat for at least two local populations of Bull Trout including the Chewuch and Lake Creek local populations.

Life stage presence and priorities for the Chewuch-Pearrygin and Chewuch-Doe AUs were classified through *Prioritization* (Table 1.3.1). This evaluation classified spring Chinook winter and summer rearing as high priorities in the Chewuch-Pearrygin AU. The remaining life stages for both Spring Chinook and steelhead were ranked either medium or low, with both adult migration and smolt emigration for both species ranked low. Adult holding for steelhead was ranked as “life stage not supported” indicating that steelhead do not hold for appreciable periods of time prior to spawning within the LCRA area.

Identified life stages for Bull Trout differ slightly from those of spring Chinook and steelhead (Table 1.3.1). Several life stages for Bull Trout, including adult holding, spawning, and natal rearing, were classified as “life stage not supported” as there is no known Bull Trout spawning within the assessment area. Adult migration and subadult rearing were ranked as medium in the Chewuch-Pearrygin AU and low in the Chewuch–Doe AU.

To investigate target fish species presence within the larger tributaries to the lower Chewuch River, environmental DNA (eDNA) sampling was completed in July-August 2023. Both Spring Chinook and steelhead were detected in the five largest tributaries to the lower Chewuch River including Cub, Boulder, Eightmile, Falls, and Twentymile Creeks (Table 2.1.1). These species were not detected in the three smallest tributaries including Butte, Leroy, and Brevicomis Creeks. Bull Trout presence was only detected in three streams including Boulder, Eightmile, and Twentymile Creeks. Analyses also included Coho Salmon which were detected in only Cub and Falls Creek.

The results of the eDNA sampling do not indicate which life stages are present in the sampled waters, only that the species is present. While it is assumed that juvenile rearing could be year-round for Spring Chinook and steelhead in the larger tributaries, it is not certain how or when the juveniles entered the tributary. Two possible pathways including volitional entry from the mainstem Chewuch or through adult spawning in the tributary.

Table 2.1.1. Environmental DNA sample results, LCRA tributaries, summer 2023.

Stream	Chinook Salmon	<i>O.mykiss</i>	Bull Trout	Coho Salmon
Cub Creek	Yes	Yes	No	Yes
Boulder Creek	Yes	Yes	Yes	No
Eightmile Creek	Yes	Yes	Yes	No
Falls Creek	Yes	Yes	No	Yes
Butte Creek	No	No	No	No
Leroy Creek	No	No	No	No
Brevicomis Creek	No	No	No	No
Twentymile Creek	Yes	Yes	Yes	No

2.1.1 Spring Chinook Salmon

Spring Chinook Salmon use the lower Chewuch reach for all phases of their life history including adult migration (to spawning areas upstream of the assessment area) and holding, spawning, juvenile rearing, and smolt emigration. It is considered a major spawning area, with high intrinsic potential throughout the reach based on the NOAA Fisheries recovery framework (ICB TRT 2007). The Chewuch River remains an important spawning area for both wild and hatchery Spring Chinook in the Methow subbasin, with 20-30% of total spawning escapement returning to the Chewuch annually between 2006-2022 (Snow et al. 2023). While spawning occurs throughout the Chewuch River up to Chewuch Falls at RM 37, the majority of spawning occurs within the LCRA area, with an average of 125 redds/year.

Adults enter the Chewuch River from the Methow River in Winthrop beginning in late May, with peak immigration occurring in mid-June through mid-July after peak spring runoff (Table 2.1.2). Adults will generally hold in the Chewuch for 1-2 months prior to spawning from August – September, with peak spawning late August – early September. Spawning generally occurs in low gradient channel units, including pooltails, glides, and shallow riffles containing a mixture of gravel and cobble substrates.

While spawning for Spring Chinook occurs throughout the LCRA area, redd survey data show areas of higher density from RM 3-7 (Pearrygin 3-5 reaches), RM 9.5-11 (Pearrygin 9-11

reaches) and RM 12-20 (Doe 1-6 reaches). Spawning is uncommon in higher gradient reaches where spawning substrate is limited in supply, including Pearrygin 1-2, Pearrygin 6-8, and Doe 3 reaches.

Based on water temperatures in the Chewuch River and thermal units required for hatching and swim-up, fry emergence for Spring Chinook can occur over several months and likely begins during low flow periods in January and continues through April. Juveniles can rear for up to two years, but more commonly out-migrate as one year old smolts in the spring the following year. Year-round juvenile use of the LCRA has been documented by fish population surveys that have observed Spring Chinook parr through the fall and winter at various locations (Abrahamse and Parsley 2023, J. Crandall, personal observation). Parr have been observed in various habitats, including in the mainstem, side channels, and commonly associated, with pool habitats and cover elements, including large wood.

2.1.2 Summer Steelhead

Summer Steelhead adults and juveniles use the Chewuch River throughout the entire LCRA area, which is considered a major spawning area within the Methow River subbasin and contains habitat of high intrinsic value (ICB TRT 2007). Adult escapement of both wild and hatchery fish in the Chewuch River is approximately 20% (range = 10-30%) of the total annual spawners within the Methow subbasin population (Snow et al. 2023). On average, there are 107 steelhead redds/year within the LCRA, which is a majority of the overall redd count for the entire Chewuch River.

Adult steelhead are present in the Chewuch River for approximately 2-3 months each year, with spawning occurring between March-mid and May, with a peak in late March to early April (Table 2.1.2). Spawning, which has been observed throughout most of the LCRA reach, generally occurs during the ascending limb of the hydrograph, although it can coincide with earlier flow spikes if they occur in a given year.

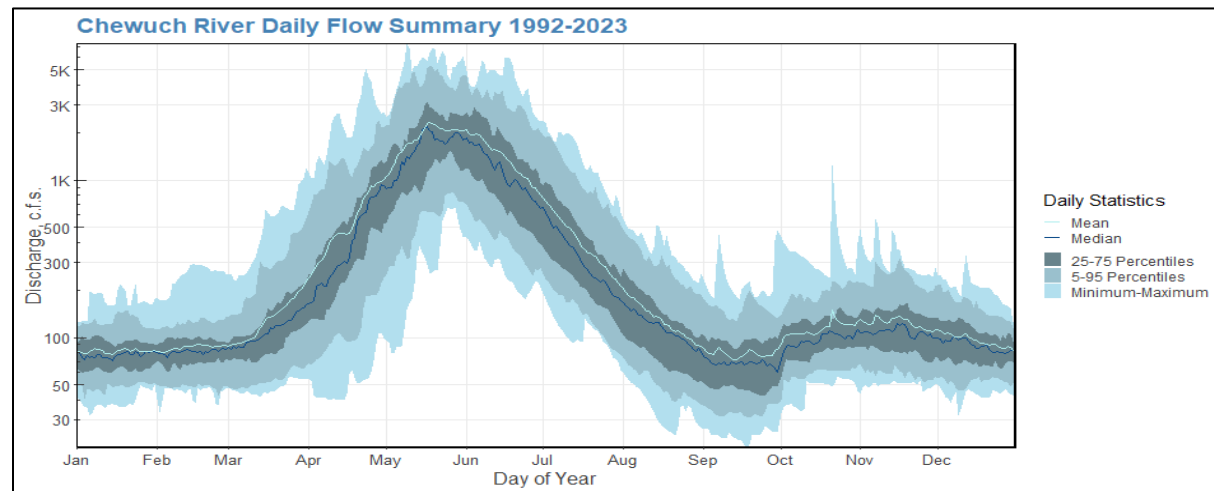
Based on passive integrated transponder (PIT) tag data, a limited number of adult steelhead enter the Chewuch River during the fall prior to spring spawning the following year. These fish may not overwinter in the Chewuch and likely move back downstream into the Methow River between November-February. While it is not known specifically why these fish move this far upstream in the fall, it has been hypothesized that they may be attracted by food including eggs from spawning coho salmon (C. Snow, WDFW, personal communication).

While steelhead spawning occurs throughout the LCRA reach, including in the broader valley reaches of Pearrygin 3-5, the highest densities occur upstream of the Boulder Creek confluence at RM 9.5. This area coincides with a significant gradient “step,” with more gentle channel gradients upstream of the step. From this point upstream to the Twentymile Creek confluence, steelhead spawning locations are similar to those used by spring Chinook and include low gradient habitat units with available gravel and cobble substrate.

Dependent on spawning date and water temperatures, steelhead fry emerge from May through early July, and they can be observed occupying shallow channel margin and riffle habitats through fall. Fry emergence occurs much more quickly for steelhead compared to Spring Chinook and Coho Salmon, and the eggs and alevins remain in the spawning gravels for only 4-6 weeks prior to emergence.

Table 2.1.2. Fish species life stage timing for Lower Chewuch River. Hydrograph provided for discharge reference. Hydrologic data from USGS gauge, Chewuch River at Winthrop, 1993-2023.

Lower Chewuch River (RM 0-20) Fish Periodicity Chart															Bold denotes higher use; Ver 2.15.24											
Species	Life Stage	Jan		Feb		Mar		Apr		May		June		Jul		Aug		Sept		Oct		Nov		Dec		Data Source
		1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31	1-15	16-31			
Summer Steelhead	Adult Immigration/Spawning migration																									Chewuch PIT data, limited summer/fall presence
	Adult Spawning																									Redd survey data
	Fry Emergence																									Stream temperature RM 11 (1000 TU to swim up)
	Juvenile Rearing																									
	Juvenile Emigration																									Chewuch trap data
Spring Chinook Salmon	Adult Immigration/Spawning																									Chewuch PIT data
	Adult Spawning																									Redd survey data
	Fry Emergence																									Stream temperature RM 11 (1650 TU to swim up)
	Juvenile Rearing																									Age 1 migrants observed
	Smolt Emigration																									Chewuch trap data
Bull Trout	Adult Foraging/Migration/Overwinter Habitat																									Peak use during non-spawning period assumed
	Subadult Rearing																									Snorkel observations, PIT detections
Coho Salmon	Adult Immigration																									Chewuch PIT data
	Adult Spawning																									Redd survey data
	Fry Emergence																									Stream temperature RM 11 (1430 TU to swim up)
	Juvenile Rearing																									Age 1 migrants observed
	Smolt Emigration																									Chewuch trap data
Pacific Lamprey	Adult Immigration																									Chewuch PIT data, telemetry
	Adult Holding/Spawning migration																									Chewuch PIT data, adults can hold >1 year
	Adult Spawning																									Limited observations, assume similar to Entiat
	Larval Rearing																									Larval monitoring data, literature supports year-round rearing
	Juvenile Emigration (larvae/transformers)																									Chewuch trap data
Resident Rainbow and Cutthroat Trout	Adult Foraging/Migration/Overwinter Habitat																									Snorkel observations, scant data available
	Juvenile Rearing																									Snorkel observations, scant data available



Juveniles may rear for several years in the Chewuch River, and they have been extensively observed during fish monitoring efforts (Masurat 2022, Abrahamse and Parsley 2023, J. Crandall, personal observation). Smolts may include age one to three individuals, and outmigration occurs mostly during spring during the ascending limb of the hydrograph.

2.1.3 Bull Trout

Bull Trout utilize the LCRA area for adult migration, feeding, and overwintering (FMO habitat) and also subadult rearing. The majority of observations of Bull Trout in the Chewuch River have been of the migratory form, but there have been observations of resident fish (e.g., <250 mm) spawning in some years.

No known spawning occurs in the LCRA area, but the Chewuch River watershed does contain two identified local populations: the Chewuch River and Lake Creek populations (USFWS 2014). The mainstem Chewuch River provides access for migratory adults to spawning areas in Eightmile Creek, Lake Creek, and the upper Chewuch River near Coleman Creek. Sub-adults dispersing from these spawning areas may utilize the mainstem Chewuch River for rearing. Based on this use, which is not well documented, Bull Trout should be considered present in the Chewuch River year-round.

Redd surveys for the Chewuch River local populations, and also Eightmile Creek (which has no formal local population assignment), have shown a decrease in redd abundance in recent years, and in 2023 no redds were observed in any of the three spawning areas (J. Crandall, unpublished data).

Most migratory adult Bull Trout using the Chewuch River likely spend the winter months in the larger waters of the Methow and Columbia Rivers and migrate into the Chewuch River post-peak flows in June-July as they make their way to upstream spawning grounds (Table 2.1.2). After spawning, generally in late September-early October, adults will migrate back downstream to access FMO habitats. Eggs hatch in spring, but young juveniles (1-2 years old) likely remain in colder natal areas for several years before dispersal, and their presence in the LCRA is unlikely.

While Bull Trout are iteroparous, not all adult Bull Trout will spawn every year (USFWS 2014). Non-spawning adults and subadults may find favorable habitat in the lower Chewuch River channel structure, especially the deeper pools and glides, despite a relatively warm summer water temperature regime that may be sub-optimal for this species. Sub-adult Bull Trout have been observed during fish monitoring surveys, especially in fall months when stream temperatures have cooled (USFS 2008, Masurat 2022, Abrahamse and Parsley 2023). Bull Trout may be attracted to inputs of cold-water, including cold tributaries such as Eightmile Creek, and other seeps and springs.

2.2 Additional Fish Species of Interest

2.2.1 Coho Salmon

Coho Salmon (*Oncorhynchus kisutch*) were extirpated from the Methow River during the first half of the 20th century. Numerous factors led to coho extirpation, including overfishing and habitat degradation. Perhaps most significantly, starting in 1918 a hydroelectric dam on the mainstem Methow River near RM 2 curtailed upstream passage for nearly two decades,

especially during periods of low flow common in the fall when adult coho were migrating into the river.

Coho Salmon were largely absent from the Methow River subbasin for over eighty years, until the Yakama Nation began a reintroduction program in 1995. The Methow River watershed now has Coho retraining annually to spawning areas in the Methow, Twisp, and Chewuch Rivers. The program has expanded in recent years with the construction of several acclimation ponds distributed across the subbasin. An acclimation pond in the Chewuch-Pearrygin AU, at RM 11 (downstream of Eightmile Creek) in Pearrygin 11 reach, was completed in 2018 to promote upstream expansion of spawning and rearing. Coho have responded to this acclimation effort and now spawn as far upstream as Twentymile Creek and recent redd counts for the Chewuch River have been 26, 225, and 30 redds in 2020, 2021, and 2022, respectively.

Adult Coho Salmon spawn in the Chewuch late in the year from October through mid-December (Table 2.1.2). They migrate into the Chewuch from the Methow River shortly before spawning from mid-September through November, generally during periods of low discharge. Spawning begins shortly after entering the Chewuch, so they may not depend as much on holding habitat in deeper pools compared to Spring Chinook. Spawning distribution is similar to that of spring Chinook Salmon and steelhead, with the majority of spawning occurring upstream of Boulder Creek.

Juvenile Coho use the lower Chewuch reach year-round for rearing and seasonally as a smolt emigration corridor. Catch of coho fry, parr, and smolts at the Chewuch screw trap has been observed every year since the trap became operational in 2019, with catches exceeding several thousand fish per year in 2021-2022. Generally, peak catches of all juvenile life stages occurs in spring from March through May and prior to peak discharge. Juvenile coho, mostly parr, are also captured in low numbers through the summer months with a noticeable increase in the fall. Juvenile coho have been observed in numerous locations within the LCRA over the past few years, including in the RM 4.2 side channel and numerous engineered log structures throughout the reach (Abrahamse and Parsley 2023, J. Crandall, personal observation).

2.2.2 Pacific Lamprey

Pacific Lamprey use the lower Chewuch River for all life stages including adult migration, holding, and spawning; larval rearing; and juvenile emigration (Table 2.1.2). The Chewuch River is a very important habitat area, a true “stronghold” for Pacific Lamprey in the Methow River subbasin and they occur year-round throughout the LCRA area.

A limited number of adult spawning observations have been documented in the Chewuch River, and these suggest that spawning occurs on the descending limb of the hydrograph in June and July (C. Frady, USFWS and J. Crandall, personal observations). This spawning timing is likely similar to what has been widely documented in the Entiat River (A. Grote, USFWS, personal communication). Pacific Lamprey spawn in gravel substrates that commonly reside in pooltails, glides, and shallow slow-flowing riffle habitats (Close 1995, Kostow 2002).

Adult Pacific Lamprey enter the Methow River in fall primarily during September-November, and some migrate into the Chewuch River for holding over the winter. They may remain in the LCRA area from winter through spring holding in and around large boulders, riprap, and bedrock

cracks and ledges. Some adults will move relatively quickly (i.e., a few days) from the lower Methow upstream into the Chewuch during these fall migrations (Nelson et al. 2009).

Larval lamprey rear year-round throughout the lower Chewuch River, often with several year classes of larvae occupying the same discrete habitat patches. Larval habitat consists of fine silt, sand, and detritus and is commonly associated with the slow water currents found in eddies, backwaters, and along channel margins. Peak catch of larvae at the Chewuch screw trap often coincides with the first significant flow pulse of the spring freshet that commonly occurs during April and May. Trap catch outside of this timeframe is relatively low, but low numbers of larvae are captured almost any month the trap is operational. Migratory transformers (i.e., juveniles) are usually captured in spring (April-May) as they make their way downstream and out to the Columbia River.

From 2015-2023, the Yakama Nation translocated Pacific Lamprey adults into the Methow River watershed, which has significantly increased adult abundance and spawning potential. Prior to this effort, the population in the Methow River subbasin was alarmingly low (Crandall 2023). The translocated adults are spawning successfully and as a result, larval abundance has rebounded significantly in the LCRA area and elsewhere in the Methow subbasin. Long-term monitoring data reveal an increase in larval catch in the LCRA since translocations began (Crandall 2023).

2.2.3 LCRA Fish Community

The fish community present in the lower Chewuch River is similar to what is observed in nearby reaches of the Methow River. In addition to the three ESA-listed species, coho salmon, and Pacific lamprey, fish monitoring efforts (PWI 2000, USFS 2008, USGS 2013, Masurat 2022, Abrahamse and Parsley 2023) over the past 20 years in the Chewuch River indicates that the native fish community also includes Mountain Whitefish (*Prosopium williamsoni*), Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*), several species of sculpin (*Cottus* sp.), Brideglist Sucker (*Catostomus columbianus*), Longnose Dace (*Rhinichthys cataractae*), and Redside Shiner (*Richardsonius balteatus*).

Several non-native fish species have also been observed including Brook Trout (*Salvelinus fontinalis*), Brown Bullhead (*Ameiurus nebulosus*), and Bluegill (*Lepomis macrochirus*). Overall, monitoring results indicate that the abundance of these non-native species is relatively low (USFS 2008, USGS 2013, WDFW 2023 screw trap data). Brook Trout pose a substantial threat to Bull Trout productivity through competition, predation, and especially through hybridization (USFWS 2014). Within the LCRA, the low abundance of Brook Trout likely does not pose an elevated threat to Bull Trout, as there is no known Bull Trout spawning and thus no potential for hybridization. However, high Brook Trout abundance has been documented in Eightmile Creek, where Bull trout spawning does occur, and Brook Trout presence in this stream poses a significant threat to the long-term persistence of Bull Trout in Eightmile Creek.

The relative abundance and distribution of the various members of the LCRA fish community likely varies over space and time in relation to several factors such as adult escapement abundance, spawning distribution, hatchery releases, habitat restoration, and annual patterns of life stage specific survival and mortality. Overall, monitoring data (i.e., rotary screw trap, snorkel surveys) indicate that in most years juvenile *O.mykiss* and Spring Chinook salmon are the most abundant species observed. Extensive snorkel surveys in 2008 revealed these two species

accounting for 58% and 21% of the total fish community, respectively (USFS 2008). Other notable species included Mountain Whitefish (10%) and sculpin (7%), with the six other species observed all comprising <2% of the total.

Interestingly, monitoring in 2000 documented a significant number of Westslope Cutthroat Trout present in the LCRA area, and they were the second most abundance species observed that year in snorkel survey completed downstream of Boulder Creek (PWI 2000). More recently, Westslope Cutthroat Trout have become much less abundant and account for <2% of fish observed in several monitoring efforts (USFS 2008, Masurat 2022).

Notably, in recent years and likely in response to increased hatchery releases and operation of the Eightmile acclimation pond, juvenile Coho Salmon have become much more common in the LCRA and in some locations and seasons are the most abundant species observed (Abrahamse and Parsley 2023).

2.3 Other Aquatic Species of Interest

The LCRA area is home to a diverse assemblage of non-fish aquatic-related species, including aquatic macroinvertebrates, Mink, River Otter, and American Beaver. Both resident and migratory birds are abundant and the reach is used by both Osprey and Bald Eagles for nesting and foraging. Harlequin Ducks are commonly observed during breeding season within the higher gradient reaches of the LCRA area.

Beaver are present throughout the LCRA area and recent beaver activity was observed in several locations during the 2023 habitat survey. The Methow Beaver Project has released numerous beavers in the tributary basins to the LCRA to assist with habitat restoration including through increased water storage (Woodruff 2015).

Freshwater mussels (and other mollusks of conservation concern) are present in the LCRA and shell fragments, but no live specimens, were observed in several locations during the 2023 habitat surveys. Signal Crayfish (*Pacifasticus leniusculus*, Figure 2.3.1), one of several native crayfish in Washington State, was observed during the 2023 habitat survey and in prior years of monitoring (J. Crandall, personal observation). Observations of this crustacean during the habitat survey were most abundant in the Chewuch-Doe AU. The recently classified Okanogan Crayfish, (*Pacifastacus okanaganensis*) is likely also present in the Chewuch River, but was not observed during field surveys.



Figure 2.3.1. Signal crayfish were observed in the LCRA area during the 2023 habitat survey.

2.4 Fish Response to Habitat Restoration

There is a limited amount of site-specific/project level data available to determine overall ESA-listed fish response to stream and riparian habitat restoration efforts in the LCRA area. However, available data and observation suggest that target species and life stages are accessing and utilizing the restored areas (e.g., side channels, engineered wood structures).

The Yakama Nation Action Effectiveness Monitoring Program is currently evaluating target fish response (i.e., density, growth, movement, and survival) to the RM 4.2 project (constructed in 2022) in the Pearrygin 3 reach (Abrahamse and Parsley 2023). Results from pilot level studies show both spring Chinook and steelhead juveniles occupying the restored side channel over several seasons.

Abundance results varied by site, species and season, but in all samples, Coho Salmon juveniles were the most abundant species observed, followed by Spring Chinook, and steelhead. The restored side channel had higher combined species abundance relative to the two control sites (one in the Chewuch, at RM 6.5, and one in the Twisp River at RM 2). Spring Chinook juveniles in the restored side channel were roughly twice as abundant relative to the upstream Chewuch control site. Juvenile steelhead in fall and winter were less abundant in the restored area compared to the two control sites. Other species observed at low abundance include: Bull Trout, Westslope Cutthroat Trout, Mountain Whitefish, Pacific Lamprey (larvae), and Brook Trout.

At the Chewuch River Right Project site (constructed in 2015) at RM 13 in the Doe 1 reach, post-project fish monitoring in 2024 documented juvenile Spring Chinook, steelhead, and Coho Salmon use in the restored side channel (S. Griep, Hinchinbrook Inc., personal communication). Spring chinook comprised 70% of the observations (189/264 fish), followed by coho (25%) and steelhead (4%). The abundance of these three species in the restored channel was approximately 60% less than what was observed in a nearby control site.

Fish recapture rates in the restored channel were not large enough to develop growth and survival estimates, but more monitoring is planned for the future which may yield these estimates.

At least four isolated pools were observed in the restored channel and contained only a few stranded target species fish (Figure 2.4.1). Adaptive management of the site in 2025 sought to establish perennial flow through the side channel which would eliminate the isolated areas observed during the LCRA field surveys.



Figure 2.4.1. Isolated pool in the Chewuch River Right Project side channel, Doe 1 reach, 7 Sep 2023.

3 Assessment Area Conditions

3.1 Geology

The geologic character of the Chewuch River watershed, and of the smaller LCRA area, is largely defined by its two constituent geologic provinces, the Methow and Okanogan provinces, which are located on opposite sides of the northwest-southeast trending Chewuch-Pasayten fault (Figure 3.1.1, Table 3.1.1). This major fault, also referred to as the Eightmile fault, extends southeast from Billy Goat Pass in the Eightmile Creek watershed and crosses the Chewuch River near Ramsey Creek a short distance upstream from the Cub Creek confluence (Barksdale 1975, Lawrence 1978). The Methow geologic province is located largely to the west of the fault, while the Okanogan province underlies the majority of the watershed north and east of the fault.

The Methow province is comprised of folded and faulted Jurassic-Cretaceous-Paleogene aged sedimentary and volcanic rocks within a trough (graben) bounded by higher elevation faults (Barksdale 1975), including sedimentary deposits of the Hart's Pass and Buck Mountain formations (Table 3.1.1 and Figure 3.1.1). The Okanogan geologic province is comprised primarily of Paleozoic-Mesozoic aged metamorphic gneiss with areas of more recent plutonic intrusion, including the Cathedral batholith and Bottle Springs pluton. Large areas both north and south of the Chewuch River are comprised of older rocks, including Doe and Tiffany Mountain gneiss (trondhjemite).

More recently, glacial activity within the Chewuch watershed has played a significant role in landscape formation, including the development of the distinctive U-shaped valley form and glacial moraines of the mainstem Chewuch River within the LCRA area. The Cordilleran Ice Sheet, which extended north into British Columbia, was present about 20,000 years ago and occupied most of the assessment area (Waitt 1972).

As a result of this glacial activity, glacial till (unsorted) and drift (sorted) material are present throughout the LCRA area. Some of the till has been reworked and transported by the river and new sediments have been introduced due to fluvial and hillslope processes. Combined, these sediments represent the quaternary alluvium within and adjacent to the current day LCRA area stream channels. The larger glacial sediments that comprise the modern-day terraces along the river are relatively immobile (except during very high flows) and serve to confine the channel and mute lateral migration in the lower Chewuch River.

Alluvial fans are present at the confluences of several major tributaries to the Chewuch River within the LCRA area, most notably at the Twentymile, Eightmile, Boulder, and Ramsey Creek confluences (Figures 3.1.2 and 3.1.3). These fans are largely comprised of glacial outwash and quaternary alluvial deposits that were transported downstream from tributary basins and have subsequently been worked through by the Chewuch River over time.

Table 3.1.1. Description of major rock units in the Lower Chewuch River assessment area.

Era	Period	Name	Lithology
Cenozoic	Quaternary	Qa	Quaternary alluvium
		Qgd	Fraser-age continental glacial drift
Mesozoic	Cretaceous	Kc	Winthrop sandstone, sedimentary
		Kia(b)	Bottle Spring pluton, intrusive
		Kia(cb)	Cathedral batholith, intrusive
		Kigd	Cathedral batholith, granodiorite
		Kiqm	Cathedral batholith, quartz monzonite
		Km	Hart's Pass formation, sedimentary
		Kva	Isabella Ridge formation, andesite
		Kvs	Buck Mountain formation, sedimentary
		Cretaceous -Jurassic	KJit
	KJmi		Tiffany Mountain formation, gneissic
	KJmi		Tiffany Complex, igneous
	KJog		Eightmile Creek Formation, orthogneiss
	KJvs		Newby Group, volcanic/sedimentary
	Jurassic	Jm	Twisp Formation, marine sedimentary

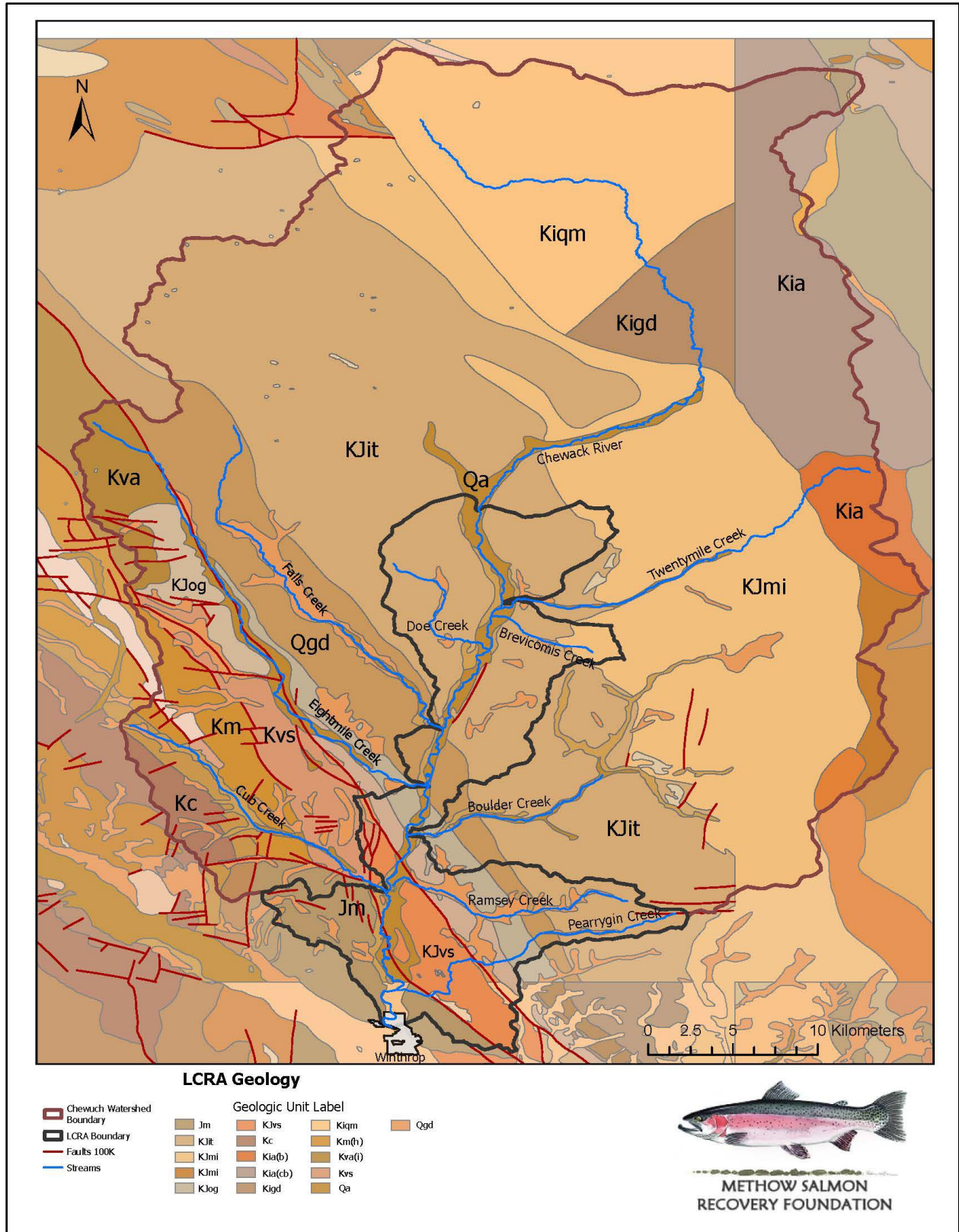


Figure 3.1.1. Geologic map of the Chewuch River watershed and LCRA assessment area.

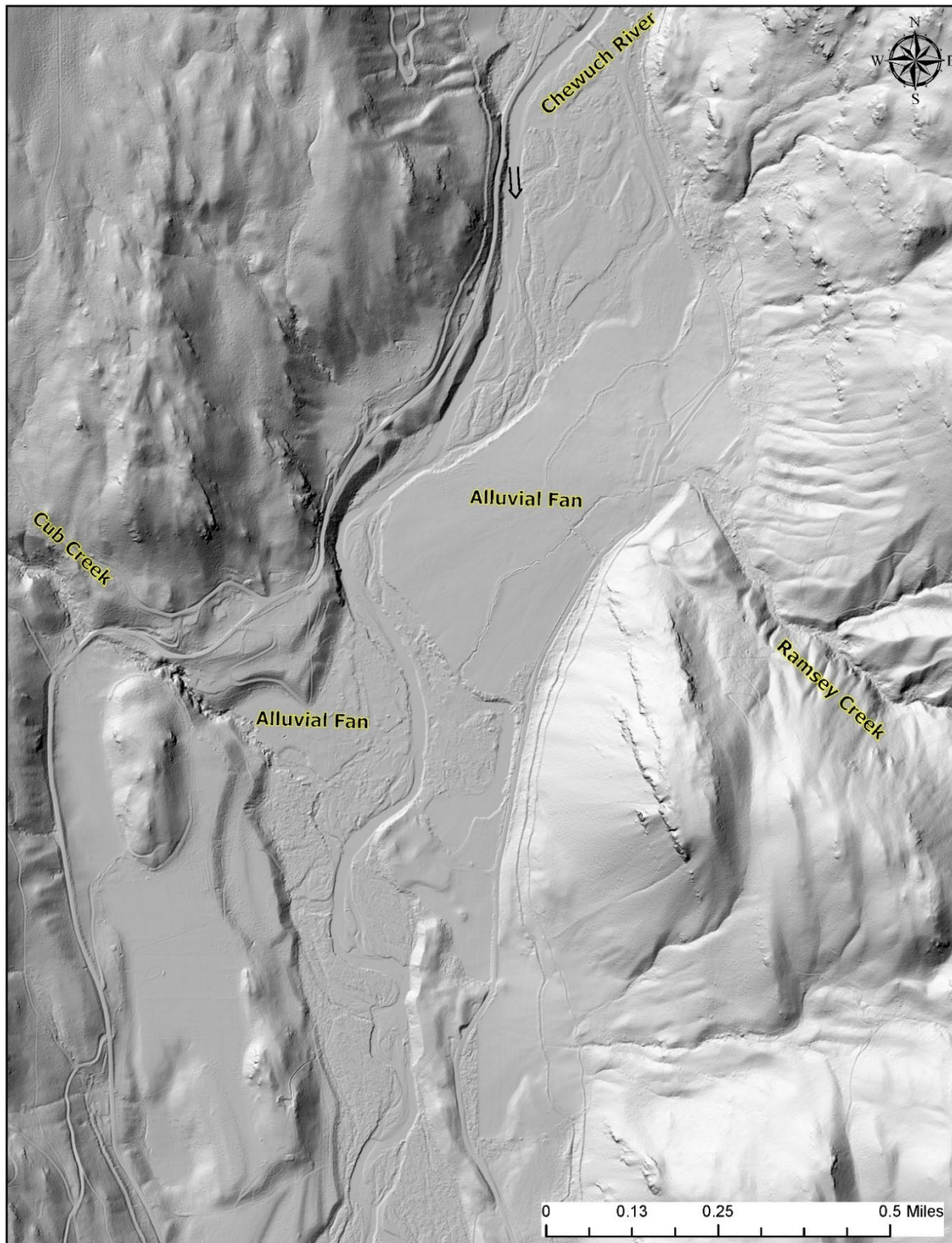


Figure 3.1.2. Ramsey and Cub Creek alluvial fans at the confluence with Chewuch River as seen in lidar surface data.

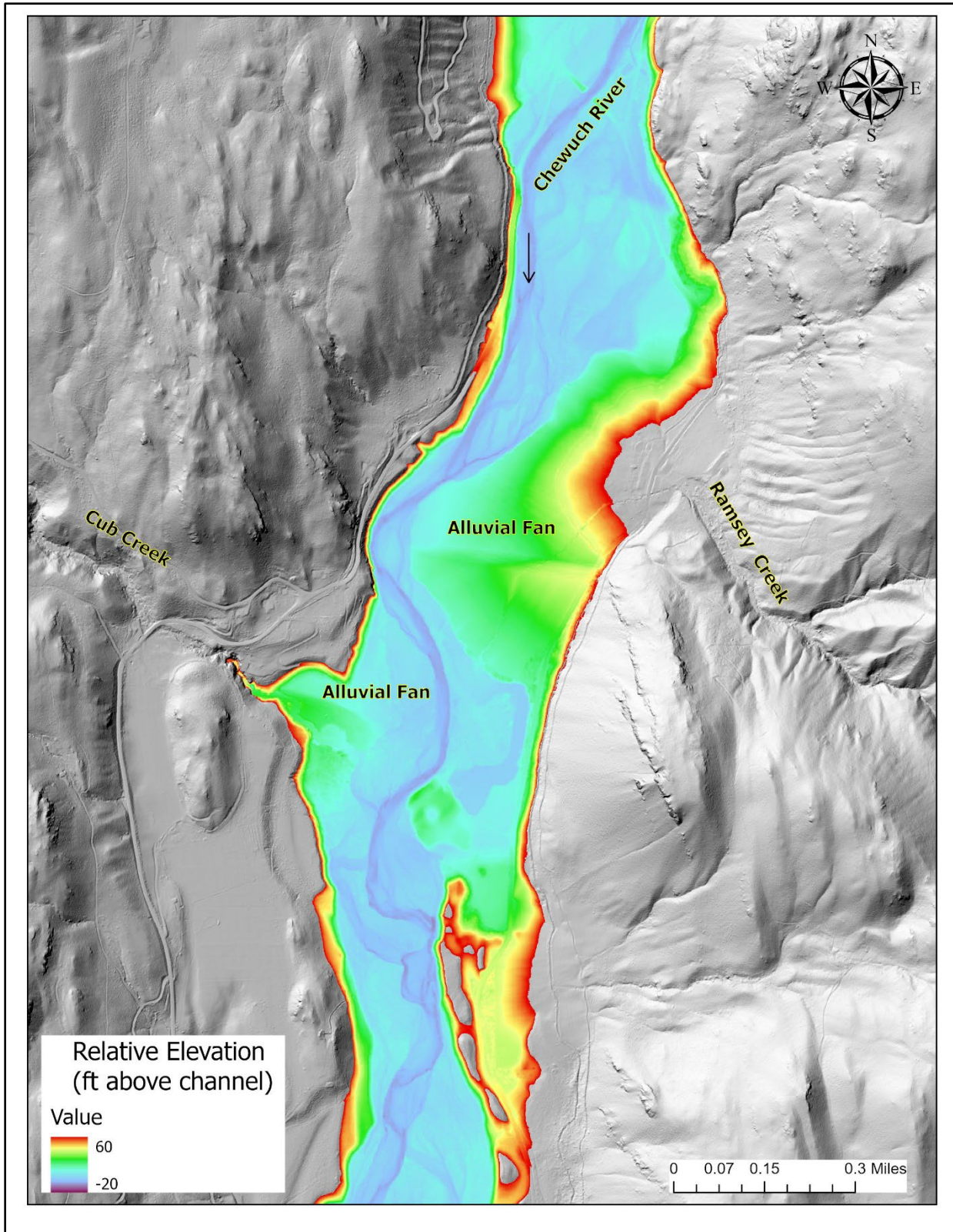


Figure 3.1.3. Relative elevations of Ramsey and Cub Creek alluvial fans at the confluence with Chewuch River.

3.2 Historic Conditions

3.2.1 Human history

3.2.1.1 *The mət̚x̚wu/Methow People*

The mət̚x̚wu/Methow People have lived along – and relied on – the Chewuch River (čwáx) for thousands of years. Discoveries of pit-house foundations along rivers in the Methow Valley, including at the mouth of the Chewuch River (at present day Winthrop), is evidence of historic year-round use (Portman 2002). The mət̚x̚wu traditional lands encompassed areas along the Columbia River from the mouth of the Methow River to the Okanogan River, the Methow River watershed, and its tributaries including the Chewuch River (USFS 1994, Hart 2017).

By the time of the first contact with Euro-Americans in 1811, most mət̚x̚wu lived in seasonal villages. The mət̚x̚wu traveled up and down the Methow River and its tributaries to gather plants and to hunt and fish. They also engaged in agriculture. In 1883, more than 300 mət̚x̚wu were farming along the Methow River. They grew oats, corn, potatoes, and watermelon and raised horses and beef cattle. By this time the native Methow population was already significantly reduced – half of the tribe had been killed by disease by the early 19th century - and half of the remaining population succumbed before the end of that century (Hart 2017).

After a series of decrees and reversals by the federal government that created a reservation and then denied the mət̚x̚wu access to their traditional territory, most tribal members were forcibly relocated to the Colville Reservation in eastern Okanogan County. Some tribal land allotments were established near the mouth of the Methow River. The area traditionally used by the mət̚x̚wu was opened to European-American settlement in 1886 (Hart 2017).

The mət̚x̚wu utilized the Chewuch River for subsistence fishing, using seines, spears, basket traps, and wooden weirs to catch fish, primarily salmon. They built platforms and dug channels in the river banks to aid in catching fish (Portman 2002). Riffles and pools in the Chewuch River upstream of Winthrop were locations of salmon harvest (USFS 1994).

Currently, the mət̚x̚wu are one of the 12 tribes of the Confederated Tribes of the Colville Reservation (CTCR) and are actively involved with land stewardship and habitat restoration in the Chewuch River watershed, including at the 320-acre ǰ́w̚námǰ́w̚nam (Hummingbird) property at the Chewuch River confluence with Cub and Ramsey creeks.

3.2.1.2 *European Settlement*

The first known Euro-Americans who came to the Methow Basin were fur traders who arrived in 1811 (Yakama Nation 2015). The Town of Winthrop was established around 1891 at the confluence of the Chewuch and Methow Rivers. A post office and trading post were started by town founder Guy Waring around this time (USFS 1994).

Euro-Americans initially came looking for beavers to supply pelts for hats, but trapping expanded to include other fur-bearers including marten, lynx, weasel, mink, and bobcat. Because beavers were so valuable, the Hudson's Bay Company conducted a systematic campaign to possess all the beaver pelts they could collect. The company dispatched 1,400 trappers to clear all streams of beavers and also enlisted Native Americans to catch them. The campaign nearly extirpated beavers in the entire Oregon territory (which included current-day Washington). By

the 1830s, trapping in and around the Methow Valley had mostly ended, and beavers slowly began to recolonize the area (K. Woodruff, U.S.F.S. retired, interview, 2019).

Starting in the 1920s, wildlife managers started limiting beaver harvest and began a reestablishment program that repopulated streams higher in the watershed, including the Chewuch River. (K. Woodruff, U.S.F.S. retired, interview, 2019). Beaver relocation and associated habitat restoration continues, and there has been an active relocation program in the Methow watershed for the past decade.

3.2.1.3 Mining

Starting in the 1860s, and following the California gold rush of 1849, Chinese immigrants came to mine the Columbia and Methow Rivers for gold. They were placer miners, sifting water and gravel in the river using simple pans and also more elaborate sluice boxes. Most placer mining was done along the Columbia mainstem, but some occurred in the Methow River and its tributaries.

Mining was one of the earliest draws for Euro-American settlers, who descended on the Methow River and started mining camps in the hills above the river. By 1897, several mining operations were underway in the Chewuch watershed, including in Eightmile Creek near Billy Goat Pass (USFS 1994). Around 1914, mining exploration started at Copper Glance Creek – a tributary to Eightmile Creek downstream of Billy Goat Pass. While these efforts initially sought gold, that element proved scarce, so they pursued the copper ore that was found (USFS 1994). In the early 1900s, other mining operations were established on other tributaries including Boulder Creek and Tungsten Creek.

Aside from the initial boom in the early 1900s, mining activity in the Chewuch River watershed has declined to minimal activity currently. Most current mining is associated with several small-scale patented claims, in localized areas around some of the historic mining developments in tributaries to the Chewuch River (G. Shull, USFS, personal communication).

More recently, a limited number of Hydraulic Project Approvals were issued for the Chewuch River for suction dredge mining (USFS 1994). This type of mining was not likely widespread in the Chewuch River. Suction dredge mining is no longer legal in the State of Washington, so it is no longer an active threat to stream habitat in the Chewuch River and there does not appear to be any legacy effects of significance.

The USFS manages several gravel pits in uplands adjacent to the lower Chewuch River around Leroy and Doe Creeks. Material from these pits is used for road maintenance, as well as a source of large boulders that have recently been used for instream habitat restoration projects. (G. Shull, USFS, personal communication).

3.2.1.4 Agriculture

In the 1880's and 1890's, Euro-Americans moving into the Methow River watershed set up homesteads or squatted until they could prove up their holdings. When the homesteaders first arrived, the riverbanks near Winthrop were covered with shrubs and bunch grasses. Cottonwood trees grew closer to water. The homesteaders cleared trees and other native riparian vegetation to establish farms and orchards along the river (Ives 1928, Figure 3.2.1). As the regional population

increased during this time, agriculture, livestock, and lumber production were mainstays of the local economy (USFS 1994).

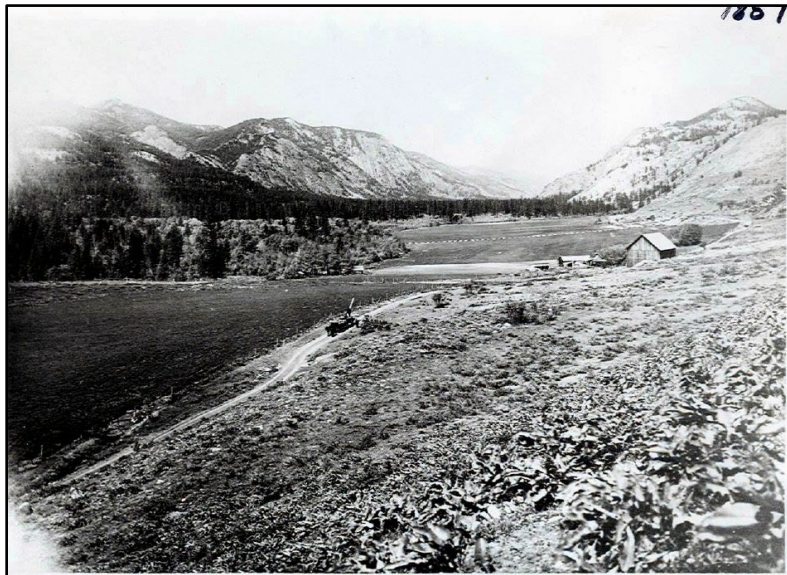


Figure 3.2.1. Early Euro-American settlers cleared extensive areas for agriculture along the Chewuch River, image is looking downstream from near the Cub Creek confluence around 1900. Photo credit: Okanogan Historical Society.

Orchards were an important component of the Methow Valley's economy through the first half of the 20th century. A drought that lasted between 1919-1932 increased the pressure for irrigation water from the Methow River and its tributaries and left many unirrigated (e.g., dry land) fields unsuitable for agricultural production. In response, many orchards and dairy operation ceased to be viable endeavors, but the lands that were cleared for these endeavors remained in a disturbed condition. The height of the apple industry lasted from 1940 to 1968. In 1968-69 a prolonged cold snap killed most of the apple trees, and the industry never recovered.

Currently, there is only one remaining commercial orchard in the lower Chewuch River near Pearrygin Creek. Grass and alfalfa hay production (fed primarily via irrigation ditches from Chewuch River surface water) continues at several locations in the Chewuch-Pearrygin AU, primarily along the east side of the river in the vicinity of Pearrygin and Ramsey Creeks.

After the Methow River watershed was opened to Euro-American settlement in the 1880s, grazing intensity from cattle and sheep increased over time up until around the 1940s. Sheep grazing in the Chewuch River watershed began around 1900 and was at its peak in the 1920s, when approximately 10,000 head were grazed on allotments throughout the watershed (USFS 1994). Sheep grazing declined after World War II, and there are no current active sheep grazing allotments in the Chewuch River watershed.

Cattle grazing has been on-going in the Chewuch River watershed for more than a century. Prior to the decline in sheep grazing, cattle grazing was concentrated in the lower portions of the watershed around Pearrygin, Cub, and Eightmile Creeks, but it expanded after the 1950s to include allotments that had been formerly used by sheep. Currently, there are several active cattle

grazing allotments in the watershed, including in Cub, Eightmile, Boulder, and Ramsey Creeks (G. Shull, USFS, personal communication).

The effects of early grazing on pasture (forage) condition was documented as early as the 1930s, when diminished pasture quality, severe erosion, and invasive weeds were recorded after the 1919-1930 drought (USFS 1994). Grazing was widespread throughout the basin, including within riparian areas surrounding streams, springs, and wetlands. Many of these water sources have direct connection to the Chewuch River. These impacts have contributed to increased soil and vegetation disturbance, caused changes in infiltration, sediment, and runoff patterns, and resulted in an overall decrease in watershed condition (USFS 1994).

3.2.1.5 Irrigation

Water withdrawals from the Chewuch River and some of its tributaries have been on-going for over a century. Soon after becoming established in the Methow watershed, Euro-American settlers began development of an extensive array of irrigation ditches to convey surface water from the Chewuch River to nearby agricultural lands that had been cleared by the settlers. Many of the ditches were build using hand and horse power as well as explosives (Portman 2002). Beyond the mainstem Chewuch, diversions were built on Falls, Eightmile, Boulder, Ramsey, Cub, and Pearrygin Creeks (Figure 3.2.2). While many of these smaller tributary diversions are no longer active, many of the cleared areas they supplied, including some floodplain areas, are still visible (and remain in a highly altered and/or developed condition) within the Chewuch-Pearrygin AU.

Currently, there are three active mainstem diversions, Fulton (RM 1.2), Chewuch (RM 8.6), and Skyline (RM 8.9) – all of which divert surface water (up to a maximum of 52 ft³/s) from within the Chewuch-Pearrygin AU (see also Section 3.3). The diversion canal alignments and service areas for these ditches are similar to when they were established in the early 1900s.

While the Skyline ditch diverts water through a bank-tied headgate, both Chewuch and Fulton diversions have relied upon channel-spanning dams to create sufficient hydraulic head for the diversions to operate. While both of these dams have been modified in recent years to facilitate fish passage, they remain in the river to impound water for the diversions. Water pools on the upstream side of the dams, creating steep, high velocity drops on their downstream sides (Figure 3.2.3). The impoundment zone at Fulton Dam is much larger relative to the pool behind Chewuch Dam (Figure 3.2.4).

Both dams, to varying degrees, create artificial hydraulics (at all flows) and impede fish passage to some degree. Chewuch Dam has been identified as only 67% fish passable, while Fulton Dam has not been extensively examined for passage (WDFW 2018, J. Novak, WDFW, personal communication).

In the early and mid-20th century, irrigation diversions in the Methow watershed lacked screens to prevent juvenile fish entrainment into the ditches. Many fish entering the diversions ended up dying in the ditches and the irrigated fields they supplied. While many of the diversions, including all three Chewuch mainstem diversions, are now screened with operational fish return channels, some fish, including ESA-listed salmonids and other native fish species (e.g., lamprey, suckers, dace, sculpin) continue to be entrained and face the possibility of injury or mortality.



Figure 3.2.3. Chewuch Dam at high flow, June 2010. The fish passage channel can be seen to left of concrete wall at left side of image.



Figure 3.2.4. The Fulton Dam impoundment zone extends upstream for approximately one-quarter mile, July 2023 photo.

3.2.1.6 Timber Harvest

Prior to the 1930's, logging in the lower Chewuch watershed was relatively light, done mainly by local residents for building materials and firewood. During the 1920s-1930s, annual timber harvest was approximately one million board feet; some of this wood supplied a small sawmill along the banks of the Chewuch River in Winthrop (USFS 1994, USFS 2015, Figure 3.2.5).



Figure 3.2.5. Early timber harvest in the Chewuch River watershed supplied the sawmill in Winthrop. The Fulton Ditch conveyance pipe can be seen crossing the river to the left of the mill. Photo credit: Okanogan Historical Society.

In the latter half of the 1940s, timber harvest in the Chewuch watershed increased significantly (as did road construction to access the timber) spurred on by a post-World War II construction boom. In terms of overall volume, timber harvest in the 1950s was the peak of timber harvest in the watershed, with 30 million board feet harvested annually during this decade (USFS 1994). Annual harvest declined in subsequent decades (as did new road construction), but it was still robust during the 1970s -1980s when more than 200 million board feet were harvested. Logging tapered off in the 1990s to around 3 million board feet annually. Currently, very little timber harvest occurs in the Chewuch watershed aside from harvest for firewood and Christmas trees.

The majority of timber harvest occurred in the lower half of the watershed and extensively within the LCRA area. Logging was widespread in USFS lands in the Cub, Eightmile, Falls, Pearrygin, Boulder, Doe, and Twentymile Creek watersheds. Harvest was also intensive along the mainstem Chewuch River downstream of the Lake Creek confluence. Very little logging occurred in the upper portions of the watershed and in areas of what is now the Pasayten Wilderness.

3.2.1.7 Transportation

The earliest transportation routes up-valley were trails established and used by the *m̄t̄x̄wu*. After Euro-American settlement, roads became established in the 1920s to access areas used by grazing, mining, and, especially, timber interests. By 1931, the West Chewuch road had been

established from Winthrop up to the Thirtymile area, and several other roads had been established in tributary basins including Cub, Boulder, and Eightmile Creeks (USFS 2015). Around this time, the East Chewuch road was established up to the vicinity of Leroy Creek. Both the West and East Chewuch roads, and many of the tributary roads, exist today and are the primary roads accessing for accessing the Chewuch River.

During the period of intensive timber harvest in the watershed during the 1950s-1980s, road construction to access timber resources expanded and was widespread. This development activity resulted in an extensive road network – among the highest density (road mi/mi²) found in the Methow watershed. The 1994 watershed analysis identified that at least 25% of these roads were constructed on highly erodible soils that can contribute fine sediment to streams (USFS 1994). Additional information on roads within the LCRA area is provided in Section 4.

Three bridges cross the Chewuch River, including the Winthrop (RM 0.3), MacPherson (8.4), and Twentymile (RM 21.5 – just upstream of the LCRA area) bridges. The downstream two bridges, both within the LCRA area, include extensive bank riprap and concrete footings that alter local instream and riparian habitat.

3.2.1.8 Stream Channel Modification

The floods of 1948 and 1972 resulted in damage to private lands, bridges, and roads (USFS 1995). In response, the U.S. Army Corps of Engineers led an effort to remove large wood accumulations from the Chewuch River (USFS 1994, Figures 3.2.6 and 3.2.7). Bulldozers were employed as a means of debris removal and debris and slash were burned nearby after removal. During these channel clearing events, the channel was also straightened to prevent future accumulations of wood and reduce flood potential (USFS 1994). Additionally, in the years following major floods a significant amount of bank armoring (e.g., riprap) occurred.

Post-flood stream clearing in the Chewuch River was concentrated downstream of Lake Creek, although precise locations and extent of clearing actions is not well documented. Channel clearing can have long-lasting effects on stream environments, including increased stream energy, increased bed and bank scour/erosion, channel widening, and altered large wood and sediment transport dynamics (USFS 1994). Stream clearing activities in the Chewuch River are likely one of the more significant legacy effects on habitat diversity and quality.

Riprap is present within the LCRA area and was placed to prevent flooding and damage to roads and bridges. Relative to the Methow River, riprap in the LCRA area is not extensive in terms of bank length. Riprap is most prevalent in Winthrop (Pearrygin 1 reach) and around residential developments in reaches Pearrygin 6-8 and 10-11. Relative to the Chewuch-Pearrygin AU, very little bank armoring exists in the Chewuch-Doe AU.



Figure 3.2.6. Chewuch River mainstem wood accumulation, pre-wood clearing event, 1963.



Figure 3.2.7. Chewuch River mainstem channel, post-wood clearing event, 1963.

3.3 Lower Chewuch River Hydrology

The hydrologic regime in the lower Chewuch River was characterized through analyses of stream flow timing, magnitude, duration, flood frequency, and high and low flows. Analyses utilized stream flow data collected at USGS gage #12448000 (Chewuch River at Winthrop) between 1992-2023. Information on irrigation diversions was obtained from various sources (USFS 1994, Golder and Associates 2002, NWPPC 2004) and summarized by MSRF.

3.3.1 Annual Hydrograph

Typical of snowmelt-driven watersheds in the North Cascades Ecoregion, the annual hydrograph of the Chewuch River is characterized by a single, prolonged duration (~4 month) snowmelt freshet followed by a long period of relatively low stream flow from September – March (Figure 3.3.1). The majority of water that passes through the LCRA area is a result of snowmelt during the spring and early summer months originating from high elevation areas within the upper Chewuch River watershed and its major tributaries, including Boulder, Eightmile, Twentymile, Lake, and Andrews Creeks.

In addition to snowmelt, rain falling during the spring contributes to runoff and can lead to rapid increases in discharge, especially when the rain falls on snow. Convective storms, which may occur throughout the year but are most common during the summer months, can also contribute to short duration increases in discharge, especially on burn scars of recent wildfires.

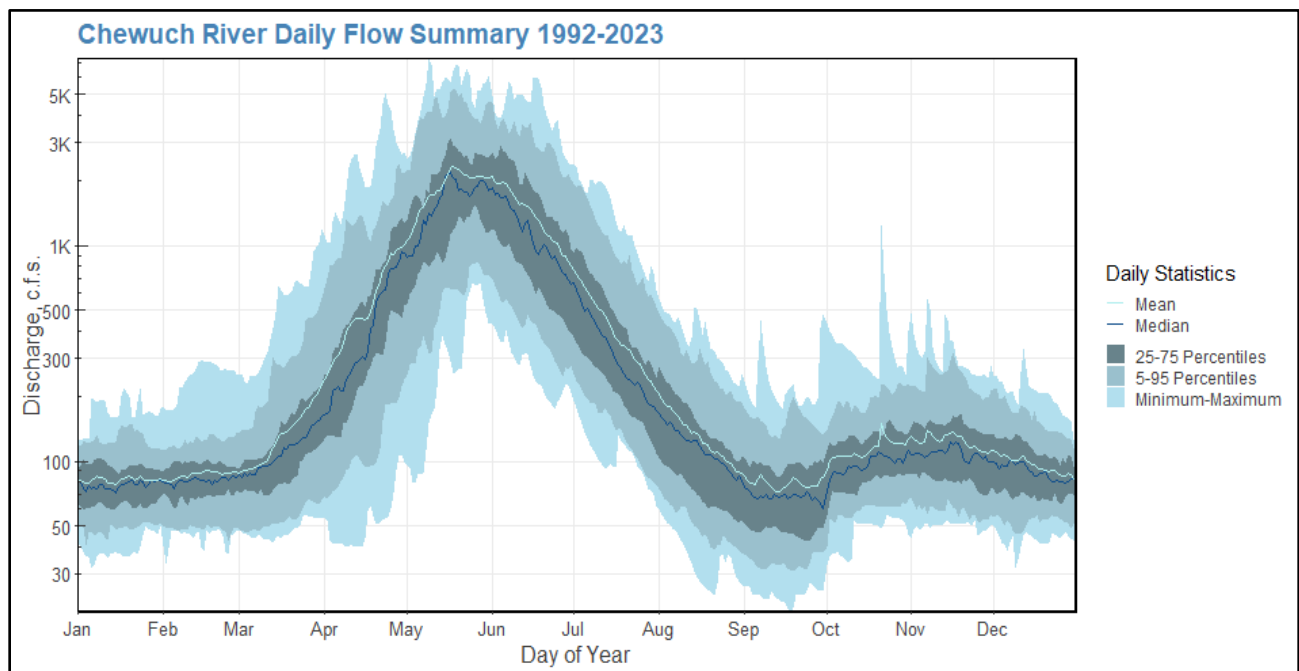


Figure 3.3.1 Annual hydrograph of the Chewuch River at Winthrop, WA. Daily statistics include the minimum, maximum, and the 25/75th, and 5/95th percentiles of the mean daily discharge measured at USGS gage #12448000 (Chewuch River at Winthrop, WA) between 1992-2023.

3.3.2 Surface Water Diversions

In most years, there is an observable increase in discharge from baseflow levels beginning around October 1st. This increase is the result of the cessation of water withdrawals associated with three irrigation diversions that divert surface water from the Chewuch River.

Diversion shut-off timing and return volume varies to some degree each year, depending on diversion-specific operations which vary year to year (C. Johnson, MSRF, personal communication), but over an approximately six-week period in the fall, instream flow downstream of all three diversions (at approximately river mile 1) can increase by as much as 50 ft³/s as a result of ditch shut-offs.

The irrigation diversions usually begin diverting flow in April when stream discharge is much higher and more variable compared to the fall shutoff period. As such, the impact of the spring onset of diversion operations on the overall river discharge volume is less significant relative to the fall shut-off and does not generally result in an obvious (i.e., measurable) decrease in total discharge.

Overall, diversion rates for the three diversions varies throughout the irrigation season based on a number of factors, including water needs for users, instream flow requirements, conveyance maintenance schedules, and variations in channel discharge. Operational summaries for the three diversions are presented in Table 3.3.1.

Table 3.3.1. Location, timing, and volume of water diversions from the Fulton, Chewuch, and Skyline diversions from the mainstem Chewuch River. Note: Operational timing and diversion rates may vary beyond those provided.

Diversion	Location	Reach	Operational Timing	Diversion Volume (ft ³ /s)	Comments
Fulton	RM 1.2	Pearrygin 1	Apr 15 – Oct 15	13	Return flow to mainstem of several ft ³ /s occurs downstream of fish screen
Chewuch	RM 8.6	Pearrygin 7	May 1-Sep 30	24 - 30	Flow trigger for reduction to 17 ft ³ /s when Chewuch gauge ≤80 ft ³ /s
Skyline	RM 8.9	Pearrygin 8	Apr 1- Nov 1	4.5 - 9	Flow trigger to reduction to 9 ft ³ /s when Chewuch gauge 80-200 ft ³ /s and reduction to 4.5 ft ³ /s when gauge ≤80 ft ³ /s

At flows >200 ft³/s (measured at the USGS gauge in Winthrop), the three diversions may remove up to 52 ft³/s. At flows ≤100 ft³/s, diversion volumes fall to 46 ft³/s, and at ≤80 ft³/s, diversions fall to approximately 41.5 ft³/s, which represents the lowest diversion volume for the three diversions combined. At 80 ft³/s, diverted flows may reduce overall instream flow by approximately 50%.

3.3.3 Hydrograph Trends

Annual variations in snowpack, rain, weather, and timing of precipitation events are primary contributors to the observed differences in annual Chewuch River discharge observed at the Winthrop gauge station (Figures 3.3.2 and 3.3.3). Each year is unique in this respect. A relatively dry (i.e., low runoff) period occurred during 2000-2005 with 2001 representing the lowest overall runoff volume on record. Other years of low annual discharge were observed in 1992, 2009, 2015, and 2019.

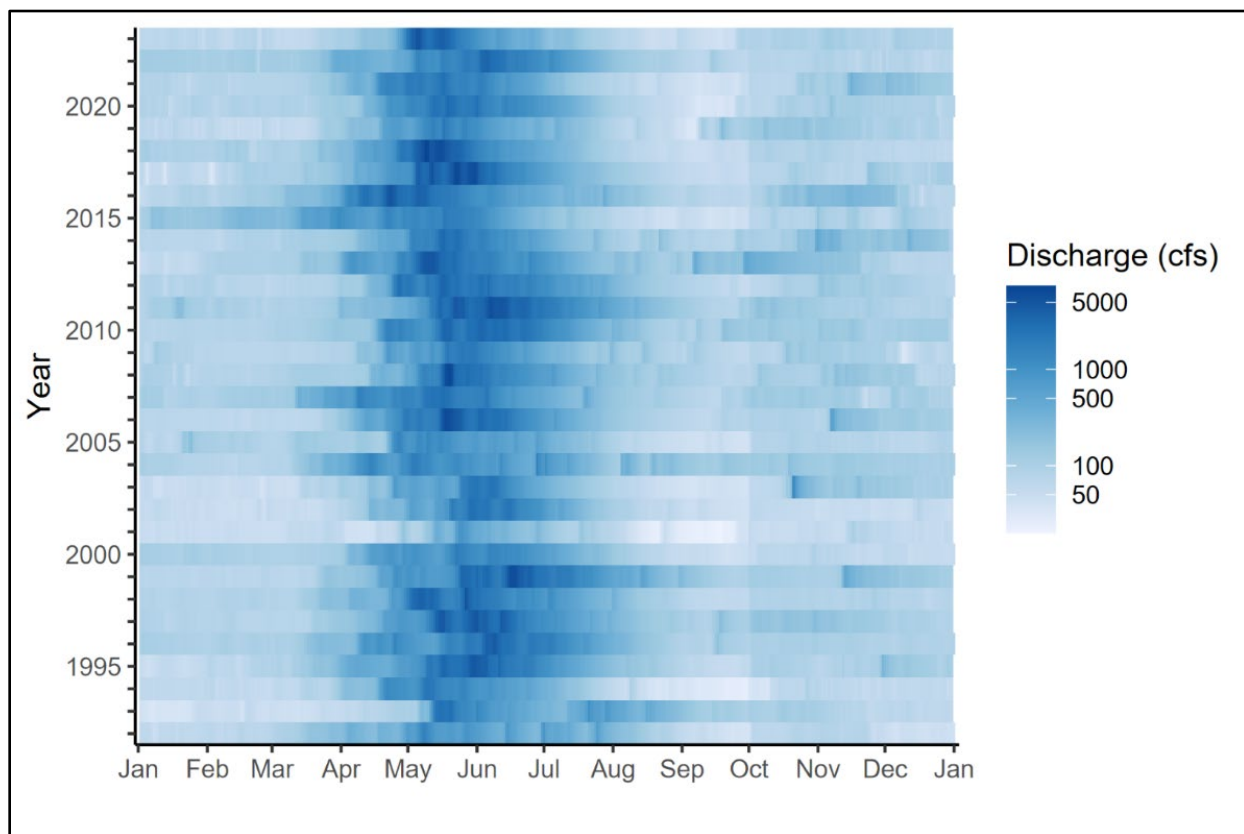


Figure 3.3.2. Annual discharge timing and rate of the Chewuch River at Winthrop, WA (USGS Gauge #12448000) from 1992-2023. Figure from Reclamation Technical Services Center.

Years with the highest annual discharge occurred in 2006, 2008, 2011, 2017, and 2018. The latter four of these occurred since 2010 (when the previous reach assessment was published) and have had a significant influence on the overall discharge estimations for the basin.

The annual snowmelt freshet typically occurs over a 4–5-month period, often beginning in early April and ending in July (Figure 3.3.4). The overwhelming majority of annual discharge occurs during this period. Average monthly flows are relatively low for at least six months each year (typically September-February).

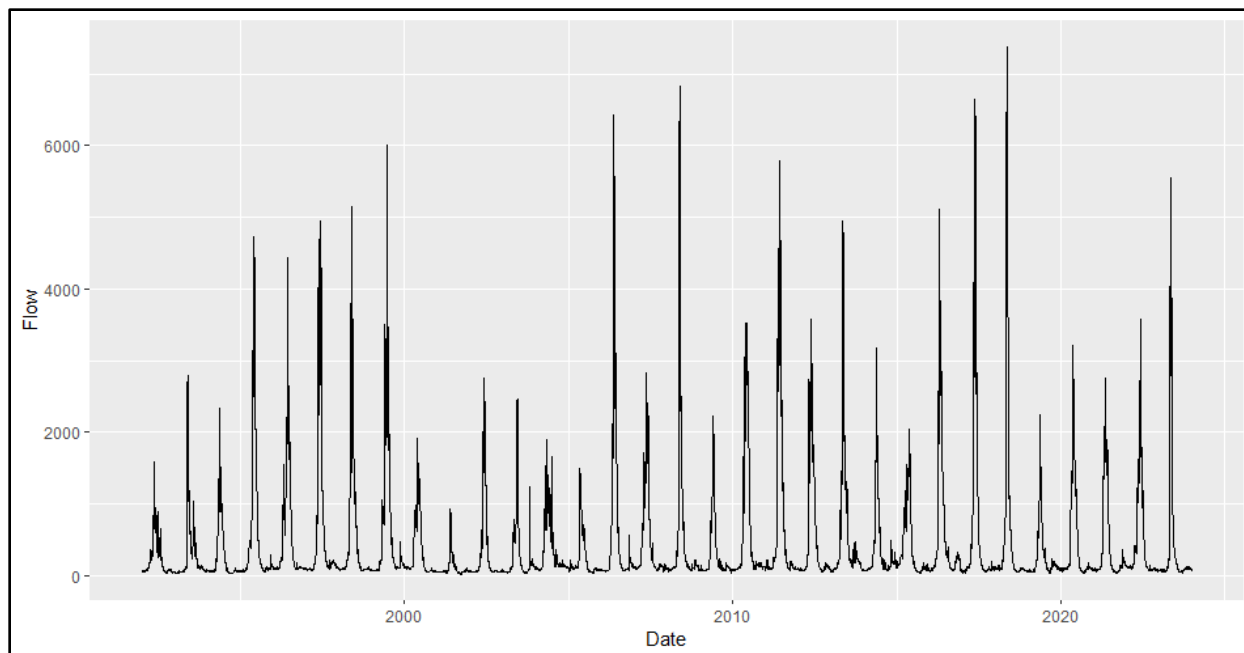


Figure 3.3.3. Annual hydrographs for the Chewuch River at Winthrop, WA (USGS Gauge #12448000) from 1992-2023.

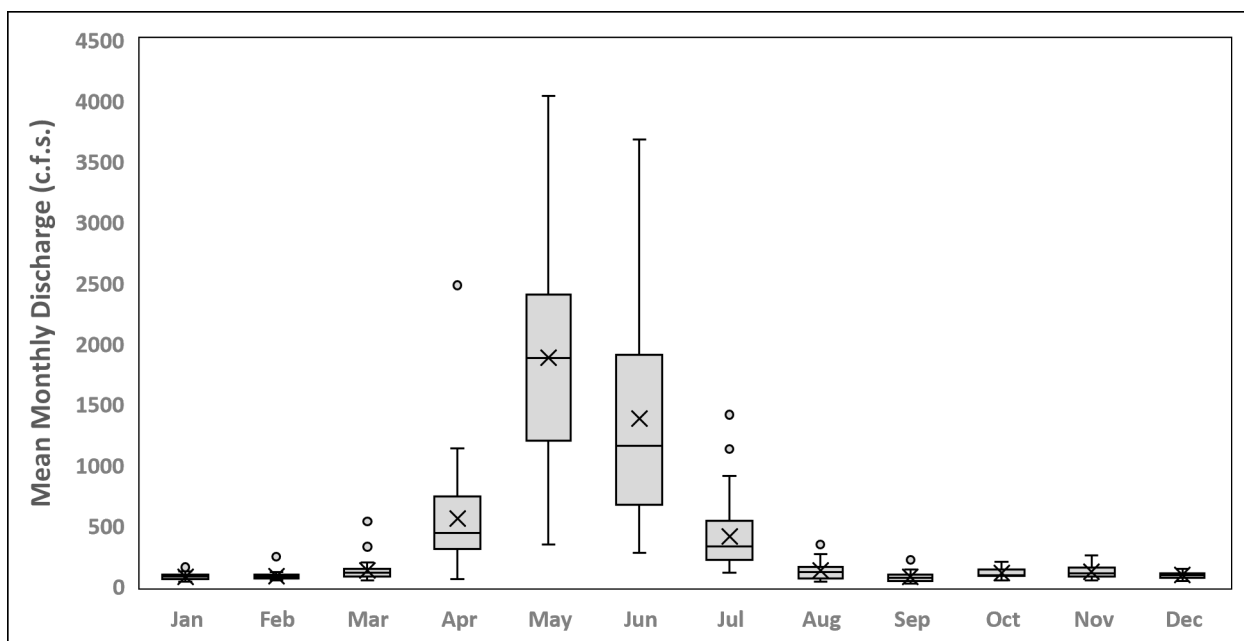


Figure 3.3.4. Monthly mean discharge of the Chewuch River at Winthrop, WA (USGS Gauge #12448000) from 1992-2023. Statistics include median (black line), mean (X), upper and lower quartiles (boxes), maximum and minimum (whiskers), and outliers (points).

3.3.4 Peak Flows

Observed peak flows between 1992-2023 in the Chewuch River have never exceeded 10,000 ft³/s (Figure 3-15). It is possible that peak flows in the largest known floods, which occurred in 1894, 1948, and 1972 exceeded this threshold. The highest flow on record was 8,910 ft³/s observed on 5/10/2018. The lowest annual peak flow was observed in 2001 at 1030 ft³/s on 5/25/2001.

The timing of peak runoff varies annually and is primarily based on spring air temperature and precipitation patterns. Over the period of record, the timing of peak discharge has been relatively stable and generally occurs over an approximately three-week window from mid-May to early June (Figure 3.3.5). The earliest recorded peak occurred on 4/22/2016 and the latest peak was observed on 6/27/2004.

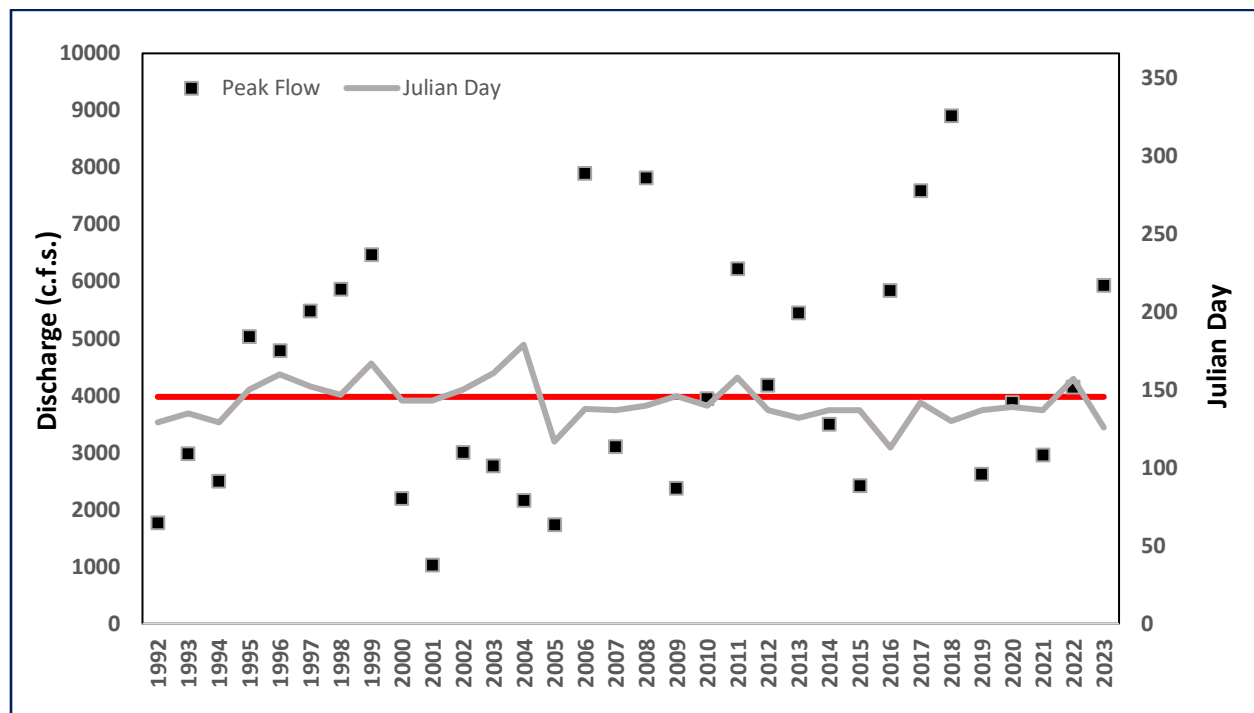


Figure 3.3.5. Annual peak discharge and Julian Day timing of peak flow, Chewuch River at Winthrop, WA (USGS Gauge #12448000) from 1992-2023. Red line denotes estimated Q2 discharge.

3.3.5 Flood Frequency

Flood magnitude and occurrence probability in the Chewuch River was analyzed using a flood frequency analysis with a Log-Pearson Type III probability distribution method used to fit the sample distribution of annual peak discharge (Figure 3.3.6, Benson 1971, IACWD 1982). The largest snowmelt floods that have occurred in the Methow River Basin since the end of the 19th century occurred in 1894, 1948, and 1972. The 1948 flood was the largest of these, with a return interval equivalent in the Methow River estimated to be >100 years (USBR 2008). No gauge station was present in the Chewuch River in 1948, but it is assumed that it also reached a flood stage similar to what was estimated for the Methow River.

The 1948 flood (peak discharge of 40,800 ft³/s) in the larger Methow River watershed resulted in significant channel and floodplain changes including changes in channel position and geometry (Beck, 1973; USBR, 2008). In particular, the 1948 flood eroded banks, caused avulsions and meander cutoffs, and channel width increases, as well as eroded and filled in secondary channels. In addition to geomorphic changes, the 1948 flood also destroyed infrastructure, including roads and buildings (Beck 1973, USBR 2008). The 1972 flood also caused significant geomorphic changes in the Methow River, particularly in the unconfined and partly confined areas within the watershed, although the peak discharge (28,800 ft³/s) was only half that of the 1948 flood. While it is not well documented, changes to the channel configuration in the Chewuch River as a result of the 1948 flood may have been significant, especially in the partially confined reaches such as Pearrygin 3-5 and Doe 1-2 and 4-6.

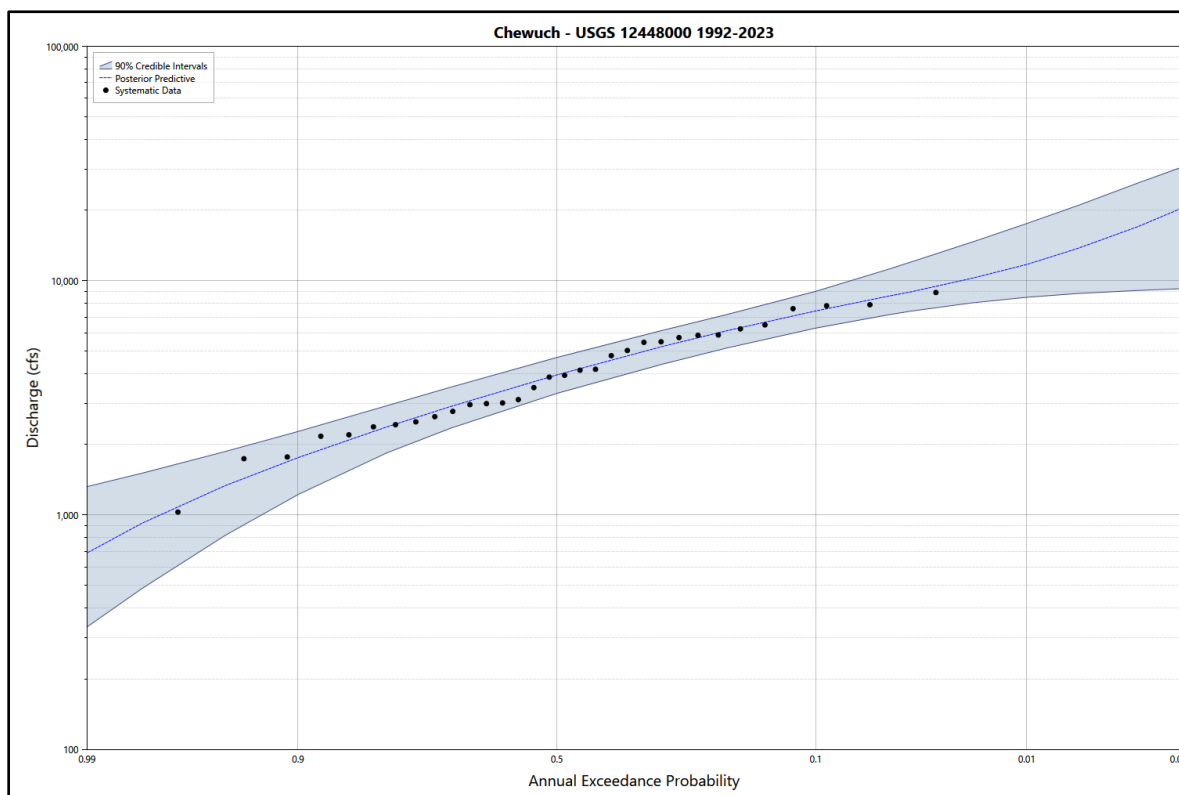


Figure 3.3.6. Flood frequency in the Chewuch River for the period 1992-2023 constructed from discharge measured USGS gauge #12448000 at Winthrop, WA. The curve was developed using the Log-Pearson Type III probability distribution method. Figure courtesy of USBR Technical Services Center.

Estimated flood recurrence levels were derived from the flood frequency analysis and provide information related to flood magnitude and stage, of the Chewuch River (Table 3.3.2). This information is useful in the development of flow levels to use in hydraulic modeling efforts as well as restoration project alternative development. The 1.5-year estimate was 3,087 ft³/s, and for the 2-year was slightly less than 4,000 ft³/s, thus bankfull, and channel forming, flow levels in the Chewuch River likely fall somewhere within the range of these two intervals. The 10-year flood was estimated at 7,427 ft³/s and the 100-year flood discharge was 11,770 ft³/s. The peak flood of record was recorded in 2018 (8,910 ft³/s) which equates to a 25-year event.

Prior to the 2010 Chewuch Reach Assessment, discharge data from 1993-2006 suggested lower flood stage magnitudes relative to those predicted from 1993-2023 data. This is due in large part to several relatively high flood flows since 2006 including in 2008, 2017, 2018, and 2023.

Table 3.3.2. Flood magnitude at selected recurrence intervals in the Chewuch River for two time periods during 1992-2023 from USGS gauge #12448000 Chewuch River at Winthrop.

Recurrence Interval	1	1.5	2	5	10	25	50	100
1992-2023 discharge (ft ³ /s)	689	3,087	3,977	6,136	7,427	8,939	10,240	11,770
1992-2006 discharge (ft ³ /s)	n/a	n/a	3,240	4,980	6,100	7,470	8,450	9,390

3.3.6 Flow Duration

A flow duration curve based off mean daily flow observations was developed to estimate the probability of occurrence of any given flow in the Chewuch River (Figure 3.3.7). Flow duration curves are useful in assessing the temporal variability of stream flow by showing the proportion of time that a particular stream flow is equaled or exceeded (i.e., exceedance probability).

The 50% exceedance value for the Chewuch River is 116 ft³/s which is a flow level commonly observed during the low flow period from August – February (see Figure 3.3.7). The 90% exceedance value is 56 ft³/s, which is less than any monthly mean discharge. A discharge of 1000 ft³/s equates to approximately a 12% exceedance probability, which is only exceeded as a mean monthly flow in May and June. Flows exceeding 3,000 ft³/s < 2% probability of occurrence.

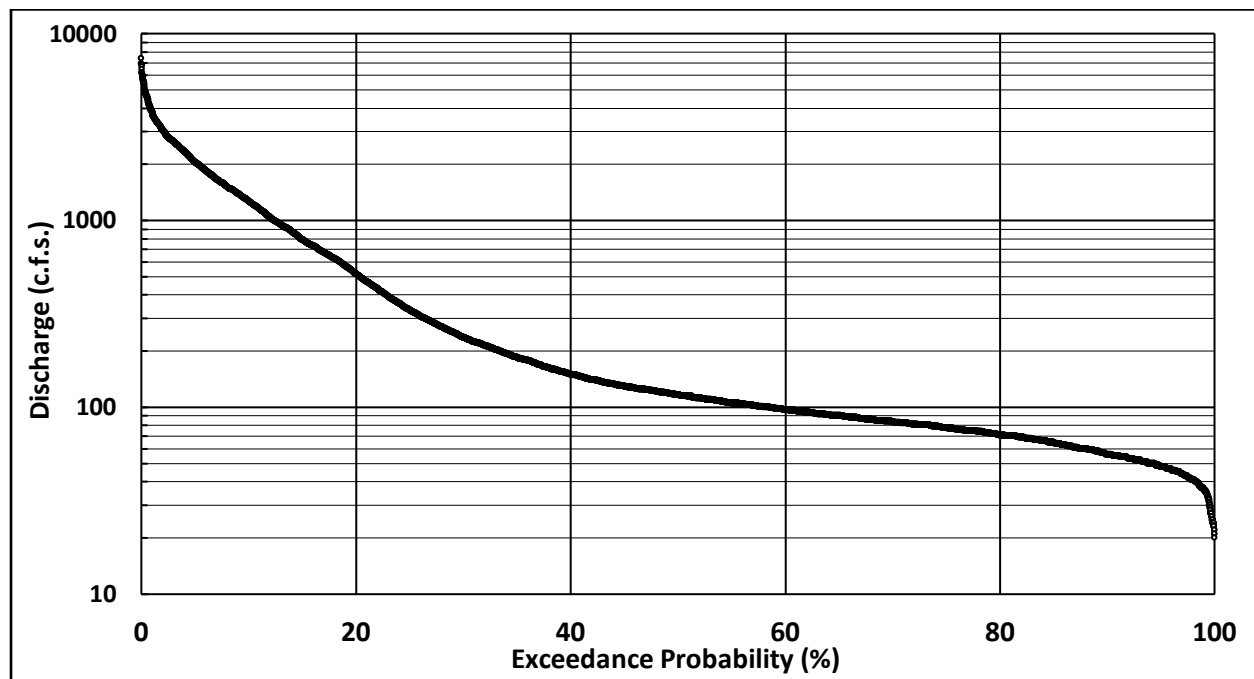


Figure 3.3.7. Flow duration curve for mean daily flow at USGS gauge 12448000 (Chewuch River at Winthrop, WA), 1992-2023.

3.3.7 Low Stream Flow

Outside of the spring freshet period, normally March to August, stream flow in the Chewuch River is relatively low and typically does not exceed 150 ft³/s (Figure 3.3.1 and 3.3.4). However, relatively small, storm-driven rapid increases in discharge may interrupt the long season of base flow. These events occur particularly in October through early December, when isolated weather systems deliver precipitation either in the form of rain, mixed rain and snow, or snow that subsequently melts.

Minimum annual low flows have always been less than 100 ft³/s during the period of record (Figure 3.3.8). It is notable that flows recorded at the USGS gauge site in Winthrop represent an underestimation of the actual flows due to irrigation diversion operations from approximately April 1 – November 1 each year. Diversion rates and timing vary by diversion location and year and it is difficult to accurately estimate the overall reduction in downstream flow that occurs as a result of irrigation withdrawals, but it has been estimated that gauged flows may underestimate flow upstream of diversions by 20-30% (Golder Associates 2002).

The lowest recorded flows in the Chewuch River were observed in 2001 (20 ft³/s), 1994 (25 ft³/s), and 2009 (32 ft³/s). Generally, minimum daily flows have increased since instream flow transactions and irrigation efficiency projects went in effect in the early 2000s, but flows currently still drop below 50 ft³/s. The periods from 1996-1999 and 2010-2011 represent the highest minimum flows which were > 65 ft³/s.

The timing of the minimum flow varies substantially more than that of the peak flow (Figure 3-18). In approximately 50% of the years, annual minimum flows have occurred during the last two weeks of September. This timing coincides with naturally occurring post-freshet low flows coupled with irrigation withdrawals.

Minimum flows can also be observed during winter from late December through early February when irrigation diversions are not operational. Winter low flows coincide with sub-freezing air temperatures, stream icing, surrounding snowpack, and periods when the majority of precipitation is falling as snow.

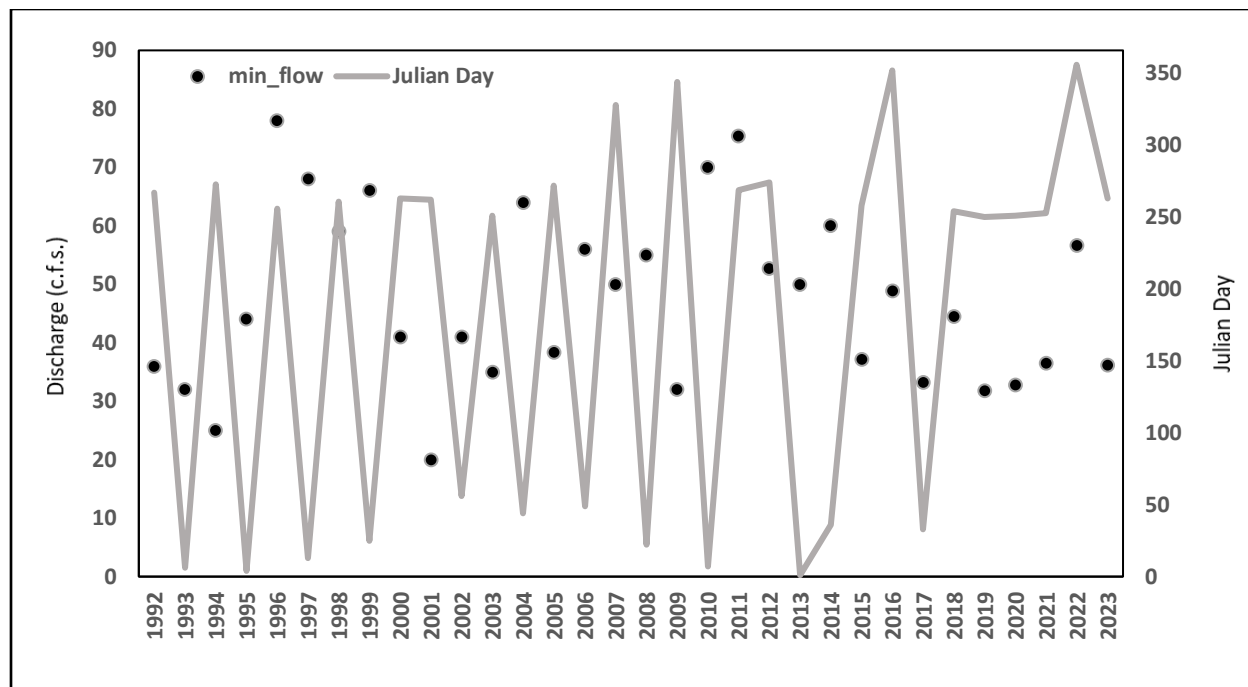


Figure 3.3.8. Annual minimum discharge and Julian Day timing of minimum flow, Chewuch River at Winthrop, WA (USGS Gauge #12448000) from 1992-2023.

3.3.8 Minimum Instream Flows

Minimum instream flows (MIF) for the Chewuch River have been set by several regulatory agencies, including Washington Department of Ecology (WA Ecology), NOAA Fisheries (via National Marine Fisheries Service, NMFS), and U.S. Fish and Wildlife Service (Washington Department of Ecology 1992, NMFS 2000, USFWS 1999). These flows were set to protect river health (e.g., water quality, fish habitat availability) and the various resources that depend on them. These flow rules also protect the river from additional water withdrawals that could exacerbate the detrimental effects of low flows on imperiled fish populations and other resources of interest.

The WA Ecology MIF are the least aquatic habitat-conservative (lowest) of the three sets of flows and are the only criteria that set a range of minimum flows for the entire year and that vary by time of year. The NOAA Fisheries and USFWS MIF flows only apply from April – mid-October and are always higher values requiring more water instream compared those of WA Ecology.

WA Ecology minimum flows range from a low 47 ft³/s from August 15 – September 30 and late fall and winter flows ranging (October – March) between 56 – 68 ft³/s (Figure 3.3.9). These flow periods coincide with the time when the lowest flows have been observed at the USGS gauge. By comparison, NMFS MIF during August-September are significantly higher and range from 121-271 ft³/s. Based on available gauge data, the Chewuch River currently is better able to meet WA Ecology MIF compared to either NMFS or USFWS criteria

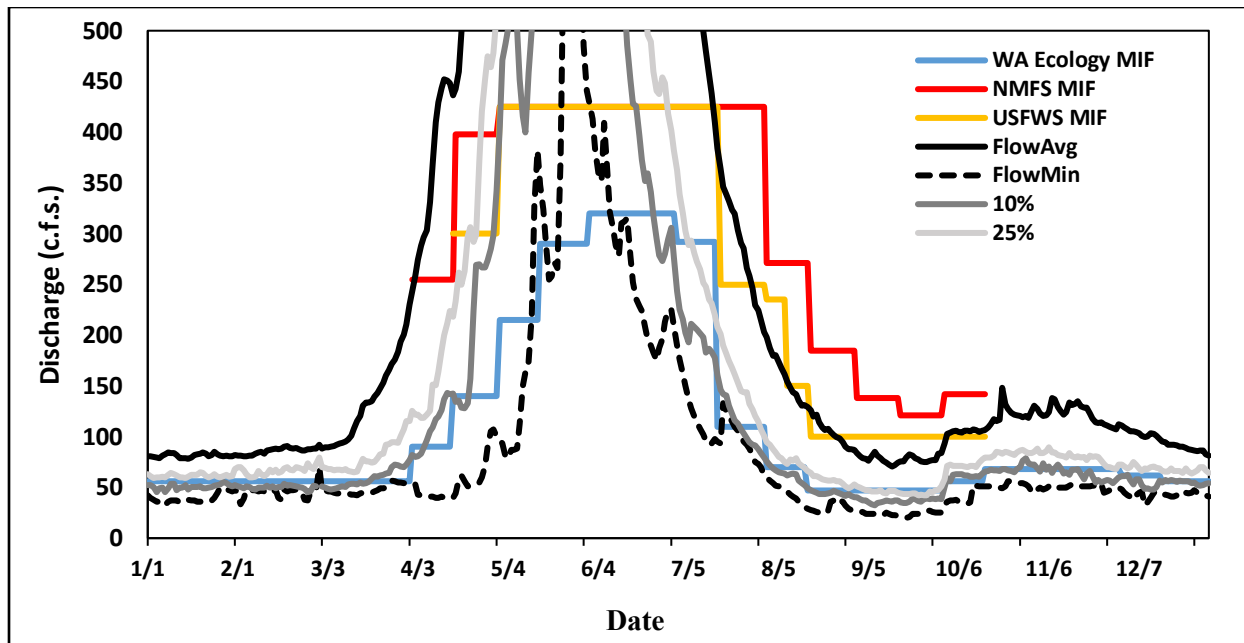


Figure 3.3.9. Minimum instream flow for the Chewuch River from WA Ecology, NOAA Fisheries, and USFWS plotted with mean, minimum, 10%/25% exceedance discharges for the Chewuch River at Winthrop, WA (USGS Gauge #12448000) from 1992-2023.

Gauge observations reveal that in many years, with the exception of high flows during the spring freshet, minimum flows in the Chewuch River often fall below MIF criteria for all three sets of criteria. For the most part, flows below all MIF criteria are most common during baseflow recession and baseflow conditions July-September (Figure 3.3.9). Of particular note, the period from late August through September is the only period when the daily average flows have been observed to drop below NMFS and USFWS MIF, but not those of WA Ecology.

An examination of the WA Ecology and NMFS criteria, which define the high and low criteria sets, the number and percentage of days that MIF are met (based on USGS gauge data) varies by year (Figure 3.3.10). Overall, both the number and percent of days exceedance is higher for the NMFS MIF relative to the WA Ecology. Because Chewuch River flows fall below NMFS MIF more often than WA Ecology MIF and NMFS MIF applies to fewer days than WA Ecology MIF, percent of days below MIF are considerably higher for NMFS requirements.

The average annual number of days that flows fall below NMFS criteria is 106 days/year (range 54-188 days) compared to 45 days/year (range 0-278 days) for WA Ecology. For percent of days of exceedance (i.e., flows less than criteria), the differences between the criteria sets are even more apparent, with average annual exceedance for NMFS (54%) over four times more than WA Ecology (12%) even though the NMFS MIF are in place for only about half of the time of the WA Ecology MIF. In some dry years, percent exceedance of the NMFS criteria exceeds 60% and in 2001, an especially dry year, exceedance was 95%.

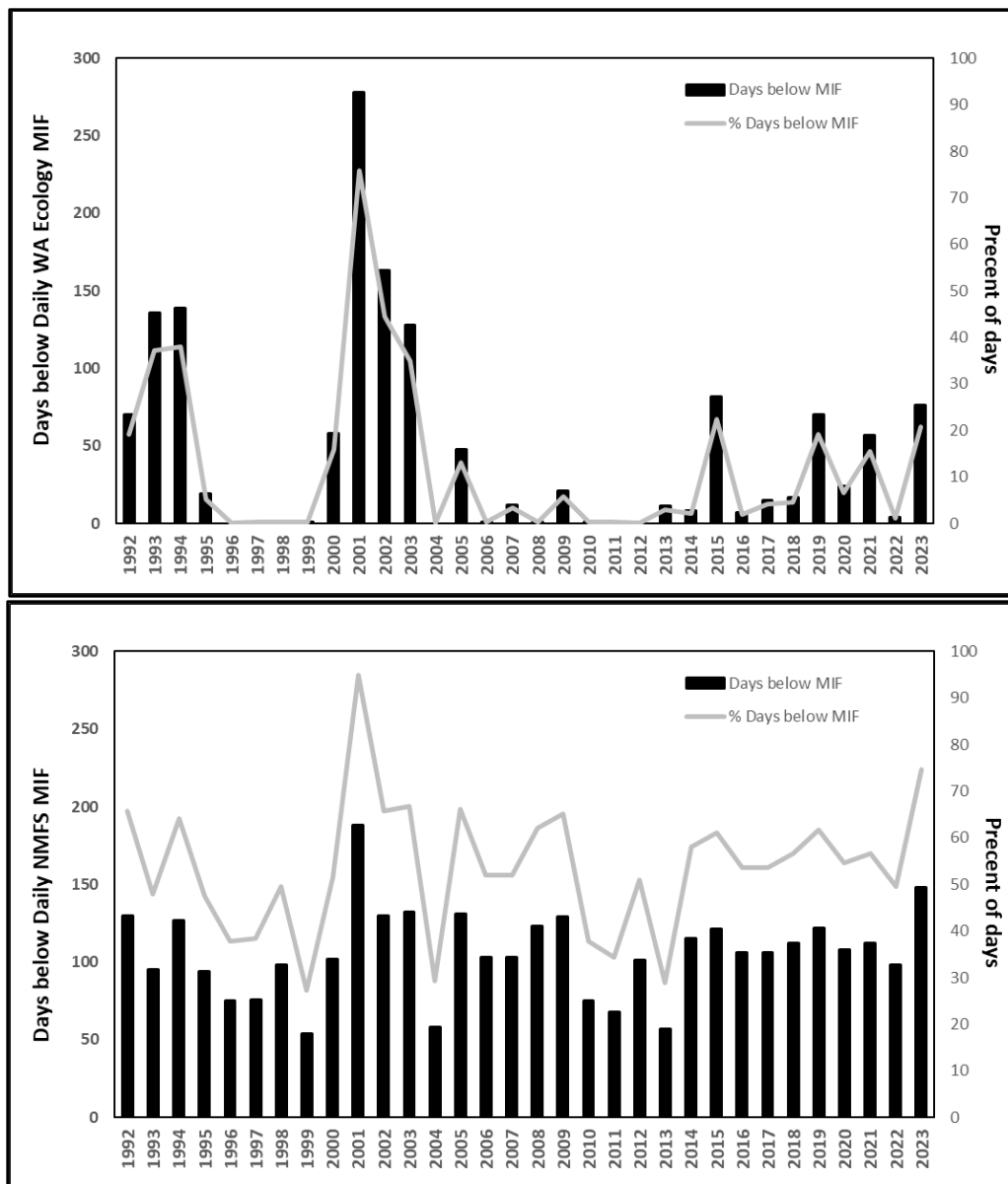


Figure 3.3.10. Annual days and percent of days of exceedance of A) WA Ecology and B) NMFS MIF for the Chewuch River based on discharge for the Chewuch River at Winthrop, WA (USGS Gauge #12448000) from 1992-2023.

3.3.9 Decadal Hydrograph Trends

To examine discharge variation over time, Chewuch River mean daily discharge data from USGS gage #12448000 were summarized over three decadal time periods, including the 1990s (1992-2001), 2000s (2002-2011) and 2010s (2012-2021).

The overall volume of annual runoff increased over time from the 1990s (105.6-million-acre feet, or ‘maf’) to the 2000s (111.5 maf) to the 2010s (121.4 maf). Flows observed in the 2010s represent a 13% increase over the 1990s and an 8% increases over the 2000s.

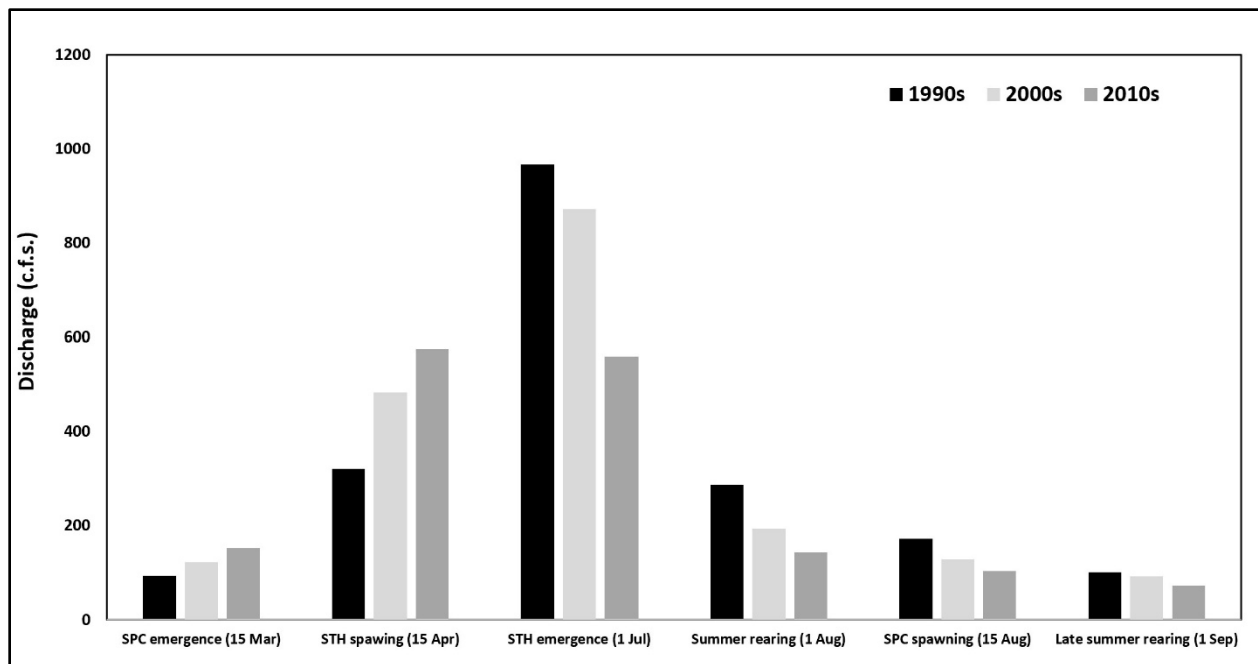


Figure 3.3.12. Chewuch River daily average flow on select dates coincident with fish life stages by decade, 1992-2021, Chewuch River at Winthrop, USGS Gauge #12448000.

3.4 Geomorphology and Hydraulics

3.4.1 Geomorphology

A geomorphic assessment and hydraulic modeling report for the LCRA area was completed with detailed methods, analyses, and results that are presented in Appendix A. The geomorphic and hydraulic analyses, summarized here, used field-collected information about geomorphology and river characteristics in combination with available lidar and streamflow data. Geomorphic analysis products include relative elevation maps, height above surface water maps, geomorphic unit maps, and calculation of change over time for geomorphic unit surface area and active channel width. Hydraulic modeling products include depth, velocity, and water surface elevation data for Fall 2022 conditions (e.g., when bathymetric lidar data were collected) as well as inundation boundaries at a range of discharges. All geomorphic and hydraulic assessment products are available in the LCRA geodatabase.

The Chewuch River within the LCRA area is characterized by areas of pool-riffle morphology interspersed with areas of more uniform width and depth. These river morphologies have developed due to the contributing hydrologic and geologic characteristics of the reach that stem from underlying geology, geography, and hydrology. Geologic conditions, including river slope, valley width, and river bed sediment grain size interact within the river's hydrologic regime to establish the fluvial geomorphological setting of the lower Chewuch River.

Channel slope is a primary driver of streamflow energy, with steeper slopes contributing to higher river energy and greater sediment and wood transport potential. Between RM 0 and 20, the Chewuch River has an average slope of 0.56%. However, individual *Prioritization* reaches range in slope from 0.1% to 1.8% (Figure 3.4.1). Channel slope in the LCRA area is often controlled by tributary confluences, with slopes immediately upstream of the confluence

shallower and slopes downstream of confluences steeper. For example, the lowest average reach slope is in Pearrygin 10 immediately upstream of the Boulder Creek confluence at approximately RM 10, while the steepest reach is Pearrygin 8 downstream of the same confluence.

Valley confinement also plays a large role in determining channel form and floodplain development in the LCRA area. Along the lower Chewuch River, alluvial fans and valley walls are the primary confining features. In addition to natural controls, rip-rapped banks along the river, where present, act as anthropogenic confining features. In the LCRA area, most of the existing riprap was placed to protect roads or residential developments.

Generally, the Chewuch River can be considered a confined or partly-confined river (based on the 1.5-year:10-year lateral inundation width ratio), with all floodplain development occurring between valley walls (Figure 3.4.2). Any meandering channel will ultimately hit a valley wall or be forced away from a valley wall by an alluvial fan or other impediment (e.g., bedrock, riprap). Even the most unconfined reach (Pearrygin 3) ends at a valley wall where the river confines and exerts a geologic control on the downstream end of the reach.

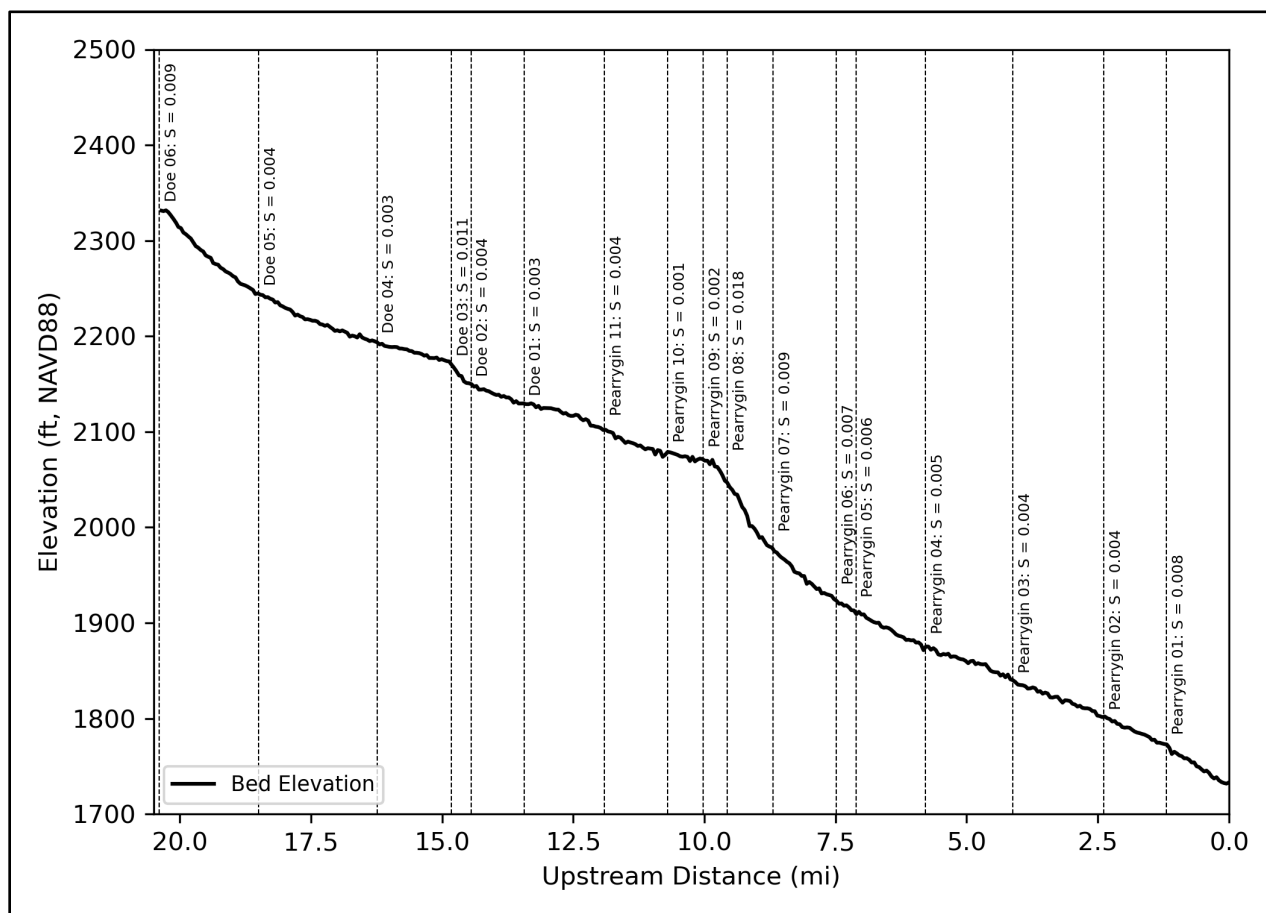


Figure 3.4.1. Longitudinal bed elevation profile of the Chewuch River from RM 0 to 20. Individual reach slopes are documented along the dashed line demarcating the upstream extend of the labeled reach.

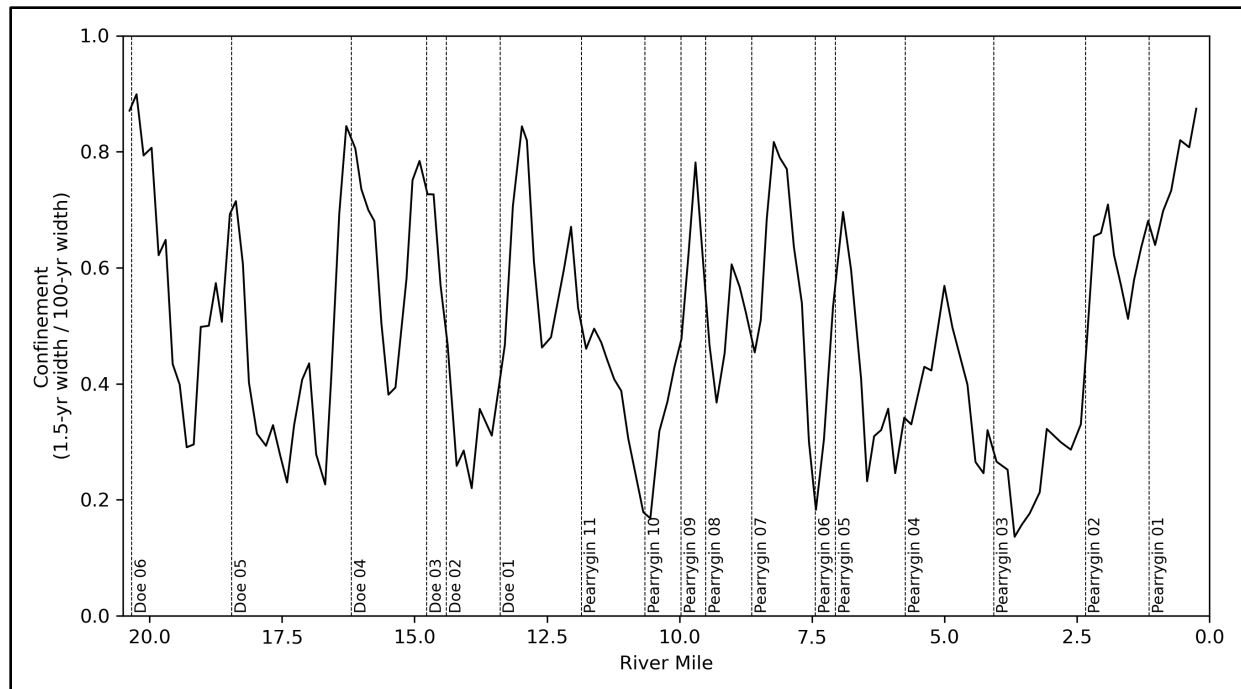


Figure 3.4.2. Valley confinement, calculated as the ratio between the inundated width of a 1.5-year flow and a 100-year flow, along the Chewuch River. Valley confinement is presented as a moving average across 1800 feet of downstream valley length.

The reaches of the Chewuch-Doe AU have variable lateral confinement, with longer pockets of broader floodplain in the Doe 2 and 5 reaches and greater confinement in the Doe 3 reach, which is a short, steep, and confined reach that lies between the valley wall to the east and the Falls Creek alluvial fan to the west (Figure 3.4.3).

The Chewuch-Pearrygin AU reaches also vary in confinement. Pearrygin 11 and 10, at the upstream end of the AU, are moderately confined, but have a relatively unconfined area (and high use spawning area) near the downstream end of Pearrygin 10 reach (Figure 3.4.2).

Downstream of these reaches near the Boulder Creek confluence, confinement remains relatively high until the Cub Creek confluence at the downstream end of Pearrygin 6 reach. Downstream of this point lie the least confined Chewuch-Pearrygin reaches including Pearrygin 3-5 reaches. The lower couple of miles of the Chewuch River, that make up Pearrygin 1 and 2 reaches, are confined between valley walls and bedrock outcrops until the confluence with the Methow River.

As an often moderately-confined system, floodplain connectivity along the Chewuch River provides habitat complexity (and high-quality fish habitat) in the form of multi-thread channels, side channels, meandering channels (resulting from lateral erosion), and riparian forests.

Floodplain connectivity in the LCRA area was examined through analysis of hydraulic model output across a range of flows (see Appendix A for details). Not surprisingly, inundation width in the LCRA area increases with increasing discharge at the September mean, July mean, and the 2- and 10-year flows (Figure 3.4.3). However, within confined valley areas, inundation widths are relatively similar between lower flows and the 10-year flow, such as in Pearrygin 1 and 2 and Doe 3 reaches.

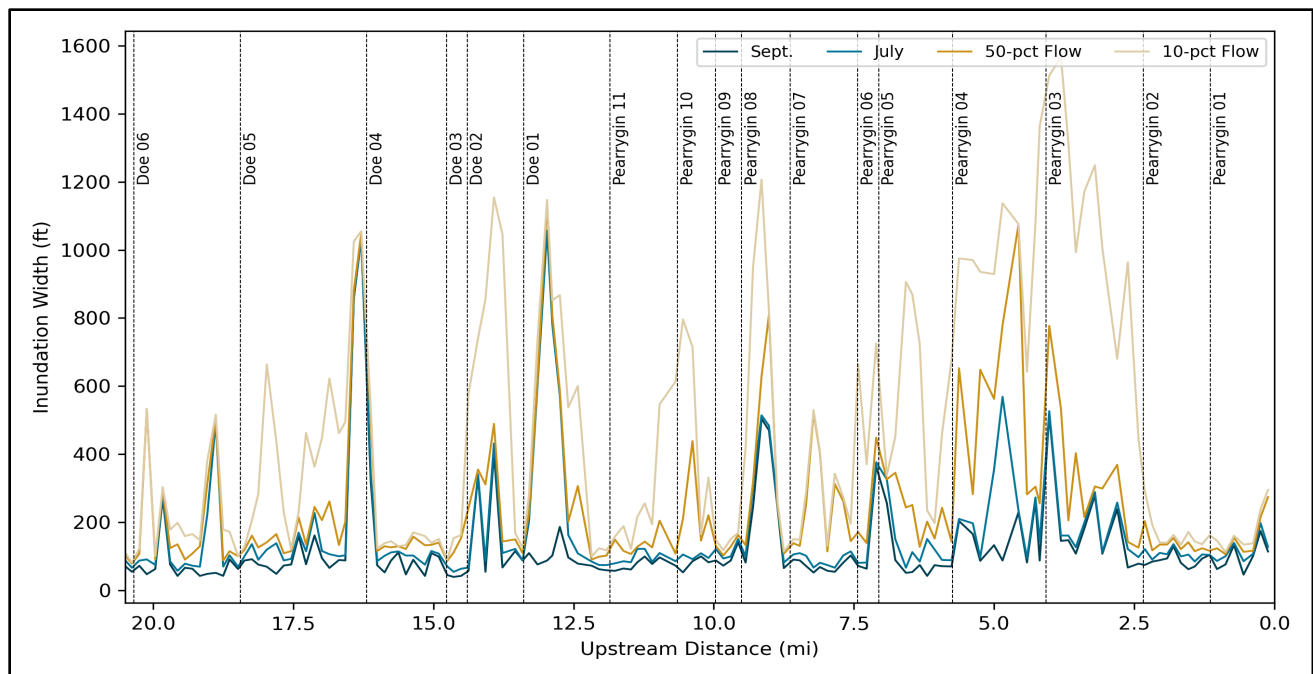


Figure 3.4.3. Modeled inundation width along the Chewuch River at a range of modeled flows including the 10-year, 2-year, and July and September mean monthly discharges.

Analyses also revealed that some reaches of the Chewuch River are more highly connected at lower flows than other reaches. For example, a highly connected portion of the river would have a similar value when comparing the inundation widths of the 10-year flow to a low flow such as the monthly mean flow in July. Doe 1 and Pearrygin 8 reaches (and portions of other reaches) exhibit this relationship and contain areas of highly connected channels and floodplains. By contrast, Pearrygin 3 reach shows the most extensive 10-year floodplain width, but there is relatively little connectivity at lower flows (highlighting potential opportunities to enhance floodplain connectivity via restoration). Other reaches with high potential for floodplain reconnection include the upstream ends of Pearrygin 4 and 8, Pearrygin 5, Pearrygin 10-11, and Doe 2 and 5.

Sediment transport increases with discharge and is a key driver of fish habitat formation. Sediment transport capacity also often decreases upstream of the major tributaries as channel slope decreases (Lane 1954). With increased discharge (from the tributary contributions) and greater slopes downstream of the confluence, transport capacity and predicted mobile sediment size increases. Analyses of LCRA sediment data support these assertions (Figure 3.4.4).

Sediment transport observed at the Falls Creek (~RM 14.8), Eightmile Creek (~RM 12), and Boulder Creek (~RM 9.5) confluences reveal noticeable upstream increases and downstream decrease in transport potential. Model results predicted that flood flows (2- and 10-year flows) predominantly transport gravels and cobbles upstream of Boulder Creek. Downstream of Boulder Creek, these flood flows are predicted to transport primarily cobbles. Boulders are predicted to be mobile immediately downstream of Boulder Creek, and this is the only area of boulder transport in the LCRA area. Throughout the LCRA area, flows >10-year event would be expected to move larger grain sizes, primarily cobbles.

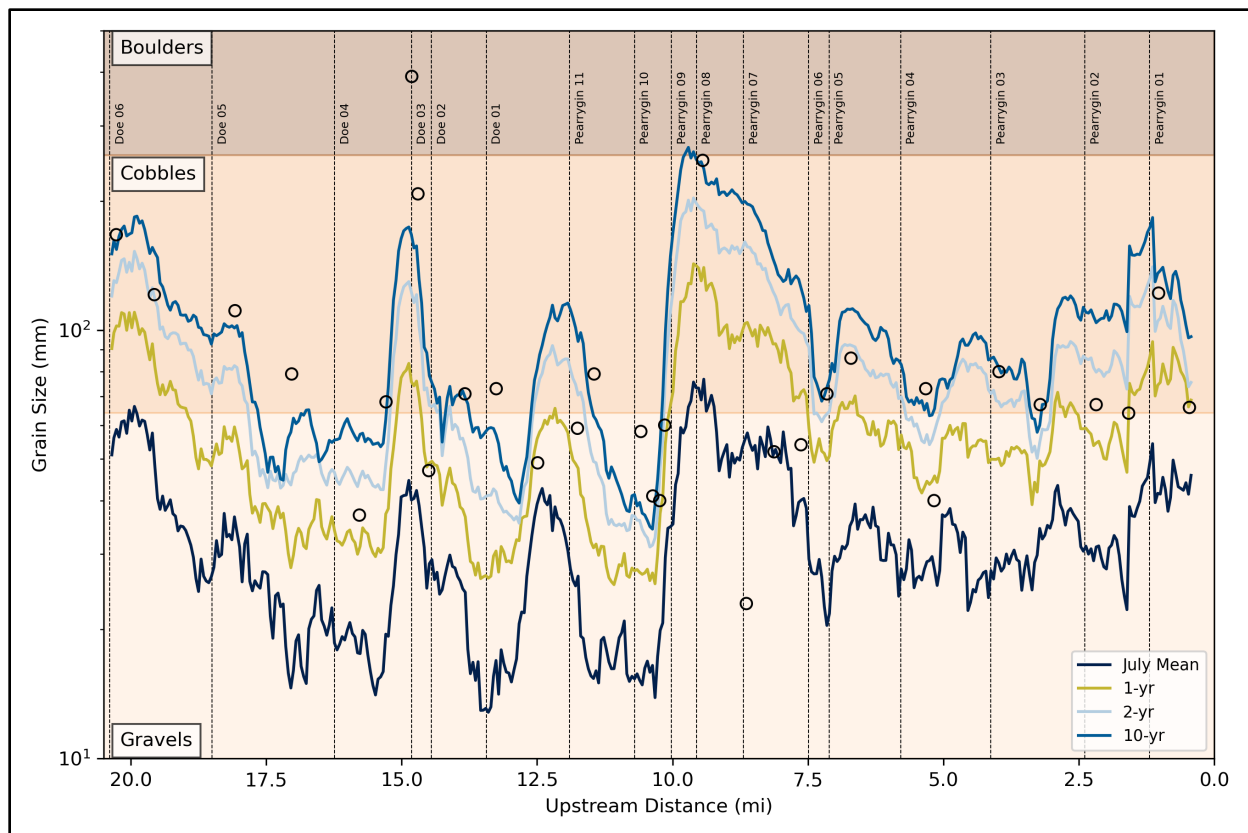


Figure 3.4.4. Predicted grain sizes transported at four flows compared with field measured 50th-percentile grain size (black circles). Shading indicates gravel, cobble, and boulder size classes.

3.4.2 Geomorphic Units

Geomorphic units were mapped throughout the LCRA through review of a time series of aerial images collected between 1947-2023. Photos from seven years were georeferenced to allow for area comparisons of discrete geomorphic units over the 76-year imagery period. Details of this analysis are provided in Appendix A.

For each year of available imagery, the geomorphic units in the reach were identified and delineated. The older imagery (1988 and earlier) was of worse quality and resolution than the newer imagery, and therefore confidence levels are lower for these years. The earlier imagery datasets were also black and white, while the newer imagery was in color. When possible, consecutive imagery years were used to help in defining geomorphic units. Geomorphic units in the LCRA included eight different types of surfaces:

- (1) *Active channel (Q_{ac})* – the wetted perimeter of the active channel. Where multiple channels were present, the widest channel was mapped as the active channel.
- (2) *Side channels (Q_{sc})* – well defined secondary (i.e., non-mainstem) channels that have inlet and outlet connections to the mainstem channel across a range of flows.
- (3) *Overflow channels (Q_{oc})* – channels with defined beds and banks that only receive flow at high discharges. Overflow channels can originate from another channel (mainstem or side channel) or from unvegetated alluvium.

(4) *Vegetated islands (Qb1)* – bars vegetated with dense shrubs or trees that are surrounded by active, side, or overflow channels.

(5) *Unvegetated bars (Qb2)* – bars that are bare or sparsely vegetated with small shrubs and grasses, indicating frequent inundation. This unit type includes lateral bars, point bars, and mid-channel bars.

(6) *Fans (Qfan)* – deposits of sediment at the mouth of tributary or debris flow channel junctions with the main valley. This unit type includes alluvial fans and debris flow fans.

(7) *Holocene alluvium (Qa)* – deposits of valley alluvium that lie outside of the other mapped features. This unit includes low-frequency inundation floodplain to Holocene-aged deposits that have not been inundated recently. The boundary of the Holocene alluvium, which typically is comprised of glacial till, was mapped at the edge of the main valley.

(8) *Landslides (Qls)* – areas of hillslope displacement and are often noted by lack of vegetation in early years. These features can be located within or outside of the bounds of *Qa*.

To represent the portion of the mapped area that is frequently inundated and dynamic, the active geomorphic corridor was defined as the combination of active, side, and overflow channels and unvegetated bars. This defines the part of the valley bottom that contains connected floodplains and actively used channels. When the river erodes into previously vegetated areas, such as during a large flood event, the size of the active corridor and the geomorphic diversity increases. Conversely, vegetation encroaching on previously bare bars or overflow channels stabilizes the banks of the channels and decreases the active corridor area (and often the active channel width) and mobility of the channel.

LCRA AUs and their reaches (reach results presented in Appendix A) have generally decreased in complexity since 1947, as indicated by a decrease in the active geomorphic corridor area and a decreased side channel and overflow channel area (Figures 3.4.5 and 3.4.6). There was an increase in the active corridor after 1947, and this may have been a result of the 1948 flood. Large floods, though channel scour, can lead to increases in the active channel area. In Chewuch-Doe AU, there was a slight increase in active corridor area coincident with the 1975 imagery, which may have been a result of the 1972 flood and associated channel scour and widening. This increase was not observed in the Chewuch-Pearrygin AU, perhaps because of anthropogenic channel modification, including bank armoring and levee construction in that AU.

Vegetation clearing and channel straightening after the 1948 flood may have also contributed to an increase in the active channel area, especially between RM 2.3 and 8.6 (reaches Pearrygin 3 to Pearrygin 7, see Appendix A). The high flows of 2017-2018 may have also contributed to slight increases in the active channel area in both AUs. The Pearrygin 10-11 reaches exhibited significant loss in complexity (i.e., active channel area) due to disconnection of large channel complexes as a result of anthropogenic floodplain development.

The Pearrygin 4 reach did incur a net overall increase in complexity over the review period, but the complexity has still declined since 1988. Pearrygin 2 was another reach with a net increase in the active geomorphic corridor area, but this was due to active channel widening rather than an increase in river process-driven complexity.

Several of the LCRA reaches are very confined and have not undergone much geomorphic change over the time series examined. These confined reaches include Pearrygin 1, 2, and 9 and Doe 3 and 4. The Pearrygin 5 reach is moderately confined compared to other reaches and has fluctuations in complexity through time, but little net change. The Doe 1 and Pearrygin 8 reaches have at least portions of lower confinement valley and have generally maintained complexity through time.

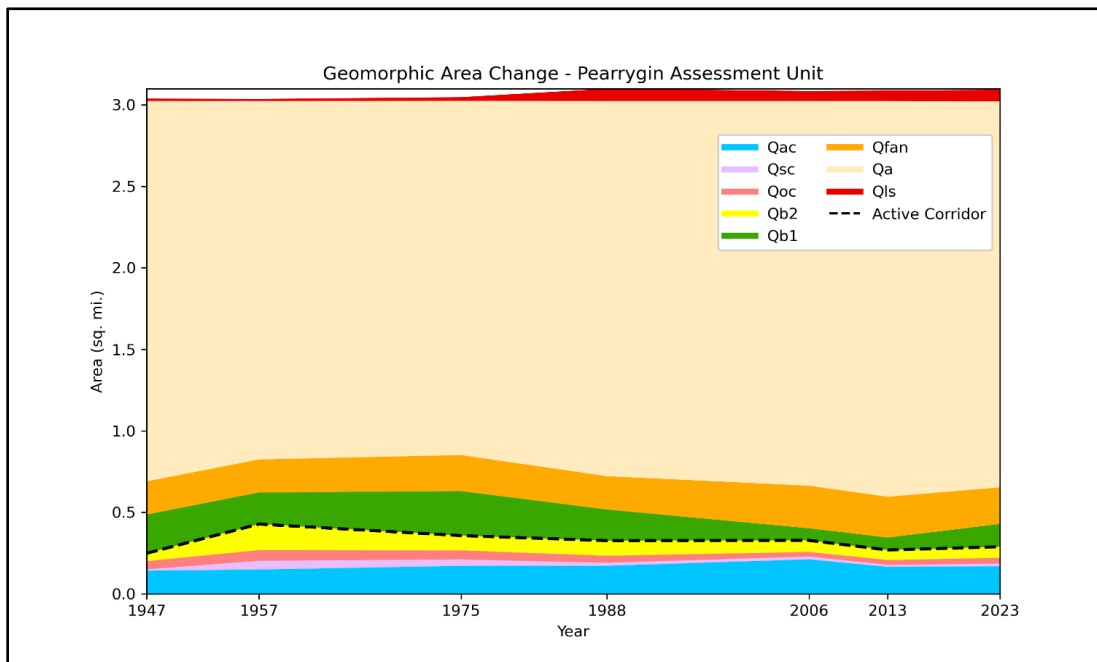


Figure 3.4.5. Chewuch-Pearrygin AU geomorphic unit area change over time, 1947 – 2023.

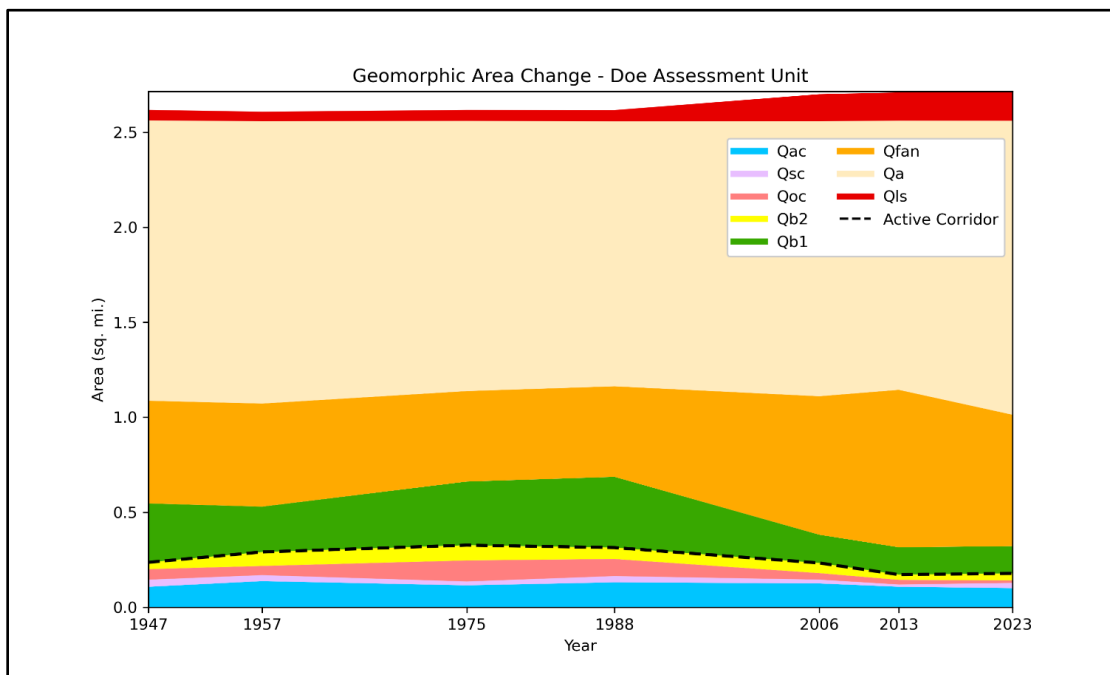


Figure 3.4.6. Chewuch-Doe AU geomorphic unit area change over time, 1947 – 2023.

Other factors may also have influenced the area of the various geomorphic units over time. Increased vegetation development of bars and side channels, resulting from periods of low flow or a lack of scour events (such as in the early 2000s), may have led to observed decreases in the active channel area prior to 2013. These types of changes may also result in increases in alluvial floodplain surfaces that are less frequently inundated.

All of the above-mentioned factors have influenced active channel width over time in the LCRA area. Both the Chewuch-Pearrygin and Chewuch-Doe AUs have gained and lost channel width over time (Figure 3.4.7). Interestingly, current channel widths are somewhat similar to what was observed in 1947, with a width range of approximately 60'-70'.



Figure 3.4.7. LCRA AU active channel width change over time, 1947 – 2023.

3.4.3 Channel Migration

When unimpeded, channel migration is a process-based occurrence in streams with rates dependent on several factors related to channel form, valley setting, and sediment composition. For the LCRA, channel migration was examined through analysis of the same series of aerial photos that were used for the geomorphic unit analyses. Channel flow path shapefiles from the various photo periods are available in the LCRA geodatabase.

Overall, rates of channel migration in the LCRA area since 1947 have been relatively low, largely averaging 1-3 feet/year (Table 3.4.1). This has been especially true since 1957. Prior to this time, the 1948 flood appears to have had a significant influence on channel migration – not surprising, since 1948 is the flood of record for the Chewuch River. Several reaches experienced >5' of lateral movement during the 1947-1957 period, including over 10' in the Pearrygin 6 reach. Some of this movement may be in response to post-flood channel manipulation and riprap installation, such as that which occurred in the Pearrygin 6 reach near the Cub Creek confluence.

Table 3.4.1. Reach-based channel migration (feet/year averaged over the photo interval) in the LCRA area, 1947-2023.

Reach	1947-1957	1957-1975	1975-1988	1988-2006	2006-2013	2013-2023
Pearrygin 1	1.8	0.7	1.3	0.5	0.8	0.5
Pearrygin 2	1	0.5	0.4	0.3	0.7	0.4
Pearrygin 3	5.5	2.3	1.2	0.6	1.8	3.2
Pearrygin 4	9.6	2.4	0.9	0.3	0.9	2.6
Pearrygin 5	7	1.7	0.9	0.5	1.7	2.2
Pearrygin 6	10.1	1.6	1.9	0.3	0.9	0.5
Pearrygin 7	4	1.6	1.1	0.4	1.3	0.5
Pearrygin 8	3	2.7	2	0.4	3.1	2.6
Pearrygin 9	2.3	2.5	5	0.5	1.1	0.5
Pearrygin 10	1.1	1.5	1.9	0.4	1.1	0.6
Pearrygin 11	2	0.3	0.7	0.6	0.5	0.6
Doe 1	3.7	1.1	1.8	1.0	1.7	1.8
Doe 2	4.6	1.5	0.8	0.4	0.7	0.9
Doe 3	1.7	0.8	0.6	0.5	1.3	1
Doe 4	1.7	0.7	1	0.7	0.8	4.9
Doe 5	4.7	2.9	1.2	0.5	1.1	2.2
Doe 6	5.8	1.3	0.8	0.9	1.3	1.1

The natural confinement of the channel within the LCRA area is one factor responsible for the observed low rates of channel migration. In many reaches channel migration has been low, with the mainstem channel occupying very similar flow paths over the period of record. An example of low channel migration can be seen in the Doe 4 reach, where there has only been very slight migration over time (Figure 3.4.8). The increased rate of migration from 2013-2023 occurred upstream of RM 15 as a result of the implementation of the RM 15.5-17 restoration project in 2017, which prompted the movement of the low flow channel from the mainstem into a side channel.

Some relatively small-scale channel natural migrations have been observed over time in discreet reaches within the LCRA. One example of a more active channel is near the Pete Creek confluence at the boundary of Pearrygin 3 and 4 reaches (Figure 3.4.9). In this reach, the channel has moved both to the east and west over time. Several meander bends have been formed and cutoff during this period. Recently, there was an avulsion as a result of high flows in 2017-2018 that resulted in the movement of the low flow channel into its 1957 alignment.

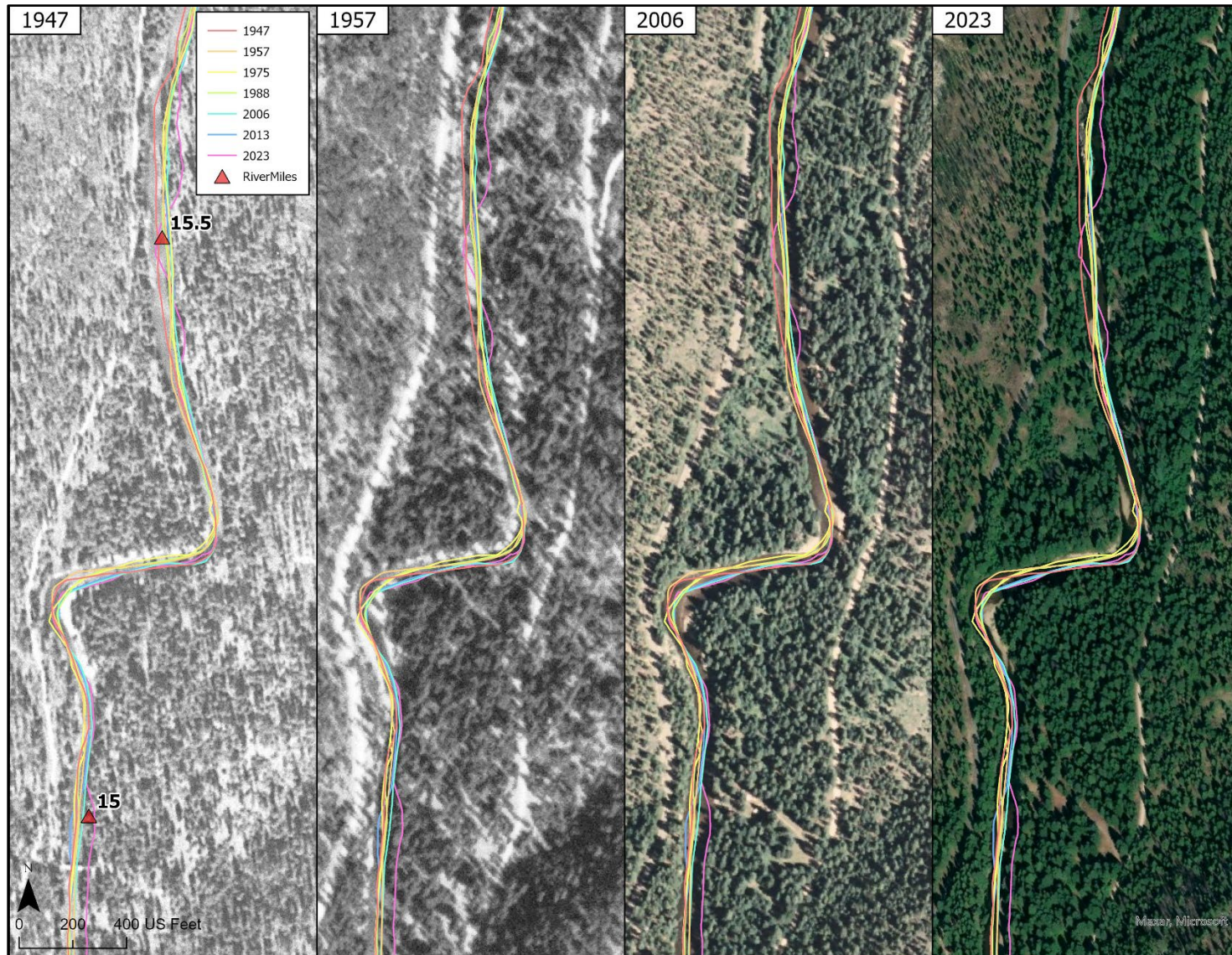


Figure 3.4.8. Example of channel migration in the Doe 4 reach near RM 15-15.5, 1947-2023.

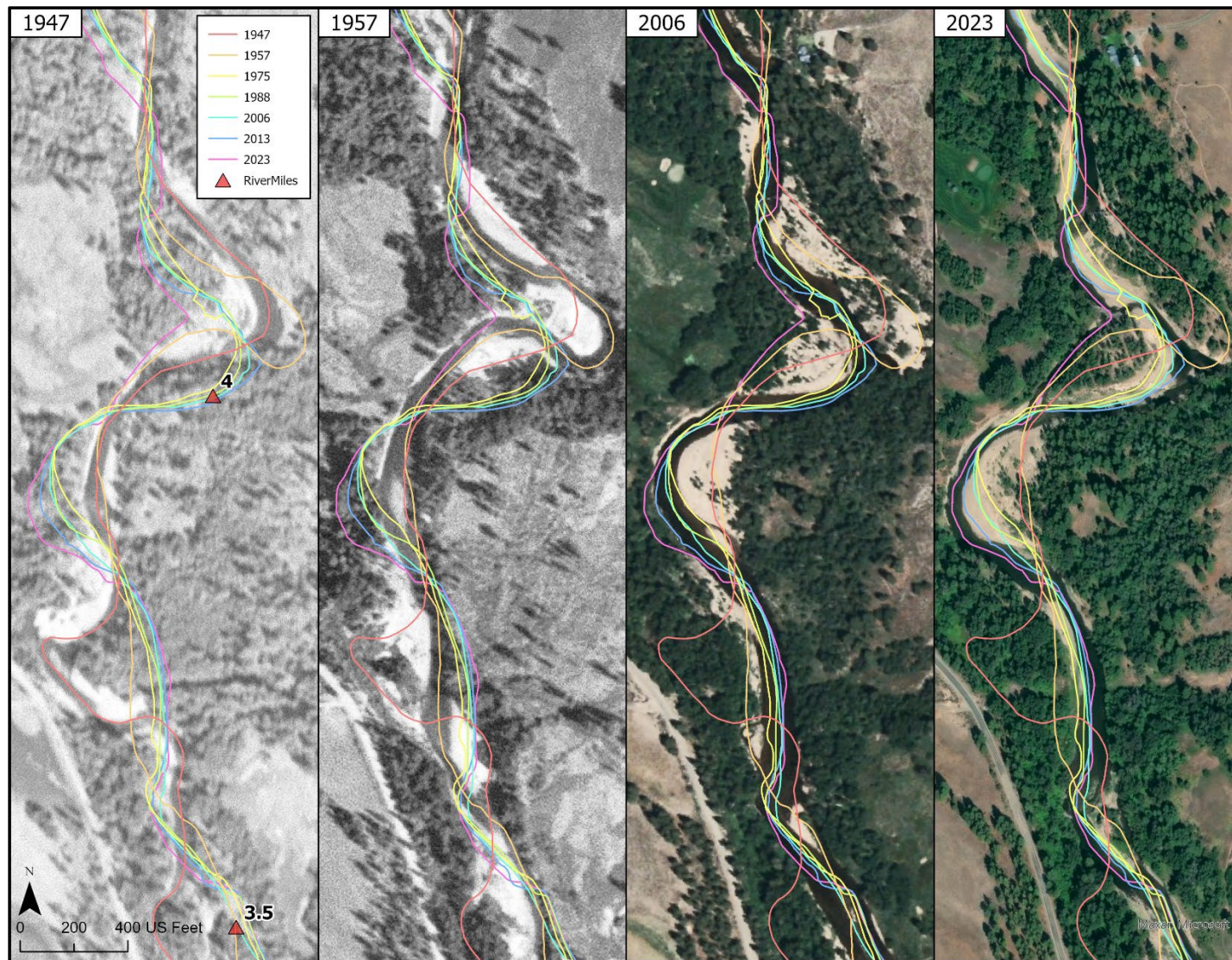


Figure 3.4.9. Example of channel migration in the Pearygin 3-4 reach near RM 4, 1947-2023.

3.4.4 Hydraulics

Two-dimensional hydraulic modeling was conducted for the entire 20-mile LCRA area. Detailed methodologies are presented in Appendix A, and all data outputs are available in the LCRA geodatabase. This modeling provides estimated flow conditions under existing conditions using the hydrology, modeling methodology, and assumptions as described in Appendix A. Model results were converted to 3-foot rasters of depth, velocity, and water surface elevation. In addition, inundation boundaries of each modeled flow were produced.

Hydraulic modeling results reveal that the Chewuch River shows large differences in hydraulic conditions between different *Prioritization* reaches. Those differences are driven largely by the defining geology of the river corridor and influences of major tributaries throughout the 20-mile LCRA area. Confinement, slope, and hydrology drive differences in hydraulics and river form. The more confined reaches generally have more uniform hydraulics and channel form, while less confined reaches allow for more alluvial process, pool-riffle formation, and more heterogenous water depths and velocities.

While the defining geology often is an influence on river form and hydraulics, anthropogenic influences are also present in selected locations where riprap or dams contribute to a decrease in dynamic river processes. Contrary to many rivers where river bed sediments become finer in the downstream direction, the mountainous characteristics of the Chewuch River and its tributaries contribute to coarser bed material in the lower nine miles relative to the upstream 11 miles.

Examples of modeled depth and velocity outputs are shown in Figure 3.4.10 for a 1.5-year recurrence interval flow event. Inundation boundaries for select flows are plotted for each of the reaches described in Section 3.5. All post-processed hydraulic model outputs are included in the LCRA geodatabase.

Additionally, hydraulic conditions within LCRA reaches were summarized by calculating the area associated with different depth and velocity combinations across a range of discharges. Analysis details are presented in Appendix A. Different reaches exhibit different patterns of depth and velocity (Figures 3.4.11 and 3.4.12) which relate to the overall habitat suitability of the reach under different flow conditions. In general, those reaches with more floodplain connectivity have less defined relationships between depth and velocity and more distributed areas across the spectrum of depth and velocity combinations. Reaches with less floodplain connectivity have more narrowly distributed depth and velocity pairings.

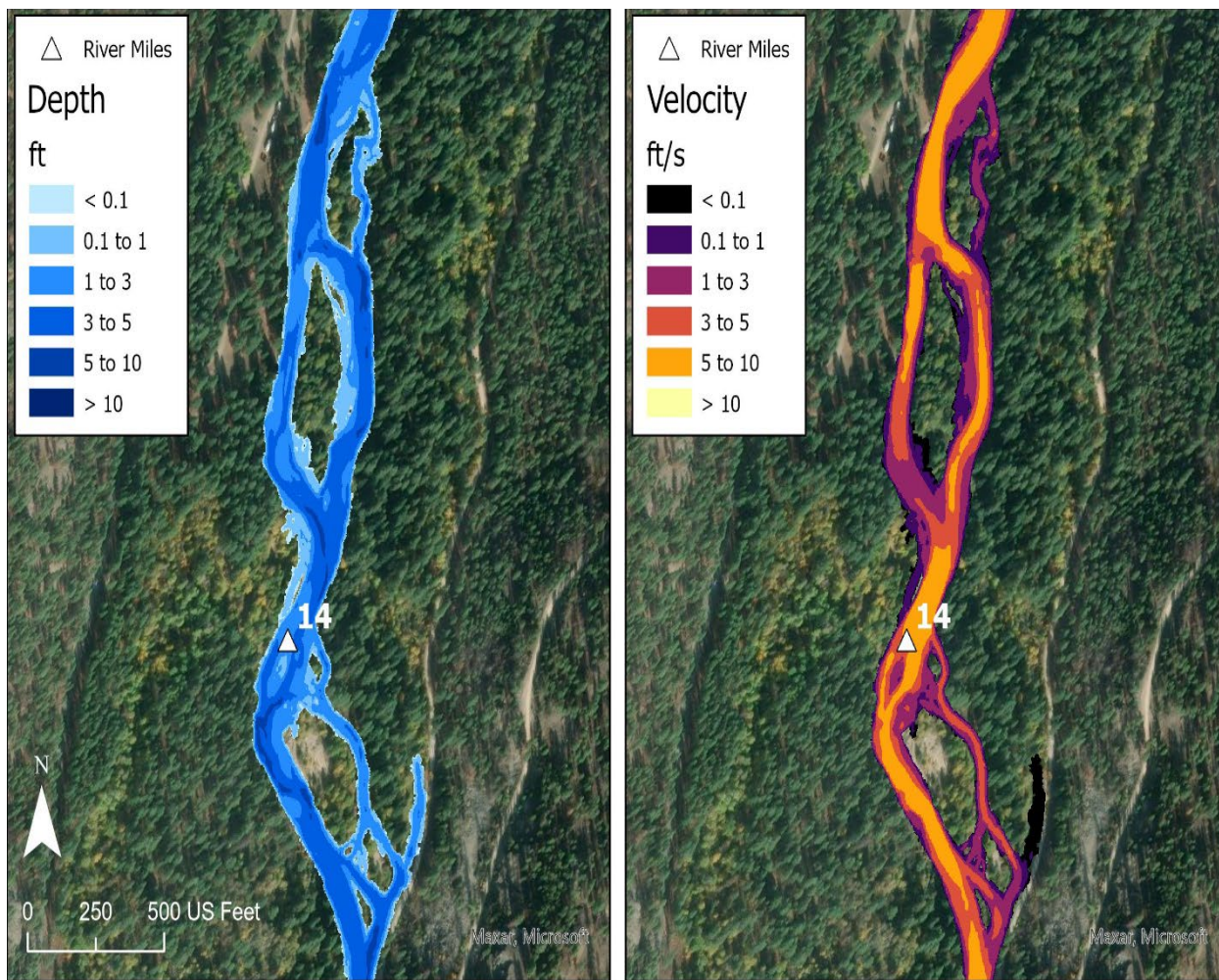


Figure 3.4.10. Example of depth and velocities predicted by hydraulic modeling of the Chewuch River near RM 14. These results are shown for the predicted 1.5-year recurrence interval flow event.

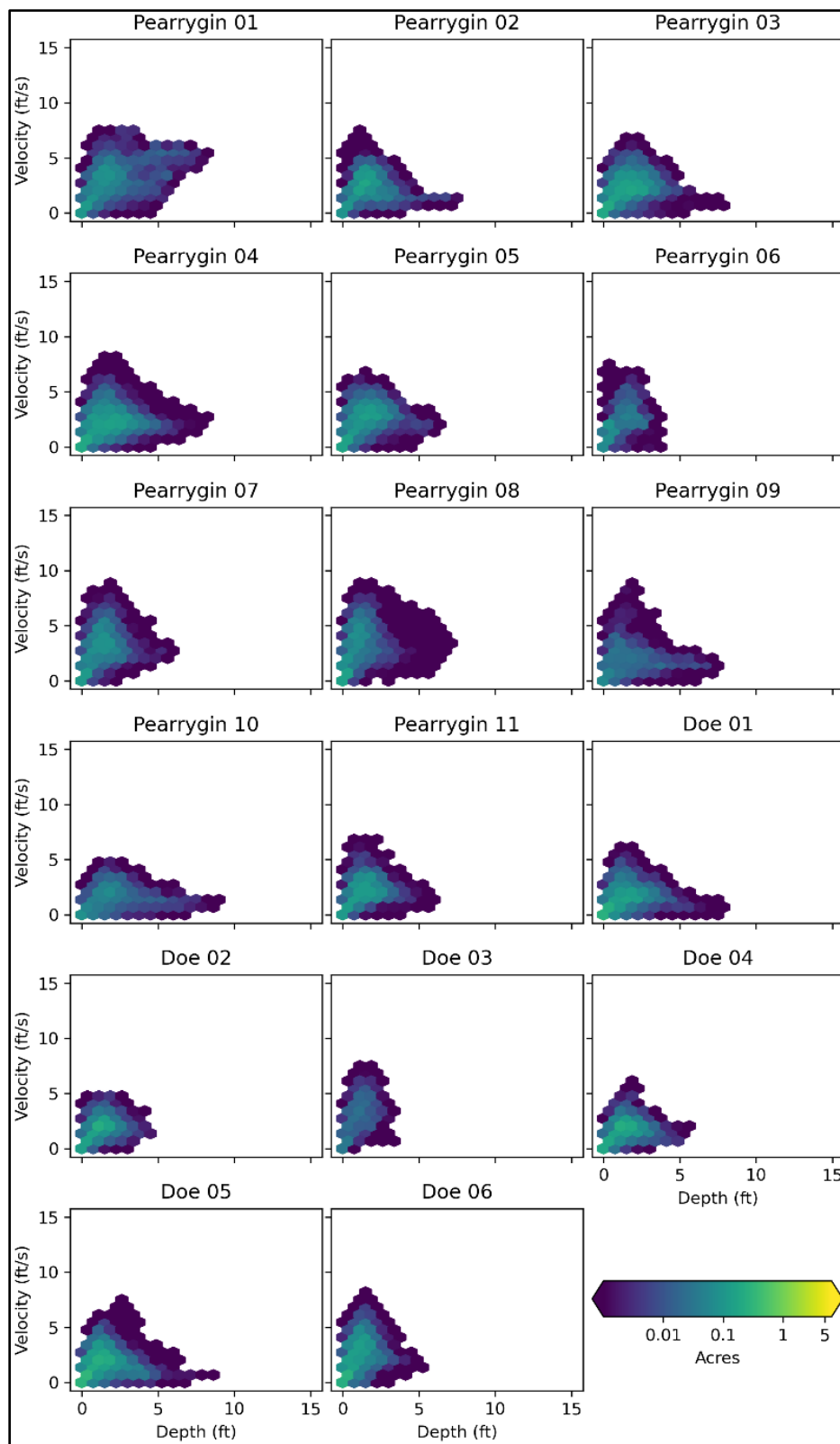


Figure 3.4.11. Total area within reach with given depth and velocity combinations under the July mean flow conditions.

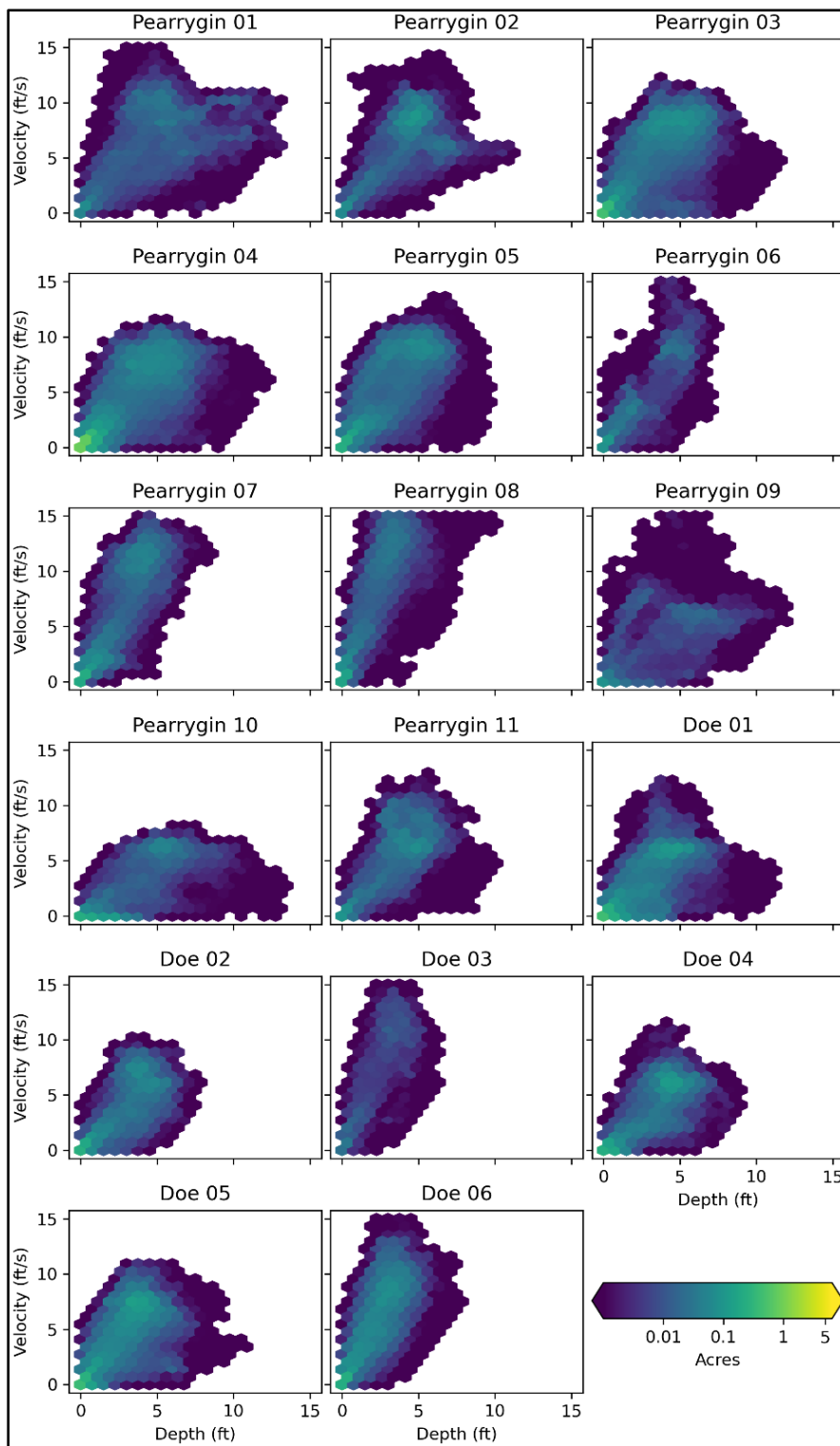


Figure 3.4.12. Total area within reach with given depth and velocity combinations under the 2-year recurrence flow conditions.

At lower flows, such as the July monthly mean, many of the reaches have similar patterns, with the largest areas having low depths and velocities in the main channel (Figure 3.4.11). As flows increase, reach differences become more apparent as floodplain surfaces, where present, become inundated (Figure 3.4.12). For example, at the 2-year recurrence interval event, Pearrygin 3 and 4 reaches have more widely distributed depth and velocity pairings, including large areas of low depth and velocity, as they have more connected floodplains. By comparison, the Pearrygin 8 reach has a much more paired depth-velocity relationship, with velocity increasing greatly at relatively low depths at the 2-year recurrence flow.

Profiles of modeled water surface elevations at selected flows are displayed in Figures 3.4.13 and 3.4.14 and detailed in Appendix A. Low water surface profiles (i.e., mean low-flow and the July mean) show smaller hydraulic controls, such as riffles, where flat water surface profiles are repeatedly created by the river bed. An example of this is within the Pearrygin 3 reach between RMs 3 and 4 (3-E). Steeper sections of river do not display this same river form, nor the impact on longitudinal water surface profiles (e.g., Doe 3 reach).

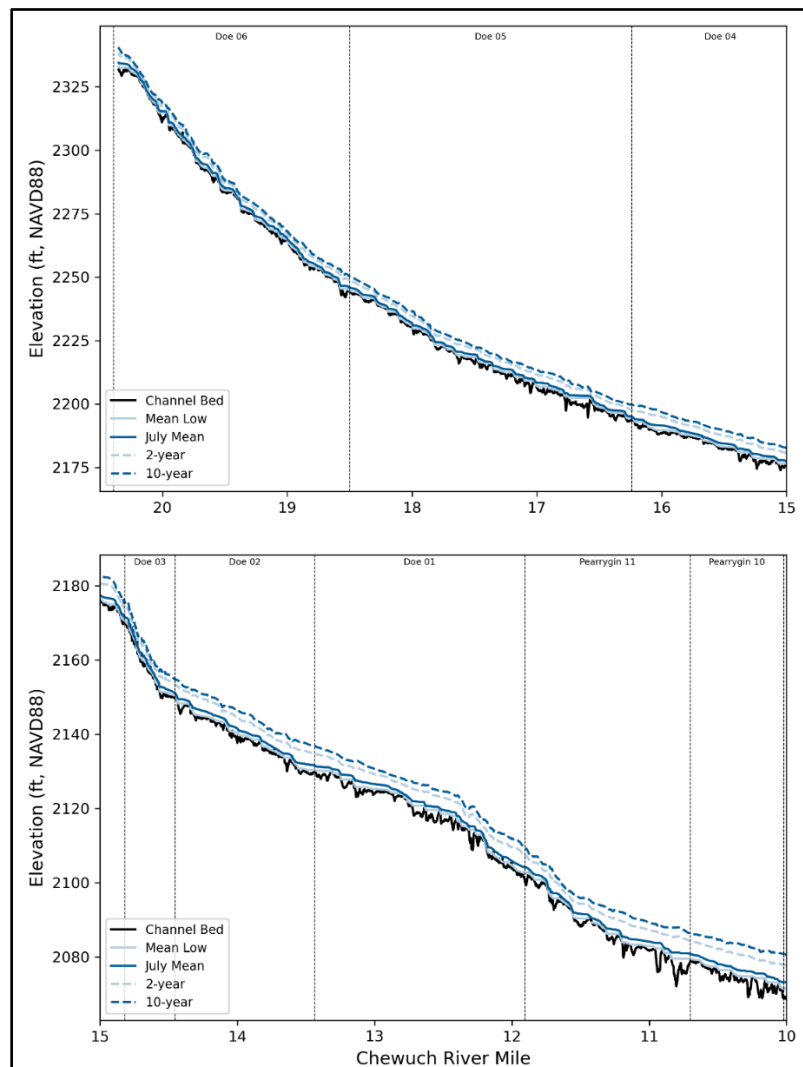


Figure 3.4.13. Longitudinal profile of river bed and water surface elevations for select flows between river miles 10 and 20 along the Chewuch River.

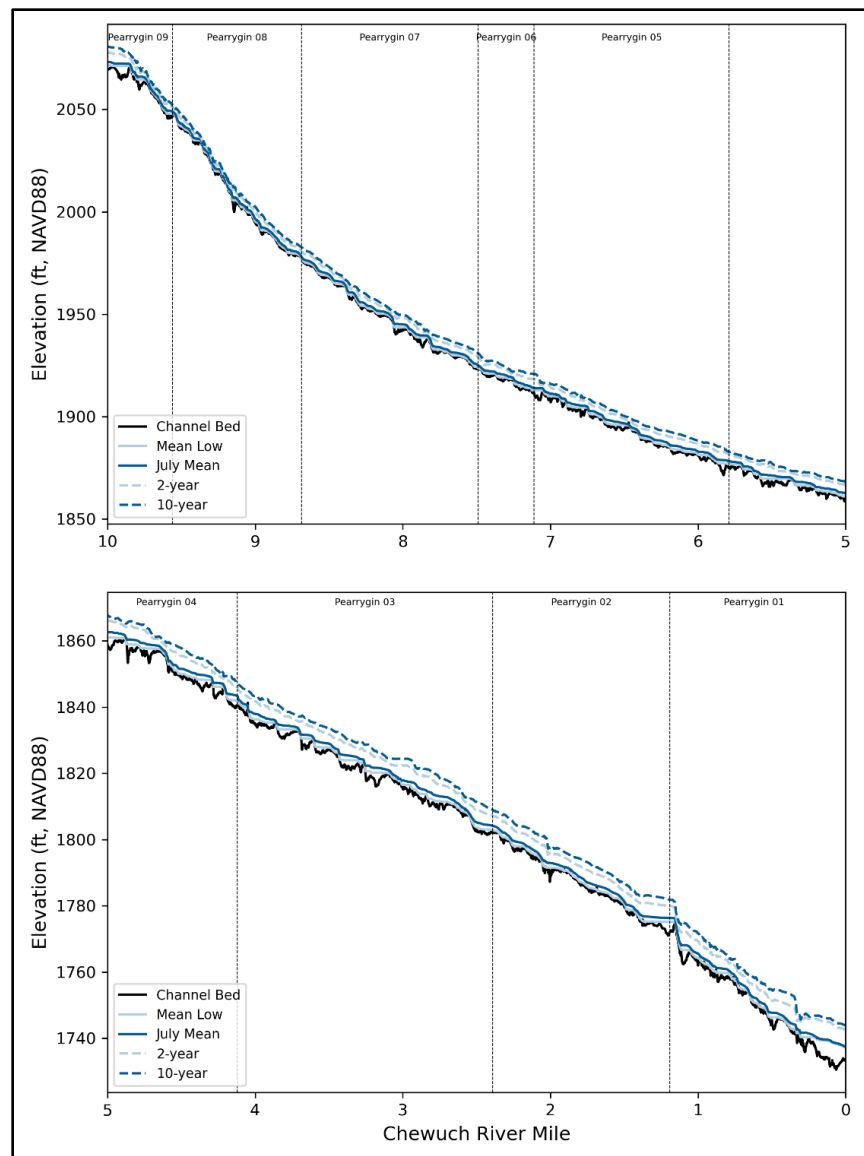


Figure 3.4.14. Longitudinal profile of river bed and water surface elevations for select flows between river miles 0 and 10 along the Chewuch River.

Other hydraulic controls can be observed in all flows. Fulton Dam at approximately RM 1.2 creates a backwater at low discharges and creates raised water surface elevations at higher flows. The hydraulic control of tributaries is most clearly observed at high flows (i.e., 2-year and 10-year flows) where the tributary fans create a flow constriction; this in turn creates higher water surface elevations upstream of the confluence. Boulder Creek provides the best example of this at RM 10.

3.5 Reach Summaries

Prioritization identified 17 reaches within the two assessment units of LCRA area (Figure 3.5.1). Over time, the reaches have been shaped by glacial, geomorphic, hydrologic, and other natural forces, such as floods and fires, which have given each reach a unique character. More recently, human activities like road building, logging, riparian clearing, and diverting water for irrigation

have further influenced the reaches. While the degree of human-caused alteration varies among the reaches, impacts to channel form, instream flow, off-channel connectivity, large wood load, and extent and quality of riparian habitat are found in varying degrees throughout the LCRA area.

Understanding the basic aspects of each reach can assist with the development of a thoughtful restoration strategy for the LCRA area. The following reach summary tables reflect current conditions and are provided as a reference of the specific characteristics of each reach and to add context for the other information and analyses contained in the LCRA.

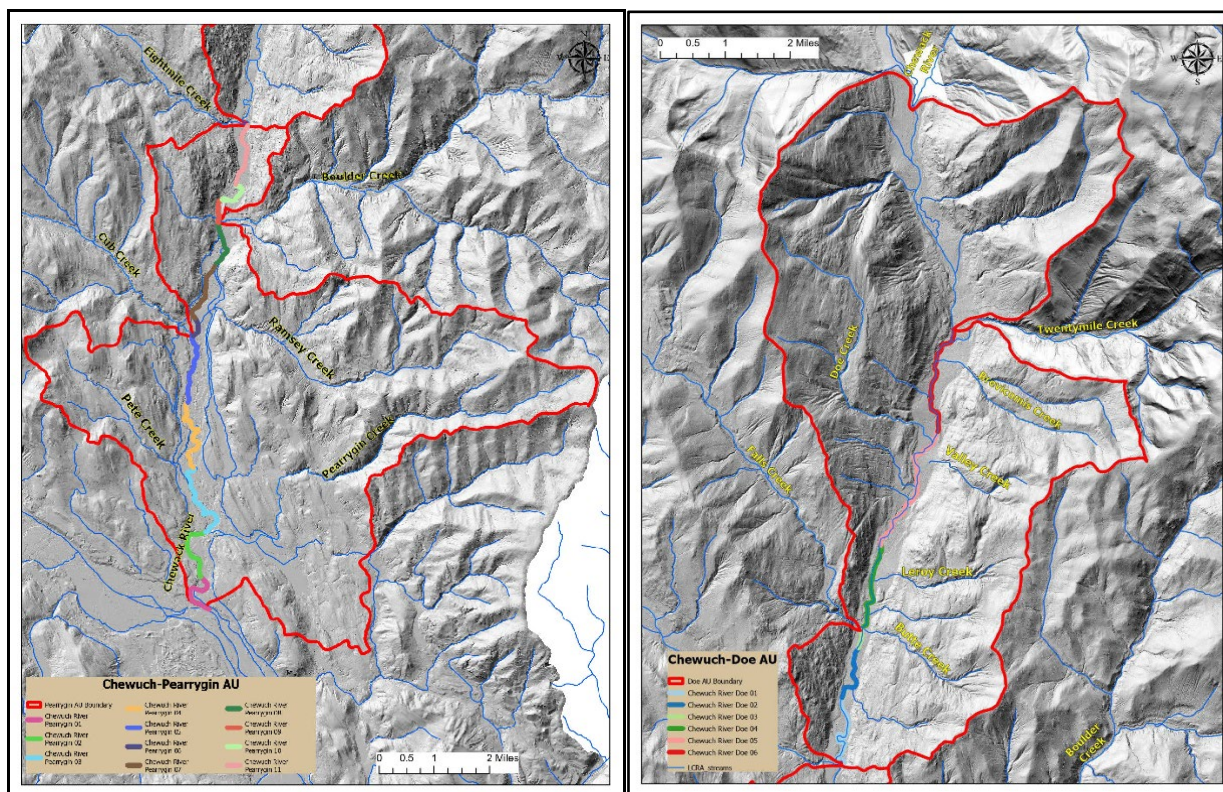


Figure 3.5.1. Chewuch-Pearrygin and Chewuch-Doe assessment unit boundaries and reaches. Data source: UCSRB.

Pearrygin 1				
Reach RM Start: 0		Reach RM End: 1.1		Reach Length: 1.1 mi
Downstream Elevation: 1731ft		Upstream Elevation: 1776 ft		Slope: 0.008
Channel Length: 1.14 mi		Valley Length: 1.00 mi		Sinuosity: 1.14
Bankfull Width: 110 ft			Flood Prone Width: 123 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 1.54			Sep Mean Flow:10-Year Flow = 1.64	
Inundated Acres				
Sep Mean Flow: 10.4		2-Year Flow: 16		10-Year flow: 17
2023 Reach Condition				
%Pool: 26.8	%Riffle: 46.7	%Rapid: 3.5	%Glide: 17.8	Modified Bank: 1174 ft
#Pools: 5		Channel Widths/Pool: 10.7		Pools/mile: 4.5
Wood Count (Nat/ELJ): 18/0		Natural LW Pieces/mile: 16.4		LW Jams (Nat/ELJ): 1/0
Reach Description				
<p>Pearrygin 1 reach is located from the confluence of the Chewuch and Methow Rivers upstream to Fulton Dam. The reach is relatively confined and low gradient, with little difference between the low flow and 10-year flood channel width. This indicates that there is very little available floodplain and that Pearrygin 1 is a high energy sediment transport reach. The reach is confined by bedrock in many areas, and bedrock is also the dominant channel bed type in several habitat units. The reach is primarily pool-riffle habitat dominated by cobble with some gravel and bedrock substrate. There is one short, fast-water side channel with sparse willow vegetation present on the cobble bar island.</p> <p>The reach is located entirely within the Town of Winthrop, and there is a significant amount of residential and commercial development present on both banks. Riparian vegetation is sparse and restricted to a narrow band adjacent to the bankfull channel. Bank armoring is present in several areas including around the SR 20 bridge and downstream of Fulton Dam. The dam represents a significant anthropogenic feature within the reach.</p>				



Downstream view of Pearrygin 1 reach from top of Fulton Dam (right). Boulder substrate was placed during dam renovation in 2009. Side channel habitat in Pearrygin 1 reach (left).

Pearrygin 2				
Reach RM Start: 1.1		Reach RM End: 2.3		Reach Length: 1.2 mi
Downstream Elevation: 1776 ft		Upstream Elevation: 1802 ft		Slope: 0.004
Channel Length: 1.2 mi		Valley Length: 1.16 mi		Sinuosity: 1.03
Bankfull Width: 128 ft			Flood Prone Width: 150 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 1.49			Sep Mean Flow:10-Year Flow = 1.7	
Inundated Acres				
Sep Mean Flow: 12.8		2-Year Flow: 19.0		10-Year Flow: 21.8
2023 Reach Condition				
%Pool: 28.6	%Riffle: 36.9	%Rapid: 4.1	%Glide: 25.1	Modified Bank: 718 ft
#Pools: 3		Channel Widths/Pool: 17.1		Pools/mile: 2.4
Wood Count (Nat/ELJ): 14/0		Natural LW Pieces/mile: 11.7		LW Jams (Nat/ELJ): 0/0
Reach Description				
<p>Pearrygin 2 reach is located from Fulton Dam upstream to the confluence with Lake Creek, which enters on river left (east). The reach is confined by glacial terraces and scattered bedrock outcrops. Similar to Pearrygin 1, there is little available floodplain, the 2-year and 10-year inundation areas are similar, and it is primarily a transport reach with little off-channel habitat potential. The reach is riffle-pool-glide habitat dominated by cobble substrate with some gravel patches. Spawning potential is very limited. Pools are not numerous, but are relatively deep and mostly formed by bedrock. Riparian habitat is limited to narrow bands along the bankfull channel with ponderosa pines on the terraces providing overstory shade. There is one short side channel active at low flows that is separated from the mainstem by a sparsely vegetated cobble bar.</p> <p>The reach is affected by the Fulton Dam backwater for approximately 1,300 feet upstream of the dam. Stream power in this inundated area is relatively low, and the substrate is dominated by fines and sand. There is significant residential development along both banks in the inundated reach and upon the terraces further upstream.</p>				



Upstream view from Fulton Dam showing pool inundation and residential development along banks (above left). Typical bedrock outcrop and riffle-cobble habitat in Pearrygin 2 reach (left). Upstream view of low flow side channel habitat and glacial terraces (above).

Pearygin 3				
Reach RM Start: 2.3		Reach RM End: 4.1		Reach Length: 1.8 mi
Downstream Elevation: 1802 ft		Upstream Elevation: 1841 ft		Slope: 0.004
Channel Length: 1.73 mi		Valley Length: 1.28 mi		Sinuosity: 1.35
Bankfull Width: 172 ft			Flood Prone Width: 525 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 2.34			Sep Mean Flow:10-Year Flow = 6.1	
Inundated Acres				
Sep Mean Flow: 18		2-Year Flow: 42.3		10-Year Flow: 110.1
2023 Reach Condition				
%Pool: 46.4	%Riffle: 18.7	%Rapid: 0	%Glide: 7.8	Modified Bank: 935 ft
#Pools: 23		Channel Widths/Pool: 3.2		Pools/mile: 9.6
Wood Count (Nat/ELJ): 62/0		Natural LW Pieces/mile: 34.4		LW Jams (Nat/ELJ): 5/0
Reach Description				
<p>Pearygin 3 reach is located from the Lake Creek confluence upstream to slightly upstream of the Pete Creek confluence. This reach is much less confined and more sinuous than Pearygin 1 and 2 and has extensive floodplain and off-channel area within the 10-year floodplain (>100 acres), which is more than twice the area of the 2-year floodplain in this reach. There are several low flow side channels in the reach, with several more active at 2-year and 10-year flows. The reach has a 0.4% gradient and is dominated by cobble and gravel substrate. Pools occupy half of the channel length with many 3 feet deep at low flow. Several backwater areas are present at low flow. Functional riparian areas are present on many of the floodplain surfaces and there is some willow established on the cobble and gravel bars separating the side channels and braids from the mainstem.</p> <p>Pearygin 3 has residential development along most of its length. Much of this is outside the floodplain. In the lower portion of the reach, riprap and development are impacting a large 10–100-year floodplain area and there are several structures and roads on this surface. Some historical clearing and grading of the floodplain and riparian vegetation has occurred further upstream, especially on the east side (river left) of the mainstem through the middle of the reach and the west side (river right) of the channel at the upstream end of the reach.</p>				



Braid habitat, large wood deposition, and right bank riprap at downstream end of Pearygin 3 reach (above). Typical cobble bank and willow vegetation in Pearygin 3 reach (right).

Pearrygin 4				
Reach RM Start: 4.1		Reach RM End: 5.7		Reach Length: 1.6 mi
Downstream Elevation: 1841 ft		Upstream Elevation: 1881 ft		Slope: 0.005
Channel Length: 1.67 mi		Valley Length: 1.28 mi		Sinuosity: 1.3
Bankfull Width: 220 ft			Flood Prone Width: 650 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 3.19			Sep Mean Flow:10-Year Flow = 7.24	
Inundated Acres				
Sep Mean Flow: 18.1		2-Year Flow: 57.9		10-Year Flow: 131.3
2023 Reach Condition				
%Pool: 46.8	%Riffle: 21.7	%Rapid: 0	%Glide: 8.1	Modified Bank: 607 ft
#Pools: 19		Channel Widths/Pool: 2.8		Pools/mile: 8.6
Wood Count (Nat/ELJ): 113/149		Natural LW Pieces/mile: 75.3		LW Jams (Nat/ELJ): 1/11
Reach Description				
<p>Pearrygin 4 is a 1.7-mile reach extending upstream from Pete Creek. The Windhaven golf course lies adjacent to the mainstem in the downstream third of the reach and occupies former west bank (river right) floodplain and mainstem channel habitat area. The reach planform is similar to Pearrygin 3; it is relatively unconfined, sinuous, and low gradient, with extensive floodplain area at both the 2-year and 10-year flows. There are several low flow side channels, including a restored side channel at RM 4.2 (completed in 2022), and numerous side channels and floodplain surfaces at both the 2-year and 10-year flows. The substrate in Pearrygin 4 is cobble-gravel, and pools account for nearly 60% of channel length. Several pools are large and deep, but lacking abundant cover.</p> <p>Residential development is low in Pearrygin 4, with only a few structures located near the channel and within the floodplain. Streambanks adjacent to residences near RM 5.4 are actively eroding, and bank protection measures have been installed, including gabions and large wood. No other anthropogenic channel migration constraints are present.</p>				



Typical pooltail gravel/cobble habitat and cottonwood/pine riparian overstory in Pearrygin 4 reach (above left). Bank erosion, riparian vegetation, and cobble bank (above right). Residential development with riparian clearing and bank protection in braided section of Pearrygin 4 reach (right).

Pearygin 5				
Reach RM Start: 5.7		Reach RM End: 7.1		Reach Length: 1.4 mi
Downstream Elevation: 1881 ft		Upstream Elevation: 1920 ft		Slope: 0.006
Channel Length: 1.32 mi		Valley Length: 1.25 mi		Sinuosity: 1.06
Bankfull Width: 191 ft			Flood Prone Width: 392 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 2.42			Sep Mean Flow:10-Year Flow = 4.67	
Inundated Acres				
Sep Mean Flow: 13.5		2-Year Flow: 32.6		10-Year Flow: 62.9
2023 Reach Condition				
%Pool: 24.7	%Riffle: 25.7	%Rapid: 0	%Glide: 40.3	Modified Bank: 0 ft
#Pools: 11		Channel Widths/Pool: 4.0		Pools/mile: 6.9
Wood Count (Nat/ELJ): 49/0		Natural LW Pieces/mile: 32.7		LW Jams (Nat/ELJ): 2/0
Reach Description				
<p>Pearygin 5 reach, which extends upstream from reach 4 to the Cub Creek confluence, is a low gradient reach with appreciable 2- and 10-year floodplain area. Relative to Pearygin 3 and 4, Pearygin 5 is more confined, less sinuous, and contains a high glacial bench that defines the high flow edge along the west bank (river right) in the lower half of the reach. Floodplain is more abundant off the eastern bank (river left) in this area. At flows below the 2-year, off-channel habitat is more abundant in the upstream half of the reach, which is relatively less confined compared to the downstream half. The upstream portions of the reach contain extensive side channel network on the east floodplain that becomes activated above the 2-year flow and is well defined at the 10-year flow. The substrate in the reach is primarily cobble, especially in the more confined sections. Gravel is more abundant in the upper half of the reach where suitable spawning habitat is present. Glide habitat is the dominant channel unit type in Pearygin 5, and there is less pool habitat than in Pearygin 3 and 4. Riparian vegetation is extensive and intact across much of the reach.</p> <p>There is only minimal anthropogenic development in the reach. Historic floodplain and channel alteration has occurred at the upstream end of the reach near the Cub Creek confluence and into Pearygin 6 reach.</p>				



Natural wood jam at island apex in Pearygin 5 reach (above left). Upstream view of lateral scour pool (bedrock formed) and pooltail habitat with adjacent high glacial terrace (above right). Upstream view of typical riffle and pooltail habitat sequence with cobble point bar and eroding outside bank in Pearygin 5 reach (right).

Pearrygin 6				
Reach RM Start: 7.1		Reach RM End: 7.4		Reach Length: 0.3 mi
Downstream Elevation: 1920 ft		Upstream Elevation: 1933 ft		Slope: 0.007
Channel Length: 0.38 mi		Valley Length: 0.34 mi		Sinuosity: 1.11
Bankfull Width: 129 ft			Flood Prone Width: 300 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 1.85			Sep Mean Flow:10-Year Flow = 4.04	
Inundated Acres				
Sep Mean Flow: 3.4		2-Year Flow: 6.3		10-Year Flow: 13.7
2023 Reach Condition				
%Pool: 0	%Riffle: 51.9	%Rapid: 0	%Glide: 38.9	Modified Bank: 2181 ft
#Pools: 0		Channel Widths/Pool: 0		Pools/mile: 0
Wood Count (Nat/ELJ): 3/0		Natural LW Pieces/mile: 10.0		LW Jams (Nat/ELJ): 0/0
Reach Description				
<p>Pearrygin 6 is a relatively short and steep reach extending less than one-half mile upstream from the Cub Creek confluence. Reach 6 has been significantly altered from its historical configuration. Floodplain surfaces are present, but the areas to both the west and east of the current mainstem are relatively disconnected, and nearly the entire east bank (river left) of the reach is riprapped. Residential development on the western (river right) floodplain is protected by some riprap, but most of this area is inundated at the 100-year flood. There is one side channel in the reach that is active at the 2-year flow, but none present at low flows. The reach is dominated by riffle-glide habitat units. Pool habitat is lacking, and the substate is mostly cobble-boulder. Sand deposition, stemming from the 2021 Cub Creek 2 fire, has likely filled in some pool habitat so that they currently function as glides. Riparian vegetation has been significantly impacted over time due to land clearing and development. There are several cold-water patches within the reach, including the Cub Creek confluence and seepage from the left bank across from Cub Creek.</p>				



Cold water seepage from the right bank at the downstream end of Pearrygin 6 reach (above left). Upstream view of river left riprapp bank and cobble-boulder riffle habitat with cottonwood riparian overstory (above right). Residential development, riparian clearing, and bank protection in floodplain habitat in Pearrygin 6 reach (right).



Pearrygin 7				
Reach RM Start: 7.4		Reach RM End: 8.6		Reach Length: 1.2 mi
Downstream Elevation: 1933 ft		Upstream Elevation: 1989 ft		Slope: 0.009
Channel Length: 1.2 mi		Valley Length: 1.14 mi		Sinuosity: 1.05
Bankfull Width: 149 ft			Flood Prone Width: 211 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 2.36			Sep Mean Flow:10-Year Flow = 3.14	
Inundated Acres				
Sep Mean Flow: 9.8		2-Year Flow: 23.1		10-Year Flow: 30.7
2023 Reach Condition				
%Pool: 20.1	%Riffle: 43.1	%Rapid: 9.4	%Glide: 21.5	Modified Bank: 2549 ft
#Pools: 6		Channel Widths/Pool: 7.1		Pools/mile: 5.0
Wood Count (Nat/ELJ): 31/0		Natural LW Pieces/mile: 25.8		LW Jams (Nat/ELJ): 4/0
Reach Description				
<p>Pearrygin 7 extends from the upstream end of Reach 6 up to the Chewuch Canal Company’s irrigation diversion dam at RM 8.6. The reach is relatively confined and steep (0.9%) with low sinuosity. It is primarily a transport reach, and the channel is primarily riffle-glide. The few pools present are not especially deep and lack cover. The substrate is mostly cobble-boulder, and the spawning habitat potential is low. Riparian areas have been heavily modified by agriculture, road, and structural development.</p> <p>Glacial terraces along the west bank (river right) confine the channel for nearly the entire reach. There is extensive riprap along this bank, which protects the county road prism, MacPherson Bridge, and some structures downstream of the bridge. Riprap on river left (east) downstream of the diversion and bridge protect diversion infrastructure and some residences. Short sections of levee downstream of the bridge curtail floodplain connectivity where there is an approximately 10-acre floodplain surface that becomes activated at the 2-year flow. There is a push-up levee near the upstream end of this surface that diminishes connectivity at lower flood flows. Downstream of this floodplain area, a glacial terrace on river left has been cleared for agriculture and riprapped.</p>				



Upstream view of rapid channel unit with right bank high flow side channel flow path and cottonwood riparian overstory in Pearrygin 7 reach (above left). Downstream view of boulder-cobble riffle habitat upstream of MacPherson Bridge (above right). Upstream view of Chewuch Dam and diversion headgate at low water with fish passage channel along river right bank (right).

Pearrygin 8				
Reach RM Start: 8.6		Reach RM End: 9.5		Reach Length: 0.9 mi
Downstream Elevation: 1989 ft		Upstream Elevation: 2073 ft		Slope: 0.018
Channel Length: 0.87 mi		Valley Length: 0.77 mi		Sinuosity: 1.13
Bankfull Width: 143 ft			Flood Prone Width: 250 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 1.98			Sep Mean Flow:10-Year Flow = 3.17	
Inundated Acres				
Sep Mean Flow: 8.4		2-Year Flow: 16.5		10-Year Flow: 26.5
2023 Reach Condition				
%Pool: 18.2	%Riffle: 18.8	%Rapid: 26.5	%Glide: 0	Modified Bank: 571 ft
#Pools: 14		Channel Widths/Pool: 3.7		Pools/mile: 9.9
Wood Count (Nat/ELJ): 26/0		Natural LW Pieces/mile: 28.9		LW Jams (Nat/ELJ): 1/0
Reach Description				
<p>Pearrygin 8 reach is approximately one mile in length and extends from Chewuch Dam upstream to the Boulder Creek confluence. It is a high energy transport reach and the steepest (1.8%) reach in the LCRA area. The reach has low sinuosity and is cobble-boulder dominated. The habitat is mostly riffle-rapid, but there are several large, deep pools that lack appreciable woody cover. The reach is relatively confined, but contains several significant low flow side channels; the upstream-most side channel provides flow to the Skyline irrigation diversion. A large side channel further downstream is separated from the mainstem by a large, sparsely vegetated island that has several high-water flow paths across it.</p> <p>The reach contains an approximately 20-acre floodplain area, which is on river right (west) downstream of the Skyline diversion. There is some residential development within this area, and the upstream bank has been modified (push-up levee) over time to reduce the extent of floodplain inundation. The MacPherson side channel restoration project (completed in 2009) was located here and has increased the extent of perennial off-channel flow and habitat in the reach.</p>				



Upstream view of pool habitat in Pearrygin 8 reach within burn scar of 2021 Cub Creek 2 fire (above). Upstream view of high energy riffle boulder-cobble habitat in Pearrygin 8 reach (above right). Upstream view of bedrock formed lateral scour pool just downstream of Boulder Creek confluence in Pearrygin 8 reach (right).

Pearrygin 9				
Reach RM Start: 9.5		Reach RM End: 10.0		Reach Length: 0.5 mi
Downstream Elevation: 2073 ft		Upstream Elevation: 2077 ft		Slope: 0.002
Channel Length: 0.46 mi		Valley Length: 0.42 mi		Sinuosity: 1.09
Bankfull Width: 124 ft			Flood Prone Width: 195 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 2.11			Sep Mean Flow:10-Year Flow = 2.94	
Inundated Acres				
Sep Mean Flow: 3.7		2-Year Flow: 7.8		10-Year Flow: 10.9
2023 Reach Condition				
%Pool: 69.9	%Riffle: 6.1	%Rapid: 5.0	%Glide: 0	Modified Bank: 466 ft
#Pools: 9		Channel Widths/Pool: 2.7		Pools/mile: 16.0
Wood Count (Nat/ELJ): 3/0		Natural LW Pieces/mile: 6.0		LW Jams (Nat/ELJ): 0/0
Reach Description				
<p>Pearrygin 9 extends upstream from the Boulder Creek confluence and around one upstream bend in the channel. It is a relatively short, straight, and low gradient reach that defines a significant gradient break from downstream reaches. The substrate is primarily gravel-cobble. Pool habitat dominates in Pearrygin 9 (>75%), which has the highest percentage of pool habitat of any reach in the LCRA area. Pooltails contain gravel spawning habitat for steelhead, spring Chinook, and coho salmon. There is a small floodplain surface on river left that is active at the 2-year flow, but it becomes more fully inundated at the 10-year discharge. Riparian vegetation is present along both banks, but it has been limited on the west bank (river right) by road development and riprapping.</p> <p>Although it is a short reach, Pearrygin 9 contains several areas of development that are impacting riparian vegetation and channel processes. USFS Road 51 runs along the west bank for much of the reach. The bank along the road has been riprapped. The Memorial Bridge area contains areas of riparian clearing as well as bridge remnants that impede natural process.</p>				



Upstream view of rapid boulder habitat downstream of Memorial Pool in Pearrygin 9 reach (above left). Downstream view of glide habitat with spawning gravel, floodplain surface, and cobble bar on river left, and vegetated riprapp bank adjacent to road, Pearrygin 9 reach (above right). Upstream view of pooltail spawning habitat and cobble bar with emergent willow riparian habitat (right).



Pearrygin 10				
Reach RM Start: 10.0		Reach RM End: 10.6		Reach Length: 0.6 mi
Downstream Elevation: 2077 ft		Upstream Elevation: 2082 ft		Slope: 0.001
Channel Length: 0.68 mi		Valley Length: 0.52 mi		Sinuosity: 1.3
Bankfull Width: 177 ft			Flood Prone Width: 461 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 3.01			Sep Mean Flow:10-Year Flow = 6.15	
Inundated Acres				
Sep Mean Flow: 6.2		2-Year Flow: 18.6		10-Year Flow: 37.9
2023 Reach Condition				
%Pool: 51.3	%Riffle: 18.5	%Rapid: 0	%Glide: 17.5	Modified Bank: 482 ft
#Pools: 7		Channel Widths/Pool: 3.2		Pools/mile: 9.4
Wood Count (Nat/ELJ): 24/101		Natural LW Pieces/mile: 40.0		LW Jams (Nat/ELJ): 3/8
Reach Description				
<p>Pearrygin 10 reach is a low gradient reach that extends around one long meander bend upstream from reach 9 and contains an approximately 15-acre floodplain surface at the 10-year inundation. Residential development and an access road disrupt overland flow on this surface, and there is a perennial, low flow alcove that enters the mainstem near the downstream end of the reach. This channel was restored in 2012 as an element of the RM 10 project.</p> <p>Pearrygin 10 is primarily pool-glide habitat interspersed with short riffles. Gravel-cobble substrate is dominant, with several areas of perennial spawning habitat. There are several short side channels present, but only one is connected at low flows. There is a narrow, vegetated island at the upstream end of the reach that has been racking natural wood for many years. The 2012 RM 10 project installed large wood in two side channels in the upstream portion of this reach. A several acre floodplain wetland area on river left at the upstream end of the reach contains residential development that is impacting floodplain habitat, with several short sections of riprap curtailing flood connectivity. Riparian vegetation is present in many areas, but has been cleared significantly around developed areas and roads. Vegetation has also been cleared along the east bank (river right) of the river along the USFS Road 5010 prism.</p>				



Downstream outlet of restored alcove channel in Pearrygin 10 reach (above). Downstream view of backwater habitat, sand deposition, and residential development and riparian clearing on high glacial terrace in Pearrygin 10 reach (above right). Upstream view of residential development and riparian clearing in river right floodplain habitat in Pearrygin 10 reach



Pearrygin 11				
Reach RM Start: 10.6		Reach RM End: 11.9		Reach Length: 1.3 mi
Downstream Elevation: 2082 ft		Upstream Elevation: 2109 ft		Slope: 0.004
Channel Length: 1.2 mi		Valley Length: 1.08 mi		Sinuosity: 1.11
Bankfull Width: 119 ft			Flood Prone Width: 198 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow: 2-Year Flow = 1.63			Sep Mean Flow: 10-Year Flow = 2.59	
Inundated Acres				
Sep Mean Flow: 11.1		2-Year Flow: 18.2		10-Year Flow: 28.9
2023 Reach Condition				
%Pool: 23.7	%Riffle: 32.2	%Rapid: 0.7	%Glide: 22.7	Modified Bank: 840 ft
#Pools: 9		Channel Widths/Pool: 7.2		Pools/mile: 6.1
Wood Count (Nat/ELJ): 15/143		Natural LW Pieces/mile: 11.5		LW Jams (Nat/ELJ): 0/8
Reach Description				
<p>Pearrygin 11 reach is a low gradient, moderately sinuous, and confined reach that extends for 1.2 miles downstream of the Eightmile Creek confluence. The reach is primarily riffle-glide habitat, with a low amount of pool habitat. Where present, pool habitat has been enhanced with the addition of large wood jams in the upper half of the reach (via the 2010 RM 8 project). Substrate in the reach is primarily cobble-boulder with some areas of gravel deposition, but Pearrygin 11 is not a significant reach for spawning in most years. Floodplain habitat is present, primarily along the east (river left) bank. The west (river right) bank is confined by a high glacial terrace along most of the upper half of the reach. Where present, floodplain habitat lacks full connectivity due to residential development and associated bank protection, especially along the east bank. Pearrygin 11 contains relatively high amount or riprap –the highest any reach in the LCRA area. Riparian vegetation is intact in many areas, but has been cleared for residential and road development. USFS Eightmile Ranch and an adjacent hatchery fish rearing pond developments cleared significant areas of riparian habitat from the floodplain and glacial terrace.</p>				



Backwater habitat adjacent to lateral scour pool habitat in Pearrygin 11 reach (above). Upstream view of typical cobble riffle habitat with riprap bank along USFS road (above right). Upstream view of typical riffle habitat, agricultural development, and clearing on high glacial terrace, and limited riparian cover in Pearrygin 11 reach (right).

Doe 1				
Reach RM Start: 11.9		Reach RM End: 13.4		Reach Length: 1.5 mi
Downstream Elevation: 2109 ft		Upstream Elevation: 2130 ft		Slope: 0.003
Channel Length: 1.53 mi		Valley Length: 1.06 mi		Sinuosity: 1.44
Bankfull Width: 157 ft			Flood Prone Width: 281 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 2.67			Sep Mean Flow:10-Year Flow = 4.14	
Inundated Acres				
Sep Mean Flow: 12.6		2-Year Flow: 33.8		10-Year Flow: 52.3
2023 Reach Condition				
%Pool: 44.5	%Riffle: 14.5	%Rapid: 0	%Glide: 26.1	Modified Bank: 0 ft
#Pools: 17		Channel Widths/Pool: 3.1		Pools/mile: 10.9
Wood Count (Nat/ELJ): 50/276		Natural LW Pieces/mile: 33.3		LW Jams (Nat/ELJ): 4/8
Reach Description				
<p>Doe 1 reach extends for 1.5 miles upstream from the Eightmile Creek confluence. It is a relatively unconfined, sinuous, and low gradient (0.3%) reach that contains a high amount of spawning habitat. Pools comprise nearly half of the channel length, but most lack abundant woody cover and not are especially deep. The substrate is cobble-gravel, with several areas of significant gravel accumulation, primarily in pooltails. Several side channels are present at low flows, including the ~0.5-mile-long river right side channel that was restored as a component of the 2015 Chewuch River Right project. The reach contains extensive areas of floodplain habitat on both sides of the mainstem at both the 2-year (>30 acres) and 10-year (>50 acres) flows. Large stands of native riparian vegetation are present throughout the reach.</p>				
<p>Anthropogenic development in the Doe 1 reach is minimal, and there are no structures, levees, or riprap present.</p>				



Upstream view of typical pooltail habitat, cobble/gravel bars, and floodplain riparian vegetation in Doe 1 reach (above). Spawning habitat (and redd) in pooltail habitat in mainstem braid in Doe 1 reach (above right). Upstream view of isolated (during low water) pool habitat in restored river right side channel in Doe 1 reach (right).

Doe 2				
Reach RM Start: 13.4		Reach RM End: 14.4		Reach Length: 1.0 mi
Downstream Elevation: 2130 ft		Upstream Elevation: 2150 ft		Slope: 0.004
Channel Length: 1.01 mi		Valley Length: 0.82 mi		Sinuosity: 1.24
Bankfull Width: 161 ft			Flood Prone Width: 429 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 2.1			Sep Mean Flow:10-Year Flow = 4.92	
Inundated Acres				
Sep Mean Flow: 10.7		2-Year Flow: 22.5		10-Year Flow: 52.6
2023 Reach Condition				
%Pool: 32.5	%Riffle: 26.7	%Rapid: 0	%Glide: 12.4	Modified Bank: 0 ft
#Pools: 14		Channel Widths/Pool: 3.3		Pools/mile: 10.1
Wood Count (Nat/ELJ): 50/110		Natural LW Pieces/mile: 50.0		LW Jams (Nat/ELJ): 4/9
Reach Description				
<p>Doe 2 is a low gradient, one-mile-long reach that is relatively confined in the lower portion and relatively unconfined in the upper three-quarters, where extensive floodplain habitat is present on both sides of the mainstem. The reach includes one large meander bend and several side channels that are connected at low flows, with significantly more side channel and floodplain habitat becoming available beginning at the 2-year discharge. The cobble-gravel substrate and pool frequency and quality is similar to the Doe 1 reach, but Doe 2 contains more riffle habitat. Riparian vegetation is extensive within the reach, with only a few cleared areas concentrated at the upstream end of the reach.</p> <p>The reach lacks significant anthropogenic development, and there are no levees or other channel impediments in the reach. Several restoration projects, including Chewuch RM 11-13 (2013) and Chewuch River Right (2015) have been implemented in the reach, and it contains engineered wood structures within the mainstem, side channels, and one backwater area. Riparian clearing has occurred near the upstream end of the reach. Dispersed recreation is the primary land use within the cleared areas.</p>				



Upstream view of backwater habitat and vegetated cobble bar in Doe 2 reach (above left). Upstream view of lateral scour pool with engineered log structure and riparian vegetation with cottonwood and pine overstory (above right). Natural wood apex jam at upstream end of vegetated island in Doe 2 reach (right).

Doe 3				
Reach RM Start: 14.4		Reach RM End: 14.8		Reach Length: 0.4 mi
Downstream Elevation: 2150 ft		Upstream Elevation: 2172 ft		Slope: 0.011
Channel Length: 0.37 mi		Valley Length: 0.34 mi		Sinuosity: 1.09
Bankfull Width: 104 ft			Flood Prone Width: 120 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 2.17			Sep Mean Flow:10-Year Flow = 2.42	
Inundated Acres				
Sep Mean Flow: 2.2		2-Year Flow: 4.8		10-Year Flow: 5.4
2023 Reach Condition				
%Pool: 21.4	%Riffle: 8.7	%Rapid: 69.9	%Glide: 0	Modified Bank: 0 ft
#Pools: 3		Channel Widths/Pool: 6.5		Pools/mile: 7.8
Wood Count (Nat/ELJ): 8/6		Natural LW Pieces/mile: 20.0		LW Jams (Nat/ELJ): 0/1
Reach Description				
<p>Doe 3 reach is located at the Falls Creek confluence and within the Falls Creek alluvial fan. Doe 3 is a short, steep, confined reach that lacks appreciable off-channel habitat. The reach is a high energy transport reach dominated by large substrates (boulder-cobble). There is limited floodplain area in Doe 3, most of which is contained within two small cobble bar surfaces. The reach is dominated by rapid channel units interspersed with pools; this pool habitat generally lacks cover. Riparian vegetation is degraded along the west (river right) bank which was historically cleared for agriculture and is currently a dispersed campground (left). Riparian vegetation along the east (river left) bank. Emergent willows are present along the banks and cobble bars. There is one engineered log structure in the reach that is an element of the 2013 RM 13-15 project.</p>				



Upstream view of engineered log structure and boulder ballast, river left, Doe 3 reach (above left). Upstream view of mainstem channel at Falls Creek confluence with bolder substrate and campground associated clearing on river right bank (left). Downstream view of rapid-boulder/cobble habitat and riparian vegetation with pine overstory (above).

Doe 4				
Reach RM Start: 14.8		Reach RM End: 16.2		Reach Length: 1.4 mi
Downstream Elevation: 2172 ft		Upstream Elevation: 2196 ft		Slope: 0.003
Channel Length: 1.42 mi		Valley Length: 1.33 mi		Sinuosity: 1.07
Bankfull Width: 144 ft			Flood Prone Width: 191 ft	
Channel Area Entrenchment of Wetted Width				
Sep Mean Flow:2-Year Flow = 1.96			Sep Mean Flow:10-Year Flow = 2.47	
Inundated Acres				
Sep Mean Flow: 13.3		2-Year Flow: 26.1		10-Year Flow: 32.9
2023 Reach Condition				
%Pool: 57.3	%Riffle: 23.3	%Rapid: 0	%Glide: 8.4	Modified Bank: 0 ft
#Pools: 23		Channel Widths/Pool: 3.1		Pools/mile: 12.0
Wood Count (Nat/ELJ): 105/87		Natural LW Pieces/mile: 75.0		LW Jams (Nat/ELJ): 6/6
Reach Description				
<p>Doe 4 reach extends for 1.4 miles upstream from the upstream end of Doe 3 reach. Doe 4 is a relatively straight, moderately confined reach with little side channel or floodplain habitat present, especially in the lower 75% of the reach. Several mainstem backwater areas are present at the downstream end of channel bends. The only significant side channel habitat is located at the upstream end of the reach (adjacent to Doe 5 reach) where there is a large island (~25 acres) that splits the channel. After the implementation of the RM 15.5-17 project in 2017, the mainstem channel switched from the west side of the island to the east side of the island, and the former eastern side channel now forms the mainstem channel at lower flows. The substrate in the reach is primarily cobble-gravel, and there is significant pool development. Riparian habitat is largely intact on both banks, but a limited amount of clearing around roads and dispersed campgrounds has occurred.</p> <p>There are three engineered log structures in the reach stemming from the 2017 RM 15.5-17 project and a concrete bridge piling remains along the banks near RM 15. No other anthropogenic features are present in the reach.</p>				

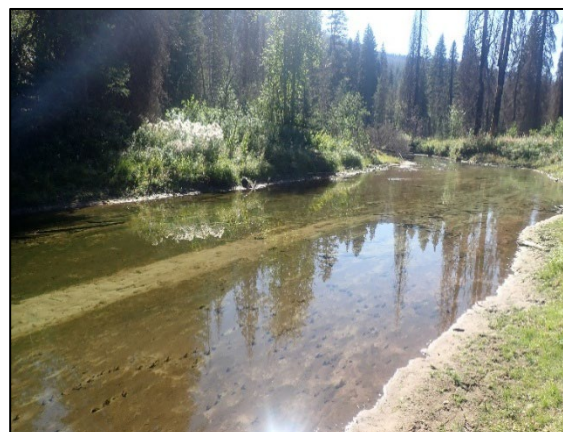


Downstream view of complex pool habitat in newly established mainstem channel in Doe 4 reach (above left). Upstream view of confluence of mainstem (former side channel) and former western mainstem (dry) channel with vegetated island separating the two channels at upstream end of Doe 4 reach (above right).

Doe 5				
Reach RM Start: 16.2		Reach RM End: 18.4		Reach Length: 2.2 mi
Downstream Elevation: 2196 ft		Upstream Elevation: 2246 ft		Slope: 0.004
Channel Length: 2.26 mi		Valley Length: 2.0 mi		Sinuosity: 1.13 mi
Bankfull Width: 139 ft			Flood Prone Width: 292 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow: 2-Year Flow = 2.09			Sep Mean Flow: 10-Year Flow = 4.0	
Inundated Acres				
Sep Mean Flow: 20.0		2-Year Flow: 41.8		10-Year Flow: 79.9
2023 Reach Condition				
%Pool: 45.0	%Riffle: 28.2	%Rapid: 0	%Glide: 12.9	Modified Bank: 243'
#Pools: 24		Channel Widths/Pool: 3.7		Pools/mile: 10.3
Wood Count (Nat/ELJ): 122/214		Natural LW Pieces/mile: 55.5		LW Jams (Nat/ELJ): 10/11
Reach Description				
<p>Doe 5 reach is a long (>2 miles), low gradient, relatively unconfined, and sinuous reach. It extends upstream to near the Doe Creek confluence. It contains significant floodplain areas with approximately 80 acres of inundated area at the 10-year discharge. Several side channels and braids are active at low flows with additional off-channel areas activated at the 2-year flow. The reach is pool-riffle dominant, with several deep pools present. Cobble is the dominant substrate throughout the reach, especially in riffles, but there are areas of gravel deposition in pooltails and glides. Riparian habitat is largely intact throughout the reach, but areas of clearing are associated with USFS roads, several dispersed campgrounds, and a formal USFS campground located near the Doe Creek confluence.</p> <p>Doe 5 does not contain significant anthropogenic development, but roads and campgrounds are impacting floodplain and riparian habitat. Two areas of bank riprap have been installed to protect the USFS road prism along outside bends in the mainstem.</p>				



Downstream view in former mainstem channel (now a seasonally disconnected side channel, including engineered log structure (above)). Upstream view of braid habitat with glide cobble-gravel habitat (above left). Downstream view into newly established mainstem channel from apex of island currently separating the two channels (right).



Doe 6				
Reach RM Start: 18.4		Reach RM End: 20.3		Reach Length: 0.9 mi
Downstream Elevation: 2246 ft		Upstream Elevation: 2334 ft		Slope: 0.009
Channel Length: 1.89 mi		Valley Length: 1.67 mi		Sinuosity: 1.14
Bankfull Width: 131 ft			Flood Prone Width: 177 ft	
Channel Area Entrenchment Ratio of Wetted Width				
Sep Mean Flow:2-Year Flow = 2.39			Sep Mean Flow:10-Year Flow = 3.1	
Inundated Acres				
Sep Mean Flow: 13.1		2-Year Flow: 31.3		10-Year Flow: 40.7
2023 Reach Condition				
%Pool: 20.8	%Riffle: 44.1	%Rapid: 0	%Glide: 8.9	Modified Bank: 1702 ft
#Pools: 18		Channel Widths/Pool: 5.5		Pools/mile: 7.4
Wood Count (Nat/ELJ): 121/77		Natural LW Pieces/mile: 134.4		LW Jams (Nat/ELJ): 7/6
Reach Description				
<p>The portion of the Doe 6 reach within the LCRA area is a one-mile-long segment that extends from near the Doe Creek confluence upstream to the Twentymile Creek confluence. Brevicomis Creek enters the reach from the east (river left) around RM 19.7. Doe 6 is relatively unconfined and sinuous, and it contains more than 40 acres of activated floodplain at the 10-year discharge. Several side channels remain connected at low flows, but flow through each is minimal during flows <math><100\text{ ft}^3/\text{s}</math>. Three additional side channels become active at $\geq 2</math>-year flow. Riffles comprise a majority of the reach length and are dominated by cobble-boulder substrates. Riparian vegetation in the reach is generally intact, but clearing has occurred along roads, campgrounds, and the east bank summer home development near Brevicomis Creek. Several areas of bank riprap protect the road prism near RM 18.7 and 19.3, and there is an old concrete bridge piling in the mainstem channel near RM 19.6.$</p>				



Upstream view of channel split around vegetated cobble bar in Doe 6 reach (above). Upstream view of riffle habitat within burn scar of the 2021 Cub Creek 2 fire, with road visible above river right (above right). Upstream view of typical cobble riffle habitat in Doe 6 reach with riparian vegetation and pine and cottonwood overstory (right).



3.6 Current Habitat Conditions

A survey and analysis of stream habitat was conducted in 2023 to document current stream habitat conditions within the LCRA area. This survey is an important component of the overall reach assessment process, as it defines the current state of aquatic habitat conditions available for fish and the habitat template on which habitat restoration and protection projects can be based. Where applicable and appropriate, data derived from this survey was compared to the previous habitat surveys that have been completed for the lower Chewuch River, most notably the 2008 survey that was completed to support the 2010 Lower Chewuch Reach Assessment.

The U.S. Forest Service Level II Stream Inventory protocol (USFS, 2016) was used as a primary means to assess current stream habitat conditions within the LCRA area. The entire 20-mile channel length from the confluence with the Methow River upstream to the Twentymile Creek confluence was surveyed by walking the mainstem, side channels, and many floodplain surfaces. Modifications to the protocol included eliminating the riparian component and the bankfull width and depth measurements. These elements were addressed through inclusion of stream channel related information derived from hydrologic modeling (based off the 2022 lidar) and GIS-based riparian and roads analyses.

The Stream Inventory was conducted during relatively low-flow conditions late July – early October 2023. Flows during the survey ranged between approximately 50-100 ft/s³ which brackets the September monthly flow of 79 ft/s³ which is the lowest monthly flow observed at the USGS Gage (#1244800) in Winthrop over the 32 years of gauge record. No attempt was made to normalize habitat units or field measurements to the slight changes in flow that occurred during the survey.

The results of this habitat assessment, and with further reporting in the Reach-Based Ecosystem Indicators analysis (Section 4), were used to define the current conditions that were examined and analyzed to support the development of desired future conditions. Additional reach information at the is presented in the individual reach summaries in Section 3.5.

Data from previous surveys of the LCRA area in 2008 were used as a reference to assess habitat change over time. It should be noted that variables inherent to point-in-time stream habitat surveys (e.g., staff experience and judgement, stream discharge), as well as differences in boundaries of the stream reaches selected for the various surveys made 1:1 comparisons for some areas and habitat attributes difficult.

3.6.1 Stream Habitat Conditions

3.6.1.1 Mainstem Channel Habitat

In total, 418 channel units were identified within the LCRA reach, with 244 units identified in the Chewuch–Pearrygin AU and 174 units in Chewuch–Doe (Table 3.6.1). While the length of each individual unit varied, the number of units/mile was similar between the assessment units (Pearrygin = 20.5 units/mile, Doe = 20.7 units/mile). The total mainstem channel length along the thalweg was 20 miles, with 11.8 miles for Chewuch–Pearrygin AU and 8.2 miles for Chewuch-Doe. Despite some recent shifts in channel alignment, most notably in the Doe 5 reach, this length is similar to the combined 20.3 miles obtained from GIS-based data.

Fast water habitats, including riffles, rapids, and glides, represent the majority of the channel length in both assessment units, including 59% and 52% of the length in the Chewuch-Pearrygin and Chewuch-Doe AUs, respectively (Table 3.6.1). Slow water scour pools, including both lateral and mid-channel formed pools, comprised the remainder of the habitat, with Chewuch-Doe AU having slightly more pool habitat (47%) compared to Chewuch-Pearrygin AU (41%). Overall, pools were the most dominant single habitat type in both AUs and occupied a longer proportion of the channel (41-47%) than either riffles/rapids (37-39%) and glides (15-20%). Rapids were relatively rare and only accounted for 3-5% of the channel. However, in two higher gradient and relatively short reaches (Pearrygin 8 and Doe 3), rapids were the dominant habitat type observed.

Table 3.6.1. Mainstem channel habitat unit composition, LCRA area, 2023.

Habitat Unit Type	# Units		# units per Mile		Length (Percent)		Surface Area (Percent)		Surface Area (acres)	
	Pear	Doe	Pear	Doe	Pear	Doe	Pear	Doe	Pear	Doe
Lateral Scour Pool	51	45	4.3	5.4	---	---	---	---	---	---
Mid-Channel Scour Pool	33	32	2.8	3.8	---	---	---	---	---	---
Total Pools	84	77	7.1	9.2	40.9	47.2	40.9	44.3	39.9	26.9
Riffles	88	65	7.4	7.7	33.6	34.2	33.9	34.3	33.0	20.8
Rapids	17	2	1.4	0.2	5.2	3.3	5.0	3.9	4.9	2.4
Total Riffles/Rapids (Fast Turbulent)	105	67	8.8	8.0	38.8	37.5	38.9	38.2	37.9	23.2
Glide	55	30	4.6	3.6	20.3	15.3	20.2	17.4	19.7	10.6
Total Glide (Fast Non-Turbulent)	55	30	4.6	3.6	20.3	15.3	20.2	17.4	19.7	10.6
Total	244	174	20.5	20.7	100	100	100	100	97.5	60.8

Under the low-flow conditions present during the survey, total channel area (unit length x unit average width) in the LCRA area was 158.3 acres, with Chewuch-Pearrygin covering approximately 1/3 more area (97.5 acres) than Chewuch-Doe AU (60.8 acres). Mean reach wetted widths of channel units ranged from 45'-77' (average = 58') in the Chewuch-Pearrygin AU and 43'-58' (average = 49') within the Chewuch-Doe AU.

Habitat unit area composition was very similar to that of length, with pools covering >40% of the low flow channel area in both AUs. Riffle and rapid coverage in both AUs was nearly identical at 39% of the channel in Chewuch-Pearrygin AU and 38% in Chewuch-Doe. Glides accounted for approximately 20% of the habitat area in Chewuch-Pearrygin AU and slightly less (15%) in Chewuch-Doe AU.

Overall, at the assessment unit scale, there was a fair degree of similarity between the 2008 and 2023 habitat survey data for the LCRA area – a potential indication that there have not been substantial changes in habitat unit composition over the past 15 years (Table 3.6.2). While some degree of change is expected in streams such as the Chewuch River, any shifts in habitat unit composition have likely been small or localized. Across the two survey periods, the majority of

habitat was comprised of pools (approximately 40% of habitat) and riffles (35-45% of habitat area). In both surveys, glides comprised the smallest amount of available habitat. Area of glide habitat in Chewuch-Pearrygin in 2023 was 67% greater compared to the earlier survey conducted in 2008. Glide habitat area was similar during both surveys in the Chewuch-Doe AU area.

Table 3.6.2. Habitat unit comparison, 2008 and 2023 survey data, LCRA area.

Habitat Type	2008		2023	
	RM 0-11.8	RM 11.8-18	Pearrygin	Doe
% Pool	43.1	38.7	40.9	44.3
% Riffle	40.3	37.8	38.9	38.2
% Glide	13.6	18.6	20.2	17.4

At the reach scale, there was an appreciable difference in channel type composition between the 17 reaches – largely a reflection of reach-specific characteristics, including length, gradient, and valley width (Figure 3.6.1). Rapids were the least common habitat unit except in the high gradient Pearrygin 8 and Doe 3 reaches, where they comprised 76% and 32% of the wetted area.

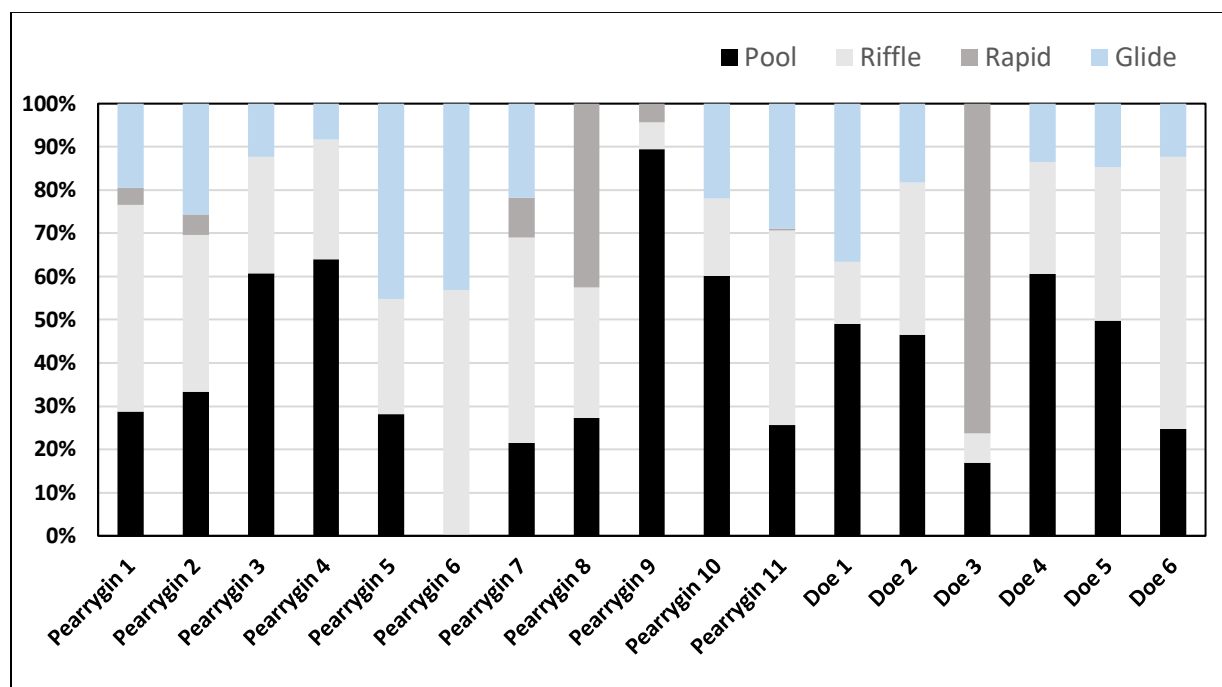


Figure 3.6.1. Reach-level habitat unit composition, percent of mainstem area, LCRA area, 2023.

Pool habitat comprised >50% of the habitat area in several reaches, including Pearrygin 3, 4, 9, 10 and Doe 4. In Pearrygin 9, pools accounted for >75% of available habitat that was derived primarily from two large and long pool units. Pool habitat was also abundant in Doe 1 and 5, where it comprised 46% of the available habitat. Pools were absent from the 0.4-mile-long Pearrygin 6 reach and comprised <25% of habitat in the Pearrygin 7, 8, 11, and Doe 3 and 6 reaches. Riffle habitat comprised >40% of the habitat in several reaches, including Pearrygin 1, 6, 7, and 11 and Doe 6.

Riffles were scarce (<15%) in Pearrygin 9 and Doe 1 and 3. Glides generally occupied <25% of available habitat, but were more abundant in several reaches, including Pearrygin 5 and 6 and Doe 1.

3.6.1.2 Pool Habitat

Pool habitat is an important component of fish habitat, and increasing and enhancing pool habitat has been a persistent goal of stream habitat restoration in the Chewuch River for many years. Pools occupy >40% of habitat area in the LCRA area, and in total, 205 pools were observed during the survey. Although pools were slightly more numerous in the Chewuch-Pearrygin AU (106 pools) compared to the Chewuch-Doe AU (99 pools), they were much more common in Chewuch-Doe where there were 12.1 pools/mile compared to 9 pools/mile in Chewuch-Pearrygin AU.

At the reach scale, pools were most common and occurred at a frequency of >8/mile in the Pearrygin 3, 4, 8, 9, and 10 and Doe 1, 2, 4, and 5 reaches (Figure 3.6.2). Many of the reaches with high pool frequency contain relatively broad floodplain surfaces. Conversely, pool frequency was lowest in the more confined reaches, including Pearrygin 1, 2, and 6.

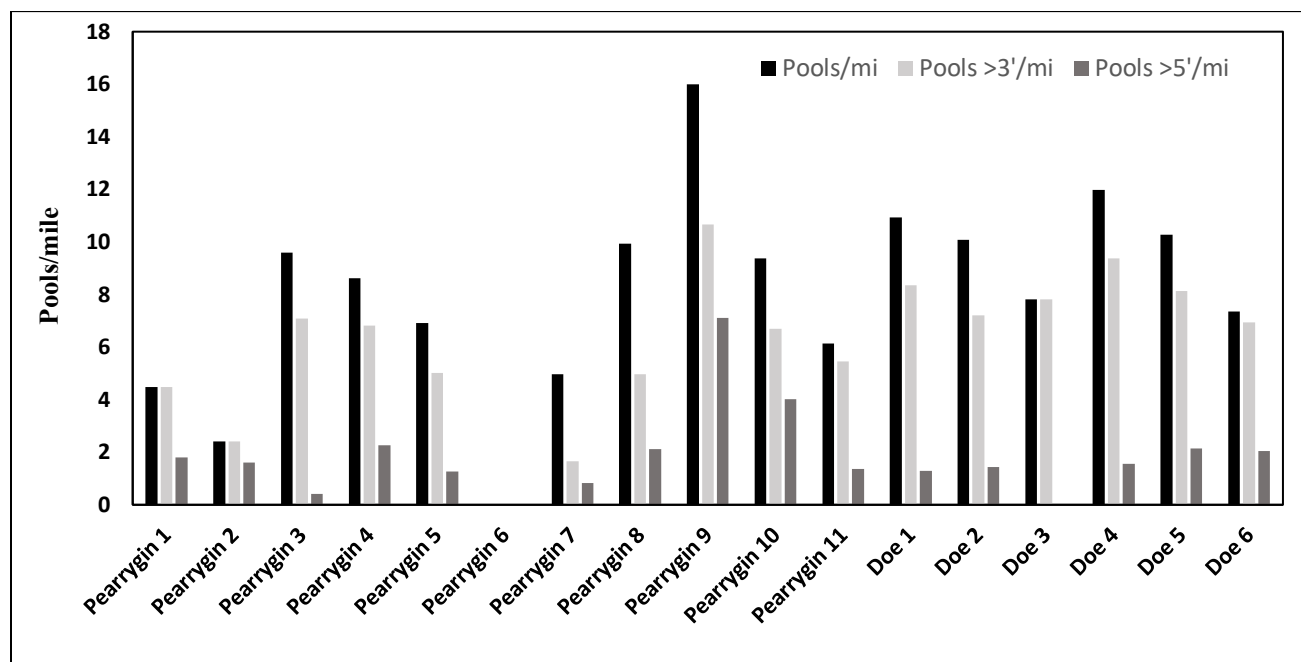


Figure 3.6.2. Pool frequency (pools/mile), within LCRA reaches, 2023.

Compared to the previous habitat surveys, pool frequency has increased in both LCRA AUs. The change has been slight (i.e., 1 pool/mile) in Chewuch-Pearrygin and more pronounced in Chewuch-Doe, where pool frequency has increased by several pools/mile compared to the 2008 survey (Table 3.6.3).

Depth is an important pool characteristic, and although average maximum pool depth varied across reaches, it was identical (4.7') for both AUs and ranged between 3.3'-6.2' in Chewuch-Pearrygin AU and 3.3'-4.7' in Chewuch-Doe AU. The deepest pool measured was 6.2' deep in a bedrock formed pool in the Pearrygin 2 reach.

Table 3.6.3. Pool frequency comparison, 2008 and 2023 habitat surveys, LCRA area.

Pool Frequency	2008		2023	
	RM 0-11.8	RM 11.8-18	Pearrygin	Doe
Pool/mi	8.1	6.7-9.5	9.0	12.1
>3'/mile	n/a	5.8-9.0	6.4	9.8
>5'/mile	1.9	0-5.3	2.1	2.1

The percentage of pools >3' deep was slightly higher in Chewuch-Doe (80.8%) compared to Chewuch-Pearrygin (71.7%), but pools >5' deep are more common in Chewuch-Pearrygin (23.6%) compared to only 17% in Chewuch-Doe.

Compared to previous surveys, average maximum pool depth shows both potential increases and decreases depending on the 3' or 5' threshold and assessment unit. Pool depths have likely increased overall in Chewuch-Doe AU, more so for pools 3'-5' deep. There was one reach in the 2008 survey (Reach 2, which falls within the Doe 1 and 2 reaches) that had 5.3 5' deep pools/mile which is twice the frequency of the 2.1 5' pools/mile observed in 2023. In the Chewuch-Pearrygin AU, frequency of pools >5' may have increased slightly.

Residual pool depth, which is measurement of “true” pool depth regardless of discharge level, was slightly higher in Chewuch-Pearrygin (2.8', range = 2.1'-4.5') compared to Chewuch-Doe (2.5', range = 1.4'-2.8'), but was <3' for both assessment units. Similar to maximum pool depths, the highest residual depths were observed in some of the more confined reaches such as Pearrygin 1, 2, and 9. Pearrygin 10, a relatively unconfined reach, was an exception to this and contained several deep pools with residual depths >3.9'.

Overall, residual pool depths observed in 2023 were similar to, but less than those observed in previous habitat surveys. Average residual depths in Chewuch-Pearrygin AU in 2008 ranged between 2.9'-3.8' (at least 0.4' and up 1' greater than in 2023) and in 2008 between RM 11.8-18 ranged between 3.7'-4.0', which represents at least one foot of deeper residual depth.

3.6.1.3 Off-Channel Habitat

Side channels and braids serve to increase the overall wetted area and habitat diversity within streams and, as such, are important stream habitat attributes for fish. For the 2023 survey, we defined side channels as channel reaches separated from the mainstem channel by vegetated islands or other landforms. Braids were similar, but were separated from the mainstem by non-vegetated bars which were exclusively cobble and gravel bars. Braids were generally shorter relative to side channels and possessed more uniform habitat features.

Within the LCRA area, there was approximately 3.5 miles (18,369') of side channel habitat and 1 mile (5,591') of braid habitat in 2023 that arose from 33 individual side channel and 30 braid habitat units (Table 3.6.4). Chewuch-Pearrygin had more side channels (n=20), and side channel length, than Chewuch-Doe (n=13). Conversely, Chewuch-Doe had both more braids (n=19) and braid length compared to Chewuch-Pearrygin (n=11).

Side channel length in the LCRA area was approximately 17% of the mainstem channel length and was very similar for both assessment units (Table 3.6.4). Braids were both less common and

shorter than side channels and occupied a combined 5.3% of the mainstem length. Braid length in Chewuch-Doe was nearly double that observed in Chewuch-Pearrygin.

Table 3.6.4. Side channel and braid information, LCRA area, 2023.

Assessment Unit	# Side channels	Side channel length (ft)	Side channel %mainstem length	# Braids	Braid length (ft)	Braid % mainstem length
Pearrygin	20	11,325	18.2	11	2,211	3.6
Doe	13	7,044	16.2	19	3,379	7.8
Total	33	18,369	17.4	30	5,591	5.3

Side channel and braid counts, and their length as a percent of mainstem length, varied considerably across reaches (Figure 3.6.3). Side channels were most abundant in several unconfined reaches, including Pearrygin 3, 4, and 11 and Doe 2 and 6. An exception to this was Pearrygin 8, which is a relatively steep reach but contains a major side channel for nearly half the mainstem length. Side channels were absent entirely from reaches Pearrygin 6 and 7 and Doe 3. No braids were observed in reaches Pearrygin 1-3, and 10 and Doe 3 and 6.

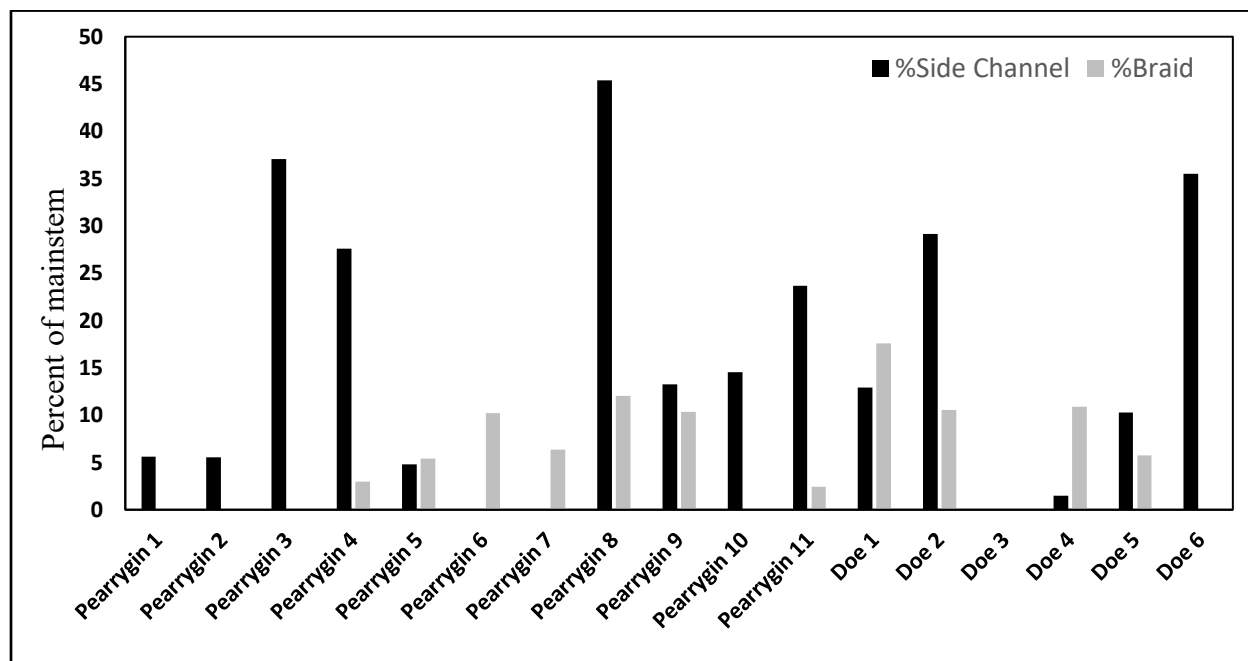


Figure 3.6.3. Side channel and braid length as percent of mainstem channel length, LCRA area, 2023.

3.6.1.4 Substrate and Fine Sediment

Sediment composition in the LCRA area was assessed through several means, including pebble counts taken during the habitat survey and fine sediment sampling completed in 2022 by the Colville Tribes. cursory visual examination of the Chewuch River within the LCRA area reveals a gravel and cobble dominated stream in many locations (Figure 3.6.4). As a result of recent fires (primarily the 2021 Cub Creek fire) and associated debris flows, sand and fines (<2 mm) have recently been observed in large quantities in some areas, and these pulses appear to be moving downstream over the past two years (Figure 3.6.5, J. Crandall, personal observation). In some

cases, it appears the volume of sand within a given habitat unit has been enough, for example, to shift a pool unit into a glide through decreased scour depth and increased velocities.



Figure 3.6.4. Typical cobble and gravel substrate within the LCRA area, Pearrygin 5 reach, 2023.



Figure 3.6.5. Sand substrate within pool habitat, Pearrygin 7 reach, 2023.

Substrate composition from pebble counts indicates gravel/cobble dominated substrate in the LCRA area. Gravel and cobble combined for 70% of observed surface substrate in Chewuch-Pearrygin and 68% Chewuch-Doe (Figure 3.6.6). Reaches exhibited some degree of difference in their composition, but all but a few reaches were gravel/cobble dominated.

Exceptions included the higher gradient Pearrygin 8 and Doe 3 reaches, where boulder substrate comprised 49% and 54% of the total, respectively. The only other reach where gravel and cobble combined were not dominant was Pearrygin 7, which had 43% fine substrates (<2 mm) that were predominantly sands.

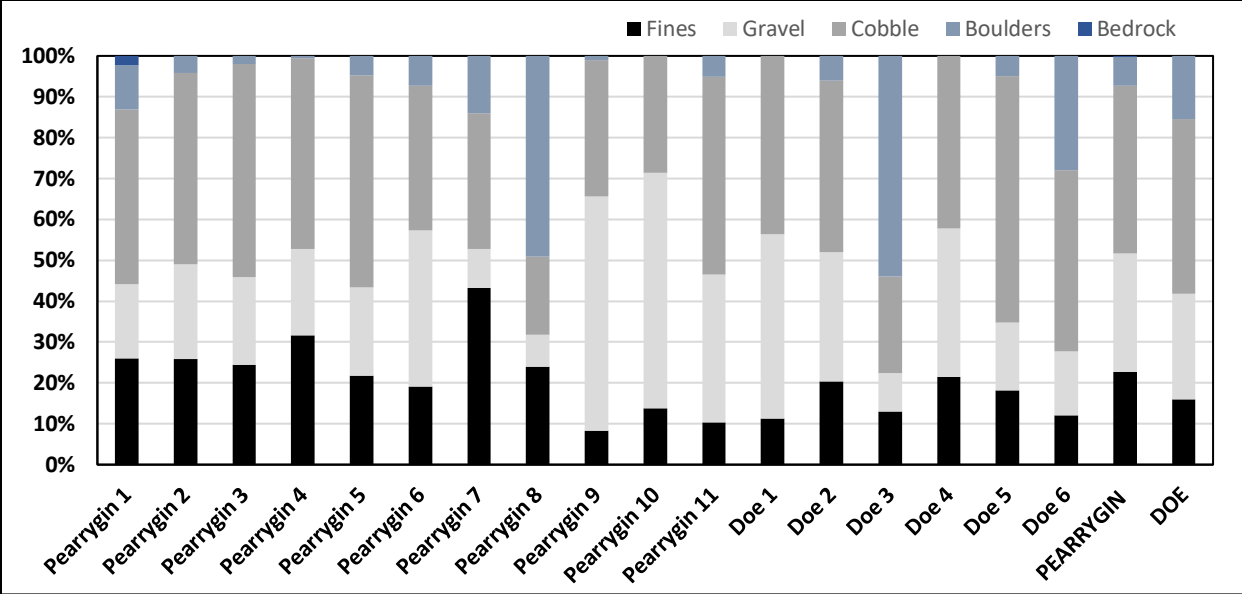


Figure 3.6.6. Average substrate composition from pebble counts, LCRA area, 2023.

Streambed grain size is an important characteristic of bed stability and can assist in determining potential response to erosional and depositional forces. Examining representative particle sizes including the median grain size (D50) and coarse fraction (D84) can be used to assist in assessment of channel stability and stream power at the sample location.

The average D50 in 2023 for the Chewuch-Pearrygin and Chewuch-Doe AUs were 73 mm and 119 mm, respectively, and indicate small cobble as the median size bed grain (Table 3.6.5). In 2008, sampling in the Chewuch-Pearrygin AU revealed a larger D50 of 149 mm (large cobble, range = 94-236 mm) and a slightly smaller D50 in the Chewuch-Doe AU of 105 mm (small cobble, range 61-160 mm).

In 2023, the D84 was 179 mm for Chewuch-Pearrygin and 288 mm for Chewuch-Doe, which places them in the large cobble and small boulder classes, respectively. These values were both finer grained (Chewuch-Pearrygin) and coarser (Chewuch-Doe) compared to the 2008 samples, which recorded D84 of 304 mm¹ and 196 mm for the Chewuch-Pearrygin and Chewuch-Doe AUs, respectively.

At the reach-scale, D50 in 2023 generally ranged between 50-95 mm (coarse gravel – small cobble), but was higher (>249 mm, large cobble-bolder sized) in several higher gradient reaches, including Pearrygin 8 and Doe 3. Substrate in these reaches was noticeably larger reflected the high energy environment (Figure 3.6.7). Reaches with gravel sized D50 tended to have higher abundance of spawning substrates, but small patches of suitable substate were observed in nearly all reaches except for Pearrygin 1, 2, 8 and Doe 3, where it was scarce.

¹ A sample in bedrock substrate in Pearrygin 1 reach was removed as it significantly skewed the results, and this type of habitat was not sampled in 2023.

Table 3.6.5. Pebble count D50 and D84 particle sizes, LCRA reaches, 2023.

Reach	D50	D84
Pearrygin 1	94	216
Pearrygin 2	66	147
Pearrygin 3	74	149
Pearrygin 4	57	111
Pearrygin 5	79	161
Pearrygin 6	54	176
Pearrygin 7	38	243
Pearrygin 8	249	703
Pearrygin 9	50	88
Pearrygin 10	50	88
Pearrygin 11	69	149
PEARRYGIN AU	73	179
Doe 1	61	110
Doe 2	59	155
Doe 3	300	827
Doe 4	53	104
Doe 5	95	185
Doe 6	144	348
Doe AU	119	288

**Figure 3.6.7.** Boulder substrate, Doe 3 reach, 2023.

High amounts of fine sediment can be detrimental to spawning and incubation habitat quality. Fine sediment in the LCRA area was examined through both surface and sub-surface sampling. Surface fine substrates (<2 mm) from pebble counts exceeded the criteria 12% threshold in both

assessment units, but were more common in Chewuch-Pearrygin AU (23%) compared to the 16% observed in Chewuch-Doe (Figure 3.6.5, Table 3.6.6). This was also the case in 2008, when pebble counts revealed similar values of 16% and 17% surface fines in the Chewuch-Pearrygin and Chewuch-Doe AUs, respectively.

There was a fair degree of variability in reach-based fine substrate presence in 2023, but only three reaches, Pearrygin 9 and 11 and Doe 1 had <12% surface fines. Chewuch-Pearrygin reaches ranged from 8%-43% and Chewuch-Doe samples ranged from 11%-21% (Table 3.6.6).

Table 3.6.6. Surface orientated fine substrate (<2 mm) percent composition, pebble counts, LCRA area, 2023.

Reach	Sample River Mile	Sample 1 %	Sample 2 %	Average %
Pearrygin 1	0.4/1.0	32.41	22.79	27.60
Pearrygin 2	1.6/2.2	32.94	21.95	27.45
Pearrygin 3	3.2/3.9	22.86	28	25.43
Pearrygin 4	5.1/5.2	41.58	28.57	35.08
Pearrygin 5	6.5/6.8	23.55	20.35	21.95
Pearrygin 6	7.3	21.38	---	21.38
Pearrygin 7	7.8/8.3	43.48	48.28	45.88
Pearrygin 8	9.2	28.85	---	28.85
Pearrygin 9	9.8/9.9	6.25	16.83	11.54
Pearrygin 10	10.1/10.3	9.92	19.27	14.59
Pearrygin 11	11.2/11.4	12.96	7.62	10.29
Doe 1	12.2/13.2	9.91	18.27	14.09
Doe 2	13.8/14.4	17.2	26.42	21.82
Doe 3	14.7/14.8	15.05	15.65	15.35
Doe 4	15.3/15.8	15.74	33.64	24.69
Doe 5	16.9/17.9	26.96	10.43	18.69
Doe 6	19.6/20.3	13.51	14.29	13.9

Sediment sampling conducted by the Colville Tribes in 2022 provides an examination of sub-surface conditions that are extremely relevant to spawning habitat quality within the LCRA area. This type of sampling is better suited to assess smaller substrate particles, including those <0.85 mm (i.e., silts). Excessive silt can diminish spawning and incubation quality.

Silts in the Chewuch-Pearrygin AU varied between 4.3-10.5% of the total sample volume (Table 3.6.7). Results were somewhat similar, but more variable, further upstream in the Chewuch-Doe AU, where they ranged from 3.3-23.7%. The most fines, twice that of any other sample, were observed in the Doe 2 reach, which contains several areas of annual spawning by both steelhead and spring Chinook. This was the only sample that contained >12% fines.

Colville Tribes' sampling of fines <2 mm and <6.3 mm in 2022 revealed a slightly different picture compared to the 2023 samples, with more fines observed in the upstream sampling locations, especially those <6.3 mm. Chewuch-Doe contained 20.3% <2 mm fines compared to 12% in Chewuch-Pearrygin. The percent of particles <6.3 mm was also more in Chewuch-Doe compared to Chewuch-Pearrygin AU, and all sites exceeded the 12% properly functioning condition threshold for this particle class.

Table 3.6.7. Percent fine sediment size classes, LCRA area, 2022.

Site	Reach	River Mile	<0.85 mm	<2 mm	<6.3 mm
C1A	Pearrygin 1	0.2	4.27	6.80	13.63
C4A	Pearrygin 9	9.9	6.23	9.63	16.36
C4C	Pearrygin 11	10.8	10.50	19.60	26.66
C5A	Doe 1	11.9	9.63	22.73	31.78
C5B	Doe 2	13.9	23.70	38.13	48.33
C8	Doe 5	18.4	5.80	10.70	19.92
C9B	Doe 6	20.2	3.33	9.77	17.58

3.6.1.5 Large Wood

Large wood plays an integral role in the development and sustainability of instream habitat complexity. Stream restoration in the Chewuch River over the past two decades has had installation of large wood as a primary project element. Current accepted criteria for the Methow River watershed target 42.5 pieces of large wood/mile as the properly functioning/adequate wood level.

All naturally occurring wood was counted within the bankfull channel during the 2023 survey. Wood counts for engineered log structures (ELS) were obtained off of the existing as-built drawings for each project. If no as-builts were available, as was the case for several projects, ELS wood counts were field based. Any large wood pieces that had racked upon an ELS were counted in the field as naturally recruited wood.

In total, 1925 pieces of large wood were counted within the LCRA area in 2023 (Table 3.6.8). Of these, 762 (39.6%) were naturally recruited, with the remainder (1163 pieces, 60.4%) comprised of installed wood within ELS and other anthropogenic structures. In 2008, 908 natural large wood pieces were counted, which was approximately 20% more natural pieces compared to 2023.

Table 3.6.8. Large wood counts and pieces per mile, LCRA area, 2023.

Assessment Unit	Natural Pieces	ELS Pieces	Total Pieces	Natural/mile	ELS/mile	Total/mile	# Natural Jams	# ELS
Pearrygin	306	393	699	30.1	33.0	58.7	17	27
Doe	456	770	1226	61.6	91.7	146.0	31	41
LCRA	762	1163	1925	40.1	57.3	94.8	48	68

Total large wood was nearly twice as abundant in the Chewuch-Doe AU (1226 pieces) compared to the Chewuch-Pearrygin AU (699 pieces), and the majority of this wood were within ELS (60.4%), including 393 pieces in Chewuch-Pearrygin AU and 770 pieces in Chewuch-Doe AU.

Total naturally recruited large wood pieces per mile was 37.5 pieces/mile across the 20.3-mile LCRA reach (Table 3.6.8). Natural wood was twice as dense in Chewuch-Doe AU (61.6 pieces/mile) compared to Chewuch-Pearrygin (30.1 pieces/mile). In 2008, natural wood levels within the LCRA area were approximately 50.4 pieces/mile, which was 10 pieces/mile more than was counted in 2023. Much of this difference can be attributed to AU scale shifts in wood

density. Since 2008, a decrease in wood load in the Chewuch-Pearrygin AU has occurred. In 2008, 42.6 pieces/mile were observed which was 13 pieces/mile more than in 2023. Conversely, natural wood load in 2008 in the Chewuch-Doe AU was 34.2 pieces/mile and 25 pieces/mile less than the 2023 count.

ELS-installed wood was nearly three times as dense in the Chewuch-Doe AU (91.7 pieces/mile) compared to Chewuch-Pearrygin (33 pieces/mile) – which is a reflection of restoration intensity within the two assessment units – and the installed wood greatly increased the density of total wood in both assessment units. The addition of ELS wood significantly increased overall wood density within Chewuch-Pearrygin AU, where it doubled the natural density. In the Chewuch-Doe AU, the addition of installed wood nearly tripled wood density to 146 pieces/mile.

Wood jams, both natural and ELS, were more abundant in the Chewuch-Doe AU, which contained 64.5% of naturally occurring jams (31 of 48) and 60.3% (41 of 68) of ELS when compared to Chewuch-Pearrygin AU. In total, 116 wood jams were observed within the LCRA area, with 41.4% natural jams and the remaining 58.6% comprised of ELS.

At the reach-scale, and similar to other habitat characteristics, large wood density varied across reaches. In Chewuch-Pearrygin AU, only one reach, Pearrygin 4, had >42.5 pieces/mile with 75.3 pieces/mile (Figure 3.6.8). This 1.5 mile reach also had 99 ELS pieces/mile to bring the total count to 142 pieces/mile.

Several of the other relatively unconfined reaches in Chewuch-Pearrygin AU, including Pearrygin 3, 4, 5 and 10 had >30 natural pieces/mile, but only Pearrygin 10 had additional wood load from restoration-based ELS contributions from the RM 10 project. Wood was relatively scarce in several reaches, including Pearrygin 1, 2, 6, 9, and Doe 3. These reaches are either relatively confined or high gradient. In 2008, the Pearrygin 3, 4, and 5 reaches had approximately 55 natural pieces/mile, so there has been a sharp decline in natural wood load in this relatively unconfined area over the past 15 years.

Wood density, both natural and ELS, was noticeably higher in the Chewuch-Doe AU, where 5 of 6 reaches had a combined density of >30 natural pieces and >40 ELS pieces/mile within the reach. Pearrygin 10 and Doe 1 and 2 reaches had >200 pieces/mile of combined wood, of which were primarily ELS derived pieces.

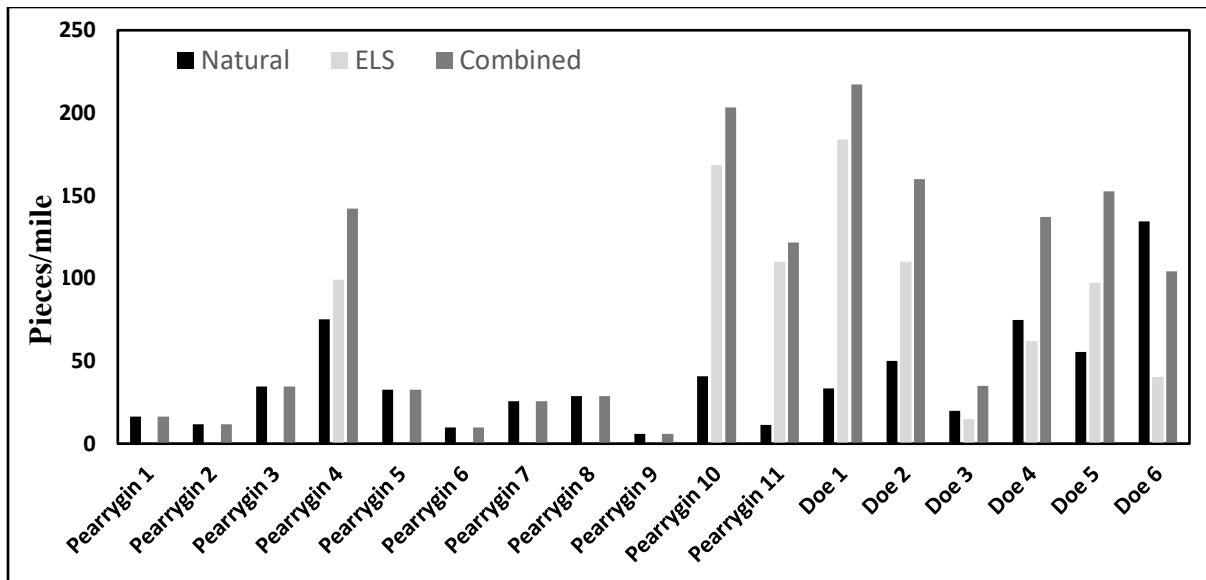


Figure 3.6.8. Natural and ELS wood per mile, LCRA reaches, 2023.

3.6.1.6 Riparian and Streambank Condition

Riparian habitat is an important component of stream habitat for a variety of reasons and is a source of shade, nutrient inputs, large wood, bank stability, and off-channel habitat during high water to the instream environment. Riparian clearing is an ongoing detriment to overall stream function and health in the LCRA area.

Riparian condition within the LCRA was assessed through analysis of floodplain and streambank cover (e.g., vegetation type, developed lands) classification layers developed through UCSRB in 2021. These layers were derived primarily from analysis of 2018 lidar data, but for floodplain cover it included additional surficial geology and floodplain delineation information that equates to approximately the 100-year floodplain surface (R. Niemeyer, UCSRB, personal communication). Some small “ground truth” corrections were made to the UCSRB data during review by MSRF for this assessment. The streambank vegetation condition was developed through analysis of a 30-meter buffer area along the National Hydrography Dataset (NHD) streamline and in most reaches this covered an area less than the bankfull elevation. It is noted that these GIS-based analyses were based on lidar data that was collected pre-2021 fires. Thus, they are unlikely to reflect current conditions in some reaches affected by those fires, especially the Pearrygin 8 and Doe 4-6 reaches.

Bank condition data from the 2023 survey was also used to document bank modifications immediately adjacent to the stream channel. In nearly all cases, these modifications consisted of various types of riprap.

In total, over 1500 acres of floodplain habitat were classified based on land cover, with 61% located within the Chewuch-Pearrygin AU (971 acres) and 39% (618 acres) in the Chewuch-Doe AU (Table 3.6.9). Cover distribution was similar in both AUs. Mature trees (>20') were the largest class in both assessment units, comprising 38% (369 acres) in Chewuch-Pearrygin AU and 41.5% in Chewuch-Doe AU. Very low (<1') and low (1'-5') classes combined accounted for approximately one-quarter of the coverage, and shrubs (5'-20') accounted for approximately 12% cover in both assessment units.

The remaining cover area was comprised of developed lands, which included areas cleared primarily for residential development, agriculture, and roads. This class covered approximately one-quarter (25%) of the total LCRA area and in both assessment units. Developed areas in the Chewuch-Doe AU were primarily roads and campground areas along the river corridor, while in the Chewuch-Pearrygin AU it was primarily residential development, agriculture, and roads.

Table 3.6.9. Floodplain cover classification and acreage, LCRA area.

Reach	Very Low	Low	Shrubs	Trees	Developed	Total
Pearrygin 1	3.9	0.7	1.7	4.5	4.6	15.5
Pearrygin 2	8.6	1.6	3.3	10.8	10.2	34.5
Pearrygin 3	47.8	19.5	24.2	73.9	67.3	232.8
Pearrygin 4	38.1	6.2	17.5	75.2	44.3	181.2
Pearrygin 5	19.5	6.7	21.7	76.8	26.2	151.0
Pearrygin 6	8.9	1.6	4.7	17.6	10.6	43.4
Pearrygin 7	27.6	4.1	9.6	30.6	31.7	103.5
Pearrygin 8	13.6	3.7	11.7	30.5	17.3	76.8
Pearrygin 9	2.8	0.9	4.1	8.6	3.7	20.2
Pearrygin 10	6.8	3.0	9.4	15.2	9.9	44.3
Pearrygin 11	15.5	2.2	6.7	25.8	17.7	67.9
Doe 1	19.5	6.7	13.6	48.8	26.2	114.6
Doe 2	15.3	3.7	10.7	47.8	19.1	96.6
Doe 3	10.2	0.6	1.1	6.5	10.7	29.1
Doe 4	7.0	2.8	6.5	21.5	9.8	47.6
Doe 5	22.4	11.5	30.5	76.4	33.9	174.8
Doe 6	31.4	10.9	14.7	56.0	42.3	155.3
Pearrygin AU	193.2	50.3	114.7	369.5	243.4	971.1
Doe AU	105.8	36.2	77.0	257.0	142.0	618.0
Total	299.0	86.4	191.7	626.5	385.4	1589.1

At the reach-scale, percent floodplain cover varied somewhat, and largely reflected trends seen at the AU scale; either trees or developed lands were the dominant class in every reach. Trees generally ranged from 30-40% cover and developed lands between 20-30% (Figure 3.6.9). Very low coverage (<1') was generally the next most abundance cover class and comprised between 12-35% of the floodplain area across reaches. Very low vegetation was the most abundant in the Doe 3 reach, but there is relatively little floodplain habitat (29 acres) in this high gradient reach. Low and shrub vegetation combined comprised between 15-30% of the total floodplain vegetation in most reaches.

Residential development in the floodplain in Pearrygin 3 was only 28% of the total area, but was the largest acreage (67 acres) of developed lands in any reach. Most of this development is concentrated at the downstream end of the reach. There were over 40 acres of developed lands in Doe 6 reach related to roads and the residential development near Brevicomis Creek. Developed lands accounted for <20% of the total cover in only four reaches, including Pearrygin 5 and 9 and Doe 2 and 5.

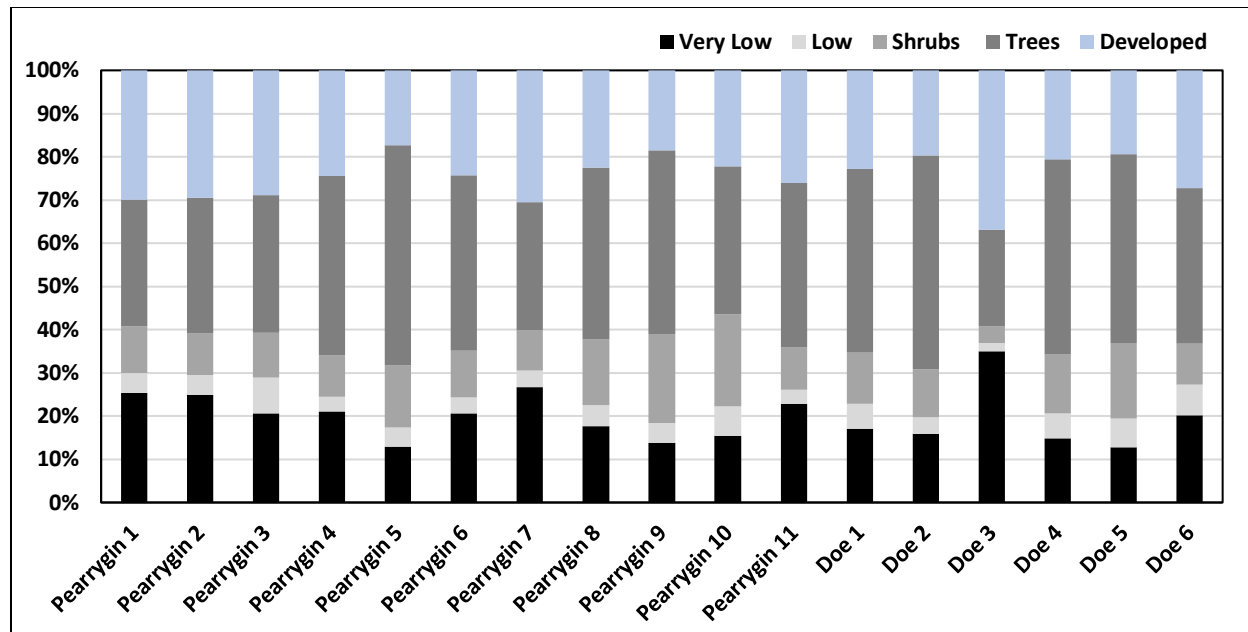


Figure 3.6.9. Reach-scale floodplain cover classification, LCRA area.

The streambank classification completed by USCRB yields information on riparian conditions immediately adjacent to the stream channel (within 30 m) and provides information that can be used to assist in the development of riparian and floodplain enhancement projects.

Owing to its longer overall length, and the linear nature of the stream buffer analysis, streambank habitat in the Chewuch-Pearrygin AU was greater (300 acres) compared to Chewuch-Doe AU (211 acres) (Table 3.6.10). Interestingly, streambank condition was similar across the AUs, with >85% of the riparian area vegetated to some extent. Trees were the dominant cover class in both AUs (Chewuch-Pearrygin=40%, Chewuch-Doe=43.9%), and trees and shrubs combined to occupy 54% of the area in Chewuch-Pearrygin AU and 58% of the area in Chewuch-Doe AU. Low vegetation was 7% in both AUs, and very low vegetation, which could include some residential and agricultural areas, was 19-25% of the area analyzed. Degraded areas (e.g., roads, structures) accounted for approximately 14% of the total streamside coverage in the LCRA area.

Table 3.6.10. Streambank class area and percent, LCRA area.

Assessment Unit	Total	Tree (>20')	Shrub (5'-20')	Low (1'-5')	Very Low (<1')	Degraded
Pearrygin - Acres	300	120	42	21	76	41
Doe - Acres	211	93	31	15	41	31
Pearrygin - %	100	40.0	14.1	6.9	25.3	13.7
Doe - %	100	43.9	14.9	7.0	19.4	14.9

Reach-based analysis of streambank cover exhibited variation across reaches (Figure 3.6.10). Degraded area adjacent to the streambank was highest in the Pearrygin 1 reach (55%), which runs through downtown Winthrop and in Pearrygin 7, which has a residential development area near its upstream end. Overall, tree coverage was the dominant vegetation in most reaches. Very low cover, which could be associated with residential (e.g., lawn grass) and agricultural areas

(e.g., pasture), was the second most dominant vegetation class and occupied between 20-30% of the total area in most reaches.

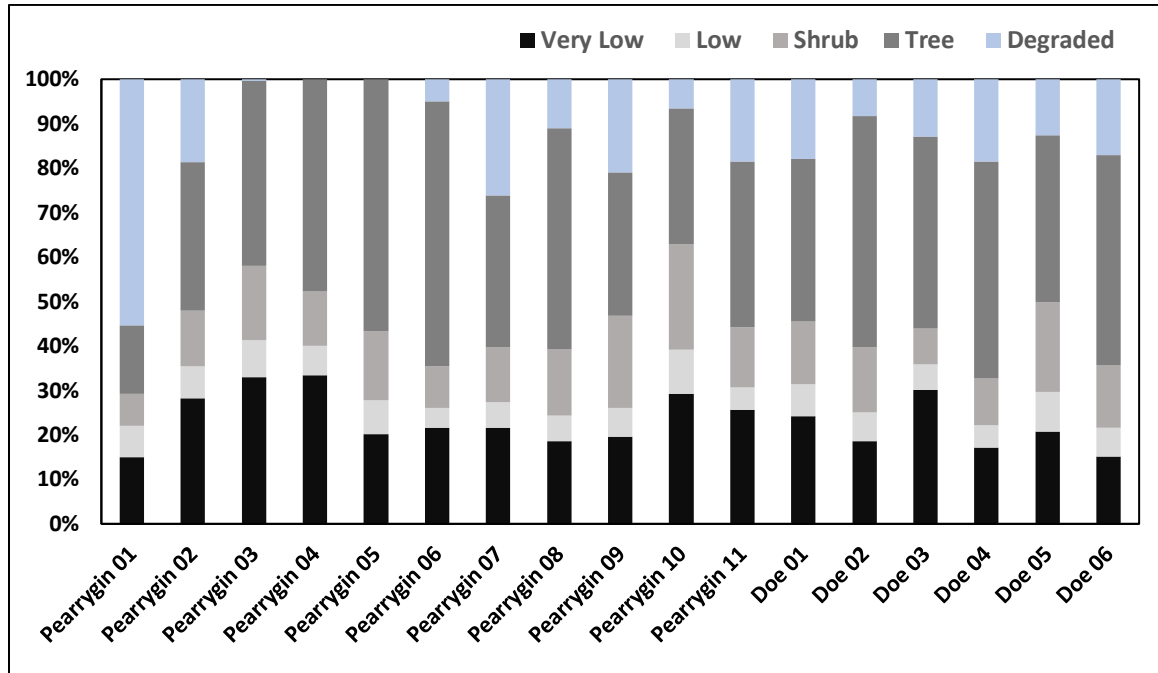


Figure 3.6.10. Streambank cover by reach, LCRA area.

Bank modification data collected during the 2023 stream survey indicate a higher degree of modification in the Chewuch-Pearrygin AU (2 miles from both banks combined, 8.4% of overall bank length) compared to the Chewuch-Doe AU (0.4 miles, 2.4% of total bank length). The majority of modification occurs along the mainstem channels in both AUs, but there is approximately 800' of modified bank in side channels of the Chewuch-Pearrygin AU.

The highest amount of modification was observed in Pearrygin 1, 6, and 7 and Doe 6 reaches, which had between 1100'-2500' feet of modified bank. Most of this was riprap was adjacent to residential development and roads. Bank modification was not observed in several reaches, including Pearrygin 5 and Doe 1, 2, 3, and 4. None of the modified banks appeared to be of recent construction, and there has likely been little change in this variable since the 2010 reach assessment.

Data from previous habitat surveys was not similar enough to LCRA data to allow for meaningful comparisons of trends in riparian extent and condition. A standardized riparian habitat monitoring framework should be developed to track changes over time in riparian habitat extent and condition.

3.7 Lower Chewuch River Water Quality

3.7.1 Stream Temperature

Throughout the LCRA area, the generalized stream temperature regime is typical of a North Cascades snowmelt-fed stream. Water temperatures approach freezing in the winter, warm up in the spring, reach summertime highs in late July-August, cool off in the Fall usually beginning in September.

Daily mean water temperatures in the Chewuch River at RM 0.1 (near the confluence with the Methow River) range from winter lows of 0-3 °C to summer highs between 17-20 °C each year. July and August are the warmest months (Figure 3.7.1). While annual temperature regimes have been relatively similar across years, some degree of inter-annual variation exists with measured temperatures, especially during the summer months.

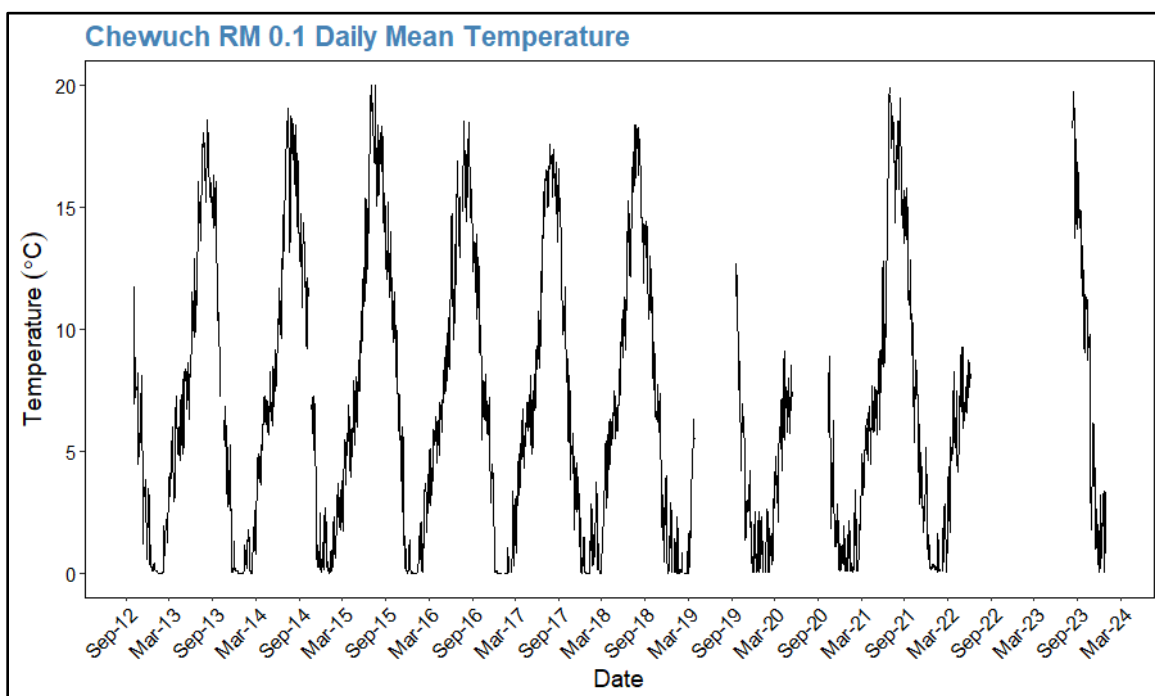


Figure 3.7.1. Mean daily water temperature, Chewuch River at RM 0.1, 2012-2023.

Water temperatures from four other established water temperature monitoring locations in the Chewuch River (RM 8.5, 10.6, 11.6 and 33.7) are similar to RM 0.1 in the timing of annual cooling and warming trends, but observed temperatures differ by varying degrees (Figure 3.7.2). While annual daily mean low temperatures are very similar across sites and range between 0-3 °C, the annual high temperatures in July and August reveal the most significant differences across locations. Annual maximum daily mean temperatures at all sites are 15 °C and exceed 19 °C at some sites, including at RM 0.1 and RM 11.6. In all years since 2012, summer temperatures measured at RM 0.1 have been the warmest of any site each year, although temperatures measured at RM 11.6 have been only slightly less (0.3 °C difference) annually.

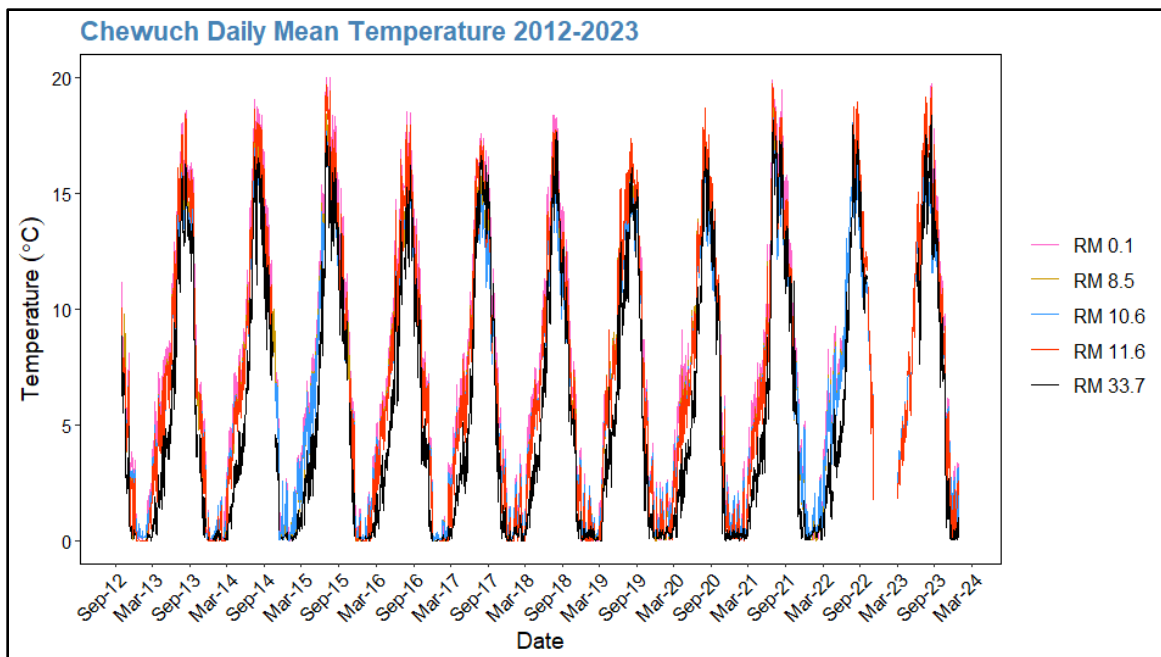


Figure 3.7.2. Mean daily water temperature, Chewuch River at several locations, 2012-2023.

By contrast, summer maximum temperatures over the past decade have consistently been lowest at RM 10.6, which is located approximately one mile downstream of the confluence with Eightmile Creek.

Long-term water temperature monitoring data from the Chewuch River, as well as thermal imagery data from 2009, reveals a somewhat atypical longitudinal temperature regime where warming does not increase uniformly from upstream to downstream. Rather, there are distinct areas where significant stream cooling and warming are observed.

The 2009 thermal infrared surface water temperature survey data (Watershed Sciences 2009), collected on August 26th and indicative of summertime high temperatures, provide a high resolution means to evaluate the longitudinal temperature characteristics of the LCRA area (Figure 3.7.3). These data represent a “snapshot in time” of summer water surface temperatures and do not capture temporal variation nor temperatures below the water surface. This survey revealed that water temperatures at the upstream end of the LCRA area (most of the Chewuch Doe AU) are relatively similar to those at the downstream end near the confluence with the Methow River.

Thermal data show that Eightmile Creek provides a significant input of cold water to the Chewuch River at RM 11.5 (upstream end of Pearrygin 11 reach), and this location has, over time, represented the most significant drop (~ 1 °C) in temperature in the LCRA area. The cooling effect of Eightmile Creek persists for approximately 2.5 miles downstream to the Boulder Creek confluence at RM 9.5 (Pearrygin 8 reach).

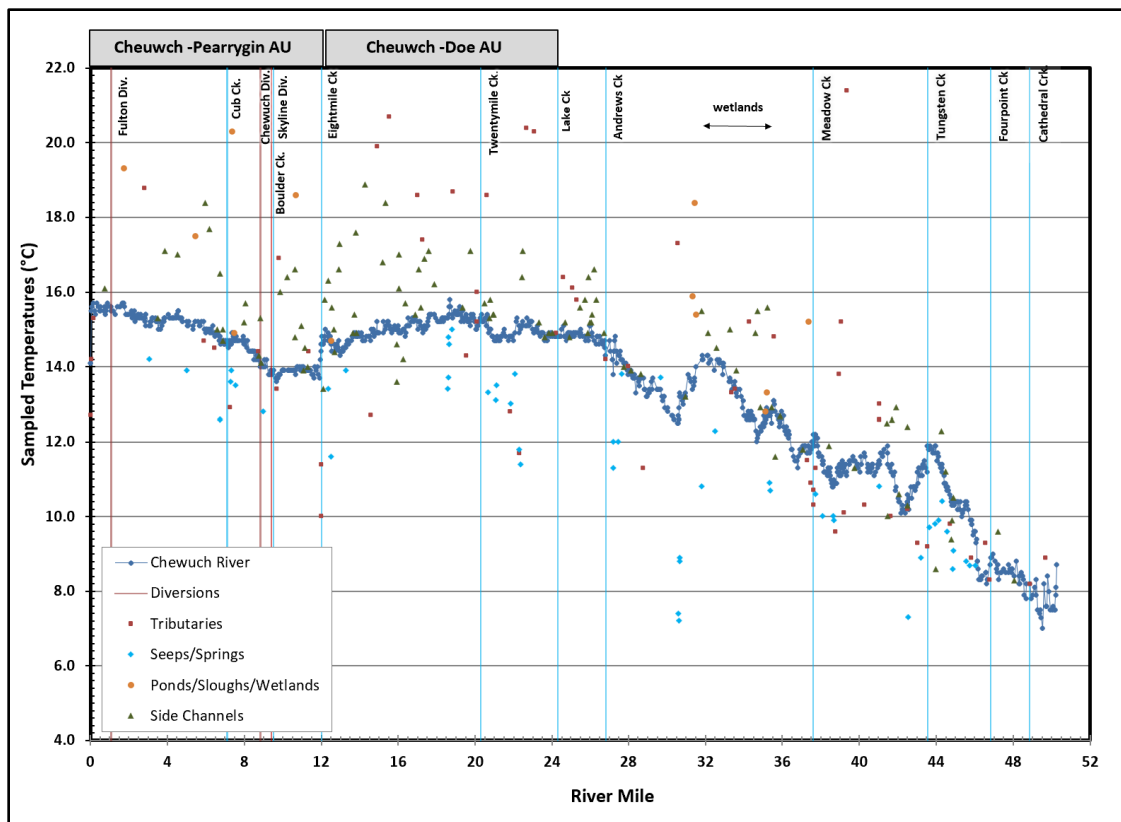


Figure 3.7.3. Surface water temperature longitudinal profile, Chewuch River, August 26, 2009. Data collected through aerial thermal infrared survey. Figure modified from Watershed Sciences, 2009.

Downstream of this location, the Chewuch River warmed for 2.5 miles to near the Cub Creek confluence (at the upstream end of Pearrygin 5 reach) where temperatures returned to levels observed nearly five mile upstream and above Eightmile Creek. From this point downstream, the river warmed, but less rapidly, down to the confluence with the Methow River.

Long-term fixed site-based monitoring data collected by MSRF generally support the thermal imagery profile collected in 2009 and reveal some changes over time. August mean temperatures have been warmest at the most downstream site at RM 0.1 and second warmest at the RM 11.6 site just upstream of Eightmile Creek (Figure 3.7.4). Prior to 2017, mean August temperatures at RM 33.7 (>10 miles upstream of the LCRA area) and RM 10.6 were the coldest of all five sites. After 2017, possibly in response to the 2017 Diamond Creek fire, August mean temperatures increased at RM 33.7, but declined at all other sites, including at RM 8.5, which was cooler relative to RM 33.7 for both 2017 and 2018. In 2018, all sites, except for RM 33.7, exhibited the coolest August temperatures of the 10 years monitoring, likely in response to the relatively high flows observed that year. The measured water temperature at all sites increased after 2018 by approximately 1-1.5 °C, and measurements in 2022-2023 were some of the highest measured at those sites.

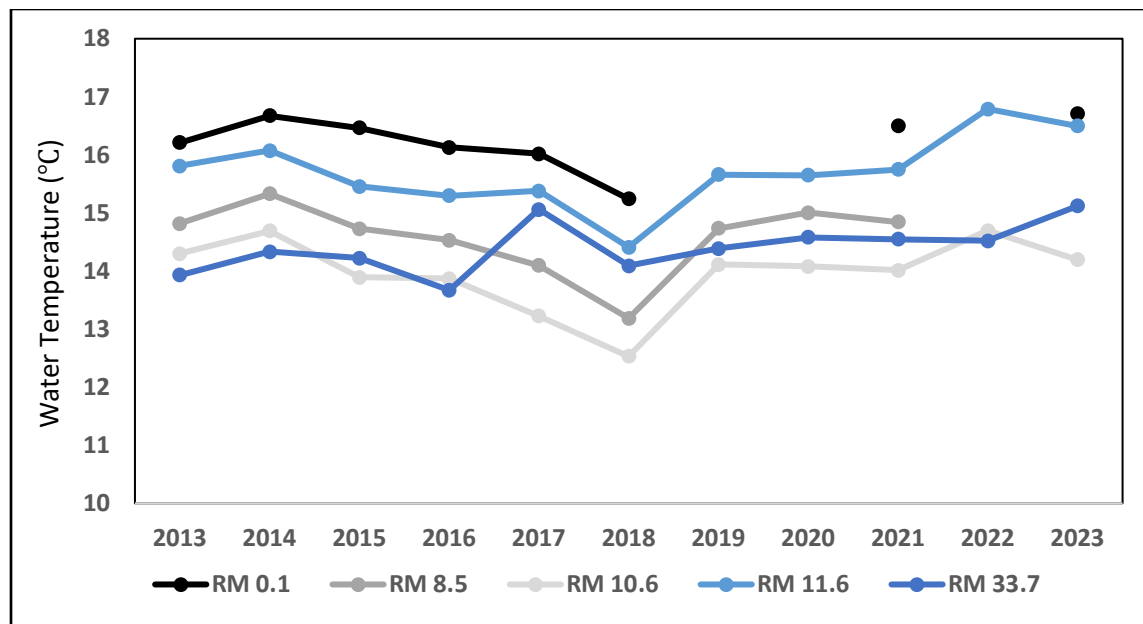


Figure 3.7.4. Mean August water temperature at five locations, Chewuch River, 2013-2023.

3.7.2 Cold Water Patches

An assessment of cold water patches (CWP) identified through the 2009 thermal imagery survey was completed by MSRF in 2022 (Crandall 2022). CWP were defined as water sources that were $\geq 2^\circ\text{C}$ cooler than ambient waters during the 2009 survey. The 2022 survey collected information from nine discrete CWP locations in the LCRA area, including four in Chewuch-Pearrygin AU and five in Chewuch – Doe AU. Relative to CWP distribution in the Methow and Twisp Rivers, CWP in the LCRA were less abundant.

CWP were distributed across four types of patches, based on source, including alcoves, lateral seeps, springbrooks, and tributaries (Table 3.7.1). Alcoves comprised $>40\%$ of the CWP locations ($n=4$) and these types of CWP were more common in Chewuch-Doe relative to Chewuch-Pearrygin AU. One lateral seep was located in each AU, and one springbrook was present in the Doe 1 reach. Two tributary confluences, at Cub Creek and Eightmile Creek, were observed as CWP, both located in the Chewuch-Pearrygin AU. Falls Creek was identified as a CWP tributary in the 2009 imagery, but was only 0.5°C cooler than the mainstem during the site visit in 2022 and did not qualify as a CWP in 2022. The Falls Creek watershed was severely burned in the 2021 Cub Creek Fire and stream temperatures likely increased in this stream post-fire.

Table 3.7.1. Cold water patch composition, Chewuch River, 2022. Data from Crandall 2022.

Reach	Alcove	Lateral Seep	Springbrook	Tributary
Pearrygin 5	1	1	0	1
Pearrygin 11	0	0	0	1
Doe 1	2	0	1	0
Doe 3	0	0	0	0
Doe 6	1	1	0	0

Overall, both minimum and average CWP temperatures were cooler in Chewuch – Pearrygin AU relative to Chewuch – Doe AU by approximately 2 °C, while the average differential from mainstem Chewuch River was 1 °C higher (more thermal difference) in Chewuch – Doe AU (Table 3.7.2). CWP plume depths in Chewuch – Pearrygin AU were twice that of Chewuch – Doe AU, and the plume area was several orders of magnitude higher in Chewuch-Pearrygin AU. Most of this difference can be attributed to the large plume associated with cold water input from Eightmile Creek, which creates one of the largest cold water plumes observed in the Methow watershed (Figure 3.7.5).

Table 3.7.2. Cold water patch average temperature, depth, and area characteristics, Chewuch River, 2022. Data from Crandall 2022.

Assessment Unit	Min Temp (°C)	Avg Temp (°C)	Max Diff (°C)	Avg Diff (°C)	Avg Plume Depth (cm)	Area Plume 2C (m ²)	Area Plume 1C (m ²)
Chewuch - Pearrygin	8.6	11.3	7.7	3.9	16.0	407.5	841.7
Chewuch - Doe	10.7	13.1	7.4	4.9	7.6	0.03	4.6

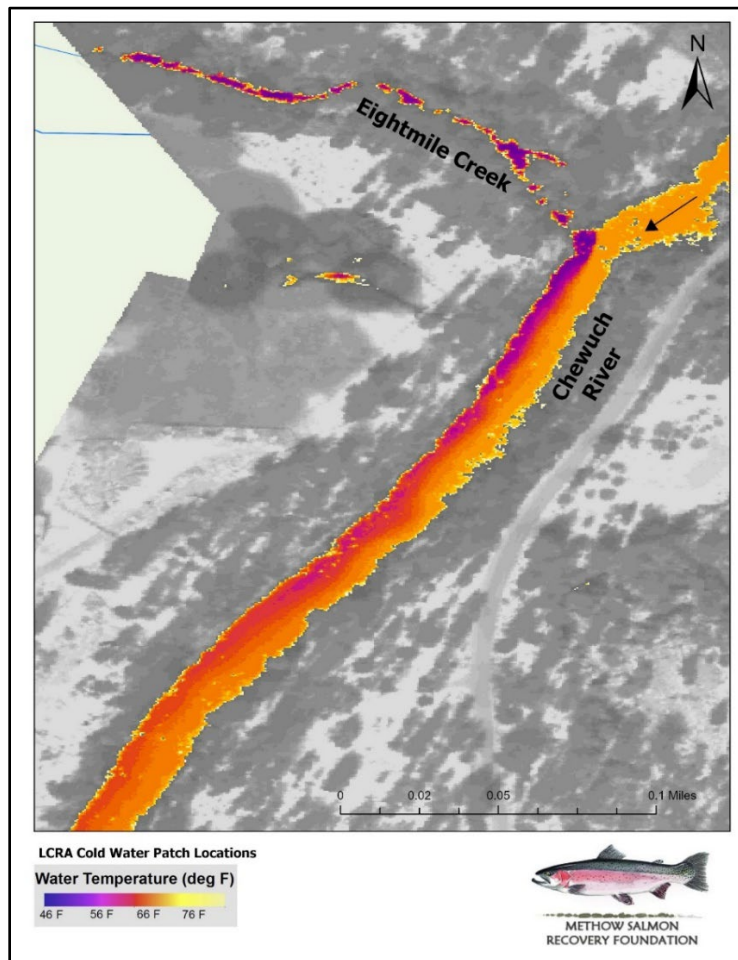


Figure 3.7.5. Cold water plume in the Chewuch River downstream of Eightmile Creek as seen in thermal imagery captured August 26, 2009.

3.7.3 Water Temperature Impairment

Stream temperature – a critical component of fish habitat and a “master variable” closely linked to ecosystem resilience (Boltz et al. 2019) – is currently and routinely measured in the LCRA area at levels that exceed Washington State Department of Ecology (WA Ecology) temperature criteria. The lower Chewuch River has a year-round 7-day average daily maximum temperature (7-DADM) threshold of 16 °C under Washington State standards for core summer salmonid habitat. The reach also has a supplemental temperature threshold of 13 °C that applies throughout the reach from August 15 – July 1 (i.e., spanning the year change), which is for salmonid spawning and incubation habitat.

As of 2022, the majority of the 20-mile LCRA reach has been categorized by WA Ecology as an impaired water body for temperature with several locations (based on data from long-term temperature loggers) placed on the Clean Water Act Section 303(d) list (for full listings see <https://apps.ecology.wa.gov/ApprovedWQA/CandidatePages/CandidateSearch.aspx>). Water temperature impairment in the LCRA area has been on-going since at least 2010, when the first 303(d) listings were assigned to the reach. Since that time, more widespread impairment has been identified as a result of more intensive water temperature monitoring conducted by MSRF.

Data from the long-term monitoring sites reveal widespread impairment and frequent excursions beyond both the 16 °C and 13 °C thresholds (Figure 3.7.6). Both the 16 °C and 13 °C thresholds have been surpassed at all sites in all years from 2012-2023. 7-DADM temperatures exceeding 19 °C have been observed at several sites and most commonly at the RM 0.1 and RM 11.6 sites, which have been the warmest sites throughout the last decade.

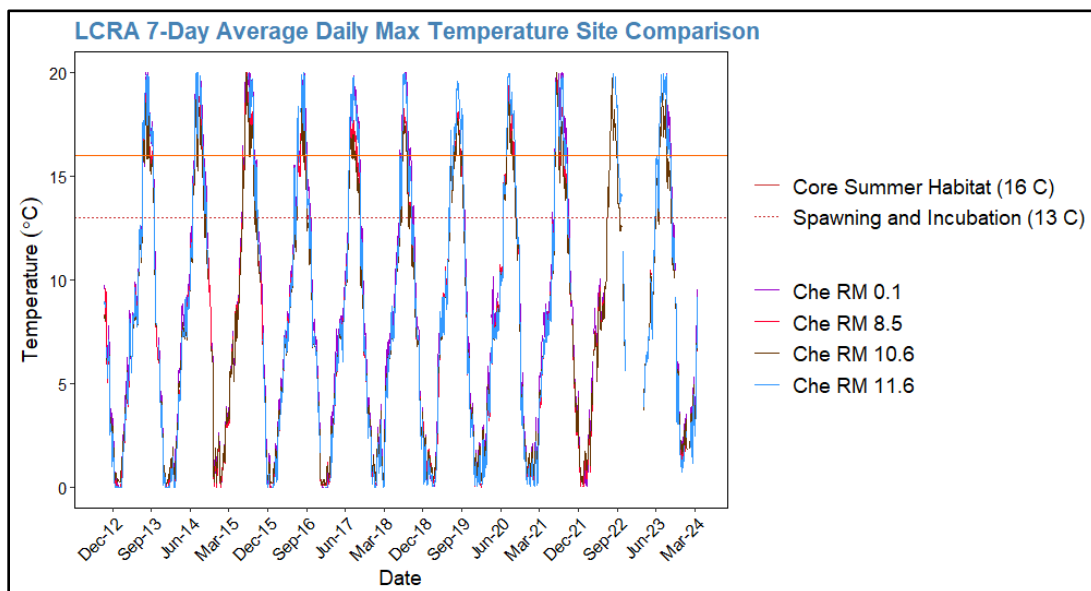


Figure 3.7.6. 7-day average daily maximum stream temperatures, LCRA area, 2012-2023.

The number of days per year of exceedance of water quality standards provides another means to assess the degree of current water temperature impairment in the LCRA area. Between 2013-2023, all four sites in the LCRA area, and also the RM 33.7 site further upstream, have exceeded the 16 °C criteria for between 11-85 days/year and the 13 °C for between 48-118 days/year

(Table 3.7.3). The number of days of exceedance is generally highest at RM 0.1 and RM 11.6 and lowest at RM 10.6.

Combined, the lowest number of 16 °C exceedance days was observed in 2016 (182 days) and the highest was in 2021 (309 days), although data are not available for all sites and years, and direct inter-annual comparisons are not possible. Another year with high exceedance (and relatively low summertime flows) was 2015 which was similar to 2021 in number of days of combined exceedance (305 days). For the two sites with complete data for all years (RM 10.6 and RM 33.7) there is a slight increasing trend in the number of annual exceedance days

Table 3.7.3. Number of days per year of 16 °C and 13 °C exceedance at temperature monitoring sites, Chewuch River, 2012-2023. Missing data are not reported for some sites in 2019, 2020, 2022, and 2023.

Site	2013		2014		2015		2016		2017		2018	
	>16°	>13°	>16°	>13°	>16°	>13°	>16°	>13°	>16°	>13°	>16°	>13°
Che RM 0.1	71	86	63	101	74	111	51	96	74	87	57	101
Che RM 8.5	57	84	53	89	63	98	39	88	53	83	31	56
Che RM 10.6	37	84	45	86	57	96	31	60	32	82	32	73
Che RM 11.6	78	85	61	96	59	89	50	89	71	86	42	88
Che RM 33.7	24	79	37	66	52	81	11	48	61	81	34	66
Site	2019		2020		2021		2022		2023			
	>16°	>13°	>16°	>13°	>16°	>13°	>16°	>13°	>16°	>13°		
Che RM 0.1	n/a	n/a	n/a	n/a	85	108	n/a	n/a	n/a	n/a		
Che RM 8.5	47	102	51	93	52	91	n/a	n/a	n/a	n/a		
Che RM 10.6	45	99	40	89	46	90	50	87	53	108		
Che RM 11.6	74	105	59	87	78	97	n/a	n/a	78	118		
Che RM 33.7	34	70	43	69	48	92	46	74	43	90		

3.7.4 Other Water Quality Data

Water quality data, aside from stream temperature, is somewhat limited for the LCRA area. However, existing data do not suggest any significant impairment. WA Ecology operates a water quality monitoring station at RM 0.1 that has been operational over several years, including 2008 and 2019. Several water quality parameters are sampled at this site with results compiled into a “water quality index” (WQI). The WQI scores for the lower Chewuch River were 83 and 80.9 for 2008 and 2019, respectively, which rank as “good” water quality (Table 3.7.4).

Table 3.7.4. Water Quality Index scores for WA Ecology Station 48B070, 2008 and 2019. Blue and yellow shading indicates “good” and “moderate concern” WQI classifications, respectively.

WQ Parameter	2008	2019
Fecal coliform	89.8	71.3
Oxygen	80.5	82.1
pH	84.8	92.5
Suspended solids	66.8	92.8
Temperature	81.3	71.7
Total Nitrogen	92.6	98.2
Total Phosphorous	87.3	n/a
Turbidity	77.5	97.6
Overall WQI	83	80.9

The individual water quality parameters that comprise the WQI were mostly all in the “good” (score >80-100) range during both years of monitoring. The exceptions were suspended solids and turbidity in 2008 and fecal coliform and temperature in 2019, which fell into the class of “moderate concern” (score >40-80). Some of these lower scoring results are, in part, due to the timing of monthly samples, which may occur during periods of high discharge. Sediment transport associated with the spring freshet, especially during April-June, likely resulted in elevated values for some parameters, such as turbidity and suspended solids.

Annual maximum, minimum, and average values for selected water quality parameters are presented in Table 3.7.5. Values for each parameter generally fall within acceptable ranges for the various parameters, especially considering that samples were collected monthly during each year, thus incorporating the annual/seasonal variation inherent in some of the parameters.

Table 3.7.5. Annual average, minimum, and maximum values for selected water quality parameters, WA Ecology Station 48B070, 2008 and 2019.

WQ Parameter	2008 Avg	2008 Min	2008 Max	2019 Avg	2019 Min	2019 Max
Alkalinity (mg/L)	44.9	16	58	n/a	n/a	n/a
Ammonia (mg/L)	0.01	0.01	0.01	0.01	0.01	0.01
Conductivity (µmhos/cm)	101.3	40	126	121.7	58	156
Dissolved Oxygen (mg/L)	11.4	9.54	13.53	11.7	9.7	13.9
Nitrate (mg/L)	0.1	0.04	0.4	0.08	0.02	0.15
Phosphate (mg/L)	0.005	0.003	0.009	0.004	0.003	0.006
pH (units)	8.07	7.87	8.28	7.8	7.4	8.01
Turbidity (NTU)	4.11	0.5	26	0.81	0.5	1.7

Additional water quality data for the LCRA area were collected by MSRF from 2014-2016 during low flow conditions, generally from July – November. Data from this monitoring was of

variable quality due in large part to challenges associated with continuous instrument deployment and instrument sensor malfunction during deployments. Similar to the results of the WA Ecology sampling, data collected from this three-year program, including pH, turbidity, specific conductance, and dissolved oxygen generally indicated no significant impairment in any of the sampled parameters.

3.8 Wildfire

Wildfire is an important driver of riverine and watershed processes in forested ecosystems in the Pacific Northwest and can strongly influence forest condition and watershed-level hydrology. Forested and shrub-steppe ecosystems in eastern Washington evolved with natural fire regimes that influenced the development of dynamic habitat conditions to which native salmonids and other aquatic species are adapted (Flitcroft et al. 2016). Within these natural regimes, wildfires can help maintain watershed conditions by affecting reach and basin scale water, sediment, and wood delivery processes that shape aquatic habitat (Ball et al. 2021). High intensity wildfire can be especially adept at increasing fine sediment and large wood inputs and also stream temperature (Flitcroft et al. 2016).

Fire is an important natural process, and the long-term effects of fire on aquatic ecosystems are generally considered to be positive, but large fires may also have short-term negative effects (Johnson and Molesworth 2014). Most of these short-term effects are dependent on burn severity and proximity to streams and on weather conditions in the few years after the fire. Large fires can increase both the volume and variability of streamflow; increase sediment delivery and transport; alter nutrient availability; change organic matter delivery, transport and storage; and affect water temperature (Dunham et al. 2003).

Both climate change and past management practices (e.g., fire suppression, timber harvest) have significantly altered fire regimes, and wildfires are increasing in frequency, extent, and intensity at local, regional, and global scales (Ball et al. 2021). The Chewuch River Watershed is no exception to this trend, with a series of large, high intensity wildfires affecting much of the watershed over the last few decades and since the 2010 reach assessment. In particular, much of the LCRA area was within the perimeter of the Cub Creek 2 fire that burned over 70,000 acres in 2021.

3.8.1 LCRA Area Fire History

Historical information suggests that before European settlement fire was common throughout the Chewuch River watershed. Historic wildfires in the lower elevation zones of the watershed were frequent, but of low severity, with fire return intervals of about 10-25 years (USFS 1994). Higher elevation areas had less frequent, but likely higher intensity, stand-replacing fires. With the exception of some larger fires in the 1920s, throughout much of the 20th century fires burned an average of 2% (7,400 acres/decade) of the watershed per decade (Figure 3.8.1, USFS 1994).

Recent years have seen a marked change in fire prevalence in the watershed. Since 2000, large fires have burned significant portions of the watershed every few years. While the total burned acreage only exceeded 10,000 acres in one decade (the 1920s) prior to the 1990s, it has exceeded this threshold every few years this century, and over 98,000 acres have burned per decade since 2000 (Figure 3.8.2). As a result, almost the entire watershed has burned within the last 20 years.

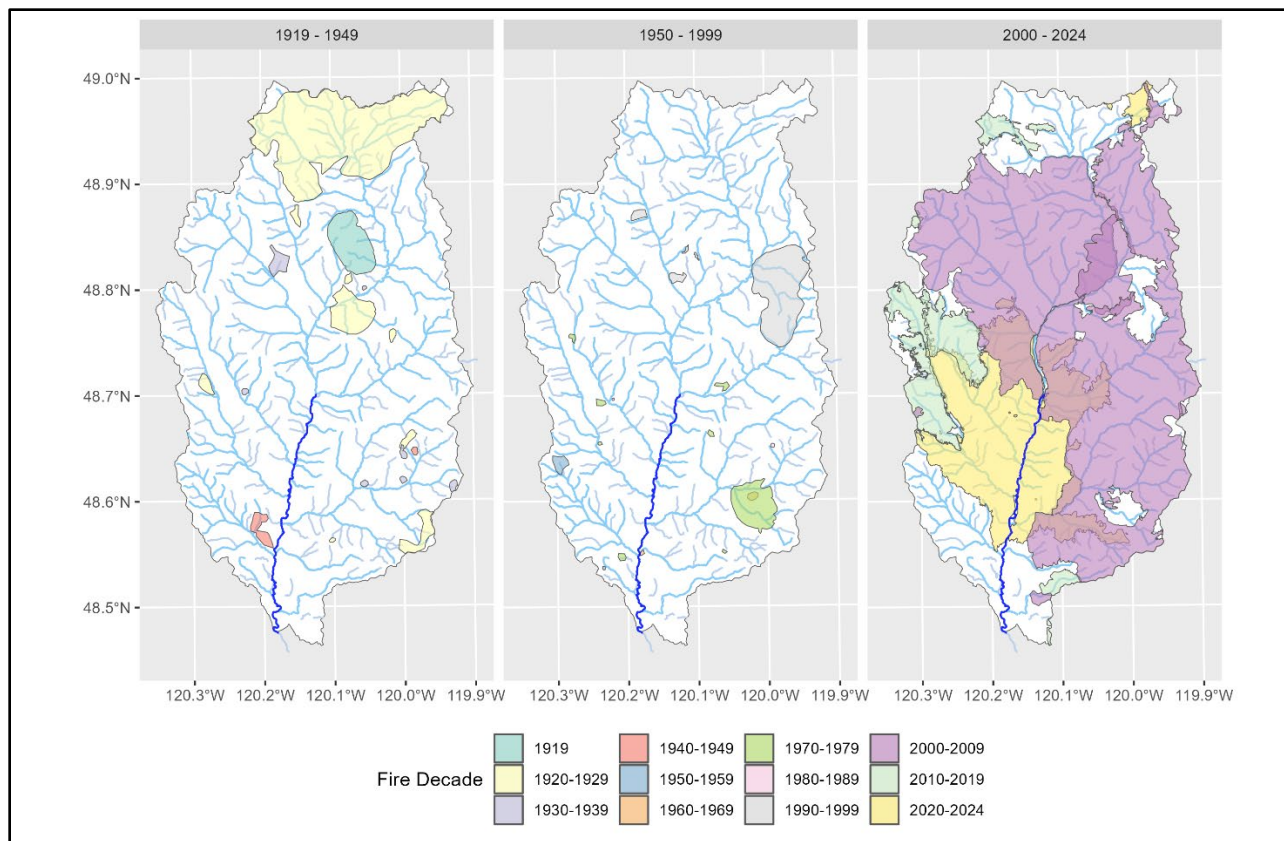


Figure 3.8.1. Fire perimeters within the Chewuch watershed by decade. Data from Chewuch Watershed Analysis (USFS 1994).

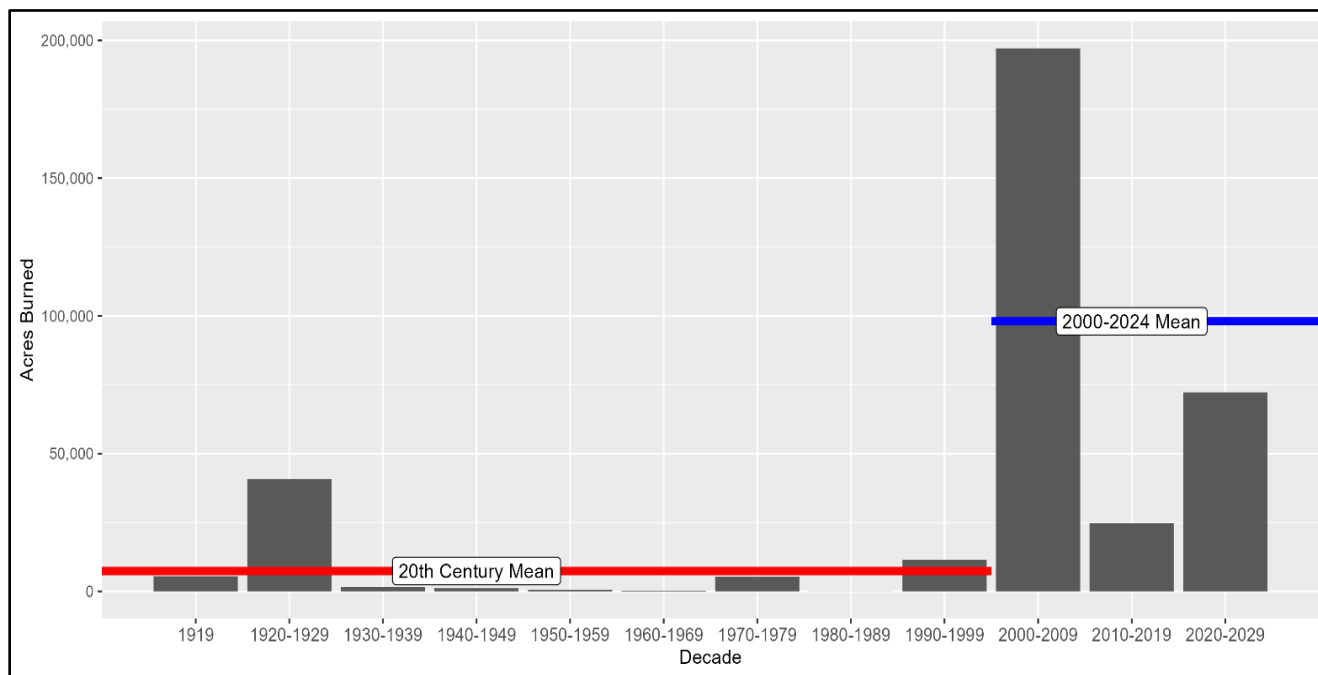


Figure 3.8.2. Total number of acres burned in the Chewuch Watershed by decade 1919-2024. Data from Chewuch Watershed Analysis (USFS 1994).

Since 2000, a larger proportion of the Chewuch River watershed has burned compared to the rest of the larger Methow River watershed (78% vs 59% of total area). In each of the last 10-year periods (2004-2013 and 2014-2023) over 40% of the Chewuch watershed was burned in large fires.

In addition to a higher total portion of the watershed experiencing wildfire, the Chewuch River watershed has also experienced more recent high-severity fires. Burn severity data indicate that a significant portion (55%) of the Chewuch Watershed burned at moderate to high severity since 2000, which was more than any other subbasin in the Methow watershed (MTBS 2024).

Changes in soil structure due to moderate or high intensity wildfire can reduce the ability of the soil to absorb water for several years (McNabb and Swanson 1990). Consequently, these areas can generate more runoff from a given amount of precipitation. When combined with reduced ground-level vegetation, organic litter, and root density, this makes severely burned areas more prone to flash floods and debris flows. These events are most likely during summer months in response to heavy precipitation from thunderstorms, but can also be triggered by rapid snowmelt in spring. Debris flow risk generally decreases 3-5 years post-fire as the soils and ground vegetation recover, but risk may remain elevated for longer in severely burned areas and until forest stands are re-established (McNabb and Swanson 1990).

The 2021 Cub Creek 2 fire burned a significant portion of the LCRA area and some adjacent assessment units at moderate and high severity (Figure 3.8.3). The fire burned particularly hot around Falls Creek (>60% of the area burned at moderate to high intensity), including in many of the small drainages that flow directly into the Chewuch River in the Chewuch-Doe AU.

Shortly after the fire in the fall of 2021, there were several debris flows from these burned areas into the Chewuch River (Figure 3.8.4). These landslides contributed significant amounts of sediment to the mainstem, and instream sand accumulations in subsequent years were observed in high volumes in downstream pool and glide habitat (J. Crandall, personal observation).

3.8.2 Floodplain and Riparian Burns

Fire effects to aquatic ecosystems are determined not only by burn extent and severity, but also by the proximity to the stream channel and extent of riparian areas burned. Burns within floodplain and riparian corridors can directly affect stream condition by decreasing stream shading and increasing large wood delivery.

Prior to the Cub Creek 2 fire, the floodplains and riparian areas of the LCRA area generally escaped significant direct effects from recent wildfires while the upper portions of the watershed were more directly affected (Table 3.8.1). The 2003 Farewell Fire burned >12 miles along the Chewuch River and >3,700 riparian acres in the vicinity of Lake Creek (Lake Creek AU), primarily upstream of the LCRA area. The 2006 Tripod Fire burned over 4,800 riparian acres, mostly to the east of the Chewuch River in the Boulder, Ramsey, and Pearygin Creek watersheds upslope of the LCRA area.

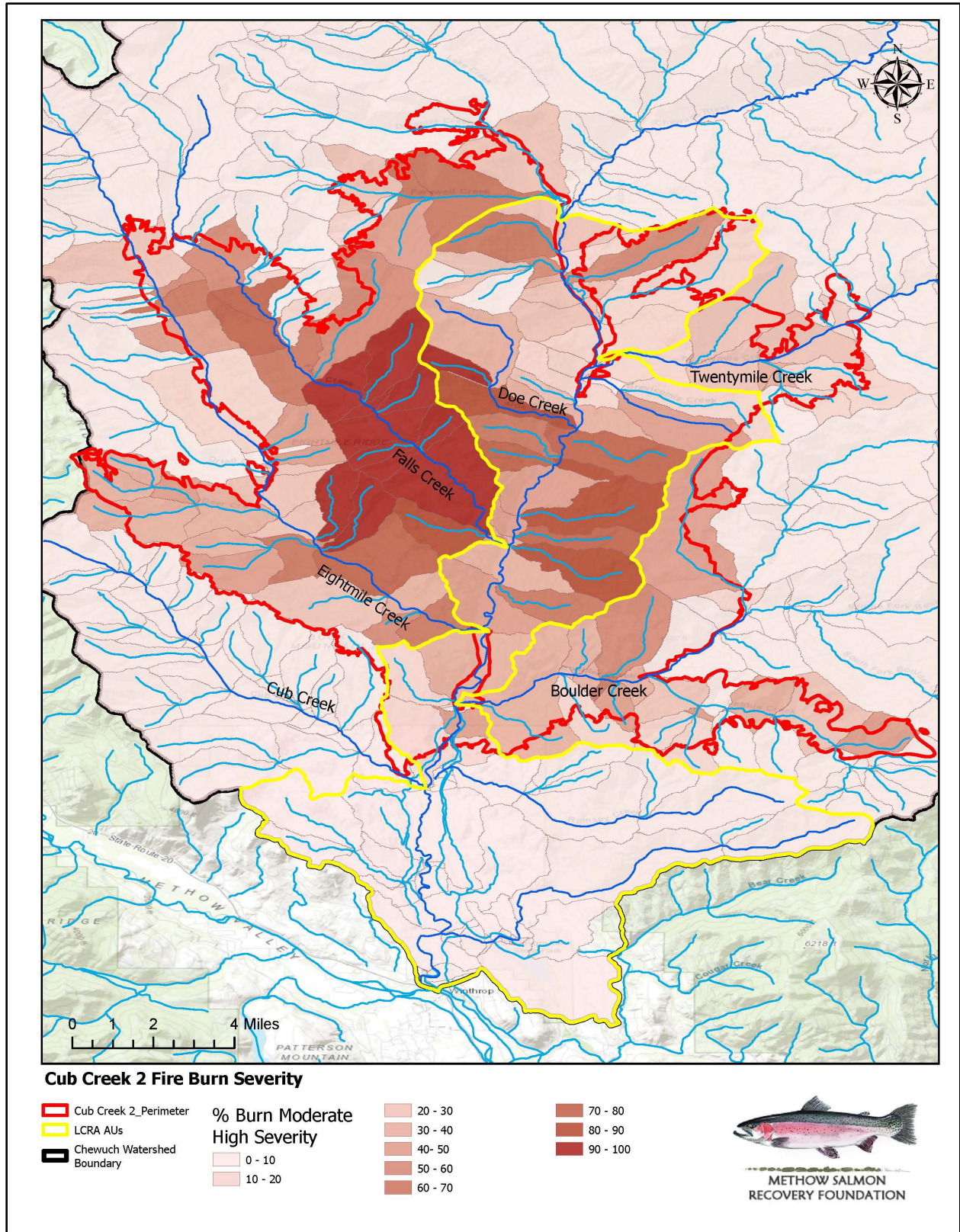


Figure 3.8.3. Moderate and high severity burn area percentage within the 2021 Cub Creek 2 fire perimeter. Burn severity data from MTBS (2024).



Figure 3.8.4. Post-Cub Creek 2 Fire debris flow and road washout, Butte Creek. Photo credit: Methow Ranger District.

The Cub Creek 2 Fire burned nearly 10 miles along the Chewuch River and significantly more (145 miles) when tributaries are included. It also burned 2,300 acres on the valley floor, 431 acres of mainstem 100-year floodplain, and >3,500 riparian acres (defined through a 100’ buffer around all streams), especially within the Chewuch-Doe AU and several downstream reaches, primarily Pearrygin 7 and 8, in the Chewuch-Pearrygin AU. The burn severity in the floodplain and riparian habitat areas was much lower compared to the larger fire; approximately 50% of the total Cub Creek 2 fire perimeter burned at moderate or higher intensity, while only 15% of the Chewuch River floodplain burned at these higher intensities (MTBS 2024).

Table 3.8.1. Wildfire, year, area, and habitat burned, Chewuch River watershed, 1994-2023.

Fire Name	Year	Acres	Chewuch River Miles Burned	Chewuch Floodplain Acres Burned	Total Stream Miles Burned	Total Riparian Acres Burned
Thunder	1994	16,259	0.3	0	15.5	383
Thirtymile	2001	10,345	8.0	0	20.2	500
Farewell	2003	81,233	12.4	1	150.8	3,747
Isabel	2003	4,267	0	0	0	0
Sweetgrass	2003	181	0	0	0	0
Bottle Two	2004	33	0	0	0	0
Pearrygin Lake	2005	531	0	0	1.5	36
Tripod	2006	174,603	3.7	8	196.2	4,859
Carlton Complex	2014	255,900	0	0	3.1	76
Upper Falls	2014	8,114	0	0	13.9	346
Diamond Creek	2017	127,786	0.8	0	14.7	370
Boulder Creek	2018	7	0	0	0	0
Doe	2018	16	0	0	0	0
Doe Falls	2018	6	0	0	0	0
McLeod	2018	22,875	0	0	14.3	353
Cub Creek 2	2021	70,248	9.8	431	145.2	3,595
Crater Creek	2023	5,134	0	0	2.9	72

At the reach scale, burned area and moderate-high severity burn during the Cub Creek 2 fire was high throughout the Chewuch-Doe AU and in reaches 7-11 in Chewuch-Pearrygin AU (Table 3.8.2). The total burn (low-high severity) area in the 100-year floodplain in several reaches was nearly complete, including in Pearrygin 8-11 and Doe 1-6 reaches. However, the moderate-high severity burn in these reaches was much lower than total burned area. The highest percentage of high severity burn was 49% in the Pearrygin 8 reach. Other reaches with >20% high intensity burn included Doe 4 and 6. The remaining reaches all burned at $\leq 10\%$ moderate-high severity. The fire did not burn in the downstream reaches of Chewuch-Pearrygin AU.

Table 3.8.2. Cub Creek 2 fire burn area and intensity in 100-year floodplain areas of LCRA reaches.

Reach	Total Reach 100-Year Floodplain Area (acres)	Burned Area (acres)	Moderate- High Severity Burned Area (acres)	Proportion of Reach Burned (%)	Proportion of Moderate- High Severity (%)
Pearrygin 1	22.3	0	0	0	0
Pearrygin 2	27.7	0	0	0	0
Pearrygin 3	163.2	0	0	0	0
Pearrygin 4	161.6	0	0	0	0
Pearrygin 5	90.3	0	0	0	0
Pearrygin 6	24.4	0	0	0	0
Pearrygin 7	43.2	13.8	4.2	32	10
Pearrygin 8	42.7	41.4	21.1	97	49
Pearrygin 9	24.8	24.9	0.4	100	2
Pearrygin 10	43.5	43.5	0.2	100	0
Pearrygin 11	40.6	40.3	0.7	99	2
Doe 1	82.0	80.7	2.7	98	3
Doe 2	79.0	79.0	0.4	100	1
Doe 3	6.9	6.9	0.2	100	3
Doe 4	123.1	122.3	29.8	99	24
Doe 5	49.9	48.3	3.8	97	8
Doe 6	66.9	66.7	19.8	100	30

Change in canopy closure as a result of the Cub Creek 2 Fire was significant, with 48% of the total burned area losing >75% of canopy cover (Table 3.8.3). However, burn extent in the canopy of the LCRA area 100-year floodplain was significantly lower, comprising only a very small (2%) portion of the canopy cover (USFS 2021). The majority of canopy in the floodplain escaped burning with >70% of the area exhibiting no canopy cover loss. An additional 19% of the floodplain area had only >0-25% loss of canopy cover.

Table 3.8.3. Portion of the Cub Creek 2 fire by percent loss of canopy cover in fire perimeter and 100-year floodplain in the LCRA area. Data from RAVG analysis (USFS 2021).

Description	Total Fire Area (%)	100-Year Floodplain Area (%)
No loss of canopy cover	17	72
0-25% loss of canopy cover	20	19
>25-50% loss of canopy cover	8	5
>50-75% loss of canopy cover	7	2
>75% loss of canopy cover	48	2

Overall, with relatively slight moderate to high intensity burn area in floodplains, the effects of the Cub Creek 2 fire on the Chewuch River within the LCRA area are likely dominated by upland watershed level effects as opposed to more direct effects due to loss of shade and direct wood delivery from falling trees.

3.8.3 Fire Effects on Restoration Areas

The effects of the Cub Creek 2 fire on instream and riparian habitat restoration projects was recently examined by Hanrahan et al. (2023). This assessment found that the fire had direct effects (e.g., burned installed logs) on eight of the fifteen large wood restoration projects that were within the Cub Creek 2 fire perimeter. Generally, the post-fire assessment results indicated that large wood structures that are lower in profile, have more submerged wood (at low flows), and include larger diameter material fared better than taller, pile supported structures with higher volumes of slash. The assessment also found that many of the sites, regardless of whether the wood structures retained structural integrity after burning, were affected by mudflows and sedimentation that occurred as a result of the fire. This was especially true for structures that were located just downstream of tributaries and within alluvial fans.

An analysis of wildfire in the Wenatchee subbasin found that larger wildfires in that watershed tended to increase habitat for adult and juvenile overwintering life stages while decreasing egg and fry type habitats (Flitcroft et al. 2016). Since spring Chinook populations in the Wenatchee subbasin were most limited by juvenile overwinter rearing habitat, wildfire was estimated to have a positive effect on the population.

3.9 Effects of Climate Change

The ecosystems of the Pacific Northwest are experiencing the impacts of climate change, including long-term warming, reduced snowpack and glacial extent, and increased periods of frost-free temperatures (Snover et al. 2013). Similar changes have been observed globally and there is strong support from the scientific community that the underlying driver is human caused climate change (World Meteorological Organization 2020). It is likely that the climactic shifts will only exacerbate if predicted global warming trends continue into the future.

The effects of climate change have significant potential to limit the effectiveness of salmon recovery efforts (Beechie et al. 2013). It is imperative that long-term habitat restoration and protection planning, including for projects in the LCRA area, consider the potential influences of climate change on aquatic resources, including volume and timing of streamflow, location and availability of cold water refugia, and species-specific responses to shifting stream conditions.

One of the more relevant effects predicted climate change will have on streams in the Methow River watershed, including in the LCRA area, will be changes in the timing and volume of runoff. The currently snowmelt dominated Chewuch River watershed is likely to experience a shift into a mixed snow and/or rain driven hydrograph, with an earlier peak by the 2080s (NOAA 2014). Some climate scenario models predict a substantial shift in the ratio of winter to summer runoff volume, with a 2-4-fold increase in winter flows (Climate Impacts Group 2022; Figure 3.9.1). This shift in precipitation runoff may lead to increased flooding, landslides, and fine sediment transport (NOAA 2014). These changes, coupled with decreased summer precipitation and warmer summer temperatures, will increase the extent of the summer low flow period, which may be especially detrimental to fish populations, including salmon, steelhead, and bull trout.

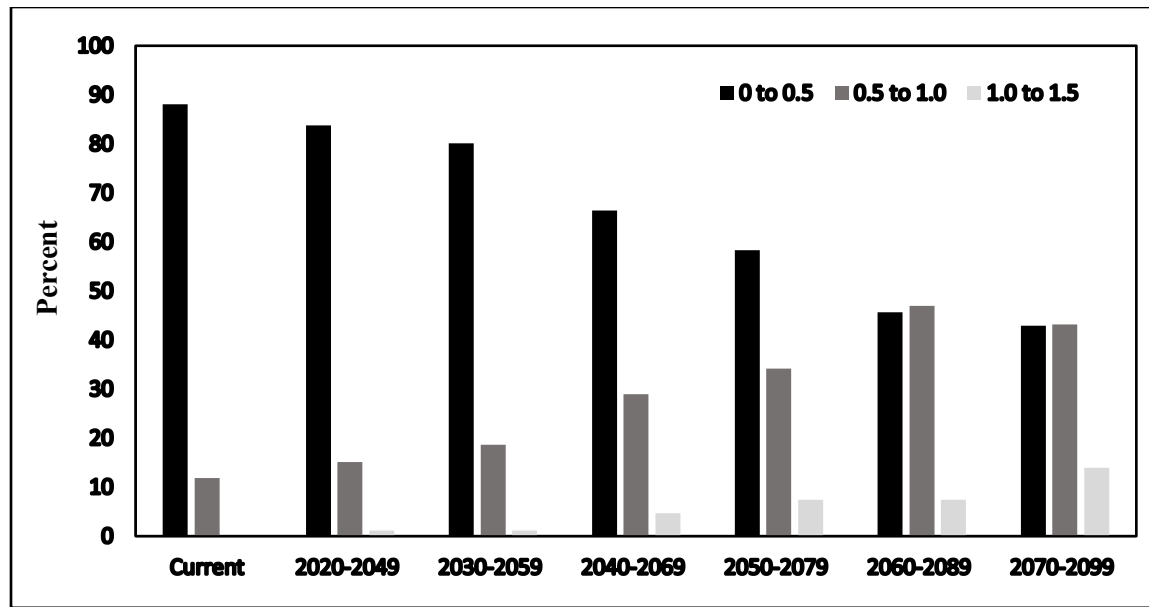


Figure 3.9.1. Percent of stream length in Okanogan County within three winter to spring runoff ratio classes. Data represent baseline high emissions scenario conditions. Data source: Climate Impacts Group, <https://cig.uw.edu/resources/analysis-tools/climate-mapping-for-a-resilient-washington/>.

Shifts in the timing of peak discharge to an earlier runoff and decreases in total volume of discharge have already been observed in Washington State (Stewart et al. 2005; Luce and Holden 2009). These sorts of changes can have a profound influence on stream ecosystems, including channel geomorphology, aquatic and riparian habitat, and water quality. Decreases in runoff volume may also reduce the availability of groundwater that is essential for sustaining instream flows during late summer and fall (Voss and Mastin 2012; Caldwell et al. 2013).

The U.S. Geological Survey completed a streamflow simulation for the Methow River that combined several climate change scenarios (Voss and Mastin 2012). Model results reveal significant shifts in the predicted Methow hydrograph from current conditions, including increased November-March discharge, earlier spring snowmelt runoff, and lower overall peak flows (Figure 3.9.2). The higher winter flows are especially noticeable in the 2080 scenario and these results are similar to those reported by Climate Impacts Group (2022).

Model results are closely linked to changes in both temperature and precipitation regimes that force shifts in the timing, magnitude, and variability of runoff. Currently, rain on snow events are relatively uncommon in the Chewuch River watershed, but are likely to become more common in the future resulting in higher and flashier flows in the winter and early spring.

Cold-water dependent fish population response to shifts in streamflow and temperature regimes will depend to a large degree on species-specific life history traits and tolerance relative to the degree of change (Beechie et al. 2013). Climate change driven environmental effects will affect the various species in different ways depending on several factors, including spawn timing, length of instream incubation and rearing, and general habitat preferences (Figure 3.9.3). Species that have protracted juvenile residency in the LCRA area, such as steelhead and Pacific lamprey, may experience more of the impacts, as they will experience multiple annual cycles and impacts may be cumulative.

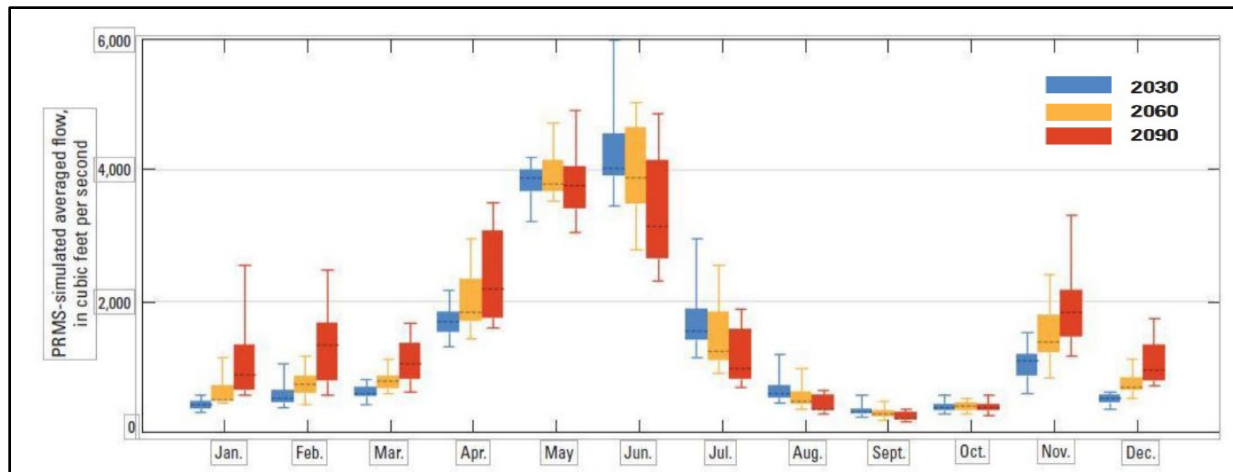


Figure 3.9.2. Simulated monthly average Methow River discharge at Winthrop in 2030, 2060, and 2090. Figure from Voss and Mastin (2012).

For example, winter flooding could be especially detrimental to the incubating eggs of spring Chinook, bull trout, and coho salmon, which could be harmed by the resulting bed scour and/or sediment deposition. Steelhead could be impacted over several years of juvenile rearing by low summer-fall flows and elevated stream temperatures, which may reduce the availability of rearing habitat, decrease growth, and increase predation. Summertime low flows and elevated temperatures also have the potential to physically or behaviorally impede and/or prevent adult migration into spawning areas.

Stream temperature is a critical environmental variable for fish in the LCRA area, as it is a significant driver of growth, movement, and behavior. Results from water temperature modeling completed by the NorWest Project (Chandler et al. 2016) indicate that streams in the Chewuch River watershed may experience significant and widespread warming by 2080 – beyond what warming has already been observed (Figures 3.9.3 and 3.9.4).

The most downstream reaches of the Chewuch mainstem and major tributaries (including Twentymile, Boulder, and Cub Creeks) may be the most impacted by warming, with potential average August water temperatures exceeding 18°C. At these levels and considering that daily maximum temperatures may spike even higher, temperature regimes in the LCRA area will likely be detrimental to ESA-listed salmonids through thermal stresses, leading to decreased growth and survival and increased disease susceptibility.

Predicted temperature increases vary by models and data used, but generally range between 1-4 °C by 2080 (Caldwell et al. 2013; NOAA 2014). Elevation plays an important role in determining stream temperatures, both in the present and into the future; thus, the more upstream reaches within the LCRA may offer more thermally tolerable habitat relative to downstream reaches. To examine these relationships, the longitudinal temperature profile of the 2009 thermal imagery (Watershed Sciences 2009) was integrated with the NorWest 2040 and 2080 temperature scenarios for the Chewuch River mainstem and stratified by temperature zones used by Fullerton et al. (2018; Figure 3.9.5).

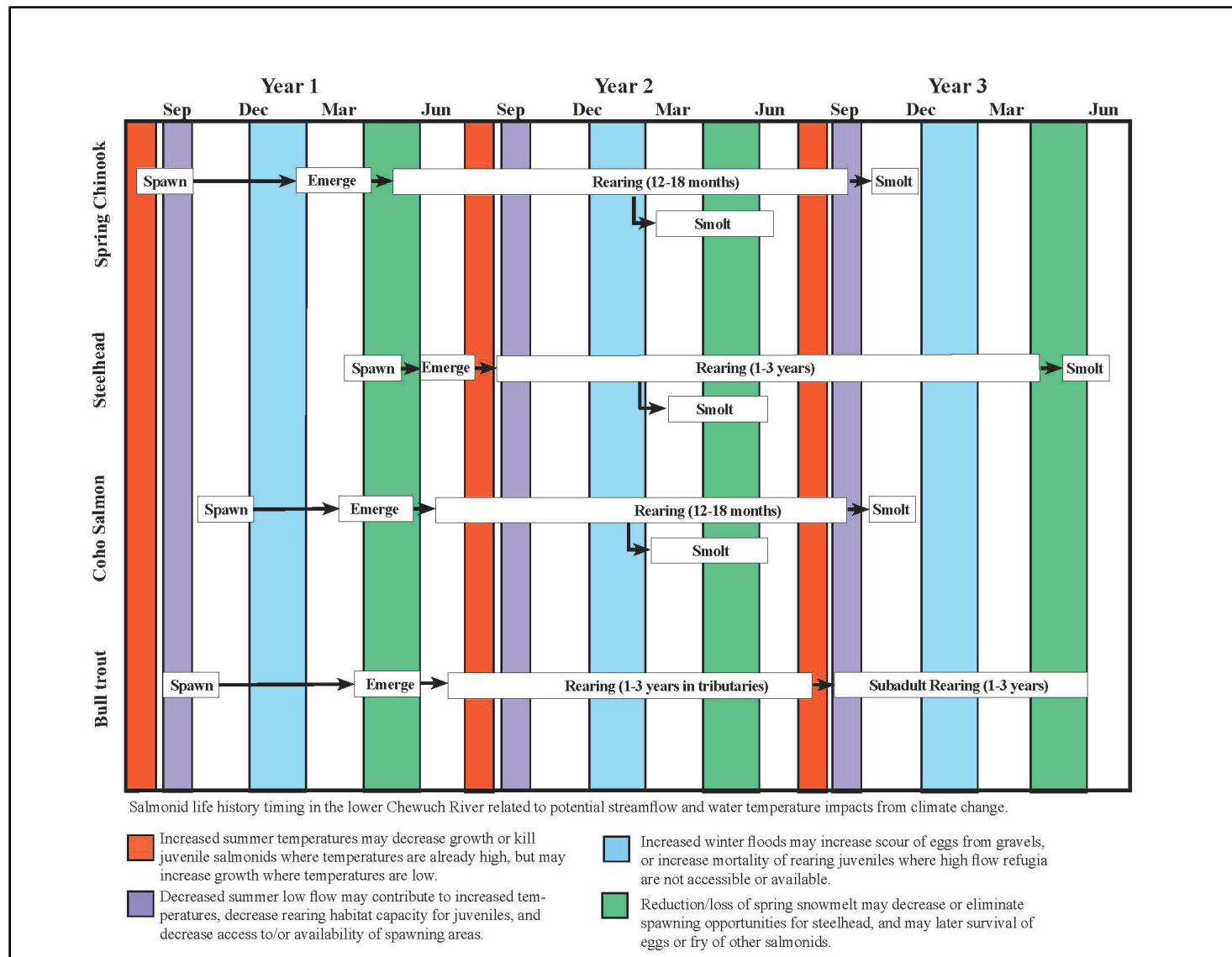


Figure 3.9.3. Salmonid life history timing in the LCRA related to potential streamflow and water temperature impacts from climate change. Figure adapted from Beechie et al. (2012).

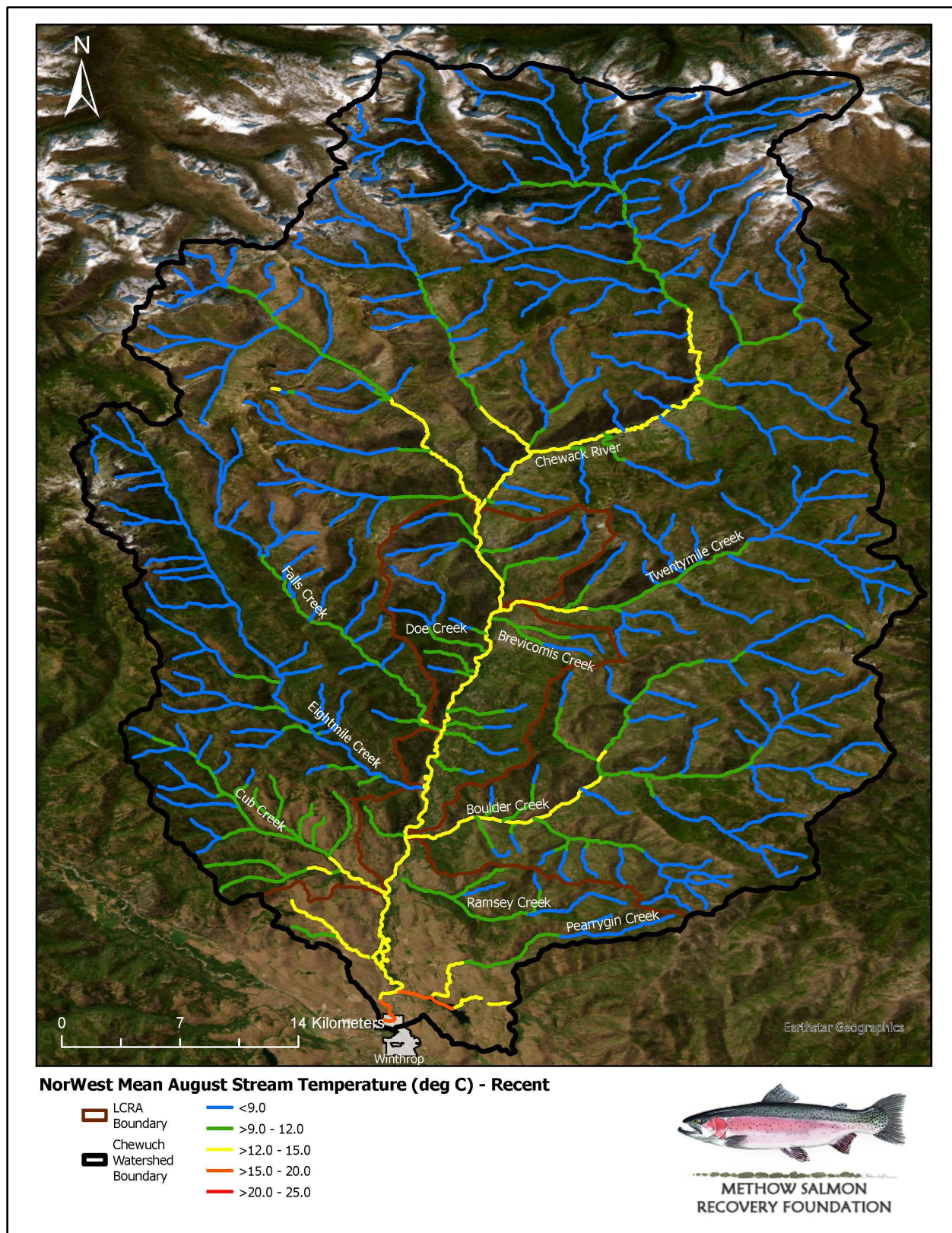


Figure 3.9.4. Average August water temperatures for recent (1990-2010s) conditions. Data from NorWest Project (<https://www.fs.usda.gov/ccrc/tools/norwest-stream-temperature>).

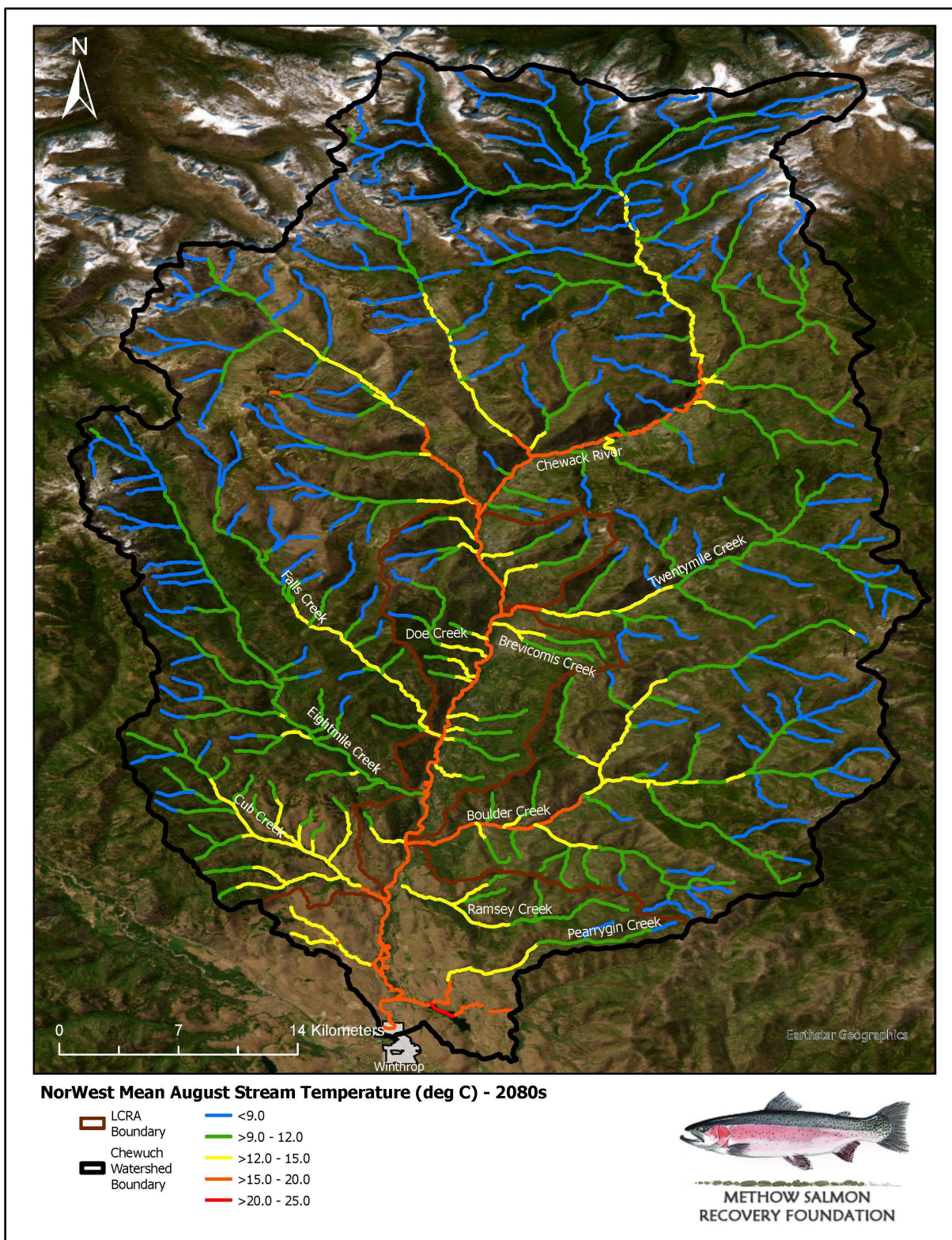


Figure 3.9.5. Average August water temperatures model predicted the 2080s. Data from NorWest Project (<https://www.fs.usda.gov/ccrc/tools/norwest-stream-temperature>).

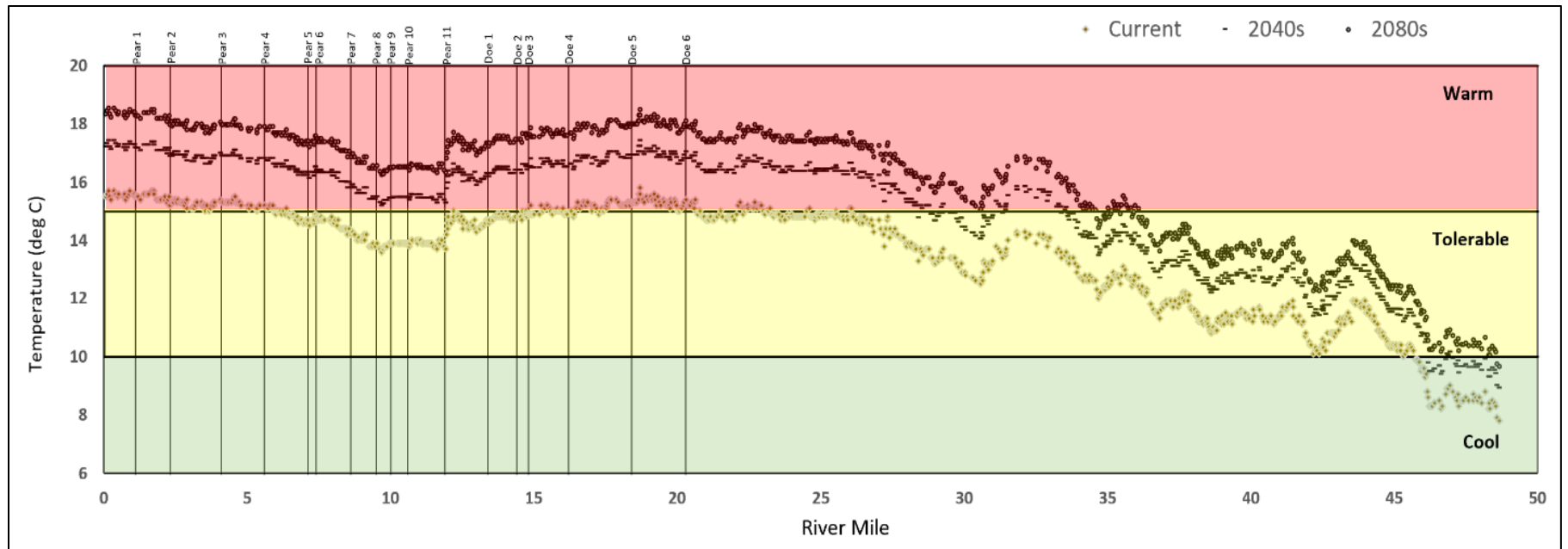


Figure 3.9.6. Longitudinal stream temperature profile for the Chewuch River, Mean August water temperatures for recent, 2040s, and 2080s scenarios.

Currently, the majority of the mainstem channel falls within the tolerable temperature range for salmonids (10-15 °C) based on August mean temperatures. Within the LCRA area, there is a noticeable drop in temperature downstream of Eightmile Creek, a reflection of its contribution of cold water to the Chewuch River. Several reaches within the LCRA area fall slightly within the warm range (>15 °C), including from RM 5 downstream to the mouth, and between RM 17-20.

By 2040, the profile of the channel downstream of RM 30 shifts fully into the warm range all the way downstream to the confluence with the Methow River. The cold water input from Eightmile Creek still provides cold input and a drop in mainstem temperature, but it will no longer be sufficient to cool the stream back down into the tolerable range. The 2080s scenario is similar to the 2040s, but there is >1-2 °C overall increase for most reaches. Combined, these data indicate that the LCRA area is likely be thermally stressful at least seasonally to fish inhabiting this reach by the 2040s.

3.10 Relative Suitability Index Analysis

The current capacity of the lower Chewuch River to support spawning and rearing for spring Chinook Salmon and steelhead was examined through analysis of habitat suitability via a Relative Suitability Index (RSI). As RSI output is derived from the relationship between surface area values (3m x 3m raster cell size from the model output) and a unitless depth and velocity preference, model results are best interpreted as an index relative to one another and not in unit of area or even weighted useable area. To this end, we employ the “relative suitability index” terminology suggested by Payne (2003). The RSI is intended to assist with interpretation of how the reaches generally function for target fish species and life stages across a range of flows. The LCRA RSI analyses only incorporated depth and velocity as habitat variables, as other adequate habitat data (e.g., substrate) were lacking.

RSI results provide a “broad brush” approach to interpreting flow and fish habitat relationships and may not provide the detail necessary on which to base decisions for more advanced restoration planning. While the LCRA Restoration Strategy did not directly incorporate RSI results into the concepts or priorities, the RSI data should be used during project-specific planning efforts that can use the information to assess the potential species and life stage habitat present at a site and how proposed actions may influence habitat availability.

For the LCRA RSI analysis, depth and velocity outputs from the 2-D hydraulic model over a range of flow levels were used in conjunction with species- and life-stage-specific depth and velocity preference curves from Beecher and Caldwell (2022) to develop an index of fish habitat suitability (i.e., weighted usable area) within the LCRA reach. Results were not normalized to account for differences in reach length, so generally the longer reaches contained more available habitat compared to the shorter reaches.

Water depth and velocity changes with discharge, so a suite of flows representing those experienced by both rearing juveniles (average low flows up through the 100-year discharge) and spawning adult spring Chinook and steelhead (April and August monthly averages, respectively) were included in the analysis.

For juvenile rearing, RSI model results indicate that, overall, the lower Chewuch River provides more suitable habitat for steelhead compared to spring Chinook across all flow levels including low flow conditions (47 ft³/s) up to July average flows (412 ft³/s) which are levels typically

observed in summer, fall, and winter. The increasing habitat availability largely represents mainstem conditions, with useable habitat increasing along with discharge (e.g., wetted habitat).

As flows increase over the 1–2-year flows (1700 – 4000 ft³/s), RSI declines slightly as habitat conditions in the mainstem become less suitable, and floodplain and other off-channel habitats have yet to fully activate. Below the 1-year flow, these off-channel areas were largely inaccessible or dry. Above the 2-year flow, RSI increases across the higher modeled flows (Q5, Q10, and Q100), achieving maximum RSI for both species at the 100-year flow (11,770 ft³/s) when floodplain surfaces are fully inundated.

The differences in RSI results for rearing between the species are most likely due to a wider range in velocity preference for juvenile steelhead (depth preferences are similar). For both species, suitable habitat diminishes from ~400 ft³/s up to 4,000 ft³/s, a likely result of an increase in increased water velocities throughout the channel. Above these flows, floodplain areas become available through overbank flow above the bankfull stage, resulting in available habitats that are both slower and shallower relative to the mainstem. The increase in the RSI between the 5-year and 100-year flow levels are likely the result of similar floodplain and off-channel surface inundation and are an indication of the importance of floodplain habitat availability to juvenile steelhead and chinook habitat in the LCRA area.

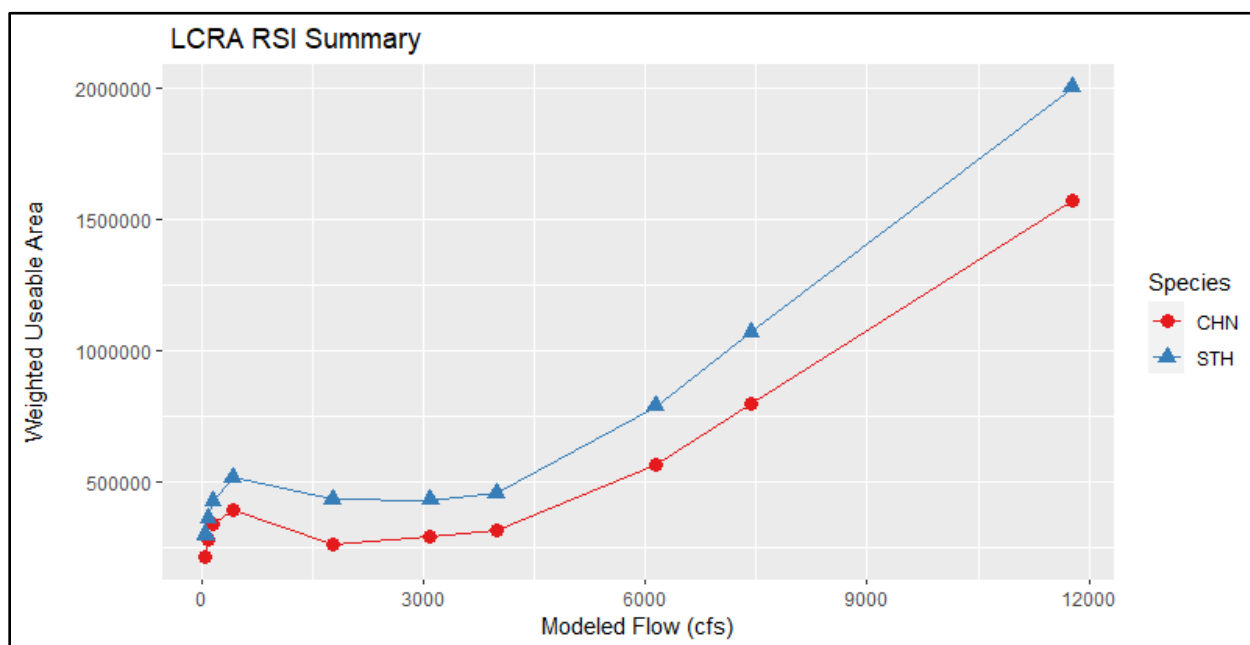


Figure 3.10.1. Relative habitat suitability for spring Chinook and steelhead rearing across the range of hydraulically modeled flows for the LCRA area.

An example of species preference similarities and differences, can be seen in the Pearrygin 5 reach downstream of Cub Creek (Figure 3.10.2). Many areas of high value habitat are similar during September flows (~79 ft³/s), but there is more shallow water habitat in the mainstem preferred by steelhead and less suitable for spring Chinook. These areas generally have higher velocities, such as in riffles and shallow glides.

Reach-based RSI results reveal some distinct differences between the LCRA reaches in terms of combined (for both species) habitat availability as observed at the September mean, 1.5-year, and

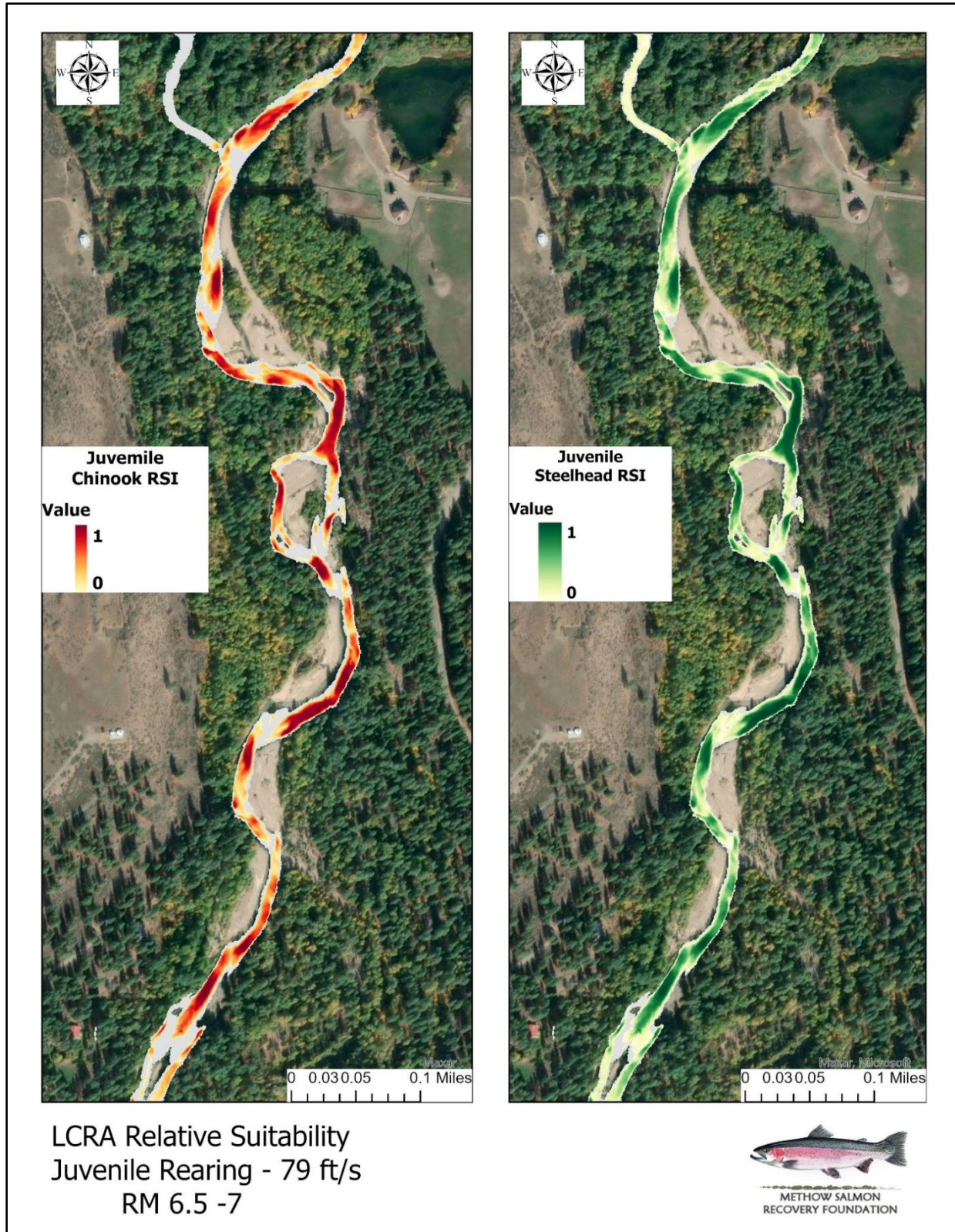


Figure 3.10.2. Relative habitat suitability for spring Chinook and steelhead rearing at Chewuch River (RM 6.5-7) in the Pearygin 5 reach at average September flows (79 ft³/s). Grey areas denote 0 RSI value.

10-year flow levels (Figure 3.10.3). Aside from the longer reaches, the less confined reaches, such as Pearrygin 3, 4, 5 and 10 and Doe 1, 2 and 5, contain more suitable habitat area relative to the more confined reaches such as Pearrygin 1 and 2 and Doe 3 (Figure 3.10.4).

Doe 3, a short and relatively steep and confined reach, had the lowest overall habitat availability, but similar availability across the range of flows. This is due, in part, to the presence of small areas of inset floodplain within that reach that provides suitable habitat when the mainstem floods. Pearrygin 1 and 2 were the only two reaches that had less available habitat at both the 1.5 and 10-year flows compared to the low September flows – an indication of the confined nature of these two reaches and a lack of floodplain area.

Habitat availability on floodplains was also apparent in the more unconfined reaches when the ratio of the weighted usable habitat between the 1.5 and 10-year flows was >3 . These reaches included Pearrygin 2, 3, 5 and 10 and Doe 2. Other reaches with appreciable floodplain habitat available above the 1.5-year flow included Pearrygin 8 and 11 and Doe 5. The shifts in useable habitat, such as observed in Pearrygin 4 reach, can be seen across the range in modeled flows and show a shift from mainstem availability to floodplain activation and a decrease and the amount of suitable habitat available in the mainstem channel (Figure 3.10.5).

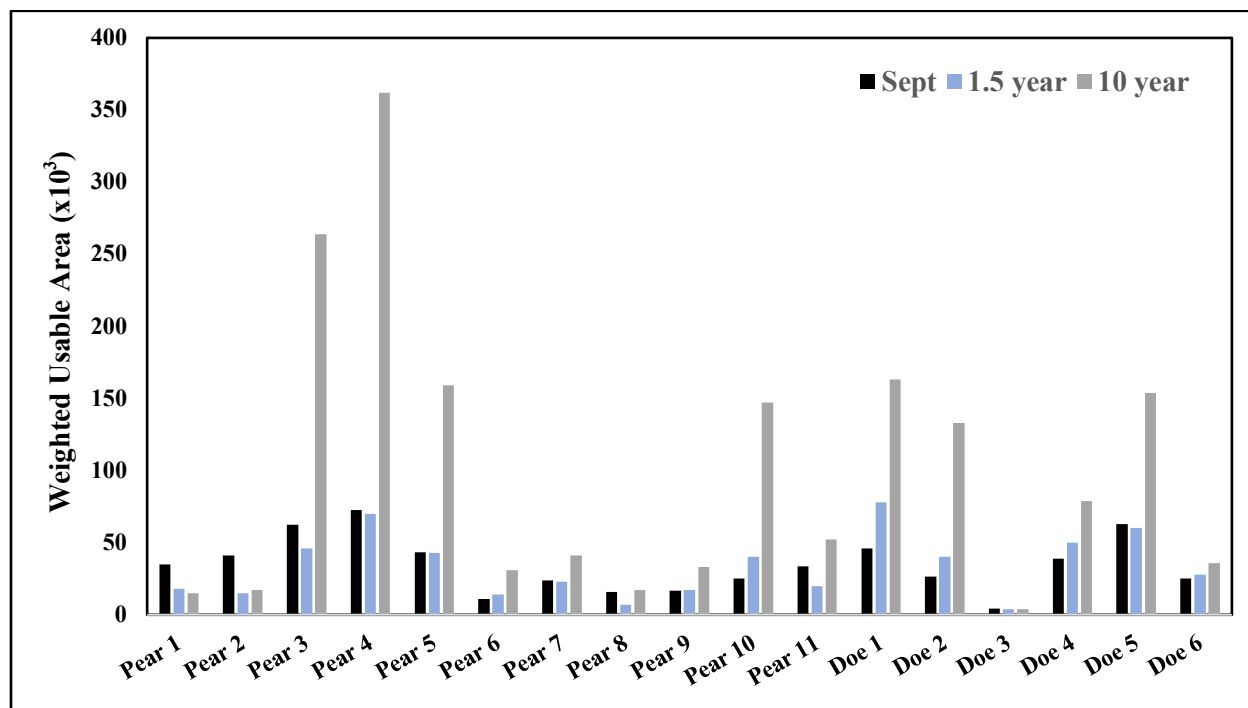


Figure 3.10.3. Relative habitat suitability for spring Chinook and steelhead rearing for LCRA reaches at September (79 ft³/s), 1.5-year (3,087 ft³/s), and 10-year (7,427 ft³/s) flows.

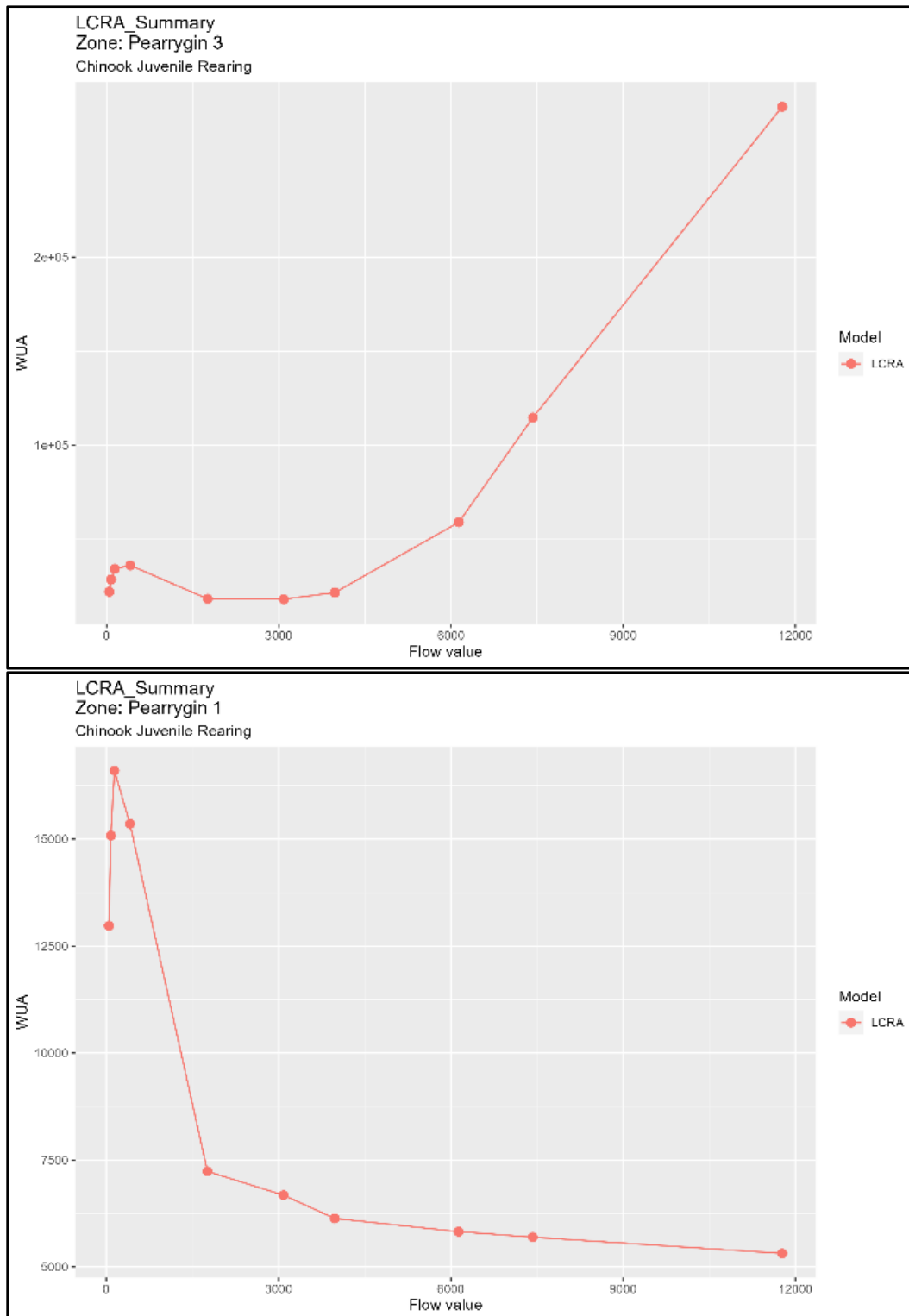


Figure 3.10.4. Relative habitat suitability for spring Chinook rearing for Pearrygin 3 (relatively unconfined) and Pearrygin 1 (confined) reaches over modeled flow levels.

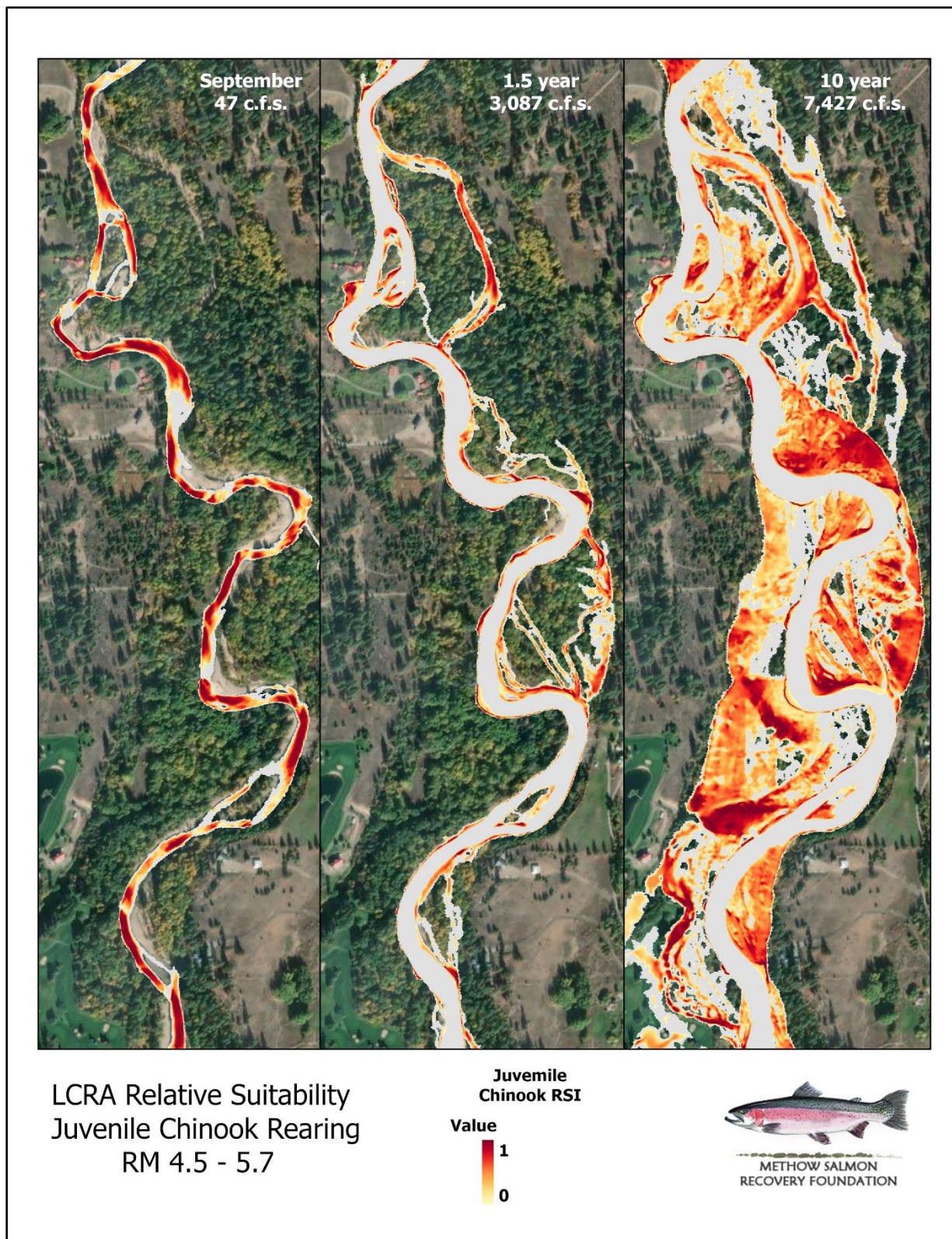


Figure 3.10.5. Relative habitat suitability for spring Chinook rearing for Pearrygin 4 reach (RM 4.5 – 5.7) at September, 1.5-year, and 10-year discharge levels. Grey areas denote 0 RSI value.

RSI results for adult spawning indicate reach-scale differences in potential spawning habitat for both steelhead and spring Chinook. Detailed substrate data were not available for this analysis, so the analysis relied solely upon modeled depth and velocity data, which do not capture aspects of the sediment regime that are a vital component of spawning habitat.

Overall, the longer, more unconfined reaches contained more suitable spawning habitat relative to the shorter and/or higher gradient reaches (Figure 3.10.6). Flows during steelhead spawning (April, 596 ft³/s monthly mean flow) are several times higher than those during spring Chinook spawning (August, 126 ft³/s monthly mean flow), so it is not surprising that in the LCRA area there is more than twice as much potential spawning habitat for steelhead compared to spring Chinook. Steelhead can take advantage of increased habitat availability in the mainstem, side channels, and braids that are not wetted at the time of spring Chinook spawning.

Redd survey data (Snow et al. 2023) indicate there is a fair degree of spatial overlap between steelhead and spring Chinook spawning locations, with fish using similar, discreet areas for spawning over many years. These areas are likely to possess suitable depth, velocity, and substrate characteristics that may remain in place for many years in the same general area.

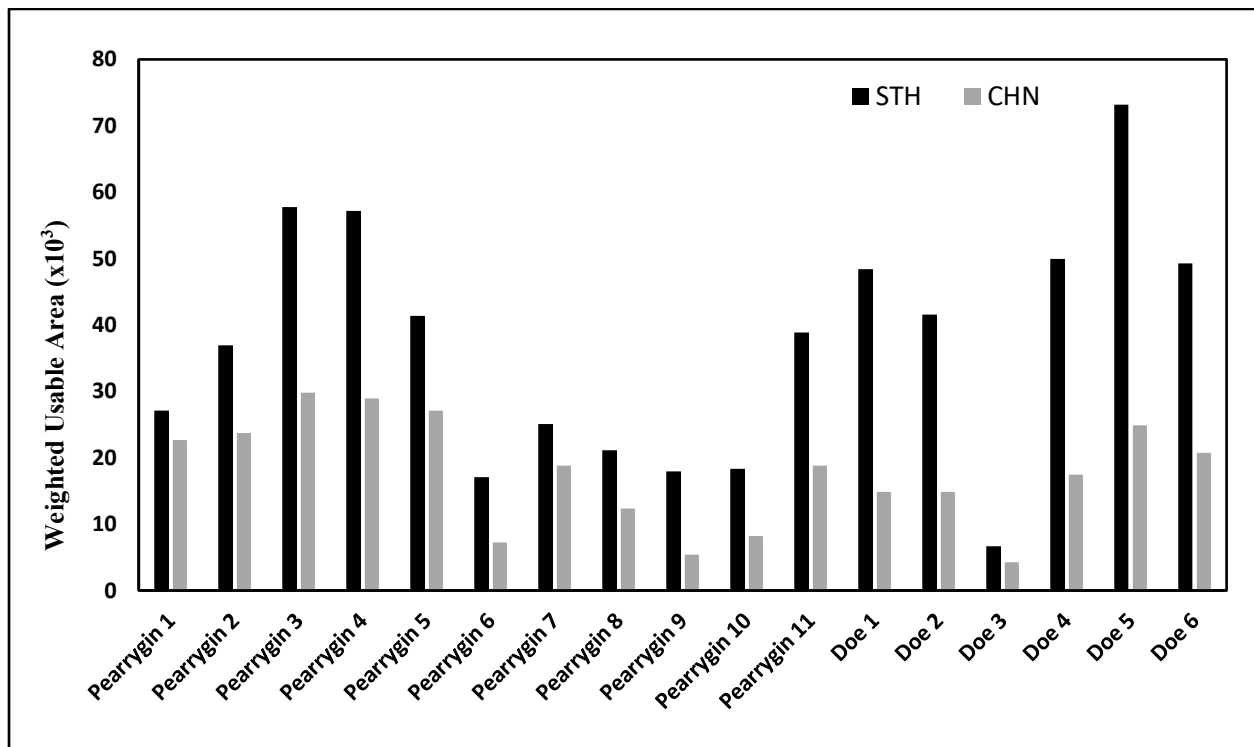


Figure 3.10.6. Relative habitat suitability for steelhead (April flows) and spring Chinook (August flows) spawning in LCRA reaches.

4 Reach-Based Ecosystem Indicators

Habitat conditions within the LCRA were examined through a Reach-based Ecosystem Indicators (REI) analysis. The REI provides a well-established and consistent means of evaluating biological, ecological, and geomorphic processes and watershed conditions in relation to established criteria that are related to known habitat requirements for aquatic biota in the Upper Columbia.

The area considered for this REI analysis included the lower Chewuch River, its 10-year floodplain, and the riparian buffer zone (defined as a 30-meter buffer from the channel edge), as well as the 100-year floodplain surface in some areas. Information used in the analysis included habitat data collected in 2023-2024, water temperature data (2013-2023), 2-D hydraulic modeling results for the LCRA area (based on the 2022 lidar data), various GIS-based spatial analyses (e.g., riparian condition, road density, wildfire, channel migration), results from *Prioritization*, USGS streamflow data, and general observations from the LCRA area made over the past decade.

The criteria used in this REI analysis are presented in Table 4.1 and based on the framework outlined in the reach assessment guidance document developed by the Upper Columbia Regional Technical Team (UC RTT 2021a). The REI approach for habitat analysis has its origins in the U.S. Fish and Wildlife Service Matrix of Diagnostics/Pathways and Indicators (USFWS 1998), the National Oceanic and Atmospheric Administration National Marine Fisheries Service Matrix of Pathways and Indicators (NMFS 1996), as well as more recent work conducted within the region by the Bureau of Reclamation and their adaptation of these indicators (USBR 2012).

By evaluating current conditions, the REI analysis will help to identify specific factors that contribute to the ecological concerns identified for the lower Chewuch River in the *Biological Strategy* (UC RTT 2017), thus supporting the development of project and management opportunities that can help to address those factors and improve habitat conditions for target fish species. The ecological concerns identified for the lower Chewuch River include the following (listed in order of priority):

1. Sediment Conditions (Increased sediment quantity)
2. Peripheral and Transitional Habitat (Side channel and wetland connection)
3. Channel Structure and Form (Instream structural complexity)
4. Riparian Condition (Riparian condition and large wood recruitment)
5. Water Quantity (Decreased water quantity)
6. Food (Altered primary productivity and prey species composition and diversity)
7. Species Interactions (Introduced competitors and predators)
8. Habitat Quantity (Anthropogenic barriers)

Metric-specific analysis results are presented and discussed for each REI metric and are used to assign a risk condition rating of *Adequate*, *At Risk*, or *Unacceptable*. The criteria for rating categories are explained in detail for each indicator in Sections 4.1 and 4.2. For the LCRA, watershed-scale indicators were examined through the two assessment units, and reach-scale indicators were examined through each of the 17 reaches contained within the LCRA area.

Table 4.1. Pathways and Indicators included in the LCRA REI analysis.

Pathway	General Indicator	Specific Indicator
Watershed-scale Metrics		
Watershed Condition	Drainage Network and Hydrologically Impaired Surfaces	Increase in Drainage Network/ Hydrologically Impaired Surfaces
	Disturbance Regime	Natural/Human Caused
Flow/Hydrology	Streamflow	Alterations to Peak/Base Flows
Water Quality	Stream Temperature	7-day Average Maximum Temperature
Reach-scale Metrics		
Habitat Access	Physical Barriers	Main Channel Barriers
Habitat Quality	Substrate	Substrate/Fine Sediment
	Large Woody Material	Pieces per mile in bankfull channel
	Pools	Pool Spacing
	Off-Chanel Habitat and Refugia	Connectivity with Main Channel
Riparian Vegetation	Condition	Structure
		Disturbance (Human)
		Canopy Cover
Channel	Dynamics	Floodplain Connectivity
		Channel Migration
		Vertical Channel Stability

A summary of the REI ratings for the 15 specific indicators examined for the LCRA area is presented in Tables 4.2 and 4.3, with detailed indicator descriptions and results presented thereafter. REI results from the 2010 Lower Chewuch Reach Assessment are provided for comparison.

Table 4.2. Watershed-scale Reach-Based Ecosystem Indicator ratings summary for the LCRA area.

General Characteristics	General Indicators	Specific Indicators	REI Rating Chewuch- Pearrygin AU	REI Rating Chewuch- Doe AU	2010 RA Chewuch Basin
Watershed-scale Metrics					
Watershed Condition	Drainage Network and Hydrologically Impaired Surfaces	Increase in Drainage Network/ Hydrologically Impaired Surfaces	●	●	●
	Disturbance Regime	Natural/Human Caused	●	●	●
Flow/Hydrology	Streamflow	Alterations to Peak/Base Flows	●	●	●
Water Quality	Stream Temperature	7-day Average Maximum Temperature	●	●	●

● Acceptable ● At risk ● Unacceptable

Table 4.3. Reach-scale Reach-Based Ecosystem Indicator ratings summary for the LCRA area. The 2010 Reach Assessment ratings are provided for comparison. **Note:** Differences in ratings between the two assessments do not necessarily reflect a change in condition that occurred between the assessments. Some of the methods and data used to determine rankings by each of the assessments differed, which influenced ratings in some cases.

LCRA			Reach-scale Metrics																
			Pear 1	Pear 2	Pear 3	Pear 4	Pear 5	Pear 6	Pear 7	Pear 8	Pear 9	Pear 10	Pear 11	Doe 1	Doe 2	Doe 3	Doe 4	Doe 5	Doe 6
			C1	C2a	C2b	C3a	C3b	C4a	C4b	C4c	C5a	C5b	C6	C7	C8	C9			
Habitat Access	Physical Barriers	Main Channel Barriers	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
			●		●	●	●	●	●		●		●		●	●	●	●	
Habitat Quality	Substrate	Substrate/Fine Sediment	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
	Large Woody Material	Pieces per mile in bankfull channel	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
	Pools	Pool Spacing and Density	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
	Off-Channel Habitat and Refugia	Connectivity with Main Channel	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Riparian Vegetation	Condition	Structure	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
		Disturbance (Human)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
		Canopy Cover	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Channel	Dynamics	Floodplain Connectivity	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
		Channel Migration	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
		Vertical Channel Stability	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

● Acceptable ● At risk ● Unacceptable

4.1 Watershed-Scale Pathways

4.1.1 Watershed Condition

Indicator: Drainage Network and Hydrologically Impaired Surfaces

Road density and structural development were used to examine drainage network condition. Road density can function as a good indicator of watershed condition and road miles/watershed miles² was incorporated as primary metric for the REI. It has been shown that high road density can result in altered drainage networks (Montgomery 1994, Wemple et al. 1996), which in turn often increases fine sediment load to streams and rivers (Reid and Dunne 1984, Goode et al. 2011). In addition, increased road density can result in greater mass wasting events and erosion than in a less disturbed watershed (Montgomery 1994, Wemple et al. 1996). Increased sediment delivery to streams can have significant effects on aquatic systems, such as reducing suitable spawning habitat; smothering salmon eggs (Lisle 1989); clogging hyporheic flow paths (Boulton et al. 1998); reducing substrates for aquatic plants, biofilms, and aquatic invertebrates (Henley et al. 2000); as well as impacting channel morphology and water clarity (Waters 1995, Wood and Armitage 1997).

A comprehensive road network map for the Chewuch River watershed was developed by joining (and removing duplicates) the U.S. Forest Service – Methow Ranger District (2023) and Okanogan County (2022) roads shapefiles and calculating road length for each of the 13 assessment units (i.e., HUC 12 watersheds) within the entire Chewuch watershed.

Structural development (e.g., residential, commercial, industrial) within the Chewuch watershed was also examined by summarizing the structural surfaces from the 2024 FEMA USA Structures database. The analysis considered the structural developments impervious surfaces that contribute to hydrologic impairment within the watershed and LCRA area.

Data on developed lands from the Annual Land Cover Database (NLCD 2023) was also examined to investigate the percent of developed lands and impervious surfaces within the assessment area. Specifically, we compared the percent of developed lands documented in 2010 and 2023 to examine development change over time. There was strong overlap between developed lands and impervious services, and the former was selected to represent hydrologically altered surfaces within the watershed.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Watershed Condition	Watershed Road Density and Effective Drainage Network	Increase in Drainage Network/Road Density/Hydrologically Impaired Surfaces	Zero or minimum increase in the drainage network that is correlated with human-caused disturbances. Hydrologically impaired surfaces in the watershed <8% of area. Road density < 1.0 miles/mile ² .	Low to moderate increase in the drainage network that is correlated with human-caused disturbances. Hydrologically impaired surfaces in the watershed between 8- >15%. Road density 1.0 to 2.4 miles/mile ² .	Substantial increase in the drainage network correlated with human-caused disturbance. Hydrologically impaired surfaces in the watershed >15%. Road density > 2.4 miles/mile ² .

Analysis Results

Road density within the Chewuch Watershed varies considerably, with much less road development in the assessment units upstream of the LCRA area (Table 4.1.1, Figure 4.1.1). Road density was 0.14 mi/mi² in the upstream assessment units compared to 1.71 mi/mi² and 2.29 mi/mi² collectively in contributing assessment units (ones that drain into) in the Chewuch-Doe and Chewuch-Pearrygin AUs, respectively. Cub Creek had the highest individual road density of any assessment unit at 3.85 mi/mi². Interestingly, all of the assessment units downstream of Twentymile Creek had road densities >1 mi/mi², while those upstream of Twentymile contained <0.53 mi/mi² with four of six AUs <0.11 mi/mi².

Within the LCRA area, the Chewuch-Pearrygin AU had the second highest density within the entire Chewuch watershed with 3.03 mi/mi², and Chewuch-Doe AU had the third highest at 2.99 mi/mi². Both of these road densities exceed the 2.4 mi/mi² designed for unacceptable condition. The majority of these roads exist outside the 100-year floodplain surface, but there is some road development within the 10–100-year floodplain including 2 miles in Chewuch-Pearrygin AU and 0.4 miles in Chewuch-Doe AU.

Table 4.1.1. Road length, assessment unit (HUC 12) area, and road density, Chewuch River watershed.

LCRA AUs	Contributing AUs	Road Length (miles)	AU Area (miles ²)	Road Density (road miles/AU miles ²)
Pearrygin	Eight Mile Creek	120.70	46	2.62
	N. F. Boulder Creek	76.82	60	1.28
	Boulder Creek	27.14	21	1.29
	Cub Creek	92.49	24	3.85
	Chewuch - Pearrygin	121.03	40	3.03
	Pearrygin Combined	438.19	191	2.29
Doe	Twenty Mile Creek	15.16	41	0.37
	Falls Creek	51.31	27	1.90
	Chewuch - Doe	116.51	39	2.99
	Doe Combined	182.97	107	1.71
Upstream Area	Chewuch Headwaters	0.00	49	0
	Windy Creek	10.16	19	0.53
	Chewuch - Kay Creek	4.48	39	0.11
	Andrews Creek	0.28	34	0.01
	Lake Creek	4.67	53	0.09
	Chewuch - Thirtymile	10.47	28	0.37
		Upstream Combined	30.06	222

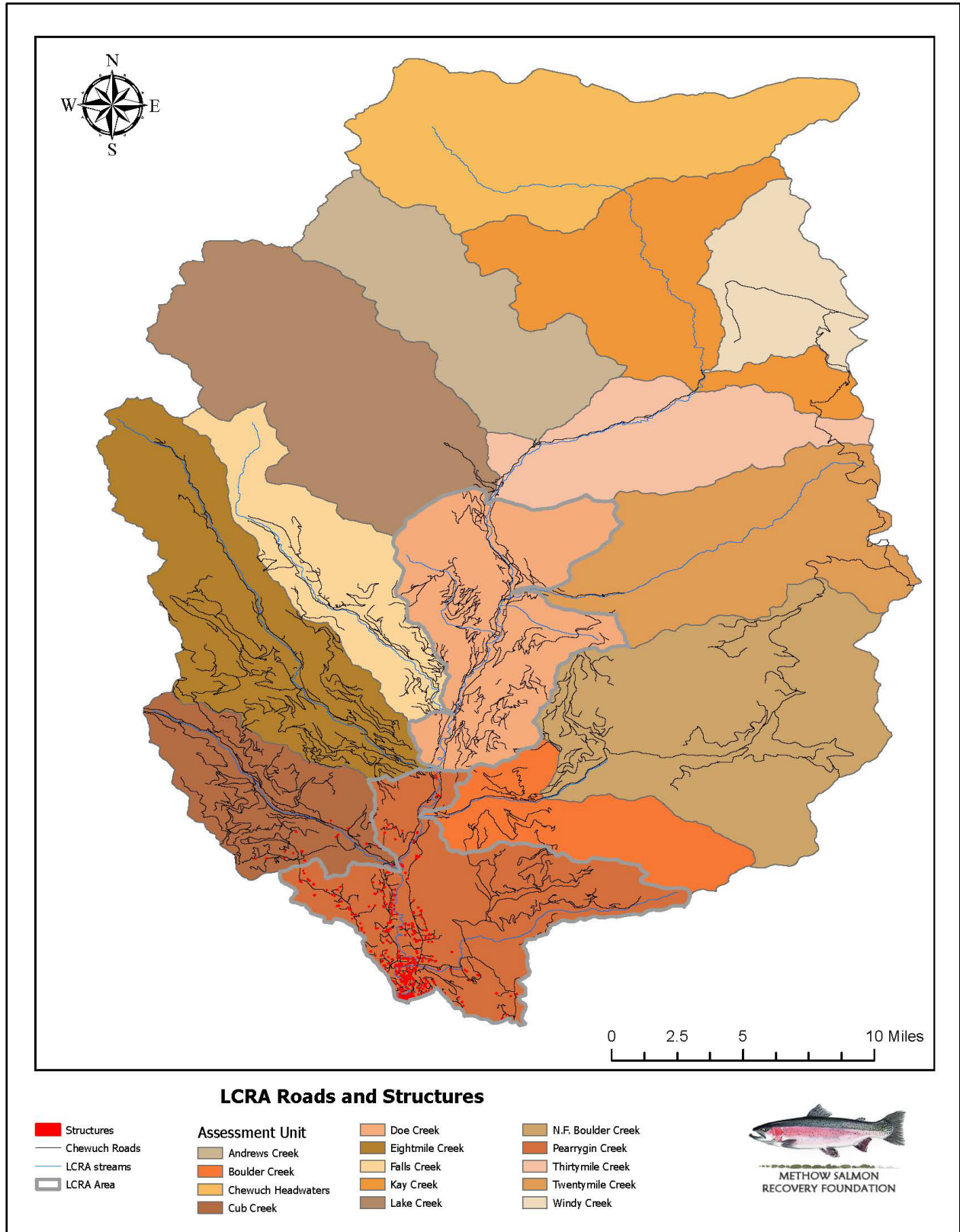


Figure 4.1.1. Roads, structures, and assessment units in the Chewuch River watershed. LCRA area outlined in grey.

Analysis of structural development (i.e., residential, agricultural, commercial structures) within the LCRA revealed that the overwhelming majority of structures are concentrated in the Chewuch-Pearrygin and Cub Creek assessment units. Private lands comprise 34% of the land area in Chewuch-Pearrygin AU, and that is where the majority of structural development has occurred. Within the Town of Winthrop, structural development is a combination of residential and commercial, while outside of town, development is primarily residential and agricultural.

Overall, structural development (as a percentage of assessment unit area) was <0.1% in Chewuch-Pearrygin AU and <0.002% in Chewuch-Doe AU, thus comprised a relatively small proportion of the LCRA area. There are a few structures in a recreational development in the vicinity of Brevicomis Creek (Doe 5 reach) and several cabins and mine structures in the Pasayten Wilderness, although these were not included in the FEMA data.

Developed lands in the Chewuch River watershed and the LCRA area followed a pattern similar to that of road development. The majority of development is concentrated in the downstream assessment units within the watershed, especially within the Chewuch-Pearrygin AU (Table 4.1.2). Development increased slightly between 2010 and 2023, but it was very minor in most of the AUs, with the exception of the Chewuch-Pearrygin AU where the area of developed lands increased by 0.7% (180 acres) to approximately 1,500 acres of total development.

Table 4.1.2. Percentage of developed lands, Chewuch River watershed, 2010 and 2023. Data from National Land Cover Database 2023.

Assessment Unit	2010 % Development	2023 % Development	2010-2023 % Change
Chewuch Headwaters	0.0	0.0	0.0
Windy Creek	0.8	0.9	0.1
Chewuch - Kay	0.1	0.1	0.0
Andrews Creek	0.3	0.3	0.0
Lake Creek	0.2	0.2	0.0
Chewuch -Thirtymile	0.4	0.4	0.0
Twentymile Creek	0.2	0.2	0.0
Falls Creek	2.2	2.2	0.0
Chewuch - Doe	3.1	3.2	0.1
Eightmile Creek	2.1	1.9	-0.2
N.F. Boulder Creek	1.2	1.3	0.1
Boulder Creek	1.3	1.3	0.0
Cub Creek	2.9	3.0	0.1
Chewuch - Pearrygin	5.1	5.8	0.7

Based on the rating criteria, the Chewuch River watershed for as a whole is functioning *At Risk* for the drainage network indicator.

However, the road density in the LCRA area, and the watersheds that contribute to it, is significantly higher than upstream watershed road density. Road density in the contributing watersheds to the Chewuch-Pearrygin AU is especially high. Residential and commercial development is also more concentrated in this assessment unit, especially in the downstream reaches surrounding Winthrop. The assessment unit also has two bridges with associated bank protection, some floodplain road development, and many paved road surfaces. For these reasons, Chewuch-Pearrygin AU is rated as *Unacceptable*.

Road density in Chewuch-Doe is less than in downstream areas, but areas of high density are present, especially within the contributing Doe and Falls Creek watersheds. Roads on both sides of the river parallel the channel for the entire length of the assessment unit, and many tributaries also have roads in close proximity to the streams in those watersheds. There is some floodplain road development, especially in the Doe 5 and 6 reaches. These factors are evidence that the Chewuch-Doe AU is functioning as *At Risk* for the drainage network indicator.

Indicator: Disturbance Regime (Natural and Human-Caused)

Disturbance is an integral part of natural systems (Ward 1998). Natural disturbance regimes create habitat and biological diversity that maintain the larger ecosystem processes (Nakamura et al. 2000, Ward 1998). Natural disturbance regimes include events such as landslides, fire, flood, drought, and windstorms. Human activities such as flow regulation, channelization, bank stabilization, road construction, and land-use modifications (e.g., wildlands conversion to agriculture, development, etc.) result in disturbances that can change how systems respond to natural events, frequency of events, and ability to recover (Waples et al. 2009) and are, therefore, included in the evaluation of this indicator.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Watershed Condition	Disturbance Regime	Natural and Human Caused	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.	Localized events of hillslope contributions, avulsion, lateral migrations, minor bed incision, scour events, debris torrents, or wildfires. Resiliency of habitat to recover from environmental disturbance is moderate.	Frequent flood or drought producing highly variable and unpredictable flows, hillslope contributions, avulsion, lateral migrations, minor to major bed incision (i.e., head cuts), scour events, debris torrents, or wildfires throughout a majority of the watershed. The channel is simplified, providing little hydraulic complexity in the form of pools or side channels. Natural processes are unstable.

Analysis Results

Alterations in the LCRA area and surrounding watershed include past and on-going human disturbance that limits the resiliency of habitat to recover from natural disturbance events. Historical and current land use activities include agriculture, timber harvest, mining, grazing, and road construction, as well as land management actions such as fire suppression (NPCC 2004). More recently, recreational development within the LCRA area has occurred, including establishment of campgrounds, dispersed camping areas, and trails. Many of these uses are concentrated in the riparian areas of the mainstem Chewuch River and its tributaries, such as Cub Creek, Boulder Creek, and Eightmile Creek.

Historic anthropogenic disturbances accelerated in the late 1800s with the arrival of European settlers who used the Chewuch River and surrounding areas for timber harvest, log drives, placer and hard rock mining, and riparian clearing for agricultural and residential development (USFS

1994, USBR 2008, see also Section 3.2). Wildfires were common before European settlement, but the severity has increased over time due to a number of factors including increased land use and disturbance (USBR 2008, see also Section 3.8).

A significant portion of the LCRA area burned during the 2021 Cub Creek 2 Fire, which burned extensively through the riparian areas in the Chewuch-Doe AU and more limited portions of the Chewuch-Pearrygin AU (See Section 3.8). These wildfires, along with human disturbances such as land development, riparian clearing, and bank armoring, are preventing riparian areas and floodplains from functioning or becoming fully functional, hampering their resilience, and contribute to additional fine sediment being transported into the Chewuch River. After the 2021 fire, several debris flows resulted in road wash-outs and sediment inputs to the Chewuch-Doe AU.

Over many decades in the LCRA area, increased land use and development have constrained channel migration, disconnected floodplain habitat, and decreased large wood availability and retention in the channel (NPCC 2004). Land clearing was followed by the addition of riprap and levees to protect agricultural fields, orchards, houses, and roads from flooding. Over 2 miles of streambank alteration -primarily riprap, which accounts for 7% of the combined AU reach length)-is present along the banks of the Chewuch-Pearrygin AU. There is less bank alteration in the upstream areas in Chewuch-Doe AU, where there is <0.5 miles (2% of combined AU reach length) of altered bank. Due to these alterations and natural confinement in many reaches, the channel is confined, simplified, and has reduced hydraulic complexity in many areas. These have all contributed to changing the composition, structure, and function of riparian vegetation and floodplain forests in the LCRA area.

Riparian and floodplain analyses (Section 3.5.1.6) indicate that approximately one-quarter (24%) of the floodplains within the LCRA area has been altered by human disturbances through either residential/commercial development, agriculture, and/or recreational development. Within the riparian zone, land use altered by human disturbances was lower at 14%, but still represents a significant amount of land degradation in close proximity to the stream channel.

Two dams are located within the Chewuch-Pearrygin AU, both constructed to support surface water diversions for irrigation. Both dams have been modified over the past 15 years to improve fish passage conditions. Fulton Dam, at RM 1 (upstream end of Pearrygin 1 reach), allows fish passage, but alters channel bathymetry and creates an approximately quarter mile backwater effect that disrupts stream energy and allows for deposition of significant volumes of fine sediment. Similar channel and backwater disruption exists at the Chewuch Dam (RM 8.6, upstream end of Pearrygin 7 reach), albeit on a smaller scale compared to Fulton Dam. Chewuch Dam was rated as only 67% fish passable (WDFW 2018), thus may pose passage challenges for some life stages at certain flows.

Only two levees were documented within the LCRA 100-year floodplain, with one each in Pearrygin 7 and Pearrygin 8 reach. While limited in scale and scope, these anthropogenic structures alter the localized resiliency of habitat and constrain hydraulic processes. While these levees are meant to protect property and structures from flood waters, modeling indicates that the levee in the Pearrygin 7 reach is inundated at the 10-year flow event.

Several roads along both banks of the mainstem channel throughout the LCRA area further alter the resiliency of stream habitat to recover from disturbance. The roads are generally located

outside of the 100-year floodplain, but require streambank armoring to protect them in some locations. This riprap protection was installed as part of the road infrastructure and further constrains the channel in some locations, limiting riparian and instream habitat development and complexity. This type of bank modification is more widespread in the Chewuch-Pearrygin AU compared to Chewuch-Doe AU.

Collectively, these changes have modified the behavior of disturbances events and increased the risk from potential severe disturbance within the LCRA area. Large and severe fires, already a frequent occurrence, may increase in the future as a result of climate change. Despite these alterations, stream and watershed processes are mostly stable. Based on the rating criteria, the Chewuch-Pearrygin and Chewuch-Doe AUs are *At Risk* for the disturbance regime indicator.

4.1.2 Flow/Hydrology

Indicator: Streamflow – Alterations to Peak/Base Flow

The magnitude, timing, duration, and frequency of streamflow within a watershed is an important ecological driver within aquatic ecosystems (Poff et al. 1997). Stream discharge and channel morphology are directly linked to these processes, which are largely controlled by climate, vegetation, and geology, but also human alterations and impacts. Alterations to the natural hydrology of a watershed can affect timing and magnitude of peak and low flow events (Kondolf et al. 2001). The frequency of high-flow events can also be dramatically affected by human actions, potentially decreasing due to flow regulation (e.g., dams) and water withdrawals, or increasing from widespread timber harvest, increased impervious surfaces, or road development (Anderson et al. 2006).

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Watershed Condition	Streamflow	Change in Peak/Base Flows	Magnitude, timing, duration and frequency of peak/base 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/base 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/base flows relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.

Analysis Results

The hydrology and streamflow regime of the Chewuch River watershed is primarily driven by precipitation and snowmelt patterns. Snowmelt associated with the spring freshet is the primary source of peak flow events, which typically occur from April through early July. The highest peaks are generally observed in May and June (see also Section 3.3.8). Peak flows typically recede relatively quickly and decline to low-flow conditions from August through March. Rain-on-snow events (primarily October-March) and infrequent high intensity precipitation events can also result in short duration increases in peak flows (Inter-Fluve 2015). Three of the highest peak flow events (>5,900 ft³/s) have occurred over the past six years.

Within the LCRA area, there are three active irrigation diversions, all of which are located in the Chewuch-Pearrygin AU. Additionally, there is a surface water diversion on Eightmile Creek that diverts water from a major cold-water tributary to the lower Chewuch River (at the upstream end of the Chewuch-Pearrygin AU). Upstream of these diversions, in the Chewuch-Doe AU, streamflows are not impacted by diversions, and flows represent a more naturalized hydrograph.

All of these diversions operate during periods of low streamflow observed from late July-October; they annually exacerbate low-flow conditions in the Chewuch-Pearrygin AU during summer-fall and are a factor contributing to the Ecology 303(d) listing for instream flow impairment for the Chewuch River. Diminished instream flows reduce instream habitat availability, reduce thermal buffering capacity, and reduce passage potential for some fish species and life stages.

Analyses indicate that streamflow in the Chewuch River regularly does not meet instream flow criteria that have been established by several regulatory agencies (see Section 3.3). Instream flow impairment has occurred annually over many years and is more pronounced in the downstream reaches in the Chewuch-Pearrygin AU largely due to the water withdrawals.

Recent wildfires, most notably the 2021 Cub Creek 2 fire, may also be influencing the peak and low flow regimes in the LCRA area. There is little current data available that would help document these post-fire changes, but observations suggest that some tributary streams are exhibiting increased flood flow conveyance and are flowing at higher discharges during low-flow periods. This type of response has been observed in other areas in the Methow River watershed, including Beaver Creek after the 2014 Carlton Complex fire (BEAR 2014).

Analysis of the long-term (i.e., 30-year) patterns of streamflow in the Chewuch River revealed shifts in several aspects of the hydrograph, including an earlier onset of the spring freshet, higher peak flow, and an earlier onset of low-flow conditions (see Section 3.3.9). These types of shifts are consistent with the broader effects of climate change in the Pacific Northwest (Beechie et al. 2013, NOAA Fisheries 2014). These types of changes may pose significant challenges for fish, including reduced productivity, as they struggle to adapt to the changing conditions.

Based on analysis information for this indicator, streamflow impairment in the Chewuch River is more pronounced in the Chewuch-Pearrygin AU, where it is ranked as *Unacceptable*, compared to the Chewuch-Chewuch Doe AU, where it is ranked as *At Risk*.

4.1.3 Water Quality

Indicator: Temperature – 7-Day Average Daily Maximum Temperature

Salmonids require clean and cold water for optimal spawning, incubation, rearing, and migration. Due to this strong interaction between temperature and fish life stage, stream temperature is considered a “master variable” that is an ecological driver of overall stream productivity (Isaak et al. 2024). Water temperature affects the amount of instream oxygen present, and affects the metabolism of all life stages from egg to adult. With extended exposure to elevated temperatures (<23-25°C) and without access to temperature refugia, high temperatures can be lethal (Ecology 2000). Some species in the Chewuch River, like steelhead, can tolerate higher temperatures for longer periods than other salmonids, such as bull trout, but even more tolerant species will demonstrate higher productivity when water temperatures are lower and within optimal ranges.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Habitat Quality	Temperature	7-day average maximum temperature	Temperatures during the following life history stages For spring Chinook and steelhead: Spawning (<13°C) Rearing (<15°C) Holding (<15°C) Migration (<15°C) For bull trout: Rearing (4-12°C)	Temperatures during the following life history stages For spring Chinook and steelhead: Spawning (13-15.5°C) Rearing (15-17.5°C) Holding (15-17.5°C) Migration (15-17.5°C) For bull trout: Rearing (<4 or 13-15°C)	Temperatures during the following life history stages For spring Chinook and steelhead: Spawning (>15.5°C) Rearing (<17.5°C) Holding (<17.5°C) Migration (<17.5°C) For bull trout: Rearing (>15°C)

Analysis Results

Observed 7-day average daily maximum temperatures from 2013-2023 for the Chewuch River (see Section 3.7) reveal that water temperatures routinely exceed Washington State water temperature thresholds for both core summer habitat (16°C) and spawning and incubation (13°C). This impairment occurs throughout the mainstem from the mouth upstream to the Pasayten Wilderness boundary. High temperatures can persist for several weeks at a time, with some reaches experiencing >100 days of exceedance/year.

Stream temperatures also seasonally exceed all of the REI criteria for all species and life stages. Impairment occurs primarily during the summer from late July-August and is most pronounced in the lower reaches of Chewuch-Pearrygin AU and in the downstream reaches of Chewuch-Doe AU. Eightmile Creek provides a significant input of cold water, which serves to cool the mainstem and reduce the frequency of temperature criteria exceedance with cooling effect extending for approximately four miles downstream.

The TIR imagery for the LCRA area revealed that the Chewuch River on a late August day in 2009 varied between 15°- 16°C on the surface of the main channel. Some of the shallow near-shore areas peaked >18°C. This is notable, as juvenile salmonids rearing in larger streams often reside the low velocity areas along stream margins. The cooling effect of Eightmile Creek was also apparent in the TIR imagery, with an immediate drop in the mainstem of approximately 1°C.

Identifiable cold-water patches in the LCRA area were limited, with only a few patches located in each AU (see Section 3.7.2). Access to temperature refuge is an important factor for ESA-listed fish species residing in the LCRA area where temperatures often exceed regulatory criteria and may be biologically deleterious.

Recent EDT results indicate that temperature is the top survival factor for steelhead in both LCRA AUs and the second ranked survival factor for spring Chinook Salmon the Chewuch-

Pearrygin AU. It was not among the top five factors identified for spring Chinook in the Chewuch-Doe AU.

Based on documented exceedances of the 7-day average maximum temperature Washington State water temperature thresholds, REI criteria for life stage temperatures, and the limited amount of cold-water refuge available in the LCRA area, the indicator for water temperature is rated *Unacceptable* for both Chewuch-Pearrygin and Chewuch-Doe AUs.

4.2 Reach-Scale Metrics

4.2.1 Pathway: Habitat Access

Indicator: Physical Barriers – Main Channel Barriers

Physical barriers restrict movement of aquatic species, such as salmonids, throughout a watershed. This can result in reduced species productivity (e.g., through loss of access to spawning and/or rearing habitat and distribution of marine derived nutrients) and reduced genetic diversity within populations (NPCC 2004, WDFW 2004). It can also impede transport of large wood and sediment from source areas. This metric evaluates mainstem fish passage barriers in the LCRA area.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Habitat Access	Physical Barriers	Main Channel Barriers	No manmade barriers present in the mainstem that limit upstream or downstream fish passage 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.

Analysis Results

There are two mainstem water diversion dams on the lower Chewuch River, both located in the Chewuch-Pearrygin AU: the Fulton Dam at RM 1.2 (upstream end of Pearrygin 1 reach) and the Chewuch Dam at RM 8.6 (upstream end of Pearrygin 7 reach). Both of these structures have been modified over the past 20 years to improve fish passage. Roughened channels were installed at both sites, and a fish bypass channel was installed adjacent to the dam structure at Chewuch Dam.

Upstream impoundment of flow and fine sediment occurs at both structures; thus, dam effects extend into the upstream reaches. These effects are more pronounced at Fulton Dam, where the backwater extends approximately one-quarter mile upstream. These impoundments slow stream velocity, and substrate composition is relatively uniform, consisting of fines and sand (J. Crandall, personal observation).

These dams are not full passage barriers. However, it is likely that both possess the potential to impede or delay fish passage at some flow levels and for some life stages (e.g., fry or parr).

Fulton Dam has not been assessed for fish passage, while Chewuch Dam was assessed at only 67% passable based on Washington State fish passage criteria (WDFW 2018).

Based on the potential effects of these physical barriers on criteria for habitat access, and the upstream impoundment effects at both structures, the physical barriers indicator is rated as *At Risk* in the Pearrygin 1, 2, 7, and 8 reaches and *Adequate* in all other reaches.

4.2.2 Pathway: Habitat Quality

Indicator: Substrate – Fine Sediment

Stream substrate is important for salmonid spawning, egg incubation, and rearing. High-quality spawning areas generally include gravel/cobble dominated substrates, with relatively low amounts of interstitial fine sediments (WDFW 2004). These factors provide conditions suitable for egg incubation and alevin development (i.e., proper aeration, not smothered by fines) and young-of-the year rearing (i.e., available interstitial spaces for cover and refuge).

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Habitat Quality	Substrate	Substrate - Fine Sediment	Gravels or small cobbles make up >50% of the bed materials in spawning areas, embeddedness <20%, <12% fines/sand (<2mm) in spawning gravel.	Gravels or small cobbles make up 30-50% of the bed materials in spawning areas, embeddedness 20-30%, 12-17% fines/sand (<2mm) in spawning gravel.	Gravels or small cobbles make up <30% of the bed materials in spawning areas, embeddedness >30%, >17% fines/sand (<2mm) in spawning gravel.

Analysis Results

Data collected and compiled for this indicator reveal that stream sediment within the LCRA area is predominately gravel and cobble along with significant accumulations of fine sediments (<6.3mm grain size) in many reaches. Spawning reaches are dominated by gravel and cobble substrates, including 78.7% (range = 43-91%) in Chewuch-Pearrygin AU and 75.8% (range = 6-89%) in Chewuch-DoE AU. All reaches, with the exception of Pearrygin 7 (43%), contained >60% gravel and cobble which rates as *Adequate* condition.

Embeddedness in the LCRA, as observed in pooltails (n = 150 pools) and defined as >35% of substrate embedded by fines, was widespread and present in all reaches. The percent of embedded pools was approximately half of the pools in each AU (Pearrygin AU average = 56%, reach range = 10-100%; DOE AU average = 50%, reach range = 17-67%). The percent embeddedness exceeded *Adequate* condition criteria in all reaches except for Doe 6 where embeddedness was observed at 16.3% averaged across 12 pools. Embeddedness exceeded the 30% level for *Unacceptable* condition in 7 of 10 reaches in Chewuch-Pearrygin AU (no pools were present in Pearrygin 6 reach) and 5 of 6 reaches in Chewuch-DoE AU. Pearrygin 4, 5 and 9 reaches fell within *At Risk* condition for this variable, with 29.5%, 20.8%, and 21.7% embeddedness, respectively.

Fine sediment core samples collected in 2022 from several reaches within the LCRA area (n = 7, 3 in Chewuch-Pearrygin AU, 4 in Chewuch-DoE AU) revealed between 13–48% fine sediment present in spawning gravels. All of these samples exceeded the 12% criteria required for

Adequate condition, and only samples from Pearrygin 1 and 9 contained between >12-17% (*At Risk* condition). All other samples were >17% and within the *Unacceptable* range.

Pebble counts collected in 2023 in support of the LCRA revealed similar patterns of fine sediment accumulations as those observed in the 2022 sampling. Fines (<6.3mm) accounted for >17% of observed substrate in 11 of 17 reaches (8 of 11 reaches in Chewuch-Pearrygin AU and 3 of 6 reaches in Chewuch-Doe AU). Fines in only two reaches, Pearrygin 9 and 11, were <12% required for *Adequate* condition. Four other reaches, Pearrygin 10 and Doe 1, 3, and 6 were observed between >12 – 17% fines.

A significant portion of the LCRA area has burned in wildfires recently, with some areas undergoing very intense burn conditions, especially in the Chewuch-Doe AU. When wildfires burn through riparian zones and uplands the loss of ground cover and other vegetation often results in an increase of surface fine materials being transported into the stream. Beaty (1994) used data from a continuously monitored small stream in eastern Canada that was subjected to two forest fires. Precipitation, stream discharge, bedload transport, and suspended material concentrations were measured, along with organic debris. Bedload transport increased by a factor of 20 after the first fire, and by a factor of 3 after the second fire. Analysis of the bedload data indicated that there was approximately a 5- to 6-year recovery period after the first fire, and a much shorter one after the second.

The LCRA area is within this 5–6-year post-fire window (and LCRA sediment data also were collected within this time period), and the stream channel may be acutely impacted by inputs of fine sediment. Several large debris flows occurred post-fire, primarily within the Chewuch-Doe AU, which contributed significant volumes of fines (and other, larger sediments and large wood) to the stream channel. Over several years from 2021-2024, this sediment was observed in large accumulations that appeared to be moving downstream after each spring freshet event.

Based on the gravel and cobble composition found throughout the LCRA area, pooltail embeddedness, and fine sediment presence, as well as ongoing impacts to sediment transport related to recent fires, the indicator for fine sediment is rated as *At Risk-Unacceptable* in most reaches. Non-spawning reaches, including Pearrygin 1, 2, and 6 and Doe 3 were generally ranked higher (less impairment), as they do not contain suitable spawning habitat where accumulations of fine sediment are more problematic. However, Pearrygin 2 was ranked as *Unacceptable* due to the excessive sediment present as a result of the Fulton Dam impoundment.

This indicator is currently in flux within the LCRA as the watershed responds to the recent fires and floods and should be re-evaluated in the next 3-5 years.

Indicator: Large Woody Material

Instream large wood (LW) provides critical instream habitat structure and helps create and sustain channel complexity over time. Individual pieces of large wood and log jams can elevate salmonid habitat quality through the provision of quality pools, cover, food resources, and refuge from predators (NPCC 2004).

Not all reaches are similar in their geomorphic capability to retain and transport large wood. For example, stream confinement, gradient, and bankfull width are variables associated with wood transport and storage potential within a stream reach (Kramer and Wohl 2017). Based on these characteristics, the majority of reaches in the LCRA area have wood storage potential, including

Pearrygin 3-5, 7, and 10 and Doe 1, 2, 5, and 6. The other reaches are higher gradient, more confined, and lacking larger off-channel and floodplain habitat. Reaches that lack appreciable wood storage potential include Pearrygin 1, 2, 6, 8, and 11 and Doe 3 and 4.

The large wood indicator evaluates the quantity of LW in pieces per mile. Although the standards for properly functioning (*Adequate*) condition are 20 pieces (≥ 12 inches diameter at breast height and over 35 feet in length) per mile (USFWS 1998), Fox and Bolton (2007) determined that this standard was low, since larger eastern Washington streams (16-164 feet bankfull width) surveyed in unmanaged forested basins had an average of 42.5 pieces of LW per mile. In addition, other inventories on eastern Washington streams have found LW quantities much higher at over 140 pieces of LW per mile (Inter-Fluve 2012).

While the target of 42.5 pieces of LW per mile has been used for other river assessments in the Upper Columbia region and during the development of stream restoration projects, we deferred to the criteria established by the RTT for this REI analysis. All reaches in the LCRA area were $>16.4'$ wetted width, so the 70 pieces/mile criteria applied to all reaches (see criteria table below).

For this metric, riparian condition and the presence and distribution of engineered or natural wood jams were also examined to assist with ranking. Wood jams provide important habitat for salmonids, especially juveniles, and are an important driver of instream habitat diversity.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Habitat Quality	Large Woody Material	Pieces per mile within bankfull channel	LW ($> 12''$ d.b.h $> 35'$ length) is greater than: $<16.4'$ wetted width 20 pieces/mile $\geq 16.4'$ wetted width 70 pieces/mile Adequate rating also indicates there are sources of LW available for both long- and short-term recruitment within the reach.	LW ($> 12''$ d.b.h $> 35'$ length) is greater than: $<16.4'$ wetted width $>0 - 17$ pieces/mile $\geq 16.4'$ wetted width $17 - 70$ pieces/mile Current levels are able to maintain the minimum requirements for an <i>Adequate</i> rating, but potential sources for long-term LW recruitment, as determined by the Riparian Structure metric, are lacking in order to maintain these current levels.	LW ($> 12''$ d.b.h $> 35'$ length) is greater than: $<16.4'$ wetted width 0 pieces/mile $\geq 16.4'$ wetted width $0 - 17$ pieces/mile Current levels are not meeting the minimum requirements for an <i>Adequate</i> or <i>At Risk</i> rating, and potential sources of LW for short- and/or long-term recruitment are lacking as well.

Analysis Results

Natural and installed LW and wood jams that were present within the bankfull elevational surface of the LCRA area was inventoried in 2023 (see Section 3.6.1.5). Due to log size criteria for this metric, only the medium and large pieces of LW applied. Of the 762 natural pieces counted during this survey, only the 229 medium and 178 large pieces qualified. Together, they totaled 407 pieces of qualifying LW in the LCRA area, which equates to 20 pieces/mile throughout the LCRA area. This number is substantially below the 70 pieces/mile needed to

meet *Adequate* condition for this indicator. The LCRA area ranks as *At Risk* condition for large wood, falling slightly above the 17 pieces/mile required for this condition rank.

When viewed at the assessment unit scale, medium and large wood was over twice as abundant in the Chewuch-Doe AU (29.2 pieces/mile) compared to the Chewuch-Pearrygin AU (13.8 pieces/mile). Both of these densities are far below the *Adequate* condition criteria, with the former at the lower end of the *At Risk* category and the latter within *Unacceptable* condition range.

Installation of engineered wood has had a significant impact on the density of large wood within the LCRA area, but the degree of impact varies substantially by location. The inclusion of installed pieces of wood (which were all considered medium or large pieces) increased the pieces/mile density over three-fold in Chewuch-Pearrygin AU (46.5 pieces/mile) and over four-fold in Chewuch-Doe AU (121.9 pieces/mile). These including installed wood improved the condition in both AUs to *At Risk* and *Adequate*, respectively.

At the reach scale, none of the 17 reaches met the REI wood criteria for *Adequate* with natural wood alone (Table 4.2.1). The majority of reaches (n=11) contained <17 natural pieces/mile (*Unacceptable*), including 10 of 11 reaches in Chewuch-Pearrygin AU. Of the remaining six reaches, none contained >30 natural pieces/mile (*At Risk*).

Adding installed wood to the count increased the total pieces/mile counts in 9 of 17 reaches, which indicates where restoration projects have been located. No increase in density (e.g., no restoration to date) was observed in Pearrygin 1-3 and 5-9 reaches. Substantial increases were observed in all other reaches, including Pearrygin 4, 10, and 11 and Doe 1-6. The addition of engineered wood placed all but Doe 3 (28.6 combined pieces/mile) into the *Adequate* category.

Table 4.2.1. Medium and large wood pieces per mile, natural and combined (includes natural and engineered pieces) LCRA area, 2023.

Reach	Natural wood pieces/mile	Combined wood pieces/mile	Meets Adequate Criteria - Natural	Meets Adequate Criteria - Combined
Pearrygin 1	2.7	2.7	No	No
Pearrygin 2	5.6	5.6	No	No
Pearrygin 3	17.6	17.6	No	No
Pearrygin 4	31.8	119.4	No	Yes
Pearrygin 5	18.5	18.5	No	No
Pearrygin 6	0.0	0.0	No	No
Pearrygin 7	12.4	12.4	No	No
Pearrygin 8	16.7	16.7	No	No
Pearrygin 9	2.0	2.0	No	No
Pearrygin 10	13.4	148.5	No	Yes
Pearrygin 11	5.0	124.2	No	Yes
Doe 1	19.3	203.3	No	Yes
Doe 2	27.0	137.0	No	Yes
Doe 3	13.0	28.6	No	No
Doe 4	33.6	95.7	No	Yes
Doe 5	29.6	121.2	No	Yes
Doe 6	38.2	83.5	No	Yes

Wood jams, both natural and engineered, were observed in many reaches except for Pearrygin 2, 6, and 9 reaches, where no wood jams were observed. All of these reaches were determined to be transport reaches based on channel characteristics, so the lack of jams is not surprising.

For the reaches that contained natural wood jams, densities ranged from 0.9 – 4 natural jams/miles (mean= 1.2) in Chewuch-Pearrygin AU and 2.6 - 4.3 natural jams/mile (mean=2.6) in Chewuch-Doe AU. Overall, natural wood jams were much more commonly observed in the Chewuch-Doe AU, with many of these present in and around floodplain surfaces and side channels.

Including engineered wood jams in the counts increased the densities in reaches where restoration projects have been located, including Pearrygin 4, 10-11 and all six reaches in the Doe AU. In all other reaches, any log jams are naturally occurring.

By combining natural and engineered wood jam counts, densities increased to 3.1 jams/mile and 6.7 jams/mile in Chewuch-Pearrygin and Chewuch-Doe AUs, respectively.

Riparian condition varies across reaches (see Section 3.6.1.6) and with it the potential for each reach to recruit large wood to the stream channel and floodplain. Trees comprised 22-51% of the floodplain area within the LCRA area. Tree coverage was generally higher in the more unconfined reaches or in reaches with less developed lands. These reaches (Pearrygin 4 and 5 and Doe 1-2 and 4-5) likely have an increased ability to contribute large wood to the stream channel. Reduced contribution and retention potential exists in some confined reaches, such as Pearrygin 1-2, 6, 8-9, and 11 and Doe 3 and 4, where floodplain habitat is less extensive and relatively limited.

Within the LCRA area, there is an overall lack of natural large wood. The assessment area has seen a decrease in large wood density since 2008 (see Section 3.6.1.5), and the low density of natural wood jams likely limits the potential for habitat quality. The installation of ELS has significantly increased the density of large wood in some reaches, and especially in the Chewuch-Doe AU, but much of this wood is located above the low-flow channel, was placed in tightly clustered configurations, and is unlikely to afford the same habitat benefits as naturally-occurring wood. There is also a systemic decrease in overall wood recruitment potential within the LCRA area due to riparian and floodplain degradation and recent wildfires. Based on this information, the indicator for large wood was rated as *Unacceptable* in the Pearrygin 2, 3, 5, 6, 7 and 9 reaches and *At Risk* in all other reaches.

Indicator: Pools – Pool Spacing and Frequency

Pools are well recognized as key habitat for adult and juvenile salmonids, providing areas for resting, rearing, and foraging (WDFW 2004). Pool spacing, frequency, and quality are important factors in providing maximum benefit to fish. Larger, deeper pools spaced closer together can provide thermal refuge for adult holding or juvenile rearing, and additional benefits are recognized when instream complexity features, such as submerged large wood or low hanging vegetation, are present to provide cover from predators and important food sources for salmonids (WDFW 2004). High quality pools that are near spawning areas provide valuable holding habitat for pre-spawn adults.

As pools provide high value habitat for fish and contribute to instream complexity, pool spacing and frequency are important metrics. Both tend to increase in lower gradient channels and with an increasing abundance of wood (Montgomery et al. 1995, Beechie and Sibley 1997). In channels with high wood abundance, pool spacing is typically around one channel width (CW)

between pools. However, in steeper channels, pool spacing tends to be controlled by the formation of steps at a spacing of about two CW per pool (Montgomery et al. 1995).

Criteria (Source: UC RTT 2021, NMFS 1996; USFWS 1998 as modified by USBR 2012):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable										
Habitat Quality	Pools	Pool Spacing Also includes Pool Frequency and quality	<p>Pool spacing</p> <p>Bankfull channel widths</p> <p>Gradient <1%: ≤ 2 CW/Pool</p> <p>Gradient >1%: ≤ 3 CW/Pool</p> <p>#pools/mile</p> <p>Wetted width</p> <table> <tr> <td>20'-30'</td> <td>23</td> </tr> <tr> <td>30'-35'</td> <td>18</td> </tr> <tr> <td>35'-40'</td> <td>10</td> </tr> <tr> <td>40'-65'</td> <td>9</td> </tr> <tr> <td>>65'</td> <td>4</td> </tr> </table> <p>Pools only have a minor reduction of pool volume by fine sediment, including pooltail fines.</p>	20'-30'	23	30'-35'	18	35'-40'	10	40'-65'	9	>65'	4	No criteria for At Risk Condition	<p>Pool spacing</p> <p>Bankfull channel widths</p> <p>Gradient <1%: > 2 CW/Pool</p> <p>Gradient >1%: > 3 CW/Pool</p>
20'-30'	23														
30'-35'	18														
35'-40'	10														
40'-65'	9														
>65'	4														

Analysis Results

Within the LCRA area, 8 of 17 reaches were determined to be relatively unconfined and, as such, can be considered for pool spacing criteria within the REI framework. All of the qualifying reaches were <1% channel gradient (see Section 3.5.), which requires ≤ 2 bankfull channel width/pool for adequate condition designation. None of these reaches had < 2 CW/pool (Table 4.2.2; range = 0-4 CW/pool, mean = 2.9 CW/pool), which places all of them into *Unacceptable* condition. Pearrygin 4 reach had the lowest ratio at 2.8 CW/pool. The remaining reaches had between 3-4 CW/pool, except for Pearrygin 6 reach, which contained no pools in 2023.

Pool density (pools/mile) condition designation is dependent on wetted width, and only three reaches (Pearrygin 1, 2, and 6) had > 65' widths, which lowers the pool count for *Adequate* condition to four pools/mile. All other reaches required 9 pools/mile for *Adequate* condition as widths were <65'. Habitat survey results revealed some reaches in *Adequate* condition for pool density, including Pearrygin 1, 3, 8-10, and Doe 1-2, and 4-5 (See Section 3.5.1.2). Five reaches, including Pearrygin 3 and 10 and Doe 1-2 and 5 were in *Adequate* condition for pools/mile, but not for pool spacing.

Pool quality (i.e., depth and cover) throughout the LCRA area was qualitatively assessed as *Adequate* to *At Risk* in many reaches (J. Crandall, personal observation). In Chewuch-Pearrygin reach, 71% of pools were >3' deep and over 80% of pools were >3' in Chewuch-Doe AU. Many pools in Chewuch-Doe AU had enhanced cover provided by engineered log structures. However, many pools lacked significant amount of woody or riparian cover or areas of undercut bank that could have increased pool quality.

For pools, the LCRA area should generally be viewed as functioning between *Unacceptable-At Risk* due to the overall high pool spacing in unconfined reaches, insufficient fish cover in some pools, and the presence high amounts of pooltail sand, fines, and algae. The reach-based condition is *Unacceptable* in reaches where both pool spacing and density did not meet adequate criteria, and *At-Risk* in reaches where density met criteria, but pool spacing did not. Many of these reaches were either unconfined or contained installed large wood.

Table 4.2.2. Reach confinement, pool count, channel width spacing, and pools per mile, LCRA area, 2023.

Reach	(Relatively) Unconfined Reach	Pool Count	Channel Widths/Pool	Meets Adequate Criteria	Pools/mile	Adequate Pools/mile	Meets Adequate Criteria
Pearrygin 1	No	5	10.7	n/a	4.5	4	Yes
Pearrygin 2	No	3	17.1	n/a	2.4	4	No
Pearrygin 3	Yes	23	3.2	No	9.6	9	Yes
Pearrygin 4	Yes	19	2.8	No	8.6	9	No
Pearrygin 5	Yes	11	4.0	No	6.9	9	No
Pearrygin 6	Yes	0	0.0	No	0.0	4	No
Pearrygin 7	No	6	7.1	n/a	5.0	9	No
Pearrygin 8	No	14	3.7	n/a	9.9	9	Yes
Pearrygin 9	No	9	2.7	n/a	16.0	9	Yes
Pearrygin 10	Yes	7	3.2	No	9.4	9	Yes
Pearrygin 11	No	9	7.2	n/a	6.1	9	No
Doe 1	Yes	17	3.1	No	10.9	9	Yes
Doe 2	Yes	14	3.3	No	10.1	9	Yes
Doe 3	No	3	6.5	n/a	7.8	9	No
Doe 4	No	23	3.1	n/a	12.0	9	Yes
Doe 5	Yes	24	3.7	No	10.3	9	Yes
Doe 6	No	18	5.5	n/a	7.4	9	No

Indicator: Off-Channel Habitat and Refugia

Off-channel habitats, sloughs, wetlands, oxbow lakes, backwaters, floodplain channels, and side channels can provide important rearing habitat for juvenile salmonids (Roni et al. 2002). These areas can provide high-flow refugia, temperature refugia, and protection from predators, as well as productive feeding areas. Off-channel habitats in the LCRA area were identified during field surveys for the reach assessment and spatial analysis using the 2022 lidar data.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Habitat Quality	Off-Channel Habitat	Connectivity with main channel	Reach has many ponds, oxbows, backwaters, side channels and other low-energy off-channel areas with cover. No manmade barriers present along the mainstem that prevent access to off-channel area. Reach possesses conditions that would be expected in the absence of human disturbance.	Reach has some ponds, oxbows, backwaters, side channels and other low-energy off-channel areas with cover. Side channels are generally high-energy areas. Manmade barriers present along the mainstem that prevent access to off-channel areas at some flows that are biologically significant.	Reach has few or no ponds, oxbows, backwaters, side channels and other off-channel areas. Manmade barriers present that prevent access to off-channel habitat at multiple or all flows.

Analysis Results

The 2023 habitat survey data revealed 33 perennial side channels present in the LCRA area, with 20 in Chewuch-Pearrygin AU and 13 in Chewuch-Doe AU (see Section 3.6.1.3). Combined, these side channels comprised approximately 3.5 miles of off-channel habitat at low flows, including 2.2 miles and 1.3 miles in the two AUs, respectively. Side channels accounted for 18% and 16% of the mainstem length in Chewuch-Pearrygin and Chewuch-Doe AUs, respectively, which is nearly one-fifth of the total reach length in the LCRA area.

2-D hydraulic modeling revealed additional side channels connected at the 2-year discharge, including 36 in Chewuch-Pearrygin AU and 17 in the Chewuch-Doe AU. Some of these included multi-threaded side channels flowing over floodplain surfaces, so the precise number of side channels present at the bankfull stage may differ slightly depending on how they are defined. Additional side channels are activated at the 100-year modeled flow inundation levels, but others disappear as the islands separating them from the mainstem become inundated. Reaches with the largest gains in side channel habitat at bankfull flows included Pearrygin 3-5 and Doe 1, 5, and 6.

The 2023 habitat survey and review of 2022 lidar data, revealed only one levee (in Pearrygin 7 reach) that appears to prevent side channel and floodplain inundation at flows >1.5-year discharge. Three reaches, including Pearrygin 6 and 7 and Doe 3, had no low flow side channels, but also no off-channel areas that were blocked at either low flows or higher discharges by levees or other anthropogenic structures in these reaches.

Road, residential, and agricultural development have curtailed off-channel connectivity to varying degrees in several reaches, including Pearrygin 3, 6-8, and 10.

Backwaters and sloughs were present in many reaches at bankfull discharge. Not surprisingly, far fewer were present during low-flow conditions. Similar to side channel presence, the reaches with the most off-channel habitat development included the unconfined reaches such as Pearrygin 3-5 and Doe 1 and 5.

Several areas of oxbow and slough type habitat were observed, but these are uncommon in the LCRA area. Reaches Pearrygin 3 and 10 and Doe 1 and 4 all contain oxbow type habitats, but none of them are well connected at low flows. At bankfull flows, all are more connected and likely allow much more potential for fish access. The backwater pond area in Doe 1 reach (near RM 12.5) was the site of recent restoration efforts to increase cover and complexity.

The RSI model outputs for both juvenile steelhead and spring Chinook Salmon (see Section 3.10) indicate several locations of off-channel habitat (backwaters, alcoves) that have pockets of highly suitable habitat, yet it is likely the many reaches would benefit from additional off-channel habitat enhancement.

Based primarily on the high degree of mainstem and off-channel habitat connectivity, many reaches in the LCRA area were rated as *Adequate* for the off-channel habitat indicator. Many of these reaches are functioning appropriately given their geomorphic setting (e.g., within a confined channel). There are several areas where connectivity could be increased to improve habitat access, and these are ranked as *At Risk*. Many of these reaches have been impacted by anthropogenic development such as residential development in floodplain habitat.

4.2.3 Pathway: Riparian Vegetation

Indicator: Structure

Riparian areas have many important geomorphic and ecological roles within the stream ecosystems. Intact riparian corridors help maintain streambank stability, and provide a source of large wood, water filtration processes, organic input, streambank habitat and cover, hydraulic regulation, and temperature fluctuation modification (Gregory et al. 1991).

For the purposes of this REI analysis, the riparian area was defined as the area contained by a 30-meter buffer from the 2-year modeled flow bank, which approximates one site potential tree height. Riparian vegetation and cover were also examined within the 10-year floodplain surface perimeter. The structure of riparian areas is evaluated based on how well the seral stage, species composition, and complexity approximate natural conditions that would be expected in the absence of human alterations. The analysis for this indicator used spatial analysis based off the 2018 lidar and professional judgement evaluating post-Cub Creek (2021) fire impacts.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Riparian Vegetation	Condition	Structure	>80% species composition, seral stage, and structural complexity are consistent with potential native community.	50-80% species composition, seral stage, and structural complexity are consistent with potential native community.	<50% species composition, seral stage, and structural complexity are consistent with potential native community.

Analysis Results

Riparian habitat structure within the LCRA area varies considerably based on location and past and current disturbance regimes. No specific analyses were completed to assess species composition, but qualitative observations made during the 2023-2024 habitat surveys indicated that nearly all riparian vegetation along the lower Chewuch River was native, with very few observations of non-native species. Observations of non-native species were generally confined to areas where residential or agricultural development was present, especially in reaches in and around the Town of Winthrop (i.e., Pearrygin 1-3 reaches).

Overall, many reaches across both AUs were similar in their riparian structural composition (see Section 3.6.1.6). Outside of developed areas, mature trees occupied the most area in riparian zones in all reaches except for Doe 3 reach. Doe 3 is a relatively short, confined reach with extensive areas of riparian clearing (37% of the 10-year floodplain), including campgrounds and old agricultural fields. Reaches Pearrygin 1 and 2 lie adjacent to the Town of Winthrop, and residential development has been extensive along the stream channel in this area and resulted in clearing of extensive amounts of riparian vegetation.

No reaches had >50% development within the 10-year floodplain, but 12 of 17 had between 20-30% developed area, which represents a significant reduction in the overall extent of riparian habitat in these reaches and places them *At Risk* for this indicator. Only five reaches, including Pearrygin 5 and 9 and Doe 2, 4, and 5 had 20% or less developed areas. Within these reaches, mature trees were the dominant vegetation class, with appreciable amounts of shrub habitat (10-

17% understory vegetation), indicating that these reaches possess relatively functional riparian structure.

However, recent disturbance from the 2021 Cub Creek 2 fire significantly impacted riparian habitat, including significant floodplain areas within the Pearrygin 8 and Doe 4 and 4 reaches. The burn reduced the structural complexity of riparian habitat in these reaches, and it will take many years to recover to a functional state.

The appreciable development (e.g., roads, residential, recreational) of riparian areas within the LCRA area has dramatically altered riparian structure in some reaches including Pearrygin 1 and 2 and Doe 3, and these reaches are rated as *Unacceptable*. Other areas have also experienced >20% development within the 10-year floodplain that has dramatically diminished riparian habitat function, and these reaches are rated *At Risk*. Recent wildfires have burned extensive areas of riparian habitat in some reaches where riparian habitat was relatively intact and functional (Doe 4 and 5), and these are also rated *At Risk*. Riparian structure was rated as *Adequate* in only Pearrygin 5 and Doe 2, where development was <20% and the reaches contained extensive areas of relatively functional riparian habitat despite some streamside road and recreational development.

Indicator: Disturbance - Human

Human disturbance can change and influence how a river interacts with its active channel, floodplain, and riparian areas. Often, human disturbance in the floodplain results in reduced occurrence of mature seral stages of vegetation and riparian structure, and limits channel migration and erosion processes (UCSRB 2017). This can affect riparian processes, including bank stability, wood recruitment, shade, and water quality.

Criteria (Source: UC RTT 2021):

Pathway	General Indicator	Specific Indicator	Adequate	At Risk	Unacceptable
Riparian Vegetation	Condition	Disturbance (human)	>80% mature trees (medium-large) in the riparian buffer zone 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 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 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.

Analysis Results

Overall, riparian vegetation along the lower Chewuch River has been heavily disturbed over the past 150 years due in part to clearing of riparian habitat for residential and agricultural development and logging. Road development along both banks has also occurred along the entire length of the LCRA area, and this has resulted in direct loss of vegetation and also bank armoring (to protect the road prism) in some reaches, including Pearrygin 1, 7, 9, and 11 and Doe 4, 5, and 6. More recently, recreational development (e.g., campgrounds and access roads)

has resulted in loss and conversion of riparian habitat in a number of areas, especially on public lands upstream of Eightmile Creek.

These disturbances have resulted in >20% developed areas within the 10-year floodplain in 11 of 17 reaches, including Pearrygin 1-4, 6-8, and 10-11 and Doe 1, 3, and 6 (see Section 3.6.1.6). Much of this development likely removed mature trees that could have contributed to instream large wood, but the understories were also likely significantly impacted, which served to further diminish riparian function. Additionally, the stream channel has diminished potential for migration as a direct result of development. This degree of development places these reaches *At Risk* for this aspect of the disturbance indicator.

Closer to the stream channel, streambank disturbance has been significant (>18%) in some areas, especially in Pearrygin 1-2, 7, 9 and 11 and Doe 1 and 4. Much of this disturbance (i.e., riparian clearing) is associated with development across the broader floodplain surfaces and stems from road and residential/agricultural/recreational development.

Floodplain and streambank cover data (see Section 3.6.1.6.) indicates that mature trees comprise a significant portion of the 10-year floodplain and streambank forest in many reaches. Ostensibly, these trees could be available for instream recruitment, but adjacent development has reduced this potential in many reaches. Streambank trees comprise between 35-60% of the area in a number of reaches, but this is likely much lower than was available prior to anthropogenic disturbance. Tree cover is lowest (15-35%) in the more developed areas, especially those with residential development, including Pearrygin 1-2, 7, and 9-10. Instream large wood recruitment potential in these reaches is likely very low.

Road development in the 2 and 10-year floodplain is minimal in most reaches, except for Pearrygin 3 where a residential development covers approximately 20 acres of floodplain surface (Table 4.2.3). Road development in Doe 6 reach occupies 0.08 miles and was the second highest for the 10-year floodplain surface. 10 of 17 reaches had no roads identified in the 10-year floodplain.

Road development was higher within the larger 100-year floodplain surface, but no reaches exceeded the *Unacceptable* threshold density of 3 mi/mi². Floodplain road development has been minimal in Pearrygin 5, 8, and Doe 1 reaches where residential or recreational access road development has occurred.

Only one reach, Doe 3, contained a density of >2 mi/mi². This high density is because Doe 3 is a small reach (0.01 mi²) with one 144' road segment. While this road represents a disturbance to riparian habitat, it is not as significant, or extensive, as the other anthropogenic development (i.e., riparian clearing) within this reach. Other reaches with >1 miles/miles² of floodplain road development included Pearrygin 3, 6 and 10-11 and Doe 6, but these were within *Adequate* condition (<2 mi/mi²).

The density of medium to large trees in the riparian zone is less than five percent throughout the LMRA area, and therefore the resulting potential recruitment into the river is low. Although a large portion of the LMRA area is natural land cover (>80 percent), only 26.3 percent of the riparian area has vegetation cover taller than one foot.

Table 4.2.3. Reach-based road miles within floodplain perimeter, and 100-year floodplain road density, LCRA area. Information based on 2-D hydraulic model output and road data.

Prioritization Reach	Q2 Road Miles	Q10 Road Miles	Q100 Road Miles	Q100 Road mi./sq.mi.
Pearrygin 1	0.00	0.00	0.00	0.55
Pearrygin 2	0.00	0.00	0.01	0.26
Pearrygin 3	0.00	0.18	0.45	1.77
Pearrygin 4	0.00	0.02	0.03	0.09
Pearrygin 5	0.00	0.00	0.00	0.00
Pearrygin 6	0.00	0.03	0.03	1.29
Pearrygin 7	0.00	0.00	0.00	0.26
Pearrygin 8	0.00	0.00	0.00	0.00
Pearrygin 9	0.00	0.00	0.00	0.44
Pearrygin 10	0.00	0.02	0.03	1.52
Pearrygin 11	0.00	0.00	0.09	1.65
Doe 1	0.00	0.00	0.00	0.00
Doe 2	0.00	0.00	0.00	0.28
Doe 3	0.01	0.02	0.02	2.55
Doe 4	0.00	0.00	0.03	0.92
Doe 5	0.00	0.04	0.12	0.64
Doe 6	0.03	0.08	0.13	1.22

Combined, the data for human disturbance in the riparian areas of the LCRA area suggest a significantly degraded condition throughout much of the assessment area. The higher degree of residential development, roads, and riparian clearing in Pearrygin 1-3, 6, 7, 10, and 11 leads to an *Unacceptable* ranking for these reaches. Doe 3 reach was also designated as *Unacceptable* due to the high degree of riparian disturbance in this relatively short reach. Condition was assessed as *At Risk* for all other reaches.

Indicator: Canopy Cover

Riparian canopies provide shade and moderate light availability to the stream, which directly affects water temperature, relative humidity, and algal growth (Ecology 2007). Water temperature is a primary driver of the overall health, productivity, and life cycles of many aquatic organisms, including salmonids. High water temperatures can often be a factor limiting habitat quality for rearing and spawning salmonids (Ecology 2000).

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Riparian	Condition	Canopy Cover	Trees and shrubs within one site potential tree height distance have >80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance have 50- 80% canopy cover that provides thermal shading to the river.	Trees and shrubs within one site potential tree height distance have <50% canopy cover that provides thermal shading to the river.

Analysis Results

Streambank canopy cover was assessed through analysis of a 100 ft buffer of the approximately 1-year discharge boundary (~1700 ft³/s). Riparian canopy in the LCRA area consists predominantly of black cottonwood, ponderosa pine, and Douglas fir trees. Understory species include primarily mountain alder, red-osier dogwood, water birch, and black hawthorn. The understory trees can reach over 30' in height and are able to provide stream shading, albeit limited compared to the taller overstory species. For this reason, shrub cover was included in the canopy cover calculations.

Within in the riparian buffer area, no reach contained the >80% cover necessary for *Adequate* designation (Table 4.2.4). Most reaches contained 50-70% cover, placing them in the *At Risk* class for this indicator. Pearrygin 5 reach had the highest canopy cover at 72%, followed by Pearrygin 6 and Doe 2 reaches at 69% and 66.6% cover, respectively. Without including shrub coverage, no reach would have ranked as *Adequate*, and only Pearrygin 5 and 6 and Doe 2 would have ranked as *At Risk*, with all other reaches in *Unacceptable* condition.

Three reaches, Pearrygin 1, 2, and 7 had <50% canopy cover with 22.6%, 45.9%, and 46.4% cover, respectively. These reaches were rated as *Unacceptable*.

Table 4.2.4. Reach-based shrub and tree canopy cover within 100' streambank buffer zone, LCRA area. Data based on analysis of 2018 lidar data.

Prioritization Reach	Shrub Cover %	Tree Cover %	Shrub/Tree Cover %
Pearrygin 1	7.3	15.3	22.6
Pearrygin 2	12.5	33.4	45.9
Pearrygin 3	16.8	41.5	58.3
Pearrygin 4	12.2	47.7	59.9
Pearrygin 5	15.5	56.7	72.2
Pearrygin 6	9.4	59.6	69.0
Pearrygin 7	12.4	34.1	46.4
Pearrygin 8	15.1	49.6	64.7
Pearrygin 9	20.7	32.2	52.9
Pearrygin 10	23.7	30.5	54.2
Pearrygin 11	13.6	37.2	50.8
Doe 1	14.1	36.6	50.7
Doe 2	14.6	52.0	66.6
Doe 3	8.1	43.1	51.2
Doe 4	10.5	48.8	59.3
Doe 5	20.2	37.5	57.7
Doe 6	14.1	47.3	61.4

4.2.4 Pathway: Channel

Indicator: Dynamics – Floodplain Connectivity

Floodplains serve a number of significant geomorphic and ecological functions within aquatic ecosystems, including flood energy dissipation, flood waters conveyance, sediment source and storage, large wood supply, a nutrient source, and development of diverse habitat for aquatic and terrestrial species (Allen 1970, Nanson and Croke 1992, Zwolinski 1992).

Floodplain connectivity in the LCRA area was evaluated based on the results from the 2-D hydraulic modeling, floodplain inundation analysis, geomorphic mapping, and observations of modified features made during the 2023 habitat survey.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
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 wetlands, 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 and succession.	Severe reduction in hydrologic connectivity between off-channel wetland, floodplain, and riparian areas. Wetland extent drastically reduced and riparian vegetation and succession altered significantly.

Analysis Results

The lower Chewuch River varies in its degree of natural confinement and contains reaches ranging from confined (e.g., Pearrygin 1 and 2) to unconfined (e.g., Pearrygin 3, Doe 1). As a result, floodplain area within each reach also varies as does the degree of impairment of floodplain connectivity.

Reaches Pearrygin 1 and 2, which are both confined within a narrow valley and bedrock, have areas of bank alteration (e.g., Fulton Dam, residential/commercial development in and around Winthrop). However, due to the natural confinement these reaches, this bank alteration has had minimal impact to floodplain connectivity, and these reaches are in *Adequate* condition.

Several levees and other floodplain developments have reduced the extent and frequency of floodplain inundation within Pearrygin 3-4 reaches and because of this these reaches are functioning *At Risk* for this indicator. Of particular note, the riprap/levee at RM 2.9 (Pearrygin 3 reach) curtails connectivity across an approximately 20-acre floodplain surface. This floodplain has also been developed for residential purposes, further degrading floodplain condition. In Pearrygin 4 reach, a golf course development has disrupted natural floodplain process and topography over approximately 58 acres.

There has also been significant floodplain alteration and disconnection in Pearrygin 6 and 7 reaches, where residential development at the Cub Creek confluence and agricultural development and water diversion infrastructure/development around the Ramsey Creek confluence has blocked floodplain extent and quality on >20 acres of floodplain. Additional

levees, residential developments, and a bridge crossing in Pearrygin 7 reach further degrade floodplain connectivity. Both of these reaches are ranked as *Unacceptable* for this metric.

There has been some degree of floodplain development within Pearrygin 8 reach, including development and floodplain and bank alteration at the Chewuch Dam site which has resulted in reduced connectivity and riparian condition on adjacent floodplain surfaces. The construction and maintenance of the Skyline Ditch has manipulated the river right floodplain at the upstream end of this reach. Relic irrigation development on the floodplain downstream of the Boulder Creek confluence currently exerts legacy effects on several acres of floodplain that has also been cleared for recreational purposes. These impacts put this reach *At Risk* for floodplain connectivity. Upstream of this reach, in Pearrygin 9, floodplain connectivity remains in in *Adequate* condition due to minimal disruptions in this relatively short reach with minimal floodplain area.

In Pearrygin 10 and 11 reaches, there has been extensive residential development and associated levee and riprap installation to protect the structures. Of particular note are the floodplain developments on river left between RM 10.5-11.2, which have reduced connectivity and blocked flow paths at flows exceeding approximately the 2-year flood elevation. Additionally, development of the hatchery fish rearing facility on river right at RM 11 has altered decreased floodplain extent above the 10-year flood. For these reasons, these reaches are ranked as *Unacceptable* for the floodplain connectivity indicator.

Overall, in the Chewuch-Doe AU floodplain connectivity is good, with few anthropogenic barriers present relative to downstream reaches in Chewuch-Pearrygin AU. The Chewuch River Right restoration project (installed in 2015) re-established side channel and floodplain connectivity, improved riparian condition, and reduced the area of recreation development on a >25-acre floodplain area in Doe 1 reach, and this reach is now ranked as *Adequate*.

Recreational and legacy agricultural development in the Doe 2 reach, which is most pronounced on river right, decreases floodplain connections and quality leading to an *At Risk* determination for this reach. Upstream of this reach in Doe 3-6 reaches, floodplain connectivity is largely intact, with no significant barriers to flood flows or manipulations to floodplains surfaces. As such, these reaches are ranked as *Adequate* for this floodplain connectivity indicator.

Indicator: Channel Migration

Channel migration is a natural riverine process that maintains river habitats by recruiting substrate and large wood and providing more complex channel dynamics (Ecology 2014). Natural channel migration rates are a result of numerous physical and biological processes, including hydrologic regime, underlying geology, sediment supply, streambank vegetation, and floodplain hydraulic roughness (Ecology 2014). Human actions can affect these processes, which subsequently can alter channel migration rates and erosion locations. Bank armoring, levee construction, and channelization restrict flow to more straightened paths and also limit where erosion can occur. Water withdrawals and dams can alter the hydrologic regime, affecting when and how much water interacts with the channel margins, and changes in riparian vegetation, such as removal of streambank vegetation and development within the floodplain, can affect channel migration rates (Ecology 2014, Collins et al. 2012).

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Channel	Dynamics	Channel Migration	Channel is migrating at or near natural rates within the geomorphic construct of the reach.	Channel migration is occurring at a faster or slower rate relative to natural rates, but significant change in channel width or planform is not detectable. Large woody debris is still being recruited.	Little or no channel migration is occurring because of human actions preventing reworking of the floodplain. 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.

Analysis Results

Anthropogenic actions to protect infrastructure, often through bank hardening or levee construction, can substantially alter lateral channel migration processes. High rates of bank erosion in disturbed areas are often a result of channel straightening, bank armoring, and vegetation removal. Bank armoring, which serves to curtail lateral erosion at the point of deployment, often results in increased stream energy downstream, thereby increasing the erosion potential in downstream reaches.

Bank armoring and levee development have reduced the ability of the lower Chewuch River to migrate laterally in some portions of the LCRA area. Data indicate that 2.4 miles, or approximately 11% of total bank length, has been modified (see Section 3.6.1.6). Notably, much of the bank armoring in the LCRA is along steep banks (often protecting roads), and the armoring in these areas is not preventing significant amounts of lateral migration from occurring.

Bank armoring and levees are most prevalent in reaches with residential and agricultural development, such as Pearrygin 1 and 3 and 6-11. Upstream reaches in the Chewuch-Doe AU mostly lack channel armoring, save for a few areas with road-oriented bank protection. Several reaches, including Pearrygin 5 and Doe 2 and 3, have no bank armoring or levees present.

The channel migration rate in the LCRA area was examined through analysis of a series of aerial photos from 1947, 1957, 1975, 1988, 2006, 2013, and 2023. Mean annual lateral migration distance (migration distance/number of years between images) varied by both reach and time period (Table 4.2.5). Overall, lateral migration rates in the LCRA area are relatively low, with many reaches moving only <1-2'/year. The relatively high degree of channel confinement within the LCRA area is likely a significant factor driving this low rate of channel migration.

The highest rate of channel migration for all reaches, except for Doe 4, Pearrygin 9, and Pearrygin 10, was observed from 1947-1957. This is likely the result of large movements coincident with the 1948 flood event. Rates slowed considerably in most reaches after this time and have generally declined to relatively slow rates from 2006 to 2023. The highest degree of lateral movement has occurred, not surprisingly, in the more unconfined reaches, such as Pearrygin 3-5 and Doe 1, 2, 4, and 5.

The largest channel migration occurred from 1947-1957 in the vicinity of the Cub and Ramsey Creek alluvial fans in Pearrygin 6 reach. This was likely a response to bank protection efforts that isolated a large meander bend, forcing the channel to the west.

Table 4.2.5. LCRA reach-based channel migration rates (ft/year) during four time periods, 1947-2023.

Reach	1947-1957	1975-1988	2006-2013	2013-2023
Pearrygin 1	1.8	1.3	0.8	0.5
Pearrygin 2	1	0.4	0.7	0.4
Pearrygin 3	5.5	1.2	1.8	1.2
Pearrygin 4	9.6	0.9	0.9	1
Pearrygin 5	7	0.9	1.7	2.2
Pearrygin 6	10.1	1.9	0.9	0.5
Pearrygin 7	4	1.1	1.3	0.5
Pearrygin 8	3	2	3.1	2.6
Pearrygin 9	2.3	5	1.1	0.5
Pearrygin 10	1.1	1.9	1.1	0.6
Pearrygin 11	2	0.7	0.5	0.6
Doe 1	3.7	1.8	1.7	1.8
Doe 2	4.6	0.8	0.7	0.9
Doe 3	1.7	0.6	1.3	1
Doe 4	1.7	1	0.8	4.9
Doe 5	4.7	1.2	1.1	2.2
Doe 6	5.8	0.8	1.3	1.1

The channel alignment throughout the LCRA area has been relatively stable since 2006. Since then, there has only been one significant change in channel alignment, which occurred in 2019 in response to side channel and large wood restoration action in the Doe 4 reach. At this location, the main channel shifted alignment into an approximately 0.4-mile-long side channel that now contains the majority of flow during low flow periods.

Many reaches in the LCRA are in *Adequate* condition for lateral channel migration, and these reaches generally have little to no bank protection or levees present that are impeding channel movement. Two reaches, Pearrygin 6 and 7, have significant bank protection and levee presence, and these alterations are curtailing lateral migration, decreasing floodplain habitat availability, and lowering large wood recruitment potential in several areas. These two reaches are ranked as *Unacceptable* for channel migration. The remaining reaches, including Pearrygin 1, 3, 8-11 and Doe 5, contain some level of bank alteration that is likely only having a minimal effect on lateral migration, and these are considered *At Risk* for this indicator.

Indicator: Vertical Channel Stability

Alluvial river systems tend towards an equilibrium state, where the channel planform and slope adjust to balance the incoming flow and sediment loads. If nothing major disturbs the system, the river will erode and deposit sediment in response flow events, but the profile, dimension, and pattern of the river will remain stable through time. These systems are frequently referred to as regime channels and are in a state of dynamic equilibrium in which there is a continuous inflow and outflow of water and sediment (Ecology 2014, Lane 1954). Natural or anthropogenic changes in flow, sediment supply, channel form, riparian vegetation, or bank strength can upset the balance, leading to higher rates of channel change and a trend of aggradation or degradation, which can result in floodplain disconnection (Cluer and Thorne 2014).

Anthropogenic channel form modifications, including bank armoring, removal of riparian vegetation, levee construction, and channel straightening can contribute to a reduction in vertical

channel stability. For example, increased channel or floodplain confinement restricts streamflow to a smaller area during floods, which in turn results in higher main channel velocities than if the water could expand into the floodplain. The increased energy in the main channel could result in the channel becoming less sinuous and incised. Increased sediment loads, often from landscape changes such as wildfire, may have the opposite effect in that the river may become more sinuous as the channel aggrades without the energy to transport the increased amounts of sediment. However, geologic controls in both the channel bed and along the channel margins limit the ability of the river to significantly adjust its geometry.

Analysis Results

There are scant data to quantitatively assess the condition and trends in vertical channel stability in the LCRA area. Analysis of historical channel alignments, including maps from 1924 and aerial photos from 1944, 1954, and 1974 reveal little change in the channel planform. If there were major changes in the stability in the vertical form of the channel, there would likely also be changes in channel planform. There is a significant geological control on bed elevation where the Chewuch-Pasayten Fault underlies the channel around RM 7.5 (at the upstream end of Pearrygin 6 reach, see Section 3.1). This control maintains bed elevations upstream of the fault and prevents significant planform change from occurring. In addition, multiple alluvial and tributary fans throughout the LCRA area constrain the river channel and provide hydraulic controls to upstream reaches.

Criteria (Source: UC RTT 2021):

Pathway	General Indicators	Specific Indicators	Adequate	At Risk	Unacceptable
Channel	Dynamics	Vertical Channel Stability	No measurable trend of aggradation or incision and no visible change in channel planform beyond the natural geomorphic processes of the reach.	Measurable trend of aggradation or incision that has the potential to, but not yet caused, disconnection of the floodplain or a visible change in channel planform (e.g., single thread to braided).	Enough incision or human infrastructure has occurred that the floodplain and off-channel habitat areas have been disconnected from the main channel. Enough aggradation has occurred to create a visible change in channel planform (e.g., single thread to braided).

Although bed elevations may change locally in response to a change in channel position (i.e., avulsion, migration) and/or human disturbances (e.g., levees, roads, or bridges), or natural disturbance events such as wildfire, trends in aggradation or degradation across the LCRA area were not detected and no significant areas of floodplain incision were located. Areas of significant sediment deposition (primarily sand) resulting from the recent wildfires in the watershed were observed in several areas, but it is likely that these are transient in nature and will work through the systems over several years. As a result, vertical channel stability within the LCRA area is generally in *Adequate* condition.

However, localized areas of channel incision may be associated with areas of bank stabilization. Bank hardening, via riprap or other means, can increase stream energy, promote bed scour and

thereby influence bed elevation. While bank modification was not widespread within the LCRA area, there were several areas with more significant modification where these actions are influencing channel bed dynamics and contributing to changes in bed stability. Ripped banks in Pearygin 3, 6, 7, and 11 reaches may be influencing vertical channel stability and, as such, these reaches are rated *At Risk* for this indicator.

5 Habitat Restoration Strategy

The restoration strategy described below provides a framework for targeted and effective habitat restoration in the lower Chewuch River. The strategy utilizes the technical information gathered from the stream habitat, geomorphic, hydraulic, RSI, and REI analyses (Sections 3 and 4, also see Appendix A) to identify and prioritize specific project opportunities that lead to effective restoration actions. The restoration strategy considers existing and target conditions, historical information, habitat needs of the fish species of concern, information from Upper Columbia *Prioritization* (UC RTT 2023), and properly functioning conditions identified by the LCRA REI analysis (Section 4).

Detailed restoration concepts are available in two separate, stand-alone reports prepared by U.S. Bureau of Reclamation and are presented in Appendices B and C. Appendix B covers RM 1-9 and Appendix C covers RM 9-20. Developed concepts are primarily reach-based, but should not be viewed as the only locations or project types that can be implemented in the lower Chewuch River. Rather, the selected reaches are viewed as primary locations that have significant potential to address habitat limiting factors.

Additionally, concepts for RM 13-20 were previously developed by the Yakama Nation through an independent effort, and these are included in Appendix D.

Restoration concept maps are presented in this report in Section 5.6.2. Concepts were identified for eight project areas, including RM 1-2.5, RM 2.5-4, RM 4-5.5, RM 7.5-8.5, RM 8.5-9.5, RM 9.5-10, RM 13.5-14.5, and RM 16-17.5. Detailed concept descriptions for these project areas are presented in Appendices B and C. The additional concepts for RM 13-20 developed by the Yakama Nation are presented in Appendix D and cover some of these same project areas as the LCRA concepts.

It is acknowledged that stream habitat restoration within the LCRA area has been on-going for three decades, and that this work will continue into the future. Various groups are currently pursuing the development of restoration designs in several areas of the Lower Chewuch for near-term implementation. The LCRA should be viewed as a supporting document and data source for these efforts.

5.1 Restoration Strategy Overview

This section provides a narrative overview of the restoration action types identified for the LCRA area. Potential restoration, protection, and land management opportunities and project actions are grouped into resource conservation/protection and land management, described in Section 5.1.1, and instream, riparian, and floodplain restoration, described in Section 5.1.2. Specific project opportunities are discussed generally herein and detailed project area descriptions are presented in Appendices B, C, and D.

The LCRA restoration strategy is based on several central tenets that are closely linked to the overall productivity (i.e., VSP) of target fish species: the 4 Cs of stream salmonid habitat (cold, clean, complex, connected), and site-specific appropriateness/feasibility of the actions. These key habitat features include the following:

- Habitat Connectivity – lateral, horizontal, and vertical habitat connections provide unimpeded fish movement pathways and encourage natural flow, sediment, and wood transport regimes. Connected floodplains and side channels allow for flood flow amelioration, water and nutrient storage, hyporheic exchange, complex high and low flow refugia for fish, and provide late season flow inputs to mainstem. Connected habitats ensure geomorphic (e.g., bedform) variability, which supports habitat complexity.
- Instream Flow – restore, to the highest extent possible, a natural hydrograph to the Chewuch River. Native fish species are well adapted to the habitat provided by the natural (i.e., undisturbed) hydrograph and rely on the seasonal variations in habitat that streamflow provides. Natural streamflow can also assist with maintenance of water quality, including stream temperature.
- Instream Complexity – complex habitat with a high degree of water velocity, depth, and cover heterogeneity, obtained through hydraulic variability, provides critical support to the productivity of target fish species and life stages. Instream complexity also contributes to geomorphic variability (e.g., bedform, hyporheic exchange) that supports habitat complexity.
- Temperature – stream temperature is a master variable that exerts significant control over the productivity of target fish species. Cold water, including the availability of cold-water areas during the warmer periods, is critical to the long-term viability of target species.
- Riparian Habitat – streamside and floodplain vegetation play an important role in maintaining habitat quality and diversity, providing shade, large wood, bank stability, fish cover, and nutrient inputs to the channel.
- Sediment Regime – Sediment dynamics are an important component of stream habitat. When sediment dynamics are out of balance it can negatively influence fish productivity. Complex stream channels promote both sediment deposition and erosion (i.e., sediment sorting) that can provide habitat for a diversity of species and life stages.
- Food Webs – Food webs represent the physical and biological foundation of aquatic ecosystems and are a primary driver of fish productivity. The loss of marine derived nutrients from the Chewuch River represents a significant loss of potential food web productivity.

Resource conservation actions identified for the lower Chewuch River include land and water conservation/protection, instream flow management, road rehabilitation, and forest, grazing, and beaver management. These are intended to be implemented as appropriate throughout the lower Chewuch River, but are not identified as prioritized stand-alone opportunities or concepts. Some potential actions are linked to existing forest, grazing, and road management plans overseen by the U.S. Forest Service and WDFW.

Instream, riparian, and floodplain actions identified for the lower Chewuch River include riparian restoration, floodplain restoration and reconnection, side channel and off-channel habitat restoration, tributary confluence restoration, and instream habitat complexity restoration. The

restoration action types described below are those that are best suited to address the specific limiting factors within the geomorphic setting of the lower Chewuch River.

In addition to the specific instream and floodplain restoration projects that are identified in Section 5.6, there are numerous other restoration actions that, similar to resource conservation actions, may be applied more generally throughout the lower Chewuch River. Action types that can be implemented between the specific project areas are described in Section 5.1.2, with additional information provided in Table 5.5.1.

5.1.1 Land Resource Conservation

Land Protection

Conservation actions (i.e., land protection and management) can involve preservation of existing functional floodplain, riparian, and upland habitats. It can also include protection of disturbed areas that could subsequently undergo habitat restoration to improve conditions. In some cases, protection and management objectives might be achieved through implementation of land management plans, such as Chewuch Transportation Plan (USFS 2015).

Conservation may be accomplished through purchasing lands and/or acquiring conservation easements from willing landowners. Land protection actions can be pursued to limit or curtail anthropogenic activities within riparian areas, along streambanks, and adjacent uplands. Actions could also include supporting land management agencies, such as USFS and WDFW, with implementation of their management plans.

Instream Flow Management

Actions to address decreased water quantity (e.g., diminished summer base flows), a high tier limiting factor in the LCRA area, include water rights transfer to increase instream flow (through purchase and/or lease), water banking, irrigation infrastructure efficiency improvements, and points of diversion transfer from surface flows to ground water. Instream flow management can also address fish injury and mortality at diversion structures.

In the LCRA area, these types of actions should be focused on the three primary surface water diversions: the Skyline, the Chewuch, and the Fulton. All of these diversions have been involved with previous efficiency projects to increase instream flows, improve fish passage through dams, and reduce fish injury and mortality within diversion infrastructure (e.g., diversion screening); however, there may be additional actions that may decrease the negative effects of these diversions, including replacing ageing infrastructure to improve efficiency.

Additionally, there is a surface water diversion on Eightmile Creek that could also be addressed to increase instream flow from that tributary. Increased inputs of cold Eightmile Creek water would provide instream flow and thermal benefits to the Chewuch River.

Beaver Management

Historically, beaver were abundant throughout the Chewuch River watershed, and their presence contributed considerably to habitat diversity and ecosystem function, including through direct benefits to instream flow and off-channel habitat. The overharvest of beavers from the watershed in the 1800s has likely contributed to reductions in pool quality, large wood recruitment potential, and nutrient storage capacity (NPCC 2004). The reintroduction and re-establishment of

beavers may assist in addressing several of the identified limiting factors in the LCRA area including fines, side channels, pool quantity and quality, summer base flow, temperature, cover wood, and riparian condition.

Beaver reintroduction can be complicated, particularly in populated areas with significant infrastructure. Beaver reintroduction issues may be addressed through the development and/or implementation of beaver management plans. Such a plan should include analysis of potential flooding concerns where infrastructure is present, along with possible impacts to newly planted riparian areas.

The Methow-Okanogan Beaver Project has been releasing beaver into the Chewuch River watershed since 2008, primarily in the downstream assessment units and tributaries such as Cub and Boulder Creeks.

Road Network Management

The LCRA area contains a high level of road development, with density far exceeding criteria for adequate REI condition. Much of the road network is administered by the Forest Service, but there are also Okanogan County and private roads, primarily in the Chewuch-Pearrygin AU. The road network represents a significant disturbance to the watershed and affects several limiting factors, especially embeddedness and fines.

The road network contains extensive road development in tributary watersheds including Cub, Boulder, Eightmile, and Falls Creeks. Much of this area has been recently burned and the road networks have proven susceptible to post-fire floods and debris flows that have contributed significant amounts of fine sediment to the Chewuch River.

Where feasible, actions to address issues with the road network should largely follow information and planning contained in existing road management plans, such as the USFS Chewuch Transportation Plan (USFS 2015). Actions described in this plan include options such as road decommissioning and closure to restore hydrologic conditions along the road prism and surrounding areas. Specific actions could include slope stabilization, drainage pathway restoration, vegetation plantings, and removal/modification of the road prism. These actions could increase the hydrologic function of the area, increase infiltration rates, and reduce sediment transport.

Grazing Management

Grazing can initiate a suite of ecological changes to watersheds and streams. The effects of grazing can diminish riparian habitat quality, increase bank erosion and sedimentation, and promote the spread of non-native plants (George et al. 2004, NPCC 2004).

There are three active grazing allotments that extend into in the LCRA area, including areas along the mainstem Chewuch River and in Pearrygin, Cub, Ramsey, Boulder, Eightmile, and Falls Creeks. These allotments have seen grazing for decades. In many areas, the animals have open access to streams, including those with ESA fish species presence, such as in Eightmile and Boulder Creeks. All of these allotments are located on federally-managed public land overseen by USFS. There is only one current grazing allotment on Washington State lands managed by WDFW, which due to its location above Pearrygin Lake is unlikely to have appreciable direct impacts to the Chewuch River. Grazing allotment management plans contain aquatic

conservation strategies that can be implemented to minimize grazing impacts on aquatic habitats (USFS 2009, WDFW 2021).

Potential actions to address grazing include support for management plan implementation, riparian fencing, off-channel watering, and virtual fencing.

Forest Management

The health and condition of upland forest habitats in the Chewuch River watershed are closely linked to the health and condition of adjacent aquatic habitats. Management of federal and state-owned forest lands to improve their health can provide benefits to aquatic ecosystems, but it is often overlooked as a means to accomplish this. Primary limiting factors addressed by forest management action include fines, embeddedness, temperature, cover wood, and summer base flow.

The LCRA area spans the divide between federal lands managed by the Northwest Forest Plan (west side of the river) and the PACFISH/INFISH biological opinion (east side of the river), which provides an additional layer of complexity to forest management in the Chewuch watershed. Forest management actions will almost certainly entail supporting federal and state agencies with management plan implementation to help them achieve aquatic related objectives. Specific actions could include increasing potential for large wood recruitment, improving drainage networks to reduce sediment inputs, and riparian tree retention/protection to maintain and improve shade and channel stability.

5.1.2 Instream, Riparian, and Floodplain Restoration

Side Channel and Off-Channel Habitat Restoration

In the Chewuch River, side channel and other off-channel areas provide important rearing habitat for spring Chinook, steelhead, and other native fish species. Rearing juveniles may use seasonally and perennially connected side channels in higher densities relative to the mainstem (Martens and Connolly 2014). Off channel habitat were an identified limiting factor in the LCRA area, but analyses indicate functional impairment is limited to less than half of the reaches, primarily within the Chewuch-Pearrygin AU.

A key to side and off channel restoration is to identify and treat areas where existing habitats, such as side channels, alcoves, backwaters, wetlands, abandoned meanders and oxbows, and other features within the floodplain surface have been disconnected from the mainstem. Reconnection of these areas provides an immediate increase in habitat quantity, complexity, and diversity by reestablishing previously inaccessible or under-utilized habitat. For example, removal of flow constraining features (e.g., levees) may allow for natural inundation of existing perennial and ephemeral side channels that were previously not well connected or functioning appropriately.

Specific actions to restore or enhance side channel and off-channel habitat include reconnecting or constructing perennial side channels, secondary channels, floodplain ponds, wetlands, alcoves, and backwaters. Implementation of these types of actions may be accomplished through site-specific excavations (e.g., pilot channels) intended to reconnect relict side channels, floodplain topography grading, and large wood placements to encourage surface flow into the channels.

Groundwater seeps and springs are ideal locations for alcove restoration due to consistent sources of cold groundwater that can provide high quality rearing habitat.

Caution must be used when addressing off-channel habitats so that enough flow remains within the mainstem channel to maintain habitat quality and quantity in those areas.

Floodplain Restoration and Reconnection

Floodplain connectivity is an identified limiting factor within the LCRA area, but anthropogenic barriers to floodplain connectivity with the mainstem only exist in a few reaches. Properly functioning floodplains act as extensions of the alluvial aquifer, attenuating stream flows as floodwaters disperse onto the floodplain and discharging stored water during periods of low streamflow. Functional floodplains contribute to maintenance of stream flows, water temperatures, and water quality. Groundwater discharge from floodplains to streams can contribute instream flow and cold water refugia for fish, and floodplain groundwater storage has also been shown to attenuate peak flows (Acreman et al. 2003).

Where possible, floodplain infrastructure, such as levees, should be modified or removed to eliminate the physical features responsible for the disconnection. Restoring, reconnecting, or enhancing wetlands and springs is another important aspect of floodplain restoration. Since wetlands store water during periods of heavy precipitation and then release it slowly, they provide important buffering of both water quantity and quality (Hammersmark et al. 2008). This slow release of cooled water during summer periods of low flow and warm temperatures provides thermal refugia for target fish species. Beaver reintroduction may also assist with restoring and reconnecting the floodplain; however, considerations should be made regarding potential impacts to existing infrastructure and land use.

Instream Habitat Complexity

Instream habitat complexity projects may be located in areas where the main channel lacks complex instream habitat features, such as large wood, deep pools with cover, and side channels and where geomorphic processes (i.e., channel forming and maintaining) are not functioning adequately. Habitat complexity structures commonly involve placing large wood and/or boulder structures to increase habitat complexity, cover, and flow variability. In some instances, these actions may also include pool excavation to complement the habitat structure installation and jump-start the habitat forming processes of scour and deposition.

Limiting factors addressed by this type of restoration primarily include cover and pool quality and quantity, but it can also address others such as bank stability, coarse and fine substrate (through sediment sorting), and side/off channels.

As a design consideration, habitat complexity structures should include designs to minimize risks to recreational users such as boaters. Structural design considerations may include locating projects in areas with good sight lines from upstream, installing structures that do not protrude too far into channel, and including “bumper logs” to minimize interactions with river users. Signage to educate recreational users to the potential hazards of instream wood can also be employed, and can be a good means of project-related outreach.

Riparian Restoration

Riparian restoration actions are appropriate for areas that have been significantly impacted by development and where native vegetation communities have been cleared, compromised, or are no longer properly functioning. Riparian restoration would directly address several LCRA area limiting factors, including riparian condition and riparian canopy cover, as well as bank stability, temperature – rearing, fines, and embeddedness. Riparian vegetation is in Unacceptable or At Risk condition in many LCRA reaches, and restoration of riparian areas should be considered a high priority throughout the assessment area.

The intent of riparian restoration is to enhance and/or re-establish functional riparian vegetation communities, increase riparian habitat diversity, restore canopy cover, provide streambank stability, and increase large wood recruitment potential. These actions may be accomplished through native riparian plant installation coincident with removal of invasive plant species, if necessary. In many cases, riparian restoration occurs in conjunction with other restoration actions, especially those that involve ground and streambank disturbance or vegetation removal.

Tributary Confluence Restoration

Tributary restoration actions may be located at the confluence with existing tributary channels where there is potential for significantly increasing the quantity and quality of instream habitat complexity. These projects can be completed through any combination of channel realignment, habitat creation or reconnection, large wood placement, and riparian plantings. The goals of these actions are to improve access and provide increased rearing capacity and refugia in close proximity to the mainstem river. Several LCRA area tributaries provide inputs of cold water to the mainstem, and restoration at these locations may provide expanded cold-water refugia, which addresses temperature related limiting factors.

Due to channel geomorphology and stream power and the position of many confluences on alluvial fans, the potential for implementation of this type of action should be carefully considered. In the LCRA area restoration opportunities may be limited to just a few confluences, including Cub and Eightmile Creeks.

5.2 Relative Potential of Restoration and Protection Actions

A primary objective of the LCRA is to identify potential habitat improvement opportunities that will result in measurable progress toward addressing habitat limiting factors in the lower Chewuch River. The impact of proposed restoration actions on limiting factors guides project prioritization and will ultimately determine project effectiveness. Table 5.2.1 provides a summary of the relative potential of proposed project action types to address the limiting factors identified for the lower Chewuch River. This table can be used to guide the development of projects within areas that were not specifically identified as project areas within Section 5.6.

Table 5.2.1. Relative potential of restoration action types to address limiting factors in the LCRA area.

Restoration Action Type	LCRA Limiting Factors											
	Bank Stability	Coarse Substrate	Embeddedness	Fines	Floodplain Connectivity	Off/Side Channels	Pool Quantity and Quality	Riparian Condition	Riparian - Canopy Cover	Summer Base Flow	Temperature - Rearing	Wood - Cover
Land Protection	M	L	L	M	M	M	L	H	H	M	M	L
Instream Flow Management	L	L	L	L	L	L	M	L	L	H	H	L
Beaver Management	L	L	M	M	H	H	H	H	H	H	M	M
Road Network Management	L	M	H	H	M	M	L	M	M	M	L	L
Grazing Management	H	L	M	H	L	L	L	H	H	L	M	L
Floodplain Restoration and Reconnection	L	L	L	H	H	H	M	H	H	M	M	M
Side Channels and Off-Channel Habitat Restoration	L	L	L	H	H	H	M	H	H	L	M	M
Instream Habitat Complexity	M	L	L	L	M	M	H	M	M	L	M	H
Riparian Restoration	H	L	M	M	L	L	M	H	H	L	H	H
Tributary Confluence Restoration	L	L	L	L	L	L	M	M	M	L	H	M

H = High – Actions that are critical to ameliorating limiting factors.

M = Medium – Actions that are important (but not critical) to ameliorating limiting factors.

L = Low – Actions provide limited benefit in addressing limiting factors.

5.3 Past Projects Summary

Since 1996, a total of 31 instream and riparian habitat restoration and protection projects have been completed within the LCRA area (Table 5.3.1). These projects have been varied in nature and have been located throughout the 20-mile LCRA reach (Figure 5.3.1). The majority of the projects have been restoration and implemented in the Chewuch-Pearrygin AU (n=18), with the remaining 13 projects occurring in the Chewuch-Doe AU. Five protection projects have been implemented – all within the Chewuch-Pearrygin AU.

The overall restoration treatment footprint of the combined projects covers over half of the stream length in the LCRA area (>10 miles). However, this includes reaches where only a small portion of the overall channel length actually received restoration treatment. For example, the 2015 RM 13-15.5 large wood and channel complexity enhancement project occurred over approximately 3.5 miles of stream, but actually treated approximately 0.4 miles of streambank.

Completed projects fall into five general types, including instream habitat complexity, instream flow, fish passage, riparian restoration, and riparian protection. The majority of projects have been related to instream habitat complexity (n=20), followed by riparian protection (n=5), and passage, flow, and riparian planting (n= 2 each). All of the non-instream habitat complexity projects, including all five protection projects, have occurred in the Chewuch-Pearrygin AU.

Additionally, the USFS and others have worked to improve hydrologic conditions in the watershed through road network management efforts. Several miles of roads (primarily in contributing/tributary watersheds) have been decommissioned or placed into hydrologic storage, including one section of road that was relocated away from a chronically eroding streambank in the Doe 5 reach.

Combined, these completed projects have had a measurable impact on several key limiting factors, including riparian habitat, instream flow, instream complexity, large wood, fish passage, and floodplain and off-channel habitat connectivity and availability. Collectively, these projects have installed >1100 pieces of large wood to increase channel complexity and fish cover, improved connectivity and complexity in >1 mile of side channel habitat, improved floodplain connectivity and complexity over several acres, and installed thousands of native riparian plants to help improve riparian conditions.

Many of the completed projects include multiple project opportunities (i.e., discreet locations) that were identified in the 2010 Lower Chewuch Reach Assessment (Yakama Nation 2010). In total, 129 separate project opportunities were identified in the 2010 assessment (69 in Chewuch-Pearrygin AU and 60 in Chewuch-Doe AU). Of these, completed projects have addressed 33 discreet opportunities (10 in Chewuch-Pearrygin AU and 23 in Chewuch-Doe AU) for a completion rate of approximately 25% of total identified potential locations (15% in Chewuch-Pearrygin and 38% in Chewuch-Doe AU).

Table 5.3.1. Summary of stream restoration projects in the LCRA area, 1996-2023.

Reach	Project	Year	River Mile	Sponsor	Description	Habitat Attribute Addressed	Details
Pearrygin 1	Fulton Dam Renovation	2006	1.1	MSRF	Diversion dam modification	Fish passage barriers	Installed 100' roughened channel, improved fish passage
Pearrygin 1	Satiqua Riparian	2009	0.8	MSRF	Riparian planting	Riparian Cover, Riparian Disturbance	Planted 715' bank, 2.2 acres, 260 stems
Pearrygin 3	Pete Creek Riparian	2011	3.8	MSRF	Riparian planting	Riparian Cover, Riparian Disturbance	Planted 615' bank, 2.5 acres, 1400 stems
Pearrygin 3	Pete Creek Protection	2006	3.8	MSRF	Riparian Protection	Riparian Cover, Riparian Disturbance	10.5-acre conservation easement
Pearrygin 3	Chewuch Protection 1	1999	3.5	WDFW	Riparian Protection	Riparian Cover, Riparian Disturbance	38.5 riparian acres - WDFW
Pearrygin 3	Chewuch Protection 2	2000	3.5	WDFW	Riparian Protection	Riparian Cover, Riparian Disturbance	31 riparian acres - WDFW
Pearrygin 4	Windhaven Bank Protection	2018	4.3	Private	Bank complexity/protection	Bank Stability	1 bank ELJ
Pearrygin 4	Bulldog Complexity	2011	4.8	MSRF	Large wood, riparian planting	Cover – Wood, Riparian Cover, Riparian Disturbance	1 bank ELJ, riparian planting
Pearrygin 4	Bulldog Protection	2009	4.8	MSRF	Riparian Protection	Riparian Cover, Riparian Disturbance	6.5-acre conservation easement
Pearrygin 4	Chewuch Protection 3	2008	4.8	WDFW	Riparian Protection	Riparian Cover, Riparian Disturbance	75 riparian acres - WDFW

Reach	Project	Year	River Mile	Sponsor	Description	Habitat Attribute Addressed	Details
Pearrygin 4	Chewuch RM 4.2	2022	4.7-5.0	YN	Side channel habitat connectivity, instream complexity	Side Channels, Cover-Wood, Channel Stability	1300' side channel connection with 7 ELJs and 67 large wood pieces placed, 2 mainstem ELJs
Pearrygin 4	Landowner Bank Protection	2010s?	5.3	Private	Bank complexity/protection	Bank Stability	Several bank protection large wood pieces, riparian plantings, cobble gabions
Pearrygin 8	Chewuch Dam Passage	2005	8.6	USBR	Diversion dam modification	Fish passage barriers	Roughened fish bypass channel installed, improved fish passage, adaptive management
Pearrygin 8	MacPherson Side Channel	2009	8.6-9.1	MSRF	Side channel reconnection, riparian planting	Side Channels	800' perennial side channel off Skyline Ditch flow, riparian plantings
Pearrygin 8	Chewuch Canal Instream Flow	2014	8.6	TU	Instream flow enhancement	Streamflow – Summer Baseflow	100 c.f.s. instream flow trigger, reduced diversion volume
Pearrygin 8	Skyline Canal Instream Flow	2000-2024	9.4	MSRF	Instream flow enhancement, diversion screening	Streamflow – Summer Baseflow	Instream flow trigger, reduced diversion volume 2000: 26 c.f.s. down to 27.8 c.f.s. 2024: 17.8 c.f.s. down to 7 c.f.s.
Pearrygin 10	Chewuch RM 10	2012	10-10.5	YN	Side channel and alcove enhancement, instream complexity	Off-Channels, Side Channels, Cover - Wood	1150' GW alcove channel connected to mainstem, 500' side channel complexity, 8 ELJs
Pearrygin 11	Eightmile Ranch	2012	11-11.6	YN	Instream complexity, side channel complexity	Side Channels, Cover – Wood, Channel Stability	8 ELJs; including 7 mainstem bank jams and 1 in short side channel
Doe 1	Chewuch Complexity 1	1996	12.5	PWI	side channel complexity	Side Channels, Cover – Wood,	Wood placement
Doe 1	RM 11-13	2013	11.9-12.7	YN	Instream complexity, side channel complexity	Side Channels, Off-Channels, Cover – Wood, Channel Stability	3 mainstem ELJs, 1.5-acre alcove wood complexity enhancement, 0.15-acre alcove complexity – 1 ELJ
Doe 1	Chewuch River Right	2015	12.5-13.2	YN	Side channel connectivity/complex	Side Channels, Cover – Wood, Channel Stability	3,000 side channel enhancement, 1 mainstem ELJ,

Reach	Project	Year	River Mile	Sponsor	Description	Habitat Attribute Addressed	Details
					ity, mainstem complexity		
Doe 2	Chewuch Complexity 2	1996	14.2	PWI	side channel complexity	Side Channels, Cover – Wood,	Wood placement
Doe 2	Chewuch RM 13-15.5	2015	13.5-14.3	YN	Mainstem complexity, alcove complexity	Side Channels, Cover – Wood, Channel Stability	5 mainstem ELJs, 0.2-acre backwater alcove wood treatment
Doe 2	Chewuch River Right	2015	13.5-14.3	YN	Mainstem complexity	Cover – Wood, Channel Stability	3 mainstem ELJs, Sites A and K
Doe 3	Chewuch RM 13-15.5	2015	14.4	YN	Mainstem complexity	Cover – Wood, Channel Stability	1 mainstem ELJ, Site L
Doe 4	Chewuch RM 13-15.5	2015	15-15.7	YN	Mainstem complexity	Cover – Wood, Channel Stability	3 mainstem ELJs, Sites N,O,Q
Doe 4	Chewuch RM 17-20	2018	16.1	YN	Mainstem complexity	Cover – Wood, Channel Stability	1 mainstem ELJ, Site A
Doe 5	Chewuch RM 15.5-17	2017	16.4-18.3	YN	Mainstem complexity, side channel complexity	Side Channels, Cover – Wood, Channel Stability	7 mainstem ELJs, 1 apex ELJ, 1 side channel ELJ
Doe 5	Chewuch RM 17-20	2018	18-18.2	YN	Mainstem complexity	Cover – Wood, Channel Stability	3 mainstem ELJs, Sites L, M, N
Doe 6	Chewuch Complexity 3	1996	18.8	PWI	Side channel complexity	Side Channels, Cover – Wood	Wood placement
Doe 6	Chewuch RM 17-20	2018	18.9-19.6	YN	Mainstem complexity, side channel complexity	Side Channels, Cover – Wood, Channel Stability	5 mainstem ELJs, 1 side channel ELJ

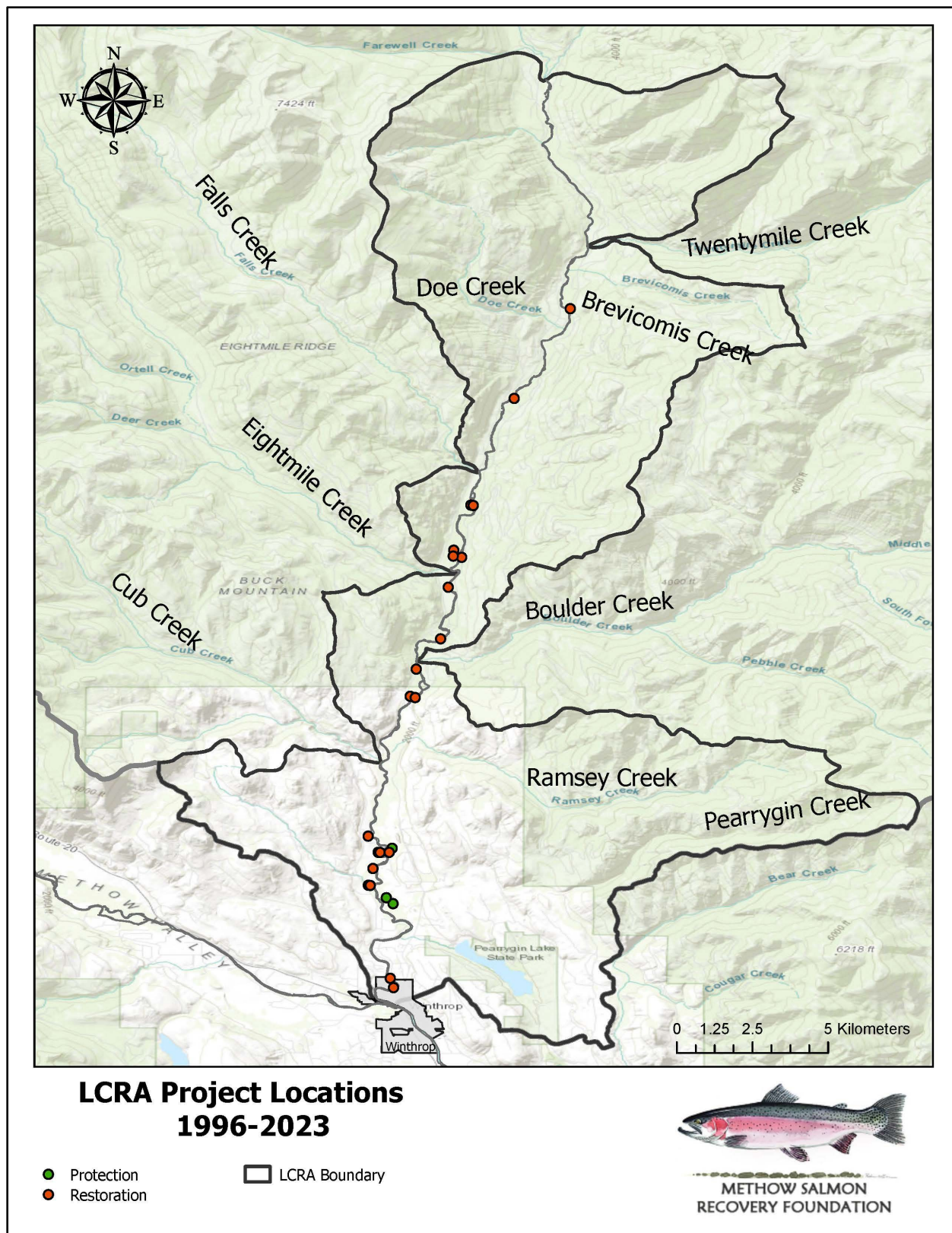


Figure 5.3.1. Restoration and protection project locations, LCRA area, 1996-2023.

5.4 Existing Conditions Summary

From watershed-scale perspective, the Chewuch River watershed currently exists in a significantly degraded state relative to historical “properly functioning conditions.” As such, the watershed is not providing habitat conditions optimal for supporting the productivity of ESA-listed fish species. There are multiple underlying causes of this diminished condition that stem from a suite of natural and anthropogenic sources.

For thousands of years, natural watershed-scale disturbance has arisen from sources such as glaciation, flooding, drought, wildfire, and mass wasting events, which have all exerted influence over the aquatic and terrestrial ecosystems within the watershed. Fish species evolved within this dynamic template to take advantage of favorable conditions and respond and adapt to changes that reduced habitat availability and condition. A diversity of available habitat afforded multiple options for fish species that were able to avoid and/or colonize habitats as they changed over time.

However, over approximately the past 175 years, anthropogenically-driven influences within the watershed have combined to increase the extent and rate of disturbance and interrupt natural habitat disturbance response and recovery mechanisms. This has resulted in diminished habitat quantity and quality available to native fish species, reduced population productivity, and contributed to observed declines in population viability, that have contributed to the need for protections afforded under the ESA.

Several anthropogenic factors have shown to be especially detrimental to habitat conditions in the Chewuch River watershed. One of the first to occur was the trapping and removal of beaver from the landscape during the 19th century. Beaver trapping was most intensive during the 1830s-1840s, and by 1900 beaver populations in the Upper Columbia region were nearly extinct (NPPC 2025).

Land development and alteration, including land clearing (e.g., removal of native vegetation) and infrastructure construction (e.g., structures, roads, bridges, and levees) to support agricultural and commercial development also contributed to degraded habitat conditions and disrupted habitat connectivity within the mainstem channel, side channels, and floodplains. Stream clearing (e.g., large wood removal and channelization) for flood control also directly altered stream habitat conditions.

Yet another early and significant disturbance to aquatic habitat in the Chewuch River was the development of water diversions to satisfy federal homesteading requirements and support agricultural and commercial development. Many dams, diversions, and associated conveyance infrastructure were constructed around the start of the 20th century, and they appreciably altered (decreased) instream flows and led to direct fish mortality through entrainment into unscreened diversions. Three of these diversions (all are now screened) currently remain active within the LCRA area in the Chewuch-Perrygin AU.

More recently, climate change has emerged as a potentially long-lasting and pervasive influence that has the potential to greatly disrupt many aspects of the temperature, precipitation, and runoff regimes to which native aquatic species in the Chewuch River are adapted.

Combined, these factors have contributed to the current conditions observed in the LCRA area and surrounding watershed and from which identification of reach-based limiting factors was

based. These limiting factors have been ranked in scale and scope through Upper Columbia Prioritization (UC RTT 2023). Prioritization identified twelve either unacceptable or at-risk limiting factors for the LCRA area (Table 5.4.1):

Table 5.4.1. Prioritization unacceptable and at-risk limiting factors condition for LCRA reaches (UCSRB 2023).

Prioritization Limiting Factor	Pear 1	Pear 2	Pear 3	Pear 4	Pear 5	Pear 6	Pear 7	Pear 8	Pear 9	Pear 10	Pear 11	Doe 1	Doe 2	Doe 3	Doe 4	Doe 5	Doe 6
Bank Stability	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Coarse Substrate	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Embeddedness	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Fines	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Floodplain Connectivity	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Off/Side Channels	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Pool Quantity and Quality	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Riparian Condition	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Riparian – Canopy Cover	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Summer Base Flow	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Temperature - Rearing	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Wood - Cover	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
● Adequate						● At Risk					● Unacceptable						

The LCRA REI analysis and supporting data represent the most up to date information relative to the habitat conditions in the LCRA, and this information was employed to update the limiting factors condition rankings (Table 5.4.2). Including this information resulted in some significant changes to many of the limiting factors, with only one factor (temperature for rearing salmonids) remaining unchanged (*Unacceptable* for all reaches).

It is not certain which causative agents are responsible for all of the changes in habitat conditions. Certainly, the number of restoration actions completed over the past two decades to restore wood-cover, floodplain connectivity, and summer base flow would have been expected to move indicators in treated reaches towards improved function. As indicated in Table 5.4.2, observed improvements can be seen in some reaches (especially in the Chewuch – Doe AU). Restoration actions were important in driving the movement to *At Risk* condition from *Unacceptable*. For some limiting factors, changes are likely the result of the availability of more recent data than were used by *Prioritization*. For others, such as sediment related factors, changes may be the result of disturbance, such as post-fire sediment inputs.

The limiting factors related to channel substrate saw significant ranking changes. Both embeddedness and fines declined in condition, with many reaches moving from *Adequate* to either *At Risk* or *Unacceptable*; this is likely a response to the high load of post-fire fine sediment and sand present in the LCRA area. Conversely, coarse substrate improved in condition throughout most of the assessment area, with all but Pearrygin 7 reach in *Adequate* condition. This shift was likely a response to more current and more detailed data available for analysis.

address the ecological concerns and lead to target conditions. Recommended restoration action types are described in Section 5.1.

Data indicate that there are several high priority and pervasive limiting factors that can be addressed with restoration, protection, and management actions. These are currently in *Unacceptable* or *At Risk* condition in most reaches in the LCRA area and include stream temperature, pool spacing and quality, large wood, instream flow, and riparian conditions. More recently, embeddedness and fine sediment, exacerbated by recent widespread and intense wildfire, have elevated the threat they pose to habitat quality.

5.6 LCRA Project Area Priorities and Concepts

For this reach assessment, conceptual designs for potential habitat restoration actions have been developed for eight project areas. For each area, basic design elements are provided in maps in Section 5.6.1. More detailed project descriptions and supporting information are available in Appendix B (RM 0-9), Appendix C (RM 9-20), and Appendix D (RM 13-20).

Additionally, there are approximately 70 other discreet opportunities that were identified in the 2010 reach assessment that have yet to be addressed (for various reasons, e.g., land ownership, costs/funding, overall feasibility). These opportunities were not developed further within this updated reach assessment.

Project area concepts should be viewed as a first step in the development of actual restoration plans for each site. Conceptual designs will need additional review and analyses (i.e., design refinement) and should not be considered an exhaustive list of possible actions within each area. The concepts can also be modified and adapted to refine the extent of project areas.

Site-specific analyses, including hydraulic modeling, would be required to refine these potential projects, evaluate design alternatives, and develop detailed designs for construction.

Table 5.6.1. Summary of habitat indicators, existing and target conditions, restoration actions and limiting factors addressed for the LCRA area. Detailed information on indicator existing conditions available in Section 4.

General Indicator	Existing Condition	Target Condition ^{1/}	Primary Limiting Factors Addressed	Potential Restoration Action Type(s)
				Appropriate Reaches
Drainage Network	Road density is 1.7-2.3 mi/mi ² and high relative to other Methow subbasins. Road density is higher in Chewuch-Pearrygin AU (and its contributing AUs). Residential and agricultural development is high, especially in Chewuch-Pearrygin AU.	Zero or minimum increase in the watershed-scale drainage network that is correlated with human-caused disturbances. Watershed road density < 1.5-2 mi/mi ² . Hydrologically impaired surfaces in the watershed occupy <3% of area in all sub-watersheds except for Chewuch-Pearrygin (<5%).	Riparian condition Riparian – canopy cover Summer base flow Fines Embeddedness	Riparian restoration, Road network management, Beaver management
				All reaches
Disturbance (Natural/Human)	Disturbance is pervasive across both AUs, but development is higher in Chewuch-Pearrygin AU. Land use actions have degraded channel complexity and habitat availability in many reaches. Recent wildfire has burnt a large portion of the watershed and resulted in large sediment inputs. Water diversion and infrastructure reducing instream flows (Chewuch-Pearrygin AU only). Channel modification and bank protection present in some reaches. Climate change looms as a significant source of disturbance.	Environmental disturbance is short lived; predictable hydrograph; high quality habitat and watershed complexity providing refuge and rearing habitat for all life stages and multiple life-history forms. Natural processes are functioning within established ranges.	Riparian condition Riparian – canopy cover Floodplain connectivity Bank stability	Riparian restoration, Road network management, Grazing management, Beaver management, Floodplain reconnection, Side/off channel restoration, Instream complexity
				All reaches
Streamflow	Significant volumes of water diverted from the Chewuch-Pearrygin AU resulting in chronic summer and fall low flows. Climate change looms as a significant source of disturbance which will impact the timing and volume of instream flows.	Magnitude, timing, duration and frequency of peak/base flows within the LCRA area are not altered relative to natural conditions of an undisturbed watershed of similar size, geology, and geography.	Summer base flow Pool quantity and quality Temperature - rearing	Instream flow, Riparian restoration, Floodplain reconnection, Beaver management
				Water diversions in Pearrygin 8 (Skyline and Chewuch) and Pearrygin 2 (Fulton)
Water Temperature	Stream temperatures chronically exceed WA state criteria throughout the LCRA area, exacerbated by diminished instream flows. Climate change will likely	Temperatures (7-DADMax) during the following life history stages For spring Chinook and steelhead: Spawning (<13°C)	Temperature - rearing	Instream flow, Riparian restoration, Floodplain reconnection, Tributary confluence restoration

General Indicator	Existing Condition	Target Condition ^{1/}	Primary Limiting Factors Addressed	Potential Restoration Action Type(s)
				Appropriate Reaches
	continue to exacerbate (increase) temperature regimes.	Rearing (<15°C) Holding (<15°C) Migration (<15°C) For bull trout : Rearing (4-12°C)		All reaches
Physical Barriers	Two dams exist in Chewuch-Pearrygin AU. Each has been modified to improve fish passage, so do not function as full barriers, but both likely impede passage for some flow conditions and/or life stages.	No manmade barriers present in the mainstem that limit upstream or downstream fish passage at any flow.	Habitat access (not identified as a LF in the LCRA area)	Barrier removal/modification
				Pearrygin 1 and 2 (Fulton Dam) and Pearrygin 7 and 8 (Chewuch Dam)
Substrate	Channel is cobble/gravel dominant, but there is a lack of sorting in some reaches (or areas within reaches) which may limit spawning potential. Current fine sediment and embeddedness levels are high in many reaches.	Gravels or small cobbles make up >50% of the bed materials in spawning areas, embeddedness <20%, <12% fines/sand (<2mm) in spawning gravel.	Coarse substrate Embeddedness Fines	Riparian restoration, Floodplain reconnection, Road network management, Grazing management
				All reaches, increased sorting in Pearrygin 3-5, 7-11, Doe 1,2, 4-6.
Large Woody Material	Natural large wood levels are low and below criteria throughout the LCRA area. Recent restoration has increased loading to ≥70 pieces/mi in some reaches, especially in Chewuch-Doe AU, but functionally wood loading is likely still inadequate in many reaches, but especially within Chewuch-Pearrygin AU.	Large wood is ≥70 pieces/mi, sources of large wood available for both long- and short-term recruitment within the reach. High wood load is not expected in high transport reaches including Pearrygin 1,2,6,and Doe 3.	Wood – cover Off/side channels	Instream complexity restoration, Riparian restoration, Floodplain reconnection
				All reaches, but target levels of wood loading may be most attainable in reaches with lower gradient and higher floodplain area.
Pools	Pool spacing exceeds <2 channel widths/pool in all eight relatively unconfined reaches. Pool density is either adequate or at-risk in all reaches, but sufficient/extensive cover and residual pool depth was lacking in many pools.	Pool spacing of ≤ 2 channel widths/pool in reaches Pearrygin 3-6, 10 and Doe 1,2,5. 9 pools/mile in reaches Pearrygin 3-5,7-11 and Doe 1,2, 4-6 and 4 pools/mile in Pearrygin 1, 2, 6 and Doe 3 reaches. Pools possess suitable depth and cover, provide cool water, and only have a minor reduction of pool volume by fine sediment.	Pool quantity and quality	Instream complexity restoration, Riparian restoration
				All reaches
Off-channel Habitat	Side channels occupy 16-18% of mainstem channel length and braids are present in many of the relatively unconfined reaches. Development has	Reach has many ponds, oxbows, backwaters, and other low-energy off-channel areas with cover. Increase length of active/connected side channels	Off/side channels Floodplain connectivity Riparian condition Riparian canopy cover	Side/off channel restoration, Floodplain reconnection Instream complexity restoration, Riparian restoration,

General Indicator	Existing Condition	Target Condition ^{1/}	Primary Limiting Factors Addressed	Potential Restoration Action Type(s)
				Appropriate Reaches
	reduced the amount of off-channel habitat availability, but levees are not extensive and interfering off/side channel and floodplain activation. Channel downcutting, where present, it likely localized in nature.	by 30% which equates to >1 mile of side channel habitat. No manmade barriers present along the mainstem that prevent access to off-channel area. Reach possesses conditions that would be expected in the absence of human disturbance.		Relatively unconfined reaches provide the most opportunities including Pearygin 3-5, 7-8, 10 and Doe 1, 2, 4-6
Riparian Condition	Development and clearing have significantly reduced the extent of riparian vegetation in many reaches. Riparian clearing is more acute in downstream reaches where residential development adjacent to the channel is most dense. Recent fires have burned into some floodplain stands, especially in Chewuch-Doe AU, but most floodplain areas were not severely burned and remain largely intact. Non-native species are not widespread, nor present in many reaches.	>80% species composition, seral stage, and structural complexity are consistent with potential native community. trees are available for recruitment via channel migration. <20% disturbance in the floodplain and <2 mi/mi ² road density in the floodplain.	Riparian condition Riparian canopy cover	Riparian restoration, Floodplain restoration,
				All reaches
Channel Dynamics	Many floodplains and side channels are connected across a range of flows and there does not appear to be extensive channel incision. The channel in many reaches appears to be migrating at natural rates, but bank armoring is preventing lateral movement in some areas. Post-fire inputs of fine sediment and sand may be aggrading some habitat units and diminishing pool quality.	Floodplain areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and species succession. Channel is migrating at or near natural rates. No measurable trend of incision and no visible change in channel planform. Channel aggradation in some areas is encouraged and can support increases in spawning and rearing habitat, especially in confined and/or incised reaches.	Floodplain connectivity Bank stability Off/side channels Coarse substrate	Floodplain reconnection, Side/off channel restoration, Riparian restoration
				All reaches, but floodplain connectivity most appropriate in Pearygin 3-5, 7-8,10 and Doe 1-2, 4-6.

1/ Target conditions were defined as the “adequate” condition for REI criteria (see Section 4).

5.6.1 LCRA Project Priorities

The reaches of the Lower Chewuch River are interconnected along the present day riverscape; the most effective restoration strategy will be one that considers these connections and strives to improve habitat functionality, connectivity, and diversity throughout the entire LCRA area. Linking individual restoration projects within a larger planning context that considers upstream conditions or the impacts of one project on concurrent and future projects is strongly encouraged.

Upper Columbia *Prioritization* employs a suite of habitat and fish use information to develop reach-based restoration and protection priority rankings for streams across the Upper Columbia, including in the LCRA area. In theory, the higher ranking reaches possess a higher potential to affect positive change towards VSP metrics for target species and should be the highest priorities for funding and implementation of restoration and/or protection projects.

However, the majority of the habitat data supporting the current iteration of *Prioritization* for the LCRA area were collected over 15 years ago and may not accurately reflect current conditions. Updating *Prioritization* with LCRA derived data should be a priority and may result in changes to the reach priority rankings detailed below. This adjustment may shift reach priorities.

For habitat restoration in the LCRA area, the Tier 1 reaches identified by *Prioritization* included Pearrygin 5-7, 9 -10, and Doe 2 and 3 (Table 5.6.2). There were six Tier 2 reaches, including Pearrygin 3,4, and 8 and Doe 1, 4, and 5. The remaining four reaches in the LCRA, including Pearrygin 1, 2, and 9 and Doe 6 were ranked as Tier 3.

Table 5.6.2. Prioritization reach-based rankings for restoration and protection projects, LCRA area. These rankings do not incorporate LCRA results and may shift once additional *Prioritization* analyses are updated.

Reach	Restoration Tier	Protection Tier	Project Areas	Project RM
Pearrygin 1	3	1	Yes	1-2.5
Pearrygin 2	3	3	Yes	1-2.5
Pearrygin 3	2	1	Yes	2.5-4
Pearrygin 4	2	2	Yes	4-5.5
Pearrygin 5	1	3	No	n/a
Pearrygin 6	1	2	No	n/a
Pearrygin 7	1	1	Yes	7.5-8.5
Pearrygin 8	2	3	Yes	8.5-9.5
Pearrygin 9	3	3	Yes	9.5-10
Pearrygin 10	1	2	No	n/a
Pearrygin 11	1	1	No	n/a
Doe 1	2	n/a	No	n/a
Doe 2	1	n/a	Yes	13.5-14.5
Doe 3	1	n/a	Yes	13.5-14.5
Doe 4	2	n/a	No	n/a
Doe 5	2	3	Yes	16-17.5
Doe 6	3	n/a	No	n/a

Prioritization rankings reveal a continuous 7.2-mile reach of Tier 1 and 2 reaches in Chewuch-Pearrygin AU between RM 2.3 – 9.5. Additionally, there is a continuous 8.4-mile length of Tier 1 and 2 reaches between Pearrygin 10 and Doe 5. Combined, these two reaches comprise approximately three-fourths of the entire LCRA area length and is an indication of the relatively high priority and restoration potential for the LCRA area.

For protection, four reaches in Chewuch-Pearrygin were Tier 1 (high priority for protection actions) including Pearrygin 1, 3, 7, and 11. Tier 2 reaches included Pearrygin 4, 6, and 10 and Tier 3 reaches included Pearrygin 2, 5, 8, and 9. There was only one reach ranked for protection in the Chewuch-Doe AU, which was Doe 5 with a rank of Tier 3. The remaining reaches in this AU were unranked due to a variety of reasons that disqualified them from protection ranking process.

All 17 reaches within the LCRA area display varying degrees of functional habitat impairment that could be addressed through habitat restoration and protection, and all have the potential to provide improved habitat for target fish species and assist with increasing productivity in the Methow River Subbasin. *Prioritization* identified over 15 miles of high priority (Tier 1 and 2) reaches in the LCRA, and all could benefit from habitat restoration. In practice, priority projects may simply be the ones where variables such as landowner support, infrastructure concerns, and funding align well enough to allow for implementation.

The Lower Chewuch River is a relatively confined river along most of its length, yet it contains several areas of less confined channel that allows for the development and restoration of significant areas of side channel, floodplain, and island habitat. In terms of increasing the volume and diversity of habitat available to target species, these reaches, including Chewuch-Pearrygin 3, 4, 5, 8, and 10 and Chewuch-Doe 1, 2, and 5, should be considered the highest priority reaches for restoration of off-channel habitats.

The more confined reaches, especially Chewuch-Pearrygin 1 and 2 and Chewuch-Doe 3 and 4, offer significantly less potential for increasing off-channel habitat. Restoration efforts in these reaches should focus on addressing mainstem habitat complexity and fish cover deficiencies as well as other limiting factors such as riparian conditions, water quality and quantity, and fine sediment.

Landowner willingness and support for habitat restoration is a key consideration and can significantly influence project implementation viability. In the LCRA area, land ownership differs significantly between the two AUs. Ownership along the Chewuch-Pearrygin AU is primarily private; along the Chewuch-Doe AU ownership is mostly public (U.S. Forest Service and WDFW).

Significant residential development in several areas, including RM 0-2 (Pearrygin 1 and 2), RM 2.5-3 (Pearrygin 2 and 3), RM 7-7.5 (Pearrygin 6), RM 9 (Pearrygin 8), and RM 10-11 (Pearrygin 10 and 11) has the potential to significantly constrain potential restoration actions in these areas. With the exception of the single residential development near RM 9, these developments consist of many structures and associated infrastructure, including roads within the 100-year floodplain area. While lacking extensive floodplain surfaces, Pearrygin 1 and 2 reaches contain substantial residential and commercial development surrounding the Town of Winthrop.

5.6.2 LCRA Project Concepts Maps

The LCRA developed restoration project concepts for eight areas, including six in the Chewuch-Pearrygin AU and two in the Chewuch-Doe AU (Figure 5.6.1). Project-specific maps are presented in Appendices B and C.

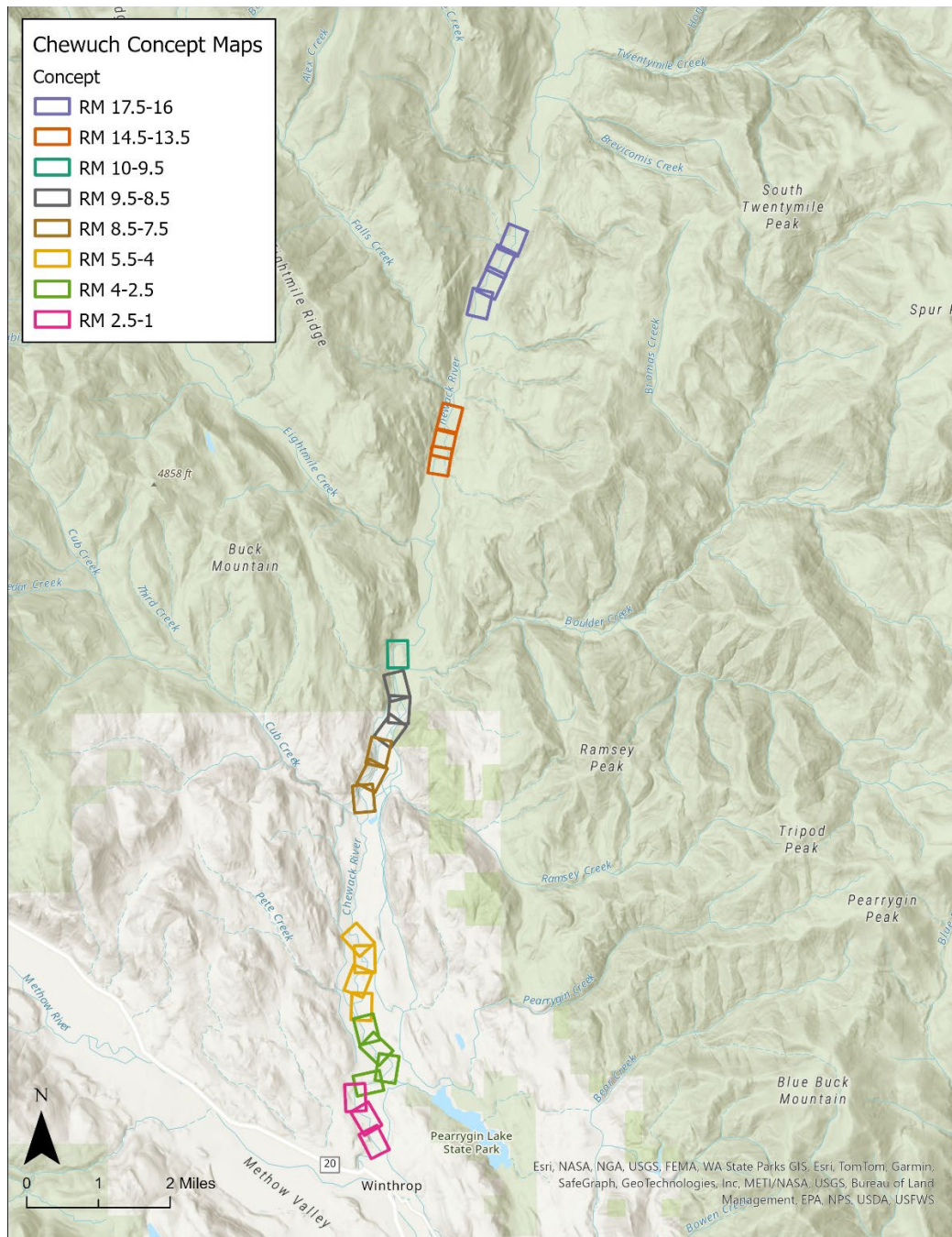


Figure 5.6.1. Project areas for LCRA restoration project concepts.

6 Literature Cited

- Abrahamse, M.S. and B. Parsley. 2023. Yakama Nation Upper Columbia Action Effectiveness Monitoring: 2023 Annual Report. Yakama Nation Fisheries Resource Management P.O. Box 151 Toppenish, Washington 98948. 19 p.
- Acreman, M. C., Riddington, R., and Booker, D. J. 2003. Hydrological impacts of floodplain restoration: a case study of the River Cherwell, UK, *Hydrol. Earth Syst. Sci.*, 7, 75–85, <https://doi.org/10.5194/hess-7-75-2003>.
- Allen, J. 1970. *Physical Processes of Sedimentation: An Introduction*. American Elsevier Company. New York, NY.
- Anderson, B., Rutherford, I., and Western, A. 2006. An analysis of the influence of riparian vegetation on the propagation of flood waves. *Environmental Modelling and Software* 21, 1290-1296.
- Ball, G., P. Regier, R. Gonzalez-Pinzon, J. Reale, D Van Horn. 2021. Wildfires increasingly impact western US fluvial networks. *Nature Communications* (2021)12:2484. <https://doi.org/10.1038/>
- Barksdale, J.D. 1975. Geology of the Methow Valley, Okanogan County, Washington. Washington Division of Geology and Earth Sciences Bulletin 68, 72p.
- BAER (Burned Area Emergency Response). 2014. Carlton Complex Fire (State and Private Team). September 14, 2014. 21 p.
- Beaty, K. 1994. Sediment Transport in a Small Stream following Two Successive Forest Fires. *Canadian Journal of Fisheries and Aquatic Sciences*; vol. 51, no. 12: pp 2723-2733.
- Beck, R.W., and Associates, 1973. Flood plain information, Methow River, Twisp to Mazama, Okanogan County, Washington: R.W. Beck and Associates, Analytical and Consulting Engineers, Seattle, WA. Report prepared for Washington Department of Ecology, Olympia, WA. 13 p., 20 figures.
- Beechie, T., and T. Sibley. 1997. Relationships between channel characteristics, woody debris, and fish habitat in northwestern Washington streams. *Transactions of the American Fisheries Society* 126(2):217-229, doi: 10.1577/1548-8659(1997)126<0217:rbcwd>2.3.co;2.
- Beechie, T., H. Imaki, J Greene, A. Wade, H. WU, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney, and N. Mantua. 2013. Salmon habitat for a changing climate. *River Res. Applic.* 29: 939–960.
- Benson, M.A., 1971. Uniform flood-frequency estimating methods for federal agencies. *Water resources research*, 4(5), pp.891-908.
- Boltz, F., N.LeRoy Poff, C. Folke, N. Kete, C. M. Brown, S. St. George Freeman, J. H. Matthews, A. Martinez, and J.Rockström. 2019. Water is a master variable: Solving for resilience in the modern era. *Water Security* Volume 8:1-10.

Boulton, A., S. Findlay, P. Marmonier, E.H. Stanley, and M. Valett. 1998. The functional significance of the hyporheic zone in streams and rivers. *Annual Review of Ecological Systems* 29: 59–81.

Caldwell, P.V., K.J. Elliott, W.T. Swank, S.T. Brantley, and S.H. Laseter 2013 Declining water yield from forested mountain watersheds in response to climate change and forest mesophication. *Global Change Biology* 22(9): 2997-3012.

Chandler, G.L.; Wollrab, S.P.; Horan, D. L.; Nagel, D. E.; Parkes, S.L.; Isaak, D.J.; Horan, D.L.; Wenger, S.J.; Peterson, E.E.; Ver Hoef, J.M.; Hostetler, S.W.; Luce, C.H.; Dunham, J.B.; Kershner, J.L.; Roper, B.B. 2016. NorWeST stream temperature data summaries for the western U.S. Fort Collins, CO: Forest Service Research Data Archive. <https://doi.org/10.2737/RDS-2016-0032>.

Climate Impacts Group. 2022. Data available at: <https://cig.uw.edu/resources/analysis-tools/climate-mapping-for-a-resilient-washington/>.

Close, D.A., Fitzpatrick, M. and Li, H. 1995. Status report of the Pacific lamprey (*Lampetra tridentata*) in the Columbia River Basin. BPA Project #94-026. 42 p.

Cluer, B., and Thorne, C. 2014. A Stream Evolution Model Integrating Habitat and Ecosystem Benefits. *River Research and Applications* 30: 135-154.

Collins, B., Montgomery, D., Fetherston, K., and Abbe, T. 2012. The Floodplain Large Wood Cycle Hypothesis: A Mechanism for the Physical and Biotic Structuring of Temperate Forested Alluvial Valleys in the North Pacific Coastal Ecoregion. *Geomorphology* 139-140, 460-470.

Crandall, J. 2022. Methow Thermal Refugia Restoration Assessment. Prepared for the Habitat Conservation Plan Tributary Fund, Project 2021-01 W. 41 p. plus appendices.

Dunham, J.B., M.K. Young, R.E. Gresswell, and B.E. Rieman. 2003. Effects of fire on fish populations: landscape perspectives on persistence of native fishes and nonnative fish invasions. *Forest Ecology and Management* 178:183-196.

Ecology (Washington State Department of Ecology). 1992. Methow River Basin Fish Habitat Analysis Using the Instream Flow Incremental Methodology. Water Resources Program. August, 1992.

Ecology (Washington Department of Ecology). 2000. Effects of Elevated Water Temperature on Salmonids. Focus Info Sheet. Olympia, WA. July, 2000.

Ecology (Washington Department of Ecology). 2007. Modeling the Effects of Riparian Buffer Width on Effective Shade and Stream Temperature. Environmental Assessment Program. Olympia, Washington. Publication No. 07-03-028.

Ecology (Washington Department of Ecology). 2014. Channel Migration Processes and Patterns in Western Washington: A synthesis of Floodplain Management and Restoration. Shorelands and Environmental Assistance Program. Olympia, Washington. Publication no.14-06-028.

Flitcroft, R., J. Falke, G. Reeves, P. Hessburg, K. McNyset, and L. Benda. 2016. Wildfire may increase habitat quality for spring Chinook salmon in the Wenatchee River subbasin, WA, USA. *Forest Ecology and Management* 359 (2016) 126-140.

- Fox, M., and S. Bolton. 2007. A regional and geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins of Washington State. *North American Journal of Fisheries Management* 27(1):342–359.
- Fullerton, A.H., C.E. Torgersen, J.J. Lawler, E.A. Steel, J.L. Ebersole, and S.Y. Lee. 2018. Longitudinal thermal heterogeneity in rivers and refugia for coldwater species: effects of scale and climate change. *Aquat Sci.* 2018 January 1; 80(3): 1–15.
- George, M.R. and K.W. Tate. 2004. Cattle grazing has varying impacts on stream-channel erosion in oak woodlands. *California Agriculture Volume* 58(3):138.
- Golder and Associates. 2002. Streamflow and channel analysis Chewuch River. Submitted to the Chewuch Basin Council, Winthrop, Washington. 25 p. plus appendices.
- Goode, J., C. Luce, and J. Buffington. 2011. Enhanced sediment delivery in a changing climate in semi-arid mountain basins: Implications for water resource management and aquatic habitat in the northern Rocky Mountains. *Geomorphology* doi:10.1016/j.geomorph.2011.06.021.
- Gregory, S., F. Swanson, A. Mckee, and K. Cummins. 1991. An ecosystem perspective of riparian zones. *Bioscience* 41(8):540–551.
- Hammersmark, C.T., M.C. Raines, and J.F. Mount. 2008. Quantifying the Hydrological Effects of Stream Restoration in A Mountain Meadow. *River. Res. Applic.* 24: 735–753.
- Hanrahan, T., Z. Sudman, M. Brunfelt, J. Goode, P. Lind, and G. Johnson. 2023. Wildfire and River Restoration: Case Studies from the Methow River Watershed. Report by RioASE and Interfluve, Inc for U.S. Bureau of Reclamation.
https://static1.squarespace.com/static/56a7fd65a2bab83fab5db986/t/6596e5cc97f8521c750cf709/1704388065172/Fire_case_study_report_final_20230718.pdf
- Hart, E. Richard. *Lost Homeland: The Methow Tribe and the Columbia Reservation*, Winthrop, WA: Shafer Historical Museum, 2017.
- Henley, W., M. Patterson, R. Neves, and D. Lemly. 2000. Effects of sedimentation and turbidity on lotic food webs: A concise review for natural resource managers. *Reviews in Fisheries Science* 2:125–139.
- Hottell, Diana. *The Whole Damn Valley: Voices from the Methow*. Winthrop, WA: Shafer Historical Museum, 2007.
- IACWD Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood-flow frequency: Bulletin 17B of the Hydrology Subcommittee, Office of Water Data Coordination, U.S. Geological Survey, Reston, Va., 183 p.,
http://water.usgs.gov/osw/bulletin17b/bulletin_17B.html.
- ICTRT Interior Columbia Basin Technical Recovery Team. 2007. Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs. Review Draft. 261 p.
- Isaak, D.J., D.L. Horan, S.P. Wollrab. 2024. Air temperature data source affects inference from statistical stream temperature models in mountainous terrain. *Journal of Hydrology* X 22, p. 1-9.
- Ives, Enid. “History of Pateros.” (Written for an English paper in December 1928.)

Johnson, J., and J. Molesworth. 2014. Carlton Complex Fire, State and Private Lands Burned Area Emergency Response Aquatic Resources Report. Section within the Burned Area Emergency (BAER) Report of the Carlton Complex Fire (State and Private Team).

Kondolf, G., Smeltzer, M., and Railsback, S. 2001. Design and performance of a channel reconstruction project in a coastal California gravel-bed stream. *Environmental Management* 28, 761-776.

Kostow, K. 2002. Oregon Lampreys: Natural History Status And Analysis of Management Issues. Oregon Department of Fish and Wildlife. 113 p.

Kramer, N. and E. Wohl. 2017. Rules of the road: A qualitative and quantitative synthesis of large wood transport through drainage networks. *Geomorphology* 279: 74-97.

Lane, E. 1954. The Importance of Fluvial Morphology in Hydraulic Engineering: U.S. Department of the Interior, Bureau of Reclamation, Commissioner's Office.

Lang, N., W. Jetz, K. Schindler, and J.D. Wegner. 2023. A high-resolution canopy height model of the Earth. *Nature Ecology and Evolution*, volume 7, November 2023, 1778-1789. DOI: <https://doi.org/10.1038/s41559-023-02206-6>

Lisle, T. 1989. Sediment transport and resulting deposition in spawning gravels, north coastal California. *Water Resources Research* 25(6):1303–1319.

Luce, C.H., and Z. A. Holden. 2009. Declining annual streamflow distributions in the Pacific Northwest United States, 1948–2006. *Ecophysical Research Letters*, Vol. 36, L16401.

Martens, K.D. and P. J. Connolly. 2014. Juvenile Anadromous Salmonid Production in Upper Columbia River Side Channels with Different Levels of Hydrological Connection, *Transactions of the American Fisheries Society*, 143:3, 1-11

Martens, K.D., T.M. Fish, G. A. Watson, and P. J. Connolly. 2014. U.S. Geological Survey's 2013 Methow River Annual Report: abundance estimates in Beaver Creek, methodology testing in the Whitefish Island side channel, abundance estimates at the Chewuch River screw trap, and hatchery survival and detection estimates in the Methow and Columbia rivers.

Masurat, Nicole, "Off-channel habitat restoration using groundwater infiltration galleries in the Methow River Basin, Washington" (2022). WWU Graduate School Collection. 1125. <https://cedar.wvu.edu/wwuet/1125>.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42,156 p.

McNabb, David H.; Swanson, Frederick J. 1990. Effects of fire on soil erosion. In: Walstad, John D.; Radosevich, Steven R.; Sandberg, David V., eds. *Natural and prescribed fire in the Pacific Northwest forests*. Corvallis, OR: Oregon State University Press: 159-176.

- MTBS U.S. Geological Survey and USDA Forest Service. 2024. Monitoring Trends in Burn Severity Thematic Burn Severity Mosaics for Washington State (MTBS). Digital data available from www.mtbs.gov. Downloaded: January 7, 2025.
- Montgomery, D. 1994. Road surface drainage, channel initiation, and slope instability. 1994. *Water Resources Research* 30(6).
- Montgomery, D., J. Buffington, R. Smith, K. Schmidt, and G. Pess. 1995. Pool spacing in forest channels. *Water Resources Research* 31(4):1097–1105, doi:10.1029/94wr03285.
- Nakamura, F., F. Swanson, and S.M. Wondzell. 2000. Disturbance regimes of stream and riparian systems – a disturbance-cascade perspective. *Hydrological Processes* 14:2849-2860.
- Nanson, G., and J. Croke. 1992. A genetic classification of floodplains. *Geomorphology* 4:459-486.
- NMFS (National Marine Fisheries Service). 1996. Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale. Lacey, Washington. Environmental and Technical Services Division, Habitat Conservation Branch. http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/matrix1996.pdf.
- NMFS (National Marine Fisheries Service). 2000. Biological Opinion – Reinitiation of Consultation on Operations of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin.
- NOAA. 2014. National Centers for Environmental Information, Monthly Global Climate Report for April 2014, published online May 2014, retrieved on February 17, 2025 from <https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/201404>.
- NPCC (Northwest Power and Conservation Council). 2004. Methow Subbasin Plan.
- NPPC (Northwest Power and Conservation Council). 2025. <https://www.nwcouncil.org/reports/columbia-river-history/beavers/#:~:text=Between%201826%20and%201834%2C%20Hudson's,left%20off%2C%20in%20a%20sense>.
- Omernik, J.M. & Griffith, G.E. Ecoregions of the Conterminous United States: Evolution of a Hierarchical Spatial Framework. *Environmental Management* (2014) 54: 1249. <https://doi.org/10.1007/s00267-014-0364-1>.
- Okanogan County. 2015. Okanogan County GIS Department 2015 Roads Layer. Found online at: <https://okanogancounty.org/planning/data.htm>.
- Okanogan-Wenatchee National Forest. 2021. Cub Creek 2 Burned Area Summary. 2500-8 Burned Area Report. Available at: <http://www.centralwashingtonfirerecovery.info/2021/wp-content/uploads/2021/09/Cub-Creek-2-Burned-Area-Report-Okanogan-Wenatchee-BAER.pdf>
- Poff, N., Allan, J., Bain, M., Karr, J., Prestegard, K., Richter, B., Sparks, R., and Stromberg, J. 1997. The natural flow regime: a paradigm for river conservation and restoration. *BioScience* 47, 769-784.

Portman, Sally. *The Smiling Country: A History of the Methow Valley*. Winthrop, WA: Sun Mountain Resorts Inc., 2002.

Reid, L., and T. Dunne. 1984. Sediment production from forest road surfaces. *Water Resources Research* 20(11):1753-1761. November 1984.

Roni, P., T. Beechie, R. Bilby, F.E. Leoneti, M.M. Pollock, and G.R. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. *North American Journal of Fisheries Management* 22:1-20.

Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2013. *Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers*. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle.

Snow, C., D. Grundy, B. Goodman, A. Haukenes, and T. Kahler. 2023. Monitoring and evaluation of the Wells Hatchery and Methow Hatchery programs: 2022 annual report. Report to Douglas PUD, Grant PUD, Chelan PUD, and the Wells and Rocky Reach HCP Hatchery Committees, and the Priest Rapids Hatchery Subcommittees, East Wenatchee, WA.

Stewart, I.T., D.R. Cayan, and M.D. Dettinger. 2005. Changes toward Earlier Streamflow Timing across Western North America. *Journal of Climate* 18: 1136-1155.

Terraqua. 2017. Geomorphic Assessment of the Methow River Watershed. Developed for the Bonneville Power Administration's Columbia Habitat Monitoring Program. Project 2011-006-00, Contract #65060.

UC RTT (Upper Columbia Regional Technical Team). 2017. *A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region*. A Draft Report to the Upper Columbia Salmon Recovery Board from The Upper Columbia Regional Technical Team.

UC RTT (Upper Columbia Regional Technical Team). 2021a. Reach assessment guidance for the Upper Columbia.

UC RTT (Upper Columbia Regional Technical Team). 2021b. Habitat action prioritization within the Upper Columbia Basin. 48p.

UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. UCSRB, Wenatchee, WA. Available at <http://www.ucsrb.com/plan.asp>.

USBR (U.S. Bureau of Reclamation). 2008. Methow Subbasin Geomorphic Assessment. Okanogan County, Washington. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise Idaho. February 2008.

USBR (U.S. Bureau of Reclamation). 2012. Lower Entiat Reach Assessment. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, ID.

USFS (U.S. Forest Service). 1994. *Chewuch River Watershed Analysis*. Methow Valley Ranger District, Pacific Northwest Region, Okanogan National Forest.

- USFS (U.S. Forest Service). 2004. Okanogan and Wenatchee National Forest Roads Analysis: Methow Sub-Basin. Methow Valley Ranger Station. March, 2004.
- USFS (U.S. Forest Service). 2008. Chewuch River Stream Survey Report 2008. Okanogan-Wenatchee National Forest Methow Valley Ranger District. 131 p.
- USFS (U.S. Forest Service). 2009. Final Environmental Assessment Cub Allotment Management Plan Revision USDA Forest Service Okanogan- Wenatchee National Forest Methow Valley Ranger District. 171 p.
- USFS (U.S. Forest Service). 2015. *Twisp River Watershed Analysis*. Methow Valley Ranger District, Okanogan National Forest.
- USFS (U.S. Forest Service). 2016. Stream Inventory Handbook, Level I & II. Pacific Northwest Region 6, Version 2.16.
- USFS (U.S. Forest Service). 2021. RAVG Initial assessment of the 2021 CUB CREEK 2 fire (Event ID WA4855212019420210716). Raster digital data available from <https://burnseverity.cr.usgs.gov/ravg/> Downloaded September 5, 2024.
- USFWS (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 (substitute core area) Watershed Scale. Region 1, Portland, Oregon.
- USFWS (U.S. Fish and Wildlife Service). 2015. Recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*). Portland, Oregon. xii + 179p.
- Voss, F., and M. Mastin. 2012. Simulation of streamflows and basin-wide hydrologic variables over several climate-change scenarios, Methow River basin, Washington. U.S. Geological Survey Scientific Investigations Report 2012-5031, 18 p.
- Ward, J. 1998. Riverine landscapes: biodiversity patterns, disturbance regimes, and aquatic conservation. *Biological Conservation* 83(3): 269–278.
- Waters, T. 1995. Sediment in Streams: sources, biological effects, and control. American Fisheries Society, Monograph 7. Bethesda, MD.
- Watershed Sciences. 2009. Airborne Thermal Infrared Remote Sensing, Methow River Basin, Washington. Developed for the Yakama Nation Fisheries and the U.S. Bureau of Reclamation.
- Waples, R., T. Beechie, and G. Pess. 2009. Evolutionary history, habitat disturbance regimes, and anthropogenic changes: what do these mean for resilience of Pacific Salmon populations? *Ecology and Society* 14(1):3.
- WDNR (Washington State Department of Natural Resources). 2023. Washington Large Fires 1973-2023. Digital map. Downloaded September 3, 2024. Available online: https://data-wadnr.opendata.arcgis.com/datasets/6f31b076628d4f8ca5a964cbefd2cccc_0/about
- WDFW (Washington Department of Fish and Wildlife). 2004. Stream Habitat Restoration Guidelines, Final Draft. Washington State Aquatic Habitat Guidelines Program. In partnership

with Washington Department of Ecology and U.S. Fish and Wildlife Service. Olympia, Washington.

WDFW 2018, J. Novak, WDFW, personal communication.

WDFW (WA Department of Fish and Wildlife). 2021. Grazing guidance and grazing management tools. Available at: https://efaidnbmnnnibpcajpcglclefindmkaj/https://wdfw.wa.gov/sites/default/files/2021-06/finalwdfw_grazingguidancetools_061021.pdf.

Wemple, B., J. Jones, and G. Grant. 1996. Channel network extension by logging roads in two basins, western Cascades, Oregon. *Water Resources Bulletin* 32(6).

Winthrop Ranger District. 1994. Chewuch River Watershed Analysis. USDA Forest Service.

Wood, P., and P. Armitage. 1997. Biological effects of fine sediment in the lotic environment. *Environmental Management* 21(2):203–217.

Woodruff, K. 2015. Methow Beaver Project accomplishment 2014. 22 p.

Woodruff, Kent (retired USFS Methow Valley R.D.), interview, March 2019.

World Meteorological Organization. 2020. WMO Statement on the state of global climate in 2019. WMO-No. 1248

Yakama Nation. 2010. Chewuch River Reach Assessment. Prepared for Yakama Nation Fisheries by Inter-Fluve. December. Toppenish, WA.

Yakama Nation. 2015. Upper Methow River Reach Assessment. Historical Conditions and Human Disturbance History (Appendix D). Prepared for Yakama Nation Fisheries by Inter-Fluve December 2015.

Zwolinski, Z. 1992. Sedimentology and geomorphology of overbank flows on meandering river floodplains. *Geomorphology* 4(6):367–379.