ANNUAL REPORT
CTUIR GRANDE RONDE WATERSHED RESTORATION PROJECT
A Columbia River Basin Fish Habitat Project

Northwest Power Planning Council Project # 1996-08-300

Report covers work performed under BPA Contract 73982 REL 101
May 1, 2020 to April 30, 2021

Prepared By:
Allen Childs, Project Leader/Fish Habitat Biologist
Jake Kimbro, Assistant Fish Habitat Biologist
Travis Dixon, Fish Habitat Biologist
Dwayne Pecosky, Fish Habitat Biologist
Dave Mack, Fish Habitat Technician

Confederated Tribes Umatilla Indian Reservation
Department Natural Resources Fish &Wildlife Program
Pendleton, Oregon
Report Created: April, 2021

"This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA."

CONFEDERATED TRIBES UMATILLA INDIAN RESERVATION

BONNEVILLE POWER ADMINISTRATION

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

Introduction

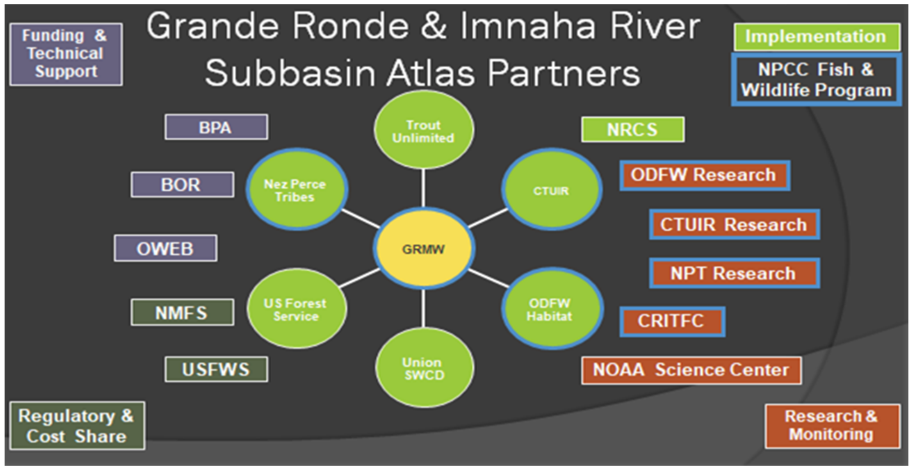
From time immemorial, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) culture and traditions have been interconnected to natural resources. The CTUIR retains aboriginal and treaty-reserved rights for fishing, hunting, pasturing of livestock, and gathering plant food and medicine throughout its Aboriginal Use Areas. Traditional access and use of available resources continue to be threatened by land and water development, watershed degradation, and climate change.

Efforts under this project provides support towards the overall Fisheries Habitat Program goal to protect, enhance, and restore functional floodplain, channel and watershed processes to provide sustainable and healthy habitat for aquatic First Food species (http://fisherieshabitat.ctuir.org/). Our Fisheries Habitat Program's hierarchical approach to restoration strategic planning, project development, and implementation and monitoring is guided by the CTUIR Department of Natural Resources (DNR) "First Foods" Mission and Policy (Quaempts et al 2018), which identifies physical and ecological processes ("key touchstones") of a highly functional and dynamic watershed important for providing water quality and fish habitat that supports First Foods integral for Tribal ceremonies and traditions (Umatilla River Vision, Jones et al. 2008; Upland Vision, Endress et al. 2019).

The CTUIR manages and implements multiple programs in the Grande Ronde, Umatilla, John Day, Walla Walla, and Tucannon River Basins under the Northwest Power Conservation Council (NPCC), Bonneville Power Administration (BPA) Fish and Wildlife Programs and the Columbia Basin Fish Accords and Extensions (2008, 2018) to restore habitat that supports fishery resources including Threatened Snake River spring-summer Chinook salmon (*Oncorhynchus tshawytscha*), summer steelhead (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*).

Background

The CTUIR Grande Ronde Watershed Restoration Project (Project) (1996-08-300) was initiated in 1996 under the NPCC-BPA Early Action Project process to fund the CTUIR to engage the CTUIR in basin conservation planning and fish habitat restoration. The CTUIR is a core partner with Grande Ronde Model Watershed (GRMW) Project (1992-026-01), Oregon Watershed Enhancement Board (OWEB), Focused Investment Program (FIP), and multiple basin resource managers. The CTUIR is represented on the GRMW Board of Directors, OWEB Core Partner Committee, and multiple technical teams and committees involved in basin planning and project prioritization through the GRMW Atlas.



Annual operating budgets have ranged from $61,000 in 1996 to a high of $1,125,477 in 2021 under the CTUIR-BPA Accord which has provided resources for project implementation, administration, planning, and project development. Annual operating budgets and associated tributary habitat efforts by the CTUIR were increased as a result of the CTUIR-BPA Accord Agreement with an annual average budget of $589,500. The Project has been successful in the development and implementation of several large-scale habitat enhancement projects and has developed effective interagency partnerships, working at the policy and technical levels with the Grande Ronde Model Watershed Program (GRMWP), federal and state agencies, and private landowners, including Natural Resource Conservation Service (NRCS) Wetland Reserve Program (WRP), CREP, WHIP, and EQIP, OWEB, EPA-ODEQ 319, GRMW-BPA, CRITFC, NMFS, USFWS, ODOT, and NAWCA and developed an effective working relationship with multiple agencies and organizations.

During the 24-year project history, the CTUIR has contributed to the development multiple fish habitat enhancement projects along 50+ river miles in the Grande Ronde Basin. In recent years the Project has developed, administered, and implemented six large-scale fish habitat and floodplain enhancement projects pursuant to the overall CTUIR Fisheries Habitat Program goal: "*Protect, enhance, and restore functional floodplain, channel and watershed processes to provide sustainable and healthy habitat for aquatic species of the First Food order.*" Guidance from the CTUIR's River Vision has facilitated the shift towards larger, contiguous stream reaches, and broader scale projects that focus on restoring floodplains and physical and hydrological process to form and maintain complex and diverse habitats using the Atlas project prioritization approach. See links below for additional information.

Annual Reports and Project Data

Grande Ronde River Basin

Project Area Description

The Grande Ronde River originates in northeastern Oregon's Blue Mountains and flows northerly 212 miles to its confluence with the Snake River in southeastern Washington at river mile 169 (NPCC, 2004). Historically, the Snake River and its tributaries were likely the Columbia River basin's most productive drainage for salmon and steelhead, supporting more than 40 percent of all Columbia River spring and summer Chinook salmon and 55 percent of summer steelhead (NOAA, 2017). By the late 1800's, fish populations in the Grande Ronde were declining with sockeye and Coho being extirpated in the early 1900's. Declines in Chinook, steelhead, and other native fish resulted in Tribal governments and State agencies eliminating or significantly reducing subsistence and sport fisheries by the mid-1970's (NPCC 2004). Further decline in salmon and steelhead returns led to Federal Endangered Species Act (ESA) Threatened listings of Snake River Spring-Summer Chinook and Summer Steelhead in 1992 and 1994 respectively (NOAA, 2017), and Columbia Basin Bull Trout in 1999 (USFWS, 2014). The Grande Ronde River and tributaries provide critical habitat for Snake River Chinook salmon, steelhead, and bull trout.

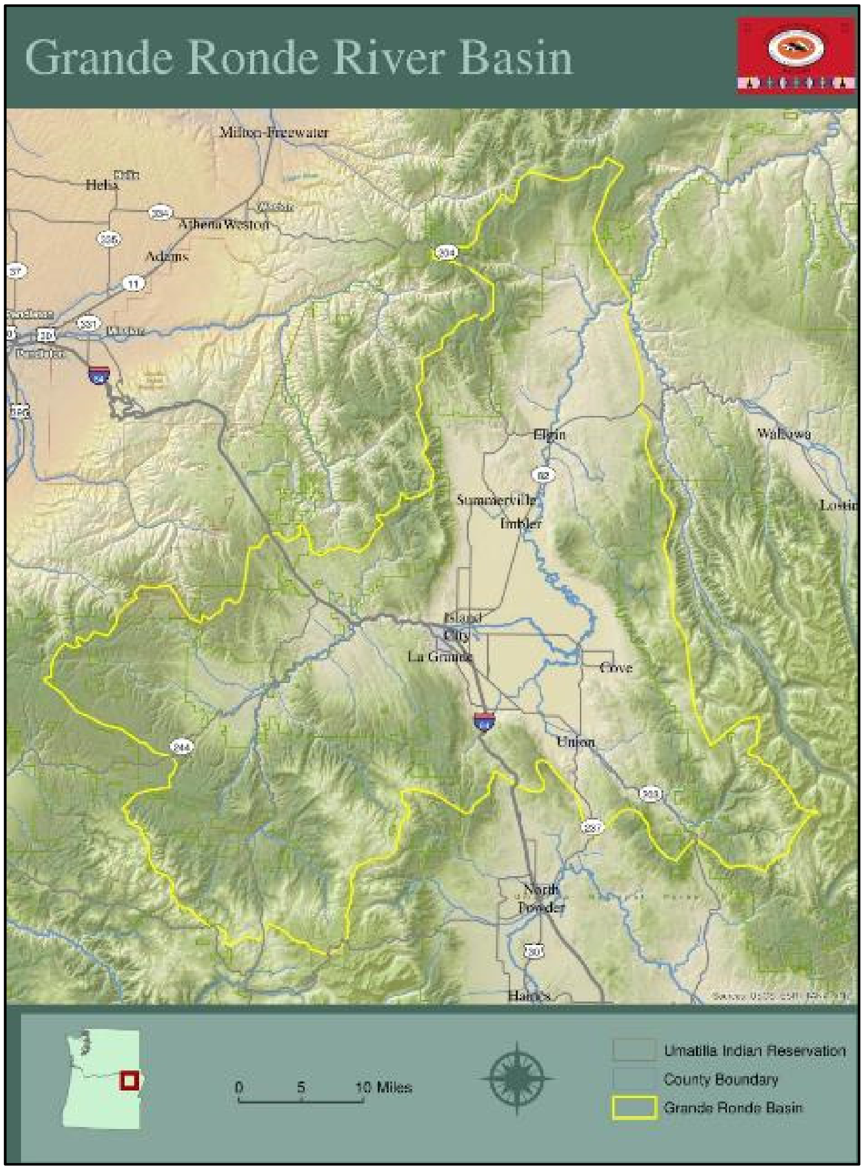


FIGURE 1 UPPER GRANDE RONDE SUBBASIN VICINITY

Degradation of instream and riparian habitat in the Grande Ronde Basin has been the dominant in-Basin cause of salmon and steelhead decline (NPCC 2004). Land use activities since the early 1800s include beaver trapping, logging, splash damming, grazing, mining, channelization, water withdrawals, road and railroad construction, and urban development. Past activities have degraded aquatic habitat conditions with extensive channel simplification (White et al. 2017, pg.

212-213), loss of large pool habitat (McIntosh 1994), significant thermal loading, and loss of cold-water refuge (Justice et al. 2017, Ebersole et al. 2003).

The Oregon Department of Environmental Quality (ODEQ) listed over 60 stream reaches in the basin on Oregon's list of water quality limited water body's 303 (d), 24 of which are listed for habitat modification, 27 for sediment, and 49 for temperature (NPCC 2004). Human-caused CO_2 emissions have contributed to a summer warming trend of Pacific Northwest streams of approximately 0.14–0.27°C per decade between 1976 and 2015 (Isaak et al. 2017, 2018). Regional climate changes and forecasted warming trends are going to contribute to salmonid range contraction and decreased habitat capacity and suitability in the basin (Justice et al. 2017). Climate change is also expected to negatively influence hydrology and availability of water resources (Clifton et al. 2018), as well as increase pathways for invasive species (Rahel and Olden 2008).

Extensive evaluation of historic habitat degradation, current habitat condition, fish life histories, and habitat limiting factors have been the focus of ESA recovery planning, Biological Opinion (BiOp) Expert Panel, NPCC Fish and Wildlife Program as amended, basin planning (NPCC 2004), research and evaluation, and recent multi-disciplinary/agency strategic planning efforts. BPA and GRMW facilitated these efforts in the development of the Grande Ronde and Catherine Creek Atlas (Atlas) and Atlas User Guide (BPA et al. 2015 and 2017). The purpose of Atlas is to focus Basin partner efforts towards the most important restoration priorities in the right locations, right order, and focused on a process-based, landscape approach (BPA 2017). The core elements of Atlas are the integration of monitoring and research findings associated with focal fish limiting factors, habitat suitability, and life history requirements and the facilitation of much needed communication and collaboration between basin partners in the evaluation, prioritization, and development of restoration actions.

Additionally, the Atlas delineated biologically significant reaches (BSR) and associated life history use/timing, habitat limiting factors, prioritized habitat actions, and habitat objectives, providing a central location of data and a strategic approach that facilitates consistent project planning, development, and coordination within the basin partnership. The Atlas is an iterative and adaptive set of procedures adjusted to incorporate new empirical data, published research evidence, results from projects, and evolving local knowledge. The Atlases have been instrumental in promoting partner collaboration, and building a consistent framework for identifying, selecting, funding, and implementing restoration efforts in core Chinook salmon and steelhead habitats. In summary, the Atlas identifies the following critical life stages and limiting factors:

Catherine Creek Atlas

- Juvenile outmigration - high mortality rate
- Adult Chinook holding/spawning - high pre-spawn mortality rate
- Juvenile Chinook and steelhead summer/winter rearing - habitat capacity
- Adult Chinook immigration - thermal barriers

Upper Grande Ronde Atlas

- Juvenile outmigration - high mortality rate
- Adult Chinook holding/spawning - high pre-spawn mortality rate

- Juvenile Chinook and steelhead summer/winter rearing - habitat capacity
- Adult Chinook immigration - thermal barriers
- Adult steelhead spawning - lack of pools

Wallowa/Imnaha Atlas

- Adult Chinook holding/spawning - lack of pools, sediment, regulated flows
- Juvenile Chinook and steelhead summer/winter rearing - habitat capacity, regulated flows
- Adult Chinook immigration - anthropogenic barriers, reduced flows

The importance of restoring salmon, steelhead, resident fish, and other natural resources is central to the CTUIR's culture and traditions. Our Fisheries Habitat Program's hierarchical approach to restoration strategic planning, project development and implementation, and monitoring is guided by the "First Foods" DNR Mission and Policy (Quaempts et al. 2018) and River and Upland Visions (Jones et al. 2008; Endress et al. 2019). The CTUIR First Foods concept of "reciprocity" comes from a creation belief that acknowledges a moral and practical obligation that humans and the natural biota have to care for and sustain one another. This belief arises from the human gratitude and reverences for the contributions these First Foods make to sustain human kind. The River Vision identifies physical and ecological processes ("key touchstones") of a highly functional watershed and dynamic river system important for providing water quality.

The CTUIR's habitat objectives and Atlas objectives were developed and linked to target species life histories and limiting factors with habitat action types specified and assigned for specific habitat uplift. (CTUIR Fisheries Habitat Program)

CTUIR habitat programs tier to the NPCC Fish and Wildlife Program (NPPC 2014 and 2020 Amendments) with consistent goals and objectives associated with rebuilding Columbia and Snake River native fisheries. CTUIR programs focus on conserving and protecting the best remaining habitat (particularly cold-water refuges), reconnecting habitat and corridors, prioritizing near term resources in core areas, and building out to interconnect habitats and life stages. Floodplain restoration, hydrologic and geomorphic processes, groundwater and hyporheic functions, and habitat diversity and complexity are core features of ecological diversity and resilience.

The vision for the 2014 NPCC Fish and Wildlife Program is "a Columbia River ecosystem that sustains an abundant, productive, and diverse community of fish and wildlife, supported by mitigation across the basin for the adverse effects to fish and wildlife caused by the development and operation of the hydrosystem. This envisioned ecosystem provides abundant opportunities for tribal trust and treaty-right harvest, non-tribal harvest, and the conditions that allow for restoration of the fish and wildlife affected by the construction and operation of the hydrosystem" (NPCC 2020).

Project Goals and Objectives

The goal of CTUIR's tributary habitat programs is to protect, enhance, and restore functional floodplain, channel, and watershed processes to provide sustainable and healthy habitat for aquatic First Food species. Objectives are a means of achieving stated goals and include 1.

Habitat protection and conservation, 2. Floodplain connectivity, 3. Channel morphology, 4. Instream structure and complexity, 5. Riparian restoration, 6. Water Quality, and 7. Fish passage.

TABLE 1 PHYSICAL OBJECTIVES THAT AIM TO RESTORE ECOLOGICAL FUNCTIONS WITHIN THE GRANDE RONDE BASIN.

Physical Objectives	Description	Measureable Criteria	Monitoring Technique	Effectiveness Criteria	Notes
1. Habitat protection and conservation	• Fee title acquisition • Term conservation easement	• Protected acreage	• Bi-weekly livestock trespass monitoring • Fence/water gap inspection • Boundary inspection	• Increased acreage protected	1. Livestock exclusion, direct benefit for riparian protection. 2. Habitat program directly involved with planning/management of acquisition/easements,
2. Floodplain reconnection	• Restore connectivity to promote hydrologic and physical processes that maintain complex and resilient habitats that hydrate/store, attenuate floods, and buffer water temperature.	• Inundation @ annual 1.25 flood flow • Summer base flow • Acreage inundated • Ground water elevations • Beaver habitat suitability (# acres)(**see notes**)	• UAV Imagery (remote sensing) • Groundwater wells • Stage recorders • Piezometer	• Inundated acreage (annual) • Groundwater elevation in relation to ground surface • Summer base flow discharge • Increase acre-foot (af) storage	1. Valley form and stakeholder/landowner buy-in are limiting factors for max potential of floodplain connectivity. 2. Increase floodplain connectivity as discharges increase without increasing flood damage to nearby infrastructure (if present). 3. Beaver habitat suitability will correlate with floodplain acreage.
3. Channel morphology restoration	• Increase stream length and channel complexity	• Lengths of main channel and side channels (miles) • Number of pools (**see notes**) • Sinuosity • Node density • Maintain side-channel activation	• Longitudinal profile • UAV (remote sensing) • River complexity index (RCI)	• Increase main and side channel lengths • Increase sinuosity (geomorphic template) • Increase pools (4'depth)/mi • Higher RCI than pre-project conditions • Side-channel and peripheral habitat persistence	1. RCI will follow standard protocol of Brown 2002. 2. Deriving a target value of pool frequency will be consistent with McIntosh et al. 2000 coupled with Rosgen morphology and BOR Tributary Assessment. 3. Sinuosity is contingent on geomorphic template of project reach.
4. Instream habitat structure and complexity	• Increase large wood (LW) in project reach	• Wood loading (pieces/mile) commensurate with reference condition wood loading (**see notes**)	• Survey prior to project start • UAV(remote sensing)	• Increase pieces/mile in relation to design based on reference	1. It is expected wood loadings will vary due to recruitment and dismissal of LW. 2. Large wood frequencies within the bankfull channel will be correlated to quantities associated with reference conditions (AQI 2005, CHaMP 2013-2015, Mcintosh et al. 1994). 3. Bioclimatic region, drainage area, and channel width are dominant predictors of instream wood load (Wohl et al. 2017).
5. Riparian restoration and management	• Restore riparian and floodplain vegetation	• Percent vegetation cover	• UAV imagery (remote sensing) • Stock/stem survival • Photo points	• Year 5: >80% fully vegetated (herbaceous cover, including sedges and rushes/herbaceous) • Year 5: 20% riparian and forest shrub tree cover • Year 25: >50% riparian and forest shrub tree cover	1. Riparian vegetation will be assessed through a combination of remotely sensed imagery and on-the-ground surveys. 2. Monitoring of vegetation can extend out to 15 years post-project completion.
6. Water quality	• Improve summer and winter altered thermal regime	• Stream temperature	• Forward looking infrared (FLIR) • Thermographs • Maximum Weekly Maximum Temperature (MWMT) • Diurnal fluctuation range	• Reduce # days under 25°C (lethal limit) • Increase #days within 10°C and 18°C (core cold temps for salmonids)	1. Contingent on funding availability, hyporheic exchange would be monitored.
7. Fish passage	• Improve fish passage for all life stages of targeted species (steelhead, chinook salmon, bull trout, and Pacific lamprey)	• Overflow capacity for floodplain connection • Native fish species present • Life history stages that require fish passage	• ODFW Fish Passage Criteria (635-412-0035)(**See notes**)	• Miles of restored or improved passage for targeted species	1. ODFW Chapter 635: Division 412 Fish Passage – 635-412-0035

Biological Objectives

Fish response to habitat actions for the Project are conducted by the CTUIR Grande Ronde RM&E Project (#2009-014-00). Biological objectives related to our habitat project are described in the RM&E proposal and were developed to assess the biological response to habitat actions. Physical habitat objectives were developed based on fish life histories, limiting factors and actions described in detail in the Atlas.

TABLE 2 BIOLOGICAL OBJECTIVES AIM TO ASSESS RESTORATION PROJECT EFFECTIVENESS FOR THE CTUIR RM&E: BPA PROJECT 2007-083-00

Biological Objectives	Measureable Criteria	Monitoring Technique	Effectiveness/Statistical Criteria	Notes
1. Salmon/steelhead abundance	• Adult abundance by species • Juvenile abundance	• Electrofishing (**see notes**) • Snorkel Surveys • Minnow traps	• t-test for pre vs. post project mean, alpha = 0.05 • 25% Increase over baseline with data	• Adult abundance monitoring contingent on permit
2. Salmon/steelhead productivity	• Pre-spawn survival • Trib survival of seasonal parr • Smolt-to-adult return (SAR)	• Adult weir (**see notes**)	• t-test for pre vs. post project mean, alpha = 0.05 • 25% Increase over baseline with data	• Only implemented on Lookingglass Creek • ODFW collects adult data within Grande Ronde basin.
3. Holding/spawning/ incubation/emerge nce	• Redd density by species (**see notes**) • Spatial arrangement of redds	• Spawning surveys (**see notes**)	• t-test for pre vs. post project mean, alpha = 0.05 • 25% Increase over baseline with data	• Gallagher et al. 2007

Habitat Protection and Conservation

The Project actively pursues properties for fee title acquisition, conservation easements, and water conservation.

Floodplain Reconnection

Historic anthropogenic activities have severely altered floodplains, channel morphology and thermal regime contributing to habitat loss, degradation, and productivity of cold water fishery habitat. Our floodplain objective is to restore the connection of rivers to their floodplain, recognizing the “River is the Floodplain.” Floodplains perform diverse physical and ecological functions, including attenuation of water, sediment and organic matter, storage, and organic matter (Wohl 2020). Floodplains are a repository of water, wood, sediment and nutrients, are resilient, and have high intrinsic value for ecological services, productivity, and resilience. The floodplain objective is to reconnect rivers to the historic floodplain and promote processes and function that creates and maintains habitat.

Channel Morphology Restoration

Main channel, side channels, pools, and off-channel areas provide rearing habitat for salmonid and other fish species, during all life stages. The Project aims to directly increase stream length and channel complexity to meet the needs of native fish species. Project restoration actions aim to restore or enhance main channel, side channel, and off-channel habitat, which include reconnecting or constructing perennial side channels, secondary channels, high-flow channels, floodplain ponds, wetlands, alcoves, and groundwater-fed off-channel habitat. The Project works with partners to evaluate the geomorphic template of the valley floor and hydraulics of given project reaches to determine the appropriate construction methods and utilizes comprehensive geomorphic assessment methods coupled with Rosgen morphology, BOR Tributary Assessments, and the River Complexity Index (RCI) to support desired project conditions.

Instream Habitat Structure and Complexity

Objective is to restore large wood density to increase complexity, cover, and complexity, consistent with reference conditions in the area (Wilderness areas, Minam basin) (Mcintosh et al. 1994, White et al. 2017, Wohl et al. 2017).

Riparian Restoration and Management

Floodplain and river connection objectives are directly related to riparian objectives. Restoring floodplains promotes hydrologic and disturbance regimes that support moist soil conditions and hydrophilic vegetation. Encouraging development of conditions that generate natural recolonization of native sedges/rushes, shrubs, and trees and a variety of seral stages is preferred to artificial planting efforts. However, planting and seeding plans are implemented to facilitate riparian vegetation establishment. Riparian objective is to enhance or re-establish riparian vegetation communities along stream reaches to increase riparian habitat diversity, restore canopy cover to increase shading, improve beaver habitat and facilitate beaver recolonization, and increase the likelihood of large wood recruitment over time.

Water Quality

Thermal restoration is dependent on restoring floodplain hydrology and channel morphology that promotes water storage, hyporheic functions, and restoration of riparian and wetland vegetation. Floodplain attenuation contributes to hyporheic lag, providing cold water refuge during summer and warm water refuge during winter. See methods section for additional detail and references. Water quality improvement is a large task in a severely degraded thermal regime and broad actions are required to address these core limiting factors. In addition to floodplain, morphology, and riparian restoration, partners are active in water transactions, water purchases, coordinating with local farm bill programs to establish greenbelts, conservation easements and riparian restoration, and water conservation programs associated with irrigation.

Fish Passage

Reviews of the effectiveness of habitat improvement have consistently reported removal of barriers or installation of fish passage as one of the most effective at increasing fish numbers and highest priority habitat improvement measures for salmon, steelhead, and other stream fishes (Roni et al. 2002, Roni et al. 2008). The Project aims to improve fish passage in the Basin and works with The Umatilla Tribe Ceded Area Juvenile and Adult Passage Improvement Project (Project # 2009-026-00) and the US Forest Service to identify potential fish impediments (typically culverts), and restore longitudinal connectivity to impacted streams.

Recent Notable Watershed Restoration Efforts

Restoration actions during the period 2014 to 2021 have resulted in reconnecting 455 acres of floodplain habitat, protection of 1,083 acres of floodplains, uplands, and riparian areas through permanent and term conservation easements, 157 acres of floodplain and riparian habitat planted with over 47,000 native trees and shrubs, 13.5 miles of main channels restored or enhanced, 8 miles of side channels constructed, 147 large main channel pools created or enhanced, 74 side channel pools created or enhanced, and 589 large wood structures installed.

Recent notable CTUIR efforts in the Grande Ronde Basin (Basin) include: fee title land acquisitions in the Catherine, Meadow Creek/Dark Canyon, and Lookingglass watersheds and implementation of large projects along Catherine Creek (CC44 Southern Cross), and the Grande Ronde River (Rock Creek, Bird Track Springs, Middle Upper Grande Ronde, and Longley Meadows). Since 2014, the project has sponsored six watershed projects in cooperation with partners, including the GRMW, OWEB, BPA, Bureau of Reclamation (BOR), Wallowa-Whitman National Forest (WWNF) and private landowners, encompassing over 4,135 acres of permanent habitat conservation (fee title acquisitions and permanent easements), 606 acres of term conservation easements, 348 acres of floodplain reconnection, 14 river miles of habitat restoration/ enhancement, creation/enhancement of 248 large and small pools, and over 400 miles of fish passage improvement (See CTUIR Umatilla Tribe Ceded Area Juvenile and Adult Passage Improvement Project # 2009-026-00).

Future project efforts include continuation with technical assistance on partner-sponsor projects (ODFW Catherine Creek Hall Ranch, WWNF Upper Fly Creek Design), and design and implementation of the following projects: 1. Complete Grande Ronde River Longley Meadows Construction (2021), 2. Limber Jim Culvert Replacement Funding (USFS implementation 2021), 3. (Middle Upper Grande Ronde River Phase 2 & 3 (2023), 4. Catherine Creek RM42 Fish Passage Project (2023), 5. McCoy Meadows Enhancements (2024-2025), 6. Dark Canyon Wood Additions (2024), and Lookingglass Restoration (2025). Additional project opportunities for conservation/protection, restoration, and passage will be ongoing and adjust to priorities and schedules with coordination through the GRMW partnership.

Noteworthy Accomplishments, FY2020

- Maintained and monitored conservation easements on the Grande Ronde River, Catherine Creek, Rock Creek, Meadow Creek, McCoy Creek, and Dark Canyon Creek (Figure 2*).*
- Continued fish habitat enhancement activities, including maintenance, monitoring, and adaptive management, on the Catherine Creek (CC 44) Southern Cross Phase III project, which permanently protects 1 mile mainstem and 64 acres of historic floodplain.
- Initiated planning, field surveys, and design on projects planned for construction through 2021 including:
    - Wood acquisition for the Middle Upper Grande Ronde River (MUGRR) Project Phase 2.
    - Continued planning and design on the Catherine Creek RM 54 Project, the Lookingglass Conservation Property, the CTUIR McCoy Meadows Conservation Property, the Longley Meadows Project, the Middle Upper Grande Ronde River (MUGRR) Phase 2 Project, and the Catherine Creek Adult Weir Project.
- Completed construction of Phase 1 of the Longley Meadows Project. Construction activities included:
    - Environmental controls followed (installation of silt fence, 1200C permit and dust abatement).
    - 11,100 cubic yards (26%) of channel excavation and 1900 cubic yards of material screening.
    - 1,676 cubic yards constructed riffles and 45 imbedded boulders.
    - 1,600 cubic yards of sod salvaged and replanted.

- 5 Apex Jams, 6 Meander Jams, 22 Channel Margin Jams, 11 Sweeper Jams, 5 Cover Logs, 29 Floodplain Roughness Structures, and 1 Reinforced Habitat Structures installed.6694 square yards access road decommissioning
- 1,492 feet Roughened Edge Bank Treatments installed.
- 506 feet Live Brush Trench installed.
- 1 temporary bridge installed and removed.
- 7,000 square yards of sod salvage, storage and placement
- 7275 square yards of Woody riparian clumps salvaged and transplanted.
- 56% of riffles and 11% of point bars completed
- Applied native grass seed (15 lbs/ acre) and straw mulch to disturbed floodplain areas.
- Approximately 27 acres of floodplain connected.

- Project Leader participated on the Grande Ronde Model Watershed Board of Directors.
- Project Leader and Assistant Biologist participated in the Technical Implementation Team as part of the GRMW Step Wise and Atlas Strategic Planning and Project Development Process.
- Staff conducted monitoring and evaluation activities on project areas, including expanded water temperature and groundwater monitoring efforts at restoration sites, photo point documentation, UAV drone flight coordination.
- CTUIR habitat staff supported other research and monitoring efforts at project sites including AEM and CTUIR physical habitat monitoring program such as juvenile salmonid population estimation and adult redds distribution surveys, large pool topographic data collection.
- Project Leader and Biologists presented at meetings and information sessions including GRMW Implementation Team meetings and the Northwest Power and Conservation Council Fish and Wildlife Committee Tributary Habitat Update.
- Pursued future restoration opportunities by continuing discussions with federal land managers and private landowners about restoration opportunities along Catherine Creek, Grande Ronde River, Indian Creek, and Rock Creek.
- Project staff coordinated with landowners, NRCS, and UCSWCD to provide technical assistance for restoration project enrollment in EQIP, CREP, and OWEB small grants on Rock Creek (For the Girls LLC) and Jordan Creek Ranch.

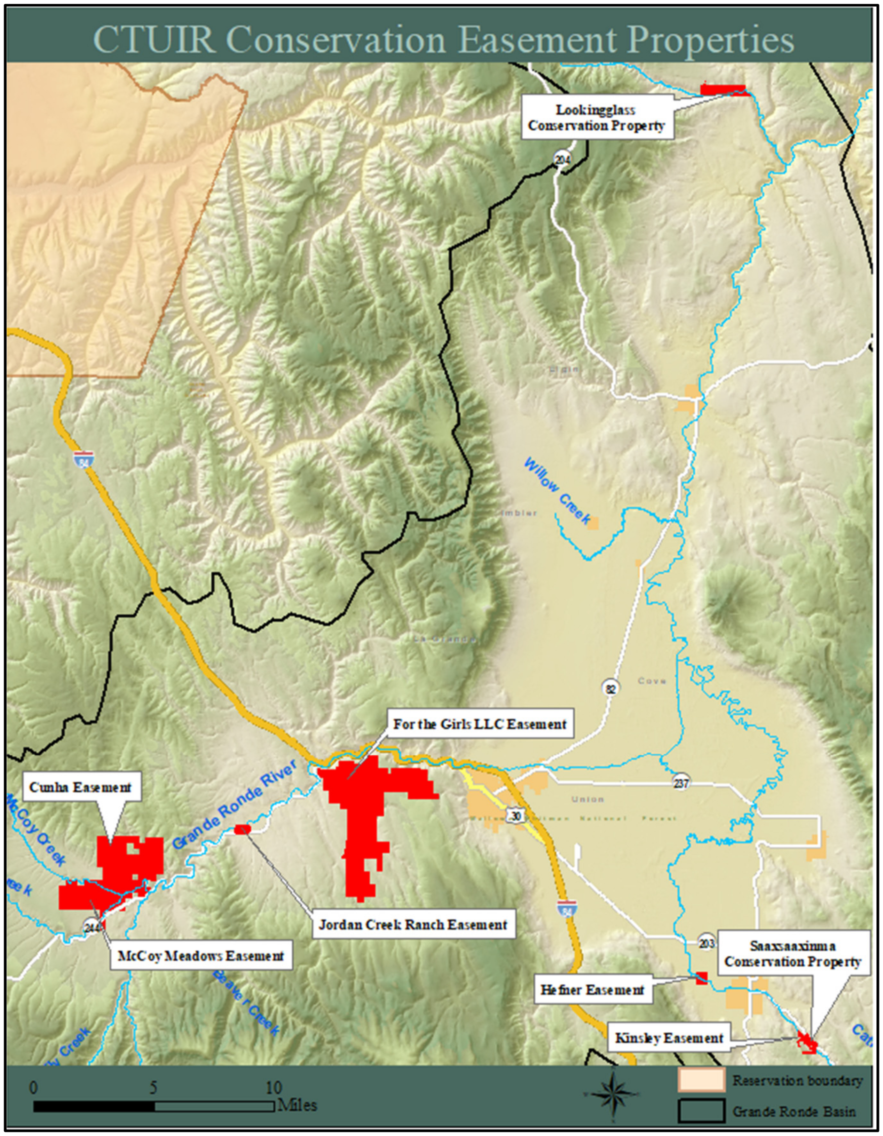


FIGURE 2 CTUIR CONSERVATION EASEMENT PROPERTIES MAP

FY 2020 Project Implementation

Longley Meadows Fish Habitat Enhancement Project 2020-2021

The Longley Meadows Fish Habitat Enhancement Project is located in the Upper Grande Ronde Subbasin along the Grande Ronde River between river miles (RM) 143.5 and RM 142.1, 10 miles SW of La Grande, Oregon (Figure 3). This project is located within Biologically Significant Reach UGR 11 as identified in the Atlas Process. Historic anthropogenic alterations including channelization, logging, mining, road building, splash damming, and livestock grazing have led to a highly degraded channel and disconnected floodplain. Conditions within the Longley Meadows project area include a homogenous, high energy, plane bed channel plan form lacking diversity and sinuosity, a simplified hydraulic geometry, channel over-widening and bed armoring, altered sediment sorting and a coarsening of streambed gravel, altered groundwater and hyporheic function, extensive loss of large pool and side channel habitat, and widespread degradation of riparian and wetland plant communities. Physical alterations to the river and floodplain environment have contributed to poor habitat suitability that lacks velocity refuge, cover habitat, large pools, presents lethal summer high water temperatures, and winter low water temperatures with extensive frazil and anchor ice formation. These simplified and degraded conditions no longer provide suitable juvenile rearing and adult holding/spawning habitat for ESA-listed Chinook salmon, Steelhead, and bull trout and other aquatic species such as Pacific lamprey and freshwater mussels (Figure 4). The project seeks to address the habitat limiting factors of a disconnected floodplain, altered stream channel, lack of large pools and large wood, low stream flows, poor riparian conditions, and an altered thermal regime.

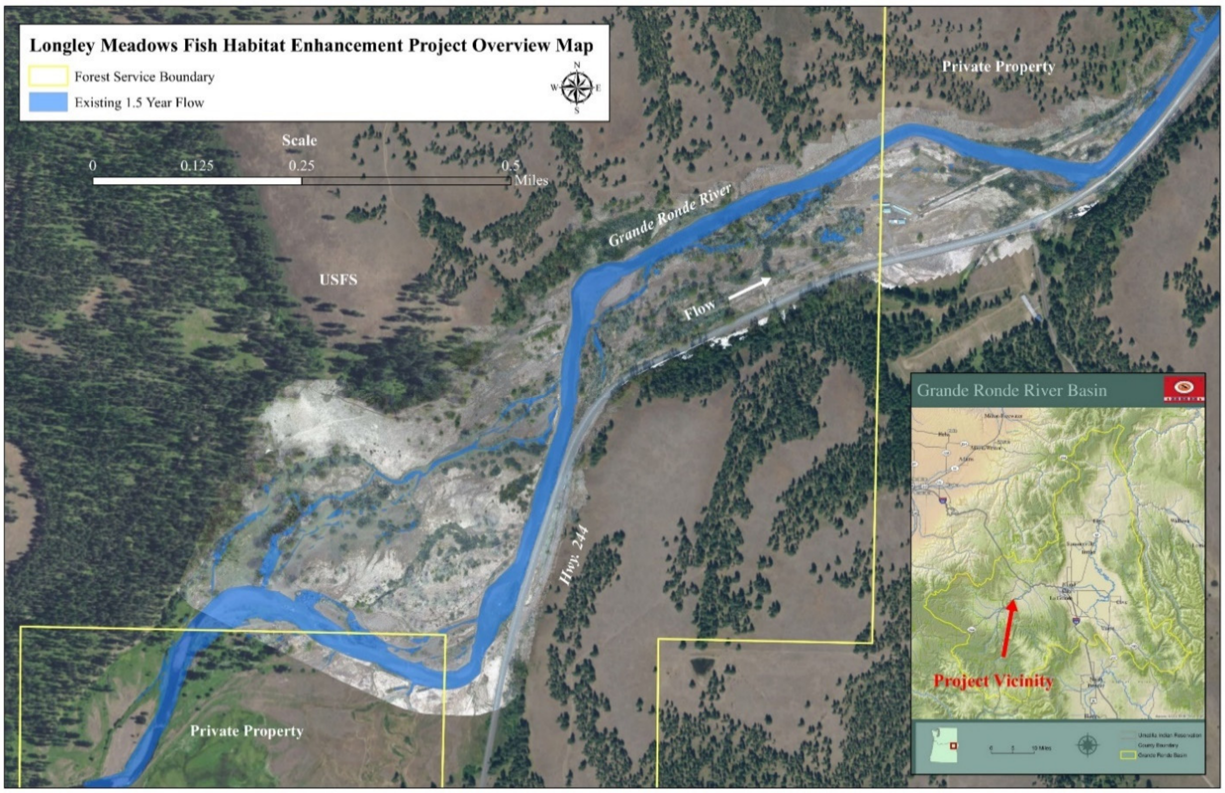


FIGURE 3 LONGLEY MEADOWS FISH HABITAT ENHANCEMENT PROJECT OVERVIEW MAP

Based on hydraulic modeling (Figure 5), the Longley Meadows restoration plan included the development of an island braided channel and floodplain system through channel, floodplain, and large pool construction, development of riparian and wetland habitat, and promoting groundwater and hyporheic functions that moderate and improve water quality. Restoration objectives include reconnecting historic floodplain and side channel networks, improving instream habitat structure and complexity, restoring channel morphology, enhance or re-establish riparian vegetation communities, and improve water quality. Additional objectives include increasing beaver habitat suitability and recolonization that supplement restoration activities and improve natural habitat forming processes that create floodplain wetlands, pools, and vegetation diversity. These restoration actions support the CTUIR's River Vision to protect, restore, and enhance First Foods by rehabilitating and restoring hydrologic processes, geomorphology, habitat and network connectivity, riverine biotic community, and riparian vegetation and provide critical habitat uplift to native fish species.

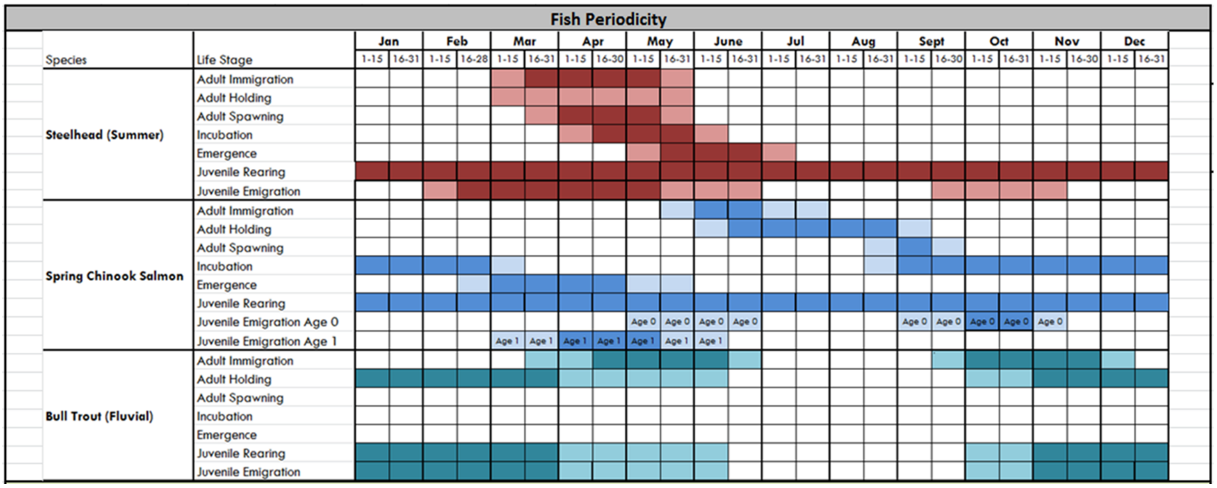


FIGURE 4 FISH PERIODICITY CHART FOR THE LONGLEY MEADOWS PREOJECT REACH

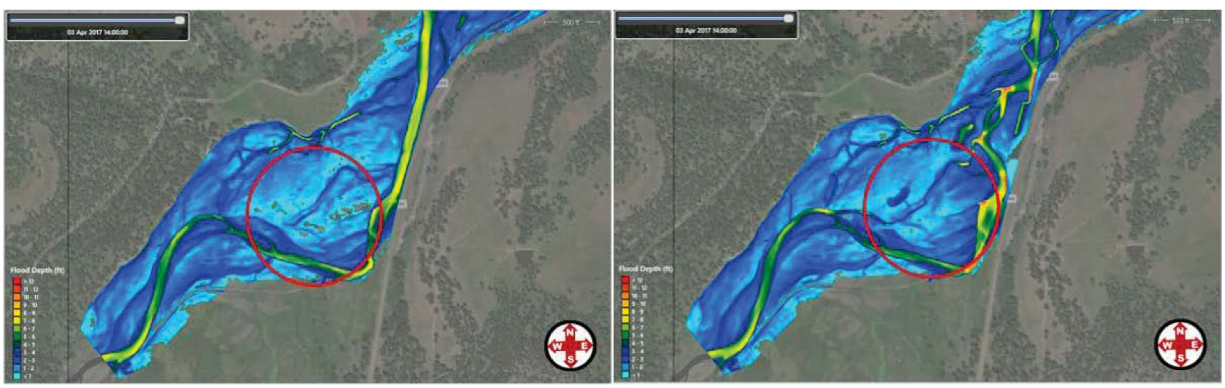


FIGURE 5 EXISTING AND PROPOSED CONDITIONS, 100 YEAR INUNDATION LIMITS FOR THE UPPER FLOODPLAIN

Year 1 construction completed in January, 2021 included BMP implementation, environmental compliance monitoring, work area isolation, fish salvage, water management, approximately 2,000 linear feet of new side channel construction, 700 feet of mainstem large pool grading, installation of 42 large wood structures, riffle construction, streambank bioengineering, and floodplain wood installation was completed.

Primary project features include:

- Sections of main channel realignment and fill of existing main channel alignment;
- Construction of riffles that mimic natural features;
- Construction of gravel bar features;
- Construction of channel banks;
- Placement and compaction of native fill material;

- Construction of network of side channels and connections to existing off-channel features including swales, remnant channel scars, and low areas to create side channels and ponds;
- ELJs (e.g., meander jams, channel-spanning jams, apex jams, small wood placement acting similarly to beaver dams, channel margin jams, and deflector jams);
- Individual large wood habitat pieces (e.g., sweepers, floodplain roughness);
- Bioengineered bank treatments; and
- Creation and enhancement of alcoves and oxbows.

FIGURE 6 ROUGHENED EDGE BANK TREATMENT IN SIDE CHANNEL 5

Accomplishments and Metrics – Year 1

Year 1 work began on the Longley Meadows Fish Habitat Enhancement Project on September 1, 2020 and was completed the week of December 21, 2020. Major construction began in mid-October due to fire risk restrictions, and environmental and cultural permit approval.
Table lists individual work elements and Year 1 accomplished quantities.

TABLE 3 LONGLEY MEADOWS PROJECT DESIGN AND FEATURES

Item	Description	Quantity Completed – Year 1
10	Sod Salvage, Store, Maintain, Place	1600 CY
12	Earthwork – Excavate, Haul, Segregate, Store, and Place	11,100 CY
14	Channel Materials Screening	1900 CY
15	Furnish Large Cobble	358.6 CY
16	Constructed Riffles Class 1	1071 CY
17	Constructed Riffles Class 2	605 CY
21	Boulder Placement	45
23	Type A – Apex Jam Small	5
24	Type B – Meander Jam – Mallet Jam	6
25	Type C3 – 3 Log Angled Channel Margin Jam	2
26	Type C6 – 6 Log Angled Channel Margin Jam	6

27	Type C9 – 9 Log Angled Channel Margin Jam	8
28	Type C12 – 12 Log Angled Channel Margin Jam	4
29	Type D – Single Sweeper Jam	11
30	Type E – Cover Logs	5
31	Type F – Floodplain Roughness	29
32	Type G – Reinforced Habitat Structure	1
33	Short Roughened Edge Bank Treatment	1197 LF
34	Tall Roughened Edge Bank Treatment	295 LF
36	Live Brush Trench	506 LF

Monitoring and evaluation activities include ground photo point documentation, aerial drone imagery, surface water temperature, ground water elevation and temperature, surface flows stage recording, and channel topography changes over time. In addition to physical habitat monitoring, biological data will be collected during snorkel surveys to measure juvenile utilization of habitat structures and adult spawning surveys.

Please see the following link for additional project design details: Longley Meadows

Ongoing Work Elements

The following sections present work elements followed by discussion of accomplishments for the project during the contract period.

Manage and Administer Projects

This work element includes a suite of management actions required to administer the project, including preparation of annual operations and maintenance budgets, managing and preparing statements of work and budgets, and milestone and metrics reporting in Pisces, supervising and directing staff activities, conducting vehicle and equipment maintenance and management, payroll, purchasing, subcontracting for services, and administering/inspecting habitat enhancement activities. CTUIR staff administered the initial phase of the Grande Ronde River Longley Meadows Project.

The Project Leader supervised 4 full-time and 1 nine-month permanent employees to accomplish fish salvage, riparian planting, and easement maintenance duties.

Environmental Compliance and Permits

Environmental compliance methods include development of appropriate documentation under various federal and state laws and regulations governing federally funded project work. Methods involve coordination with various federal and state agencies and development, oversight, and submittal of permit applications, biological assessments, cultural resource surveys, etc.

Primary accomplishments during the reporting period included coordination with BPA environmental compliance personnel to prepare supplemental documentation and reporting for ongoing and planned management actions.

Additionally, CTUIR staff continued EC compliance on projects including the Longley Meadows Project and Middle Upper Grande Ronde River Project. Activities included participation in NEPA, ESA/ARBO, Section 106, and USCOE/ODSL fill removal permit processes.

Fish Salvage Overview 2020

Longley Meadows Fish Habitat Enhancement -Year 1 fish salvage efforts began on October 20, 2020 and concluded on November 3, 2020. A total of two bypass channels were constructed in conjunction with placed sandbags in order to isolate Year 1 work areas within the main channel Grande Ronde River.

Bypass 1, located in the upper-most reach of the project area, and was established through an existing point bar on river right at approximately MC Sta. 1 + 00 downstream to Sta. 7 + 00. Main stem flows were directed into the bypass channel which allowed fish salvage crew (CTUIR) to begin relocating fish from isolated section of main channel. Salvage crew made several initial passes using sein nets to coax the majority of fish out the isolated unit before then using electro-fishing methods to capture the remaining fish and relocating them to areas outside project disturbance.

Upon completion of in-stream work elements within the upper reach bypass flows were redirected back into main channel alignment. Salvage crew seined and electro-fished Bypass 1, relocating captured fish to areas outside project disturbance.
A summary of the catch from this main channel reach and Bypass 1 is below:

- (4) age-1, (1) age-2 *O.mykiss* and (1) age-0 Chinook were captured
- (30) Pacific lamprey ammocoetes
- The majority of the biomass salvaged (903 fish) was a healthy assemblage of freshwater cyprinids (dace, sculpin, shiner and suckers)

Bypass 2 was constructed with similar methods and intentions as Bypass 1, located downstream of the confluence with Jordan Creek at approximately MC Sta. 19+75 to 22+25. Main stem flows were directed into Bypass 2 to allow salvage crews to begin removing fish from the main channel isolation area. Sein nets and electro-fisher techniques were utilized to remove fish from the work area isolation and then relocating them outside project area disturbance.

Bypass 2 was similarly de-fished and decommissioned upon conclusion of Year 1 construction activities in this reach. The following is a summary of the catch from the main channel reach below Jordan Creek confluence and Bypass 2:

- (4) age-0, (13) age-1, (3) age-2, (7) age-3 *O.mykiss* were captured
- (289) Pacific lamprey ammocoetes
- The majority of the biomass salvaged (12,254 fish) were red-sided shiners, with a variety of other freshwater cyprinids (dace, sculpin, suckers)

Two smaller work area isolation units were established using placed sand bags surrounding the entrance to Side Channel 6 from the main channel and at the confluence with Side Channel 5 and the main channel. No salmonids were encountered but salvage crew successfully removed a total of (17) non-salmonid fish from these two sites in preparation for in-stream construction activities. Stream temperatures during 2020 fish salvage window ranged between a low of 1.5 degrees C and high of 12 degrees C. Salvage operations were not at any time halted due to stream temperatures exceeding the established 18 degree C threshold.

Coordination and Public Outreach/Education

Coordination and public education were undertaken to facilitate development of habitat restoration and enhancement on private lands, participate in Subbasin planning, ESA recovery planning, BiOp/Remand project development and selection processes, and assist with providing watershed restoration education. CTUIR technical staff coordinates through the GRMW on the Board of Directors and Technical Committee to help facilitate development of management policies and strategies, project development, project selection, and priorities for available funding resources.

The Project Biologist participates in multiple basin programs and processes associated with project prioritization and selection, funding, and technical review. Focus during FY2020 included participation on the Grande Ronde Model Watershed Board of Directors, Executive Committee, and Grande Ronde Basin Technical Atlas Implementation Team to evaluate and select projects for funding recommendations through the GRMW Step-Wise Process. Additionally, CTUIR staff continued working on look forward projects with close coordination between BPA and BOR to develop core project complexes and initiate concept planning in conjunction with CTUIR-BPA Accord land acquisition strategies.

CTUIR staff also participated in a several educational and public outreach activities including project tours at the Bird Track Springs, Longley Meadows Projects, and Catherine Creek Projects with BOR staff, BPA staff, and USFS staff.

Planting and Maintenance of Vegetation

The CTUIR habitat program annually participates and/or assumes the lead role in re-vegetation activities on individual habitat restoration and enhancement projects. Planting and seeding methods are developed to address site specific conditions and vegetation objectives. Natural colonization and manual techniques are utilized.

Staff efforts associated with planting during the reporting period included the collection, storing, and planting of approximately 6,000 containerized trees (Black Cottonwood, Hawthorne, Ponderosa Pine, Douglas fir, Elderberry, Salmonberry, and Red-Osier Dogwood) on the Bird Track Springs Project for installation on point bars, riffle margins, side channels, and floodplains. Disturbed areas were also seeded and mulched with a native grass seed mix consisting of Basin Wild Rye (33.06%), Rosanna Western Wheat Grass (19.07%), Snake River Wheat Grass (9.34%), Tufted Hairgrass (10.41%), Idaho Fescue (16.51%), and Big Blue Grass (9.94%). Containerized plants were installed by a Forest Service contracted planting crew using a tracked loader with an auger attachment. Multiple applications of the animal repellant Plantskydd® occurred within the Southern Cross RMZ.

Operation and Maintenance of Habitat & Structures/Field Crew Projects and Ongoing Work Elements

CTUIR staff maintains riparian easement fences on nine fish habitat restoration project area properties throughout the field season. Project maintenance includes conducting custodial responsibilities on individual projects to ensure that developments remain in functioning repair and habitat recovery is progressing towards meeting projects goals and objectives. Operations and maintenance of habitat and structures was supervised by biologists and carried out by two permanent technicians. In addition to regular operations and maintenance the field crew participates in furthering project goals, and accomplishing objectives in myriad ways. Activities included:

- Construction and maintenance of plant enclosures (panels/cages) within the Southern Cross RMZ, and the McCoy Meadows/Meadow Creek Project areas.
- Construction and maintenance of water gaps/water access sites on Meadow Creek (Habberstad), Dark Canyon Creek, Rock Creek, and Catherine Creek Project areas (CC37, CC44).
- Inspection, repair, and maintenance of riparian easement fences along Catherine Creek (CC37, CC44), McCoy Creek, Meadow Creek, Dark Canyon Creek, Bird Track Springs, and Rock Creek Project areas.
- Manual control of noxious weeds within the Southern Cross Conservation Property.
- Assisted project biologists with monitoring of stream/air temperatures and groundwater wells on Catherine Creek and the Upper Grande Ronde River and tributary streams.
- Monitoring time lapse, and game cameras at multiple project sites.
- Collection, preparation, storage, and delivery of willow cuttings for channel/floodplain roughness enhancement, roughened edge, and bioengineered bank treatments for the Longley Meadows project.
- General maintenance of project vehicles (trucks/ATVs/trailers), power tools (pumps/chainsaws/augers/pounders), and miscellaneous hand tools.
- Treatment of noxious and invasive weeds through a cooperative agreement with the Tri-County Cooperative Weed Management Area (CWMA) on the Southern Cross Conservation Property, Lookingglass Creek Property, CC37 Project, the Rock Creek Project the Bird Track Springs, and McCoy Meadows Projects (Figure 35).
- Removal of dilapidated fences on the Bird Track Springs Project.
- Fence construction on the Jordan Creek Ranch riparian conservation easement (Bird Track Springs Project).
- Assisted US Forest Service with spring plantings at Bird Track Springs.
- Assisted project biologists with stakeout of culturally sensitive areas on the Longley Meadows project.
- Assisted project biologists with fish salvage operations on the Longley Meadows project.
- Placed closure signage at all access points to the Longley Meadows project site.
- Assisted project biologists with stakeout of roadside wood for use on the Longley Meadows project.
- Assisted project biologists with wood acquisition for adaptive management actions at the Bird Track Springs project.
- Assisted project biologists with materials/equipment purchasing.

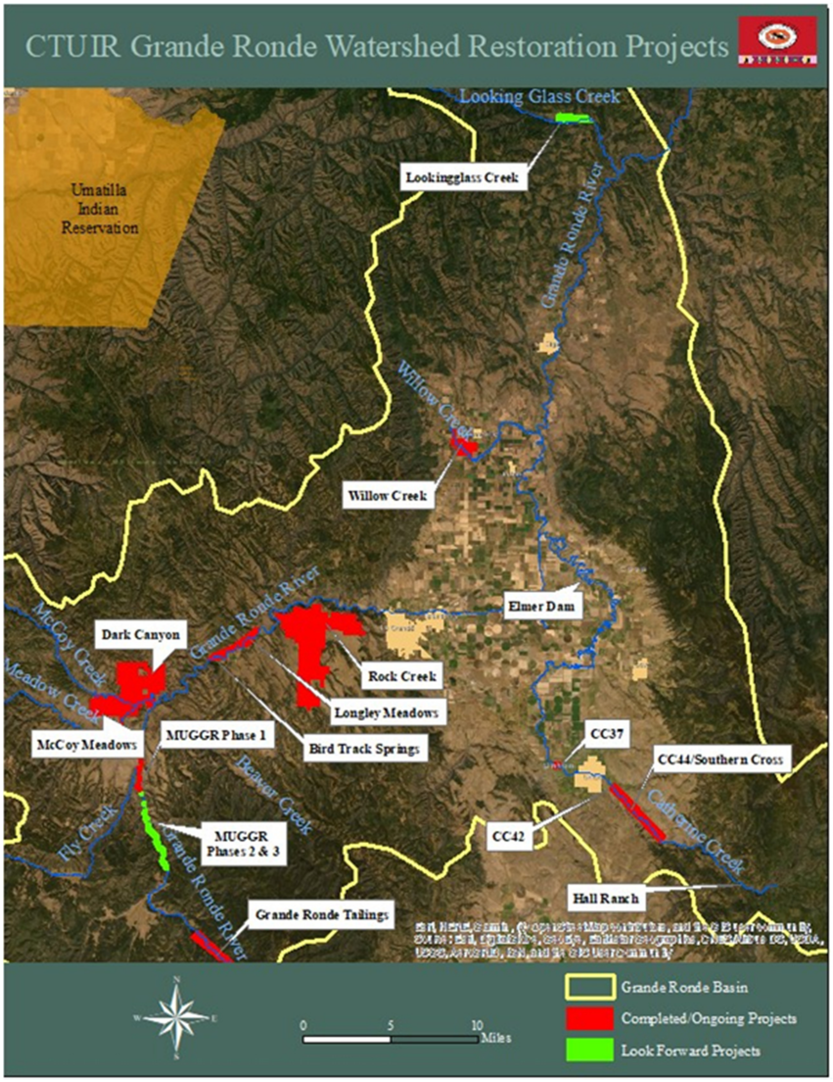


FIGURE 7 CTUIR GRANDE RONDE WATERSHED RESTORATION PROJECTS OVERVIEW MAP.

Noxious Weed Treatment

The CTUIR maintains an ongoing Cooperative Agreement with the Tri-County Cooperative Weed Management Area (CWMA) to chemically treat weeds, provide riparian vegetative enhancements (riparian plants and seeding), and administer weed treatment contracts on approximately 200 acres of CTUIR-owned and CTUIR sponsored fish habitat enhancement projects. Project areas include approximately 8.5 acres within the Catherine Creek CC 37 Fish Habitat Enhancement Project easement boundary, approximately 29.5 acres of pastures and upland terraces within the CC 44 Southern Cross Ranch Fish Habitat Enhancement Project boundary and Fite easement boundary, approximately 32.4 acres within the Rock Creek Fish Habitat Enhancement Project, approximately 76.4 acres within the Lookingglass Conservation Property, and approximately 53.2 acres within the Bird Track Springs Fish Habitat Enhancement Project. 2020 weed treatment activities include:

- Lookingglass Creek (the small private land was paid for by a grant): 15 acres treated for meadow hawkweed, knapweeds, and thistle. This project was completed by a contractor that is required to pass a 90% kill rate inspection. The main focus of this project is meadow hawkweed, but the contractor also sprayed knapweed and thistle and was a onetime treatment in June, 2020. The Umatilla National Forest prioritizes meadow hawkweed treatments upstream of this project which was also treated in June.

- McCoy Meadows (OWEB grant paid for 50% of treatment cost): 15 acres treated for leafy spurge by a contractor and additional 14 by Tri-County staff. This was a one time treatment in late summer which is the optimal time to treat leafy spurge.
- Birdtrack Springs: 1.5 acres treated for Leafy Spurge, Scotch thistle, Canadian thistle, hounds tongue, mullein, annual mustards, and knapweeds. One treatment was made this year mainly focusing on the leafy spurge, mullein, and thistle.
- Southern Cross: 1 acre of yellow starthistle treated, 5 acres treated for Russian thistle, scotch thistle, canadian thistle, whitetop, and annual mustards. Livestock grazing caused more bull thistles in the pasture areas, but there were fewer weeds in the riparian areas. The highest priority is now the whitetop and the yellow starthistle on the east side of the highway as well as treating thistles within the pastures and riparian areas.
- CC37: 7 acres treated for annual mustards, Canadian thistle, bull thistle, and scotch thistle catchweed bedstraw.

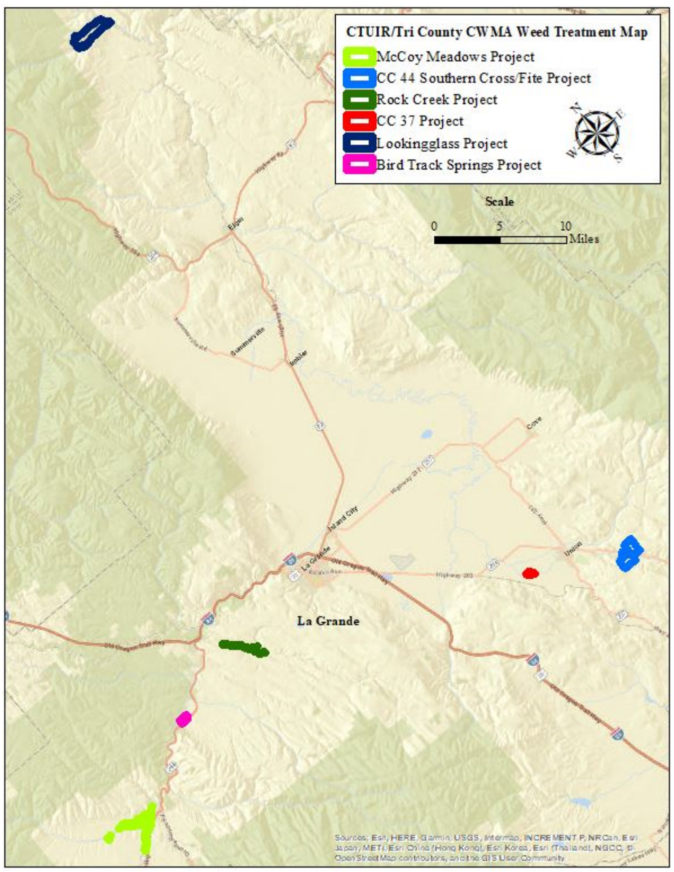


FIGURE 8 CTUIR/TRI-COUNTY CWMA WEED TREATMENT MAP

Identify and Select Projects

The Project has scheduled six sponsor projects for the next five year period illustrated in the table below. See the following link for improved viewing <Look Forward Project Table>. Project planning and design of individual projects are in various stages of development and completion schedules are estimates. See notes for current project status. Atlas prospectuses have been completed and approved for the Middle Upper Grande Ronde River, Meadow Creek McCoy Meadows, Lookingglass Creek and Catherine Creek RM 42 projects and are in development for the Meadow Creek Dark Canyon project. Specific project objectives and outcomes will be formalized during the project development process and tiered to the Atlas and project specific scope, site condition, and constraints.

TABLE 4 LOOK FORWARD PROJECT LIST FOR THE NEXT FIVE YEAR PERIOD (FY 2023 TO 2027)

CTUIR GRANDE RONDE WATERSHED RESTORATION PROJECT SCHEDULE 2023 TO 2027						
Project Title	**Description**	**Limiting Habitat Condition**	**Prioritized Actions**	**Status**	**Construction (Fiscal Year)**	**Notes**
Catherine Creek RM 42 Passage Improvement/Facility Improvement (CTUIR Adult Collection Facility) (45.1127.49/-117.4947.21)	Project is located along Catherine Creek at River mile 42 and includes CTUIR adult weir collection facility and ODFW screw trap. Year round fish passage for all life stages of concern regarding metal picket weir on Catherine Creek utilized to force adult fish into ladder and collection facility.	Fish passage	Fish Passage	Prospectus development, scoping, and development of engineering assistance subcontract solicitation	2022	Site visit and report completed. Preliminary hydraulic modeling completed. Draft engineering assistant subcontract solicitation drafted. Need to develop and submit Atlas Prospectus for review
Grande Ronde River Middle Upper Habitat Enhancement Phase 2 (45.1209.89/-118.2253.94)	Phase 2 and 3 are part of an 8 mile planning reach that ranges from confined to semi confined with inset floodplain that are disconnected due to channel incision. Large wood structure additions to aggrade channel, engage floodplain, sort and store sediment, and enhance/create structure complexity and pool habitat. Difficult ground based equipment access. Helicopter wood and boulder placement to minimize damage. Phase 2 and 3 may be combined to improve efficiencies for permitting and helicopter construction costs.	Floodplain, Instream structural complexity, sediment, temperature	Large wood and boulder. Future gravel augmentation evaluation	60% Design Drawings completed. Cultural surveys and reporting underway.	2023-24	Update hydraulic modeling with 2020 LIDAR data. Project reach construction may be combined into single season per USFS
Grande Ronde River Middle Upper Habitat Enhancement Phase 3 (45.0919.78/-118.2233.45)				30% Design Drawings completed. Cultural surveys and reporting underway.	2024	Update hydraulic modeling with 2020 LIDAR data. Project reach construction may be combined into single season per USFS
Meadow Creek Dark Canyon Wood Additions (45.639.81/-118.2253.94)	Project protected under permanent CTUIR/BPA conservation easement. Approx. 2.5 miles of Dark Canyon and 0.5 miles of lower Meadow Creek.	instream structural complexity, riparian condition	Large wood, pool development, riparian	Prepare and submit Atlas project prospectus. Initiated project planning and design.	2024-2025	Design project and schedule with other helicopter projects for efficiency and decreased project costs.
Meadow Creek McCoy Meadows Floodplain Restoration (45.1548.72/-118.2352.58)	Approximate 350 floodplain in lower Meadow Creek watershed with over 3.5 miles of Meadow, McCoy, and McIntrye Creek. Permanent conservation easement under CTUIR ownership. Previous projects (1997 and 2010) initiated uplift from channelized condition but short of achieving objectives. Stage 0/Hybrid approach to restore floodplain hydrology.	Floodplain, channel form, side channel, structural complexity, sediment, Instream structural complexity, temperature, riparian/wetland condition	Stage 0 Channel Fill, Addition of large wood, floodplain reconnection, side channel and wetland connection, riparian enhancement	Project Atlas Prospectus complete and approved. Ongoing data collection, review, concept planning, groundwater well monitoring, stage data collection, remote sensing data capture to calibrate hydraulic model.	2025 to 2026	Update hydraulic modeling with 2020 LIDAR data
Lookingglass Conservation Property Floodplain Restoration (45.4452.58/-117.5428.13)	Project areas is located on conservation property acquired under CTUIR/BPA Accord. Project includes 3 miles of mainstem Lookingglass Creek which completely channelized and entrenched. Lookingglass watershed is a cold water refuge supporting reintroduced spring Chinook (Catherine Cr stock), ESA summer steelhead and bull trout. Conceptual restoration is a Stage 0 approach	Floodplain, channel form, side channel, structural complexity, sediment, Instream structural complexity, temperature, riparain/wetland condition	Stage 0 Channel Fill, Addition of large wood, floodplain reconnection, side channel and wetland connection, riparian enhancement	Project Atlas Prospectus complete and approved. Schedule data collection, surface development using 2020 LIDAR data, hydraulic modeling and concept development.	2026 to 2027	Develop working surface from 2020 LIDAR data

Catherine Creek RM 42 Passage Improvement & Facility Improvement (CTUIR Adult Collection Facility) – 2022

The project is located along Catherine Creek at River mile 42 and includes CTUIR adult weir collection facility and ODFW screw trap. Project will provide year-round fish passage for all life stages of concern regarding metal picket weir on Catherine Creek utilized to force adult fish into ladder and collection facility.

The existing weir and collection facility is effective for adult fish capture, enumeration, and support for the Chinook supplementation program. However, the weir and fish ladder do not meet current NMFS passage criteria. The Denali ladder exceeds velocity criteria and mortality (rates not available) which occurs frequently at high flows when fish enter the main weir and are impinged on the upstream side of the pickets. Upstream juvenile passage is adversely affected by the velocities through the weir and uncertain through the ladder. Juvenile fish rearing in valley reaches may be negatively affected is not able to migrate upstream to find cold water refuge during summer periods.

Specific objectives for the facility include:

- Meet State and NMFS fish passage criteria.
- Minimize passage delay and injury.
- Ability to operate in icy conditions.
- Non-obtrusive passage during non-trapping (August – February).
- From March 1 – May 1, passively enumerate adult summer steelhead with efficiency >95%.
- From May 1 – July 31, trap, handle, and enumerate adult Chinook and steelhead with efficiency >98%.
- Ability to handle adult Chinook from May 1 – July 31 to:
    - Collect data: length, sex, record marks, and natural or hatchery origin determination.
    - Collect hatchery brood stock.
    - Mark adult Chinook.
    - Collect genetic samples.
    - Remove surplus hatchery origin adult Chinook.
- Ability to handle adult Chinook under electro-anesthesia with minimal stress on fish and personnel.
- Ability to hold fish for 24 hours.
- Incorporate antenna equipment in fishway to detect and interrogate PIT tags on adult and juvenile Chinook and steelhead.
  Incorporate equipment for safe and efficient loading of adult Chinook into transportation vehicles in-water as much as possible.

FIGURE 9 CATHERINE CREEK RM 42 PASSAGE IMPROVEMENT & FACILITY IMPROVEMENT VICINITY MAP

Grande Ronde River Middle Upper Habitat Enhancement Phase II-III – 2021-2023

Approximately 270-300 boulders will be placed by helicopter as structural ballast within previously constructed Phase I engineered log jams (ELJ) during Phase 2 of the project during the in-water work window in 2021. An average of 5 boulders will be placed within each of the 54 ELJ at strategic locations to decrease the opportunity that logs will become buoyant or shift from original placed location, and increase the structural integrity of the ELJ to withstand river forces during high water spring runoff.

Additional actions scheduled for implementation for Phases 2-3 include the continued installation of large wood structures by helicopter throughout the project reach to mimic natural historic conditions. Large wood features will be designed to force pools and maintain the multi-channel planform. Engineered Log Jam Structures (ELJS) will be constructed using the US

Bureau of Reclamation's Pacific Northwest Region Resource & Technical Services Large Woody Material Risk Based Design Guidelines, 2014. Structures are designed to be passable to fish, and are consistent with the adult and juvenile fish passage criteria provided in NOAA's Anadromous Salmonid Passage Facility Guidelines (2004) and consistent with the Aquatic Resources Biological Opinion for restoration actions on federal lands in Oregon and Washington.

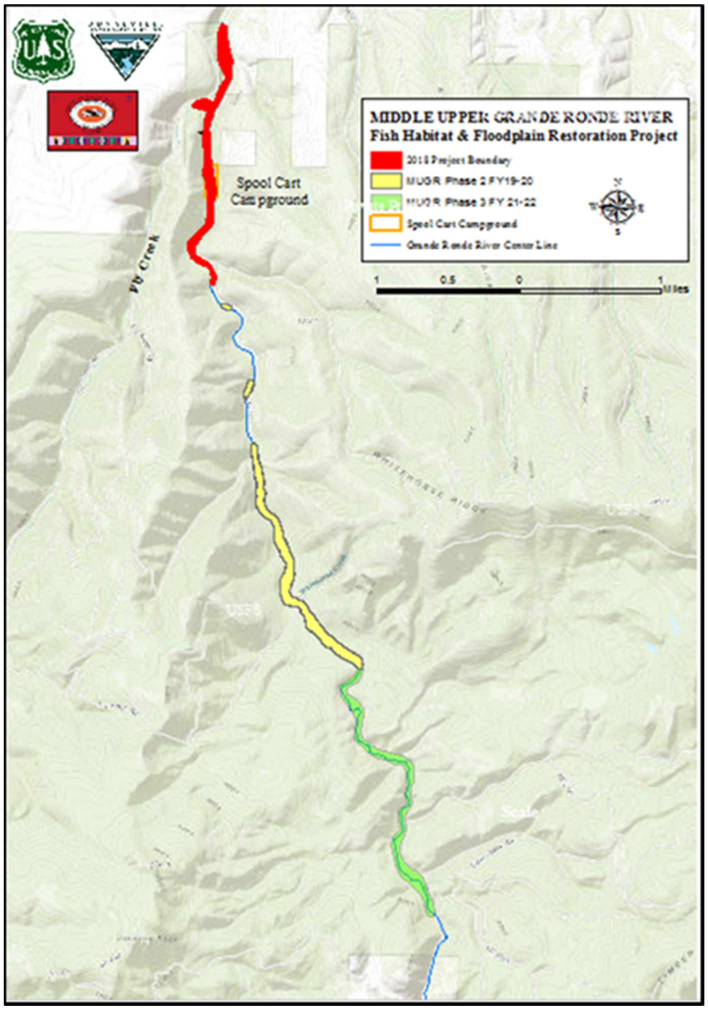


FIGURE 10 MUGRR PROJECT OVERVIEW MAP

Meadow Creek Dark Canyon Wood Additions – 2024-2025

The Meadow Creek Dark Canyon project is located within the Cunha Ranch permanent conservation easement near the confluence of the Grande Ronde River and encompasses approximately 2.5 miles of Dark Canyon Creek and approximately 0.5 miles of Meadow Creek. Initial construction occurred in 2010 and included the installation of instream log jams and boulders along sections of Meadow Creek and Dark Canyon Creek and the removal of an old railroad grade disconnecting the floodplain along Meadow Creek. Future planned actions include the installation of additional large wood structures and boulders to increase complexity and

Meadow Creek McCoy Meadows Floodplain Restoration – 2025-2026

The McCoy Meadows Ranch is located in Union County about 20 miles southwest of La Grande, Oregon, near the confluence of Meadow Creek with the upper Grande Ronde River. The property encompasses nearly 2.9 miles of lower Meadow Creek, 3.3 miles of McCoy Creek, and 0.5 miles of McIntyre Creek. The Project area has had several prior phases implemented. Phase 1 (upper meadow) in 1997, Phase 2 (lower meadow) in 2000-2002, Meadow Creek in 2006, and McCoy Creek enhancements in 2010.

Design Considerations – Stage 0

One design approach being considered for future implementation is to target a process-based *Stage 0* restoration methodology consisting of an anastomosing network of channels and wetlands that frequently flood (Cluer and Thorne, 2013). This approach would create more complex, dynamic, and self-sustaining habitat and improve fluvial processes and function such as floodplain connectivity, retention of fine sediment and spawning gravels, increased pool depths, and diversified habitat. Stage 0 Habitat and Ecosystem Benefits include:

- Habitat - Multiple channels, islands and broad floodplain provide access to rich palette of diverse habitats in close proximity and refugia across a wide range of flood events. High water table, deep pool, and continuous hyporhesis provide drought refugia in the multiple channels. Channel margins evolve semi-continuously to expose tree roots.

- Biota - Multiple, complex, dynamic channels that are connected to an extensive floodplain and which interact with groundwater and hyporhesis support large numbers of different species. This provides for the highest possible biodiversity (species richness and trophic diversity), proportion of native species, and 1st and 2nd order productivity (Thorp, et al., 2010).

- Resilience and Persistence - Physical and vegetative attributes and functions stemming from their complexity, connectivity, and diversity act to attenuate floods and sediment pulses, making habitat and biota persistent and highly resistant to natural and anthropogenic disturbances including flood, drought, and wild fire.

- Water Quality - High capacity of multi-channel network to store sediment and cycle nutrients and other suspended solids produces exceptional water clarity. Dense, diverse proximal vegetation provides abundant shade which, together with efficient hyporhesis, is highly effective in ameliorating temperatures.

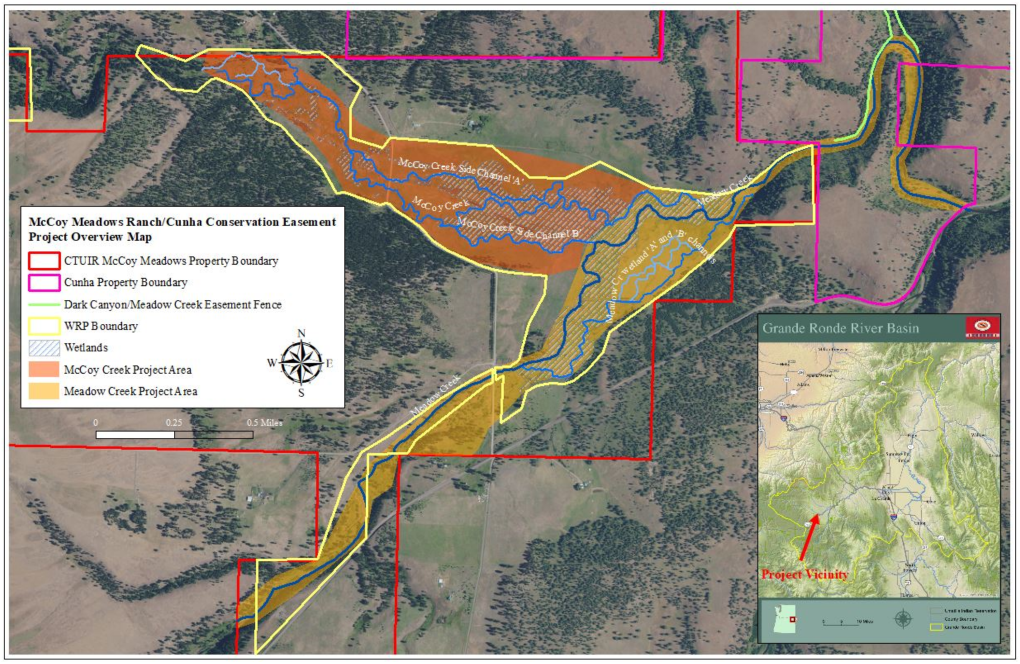


FIGURE 11 MCCOY MEADOWS RANCH/CUNHA CONSERVATION EASEMENT PROJECT OVERVIEW MAP

Lookingglass Conservation Property Floodplain Restoration – 2026-2027

The Lookingglass Creek Fish Habitat Enhancement Project is located in Atlas BSR UGR1 in the Grande Ronde River Basin along Lookingglass Creek between river miles 4 to 6 and is bordered by Umatilla National Forest System Lands along the western boundary. The CTUIR acquired the property in fee title through the CTUIR-BPA Accord land acquisition program in 2018. The project reach sits at an elevation of approximately 2,800 feet with contributing watershed area of 95 mi2, which is predominantly spring-fed and snowmelt driven. Most of the basin is forested (over 90 percent) and has very little development (less than 0.1 percent estimated impervious area) (USGS 2014). The property and resource values are protected by a permanent Bonneville Power Administration conservation easement.

The long-term rehabilitation vision (CTUIR's River Vision) for the Lookingglass Creek Fish Habitat Enhancement Project is to remove risks to native fishery resources associated with non-native fish in constructed ponds, restore the historic floodplain and morphological, ecological processes that support suitable spawning and rearing habitat for spring Chinook salmon, summer steelhead, Pacific lamprey, and bull trout. Fish habitat suitability and capacity uplift potential is significant. Juvenile salmonid rearing habitat, adult spawning habitat, and riparian-wetland habitat would benefit from restoration and enhancement (wood placement, channel and side channel reconstruction, wetland and riparian restoration, and floodplain reconnection). Activating the floodplain and utilizing the previously constructed floodplain ponds would significantly improve juvenile rearing habitat for summer and winter. CTUIR Chinook redd surveys document extensive spawning use of the of the project area despite habitat limiting factors (degraded habitat quantity and diversity, lack of large complex pools, large substrate, lack of large wood, and backwater habitat) excess fine sediment, lower summer flows, predation, alterations of the hydrologic function, and the channel being disengaged from the floodplain and elevated water temperatures (Huntington, 1993; NPCCa, 2004, GRMW 1995, WWNF 2004). A *Stage 0* design approach is also being considered.

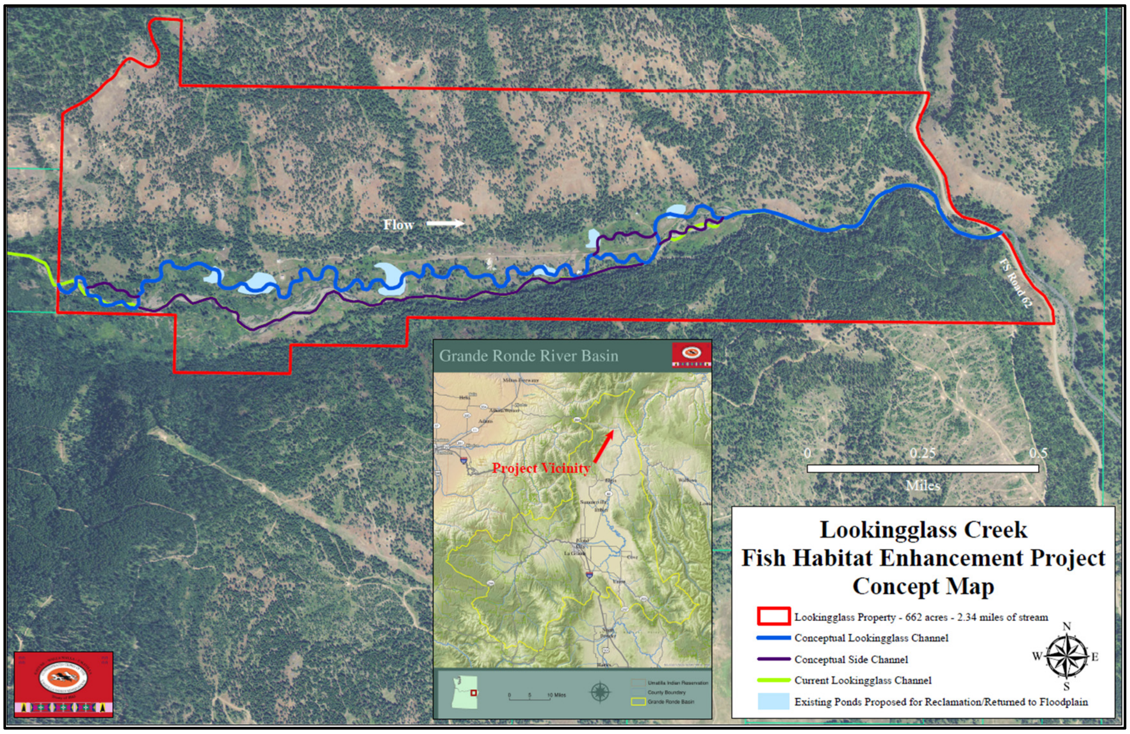


FIGURE 12 LOOKINGGLASS CREEK FISH HABITAT PROJECT CONCEPT MAP.

Grande Ronde Sub basin Monitoring & Evaluation

Monitoring and evaluation (M&E) of individual projects is conducted either independently by the CTUIR or jointly with project partners, Fish Habitat Enhancement Biological Effectiveness Monitoring 2020 Annual Progress Report (project #2009-014-00; BPA contract #71934) depending on the project.

M&E efforts include annual drone imagery collected by the GRMW including aerial video and DTM/Ortho imagery, annual photo-points, time lapse cameras at select locations, installation and maintenance of water and air temperature probes, stream channel cross sections and longitudinal profiles, pebble counts, juvenile fish population and habitat surveys, stocking/census surveys on re-vegetation efforts, and groundwater monitoring. Public tours, workshops, and presentations of individual projects will continue to be conducted. These activities provide for the discussion of various approaches, restoration techniques, successes, failures, and ultimately adaptive management.

Following are descriptions of the various M&E components of the project followed by project specific monitoring results and trends.

Groundwater Monitoring

Groundwater wells (piezometers) were installed on Forest Service and private property in November 2017 in the Bird Track Springs and Longley Meadows fish habitat enhancement project areas (Figures 10 & 11), following direction from Bureau of Reclamation (BOR) geologists (Lyons & McAfee, 2017). This action was taken as part of a larger monitoring effort in collaboration with restoration co-managers from the Pacific region and Grande Ronde Basin.

In addition to monitoring wells that will capture water levels and groundwater temperatures, 17 level loggers were installed along channel margins in the Bird Track Springs Project to monitor surface water discharge/stage in order to evaluate changes to the hydrology and temperatures associated with fish habitat enhancement activities.

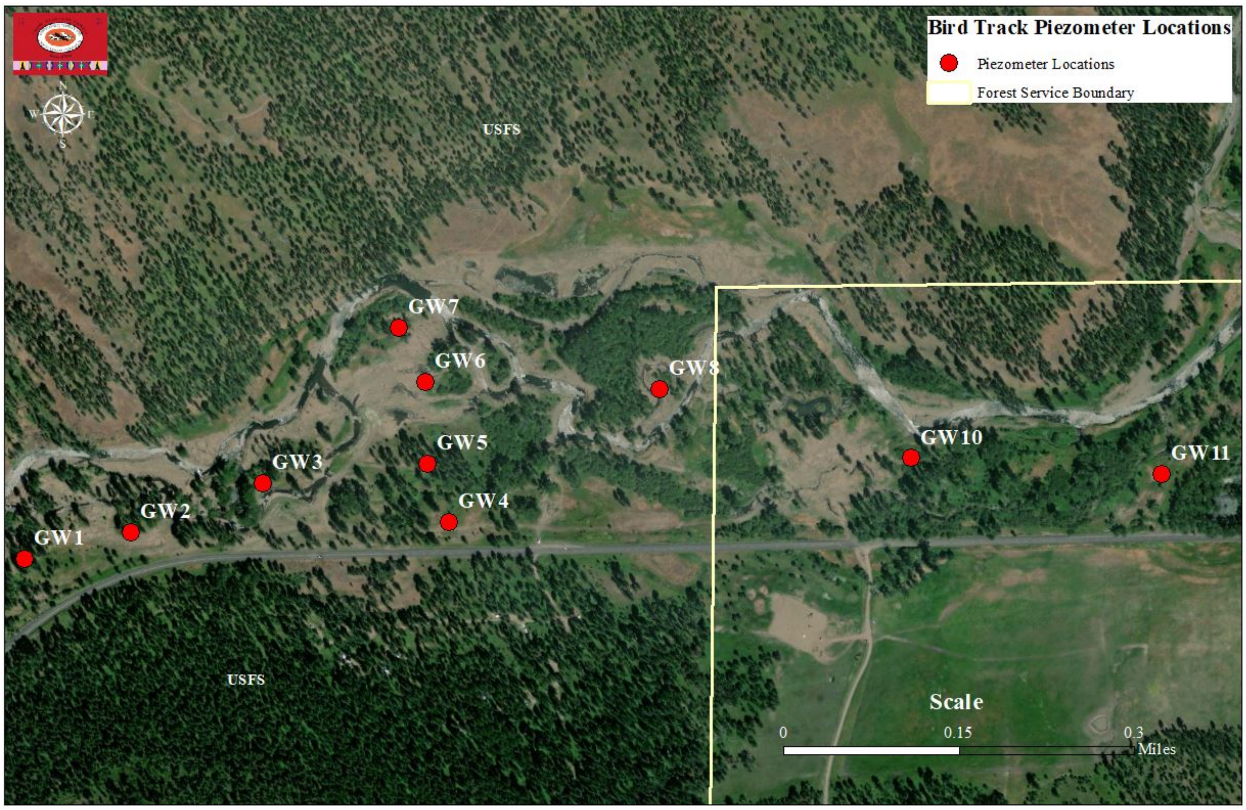


FIGURE 13 MAP OF GROUNDWATER WELL LOCATIONS IN THE BIRD TRACK SPRINGS PROJECT AREA

The Longley Meadows Fish Habitat Enhancement Project began implementation in the summer of 2020. The following report and analysis will cover data associated with the groundwater levels and temperatures at Bird Track Springs and Longley Meadows projects. Data collected in the first year of observation is included in a discussion of planned surface water discharge monitoring sites. Collaborating partners will discuss a broader analysis including surface water temperatures in annual reports and ongoing thermal refuge studies.

Monitoring Goals & Objectives

The goal of monitoring is to evaluate the benefits to salmonid species listed on the Endangered Species act and restoring first foods according to the River Vision (Jones et al., 2008) that occur in the project areas. Objectives include: 1) monitoring changes in groundwater elevation and groundwater temperature, 2) monitoring changes in stream temperature and elevation/discharge, and 3) monitoring the presence and quantity of thermal refuge and associated fish use. These efforts will be part of a larger monitoring and evaluation plan and fishery resource monitoring effort.

Fish salvage efforts during the two phases of the Bird Track Springs project have demonstrated the presence of juvenile rainbow trout/steelhead (*Oncorhynchus mykiss*), Pacific Lamprey (*Entosphenus tridentatus*) and Western Pearl shell freshwater mussels (*Margaritifera falcata*). Despite the limited habitat and cold water refuge these species persist in a degraded environment. Restoration of hydrology and thermal heterogeneity at Bird Track Springs and Longley Meadows will increase the available habitat for threatened species on the Endangered Species act and First Foods for the Confederated Tribes of the Umatilla Indian Reservation.

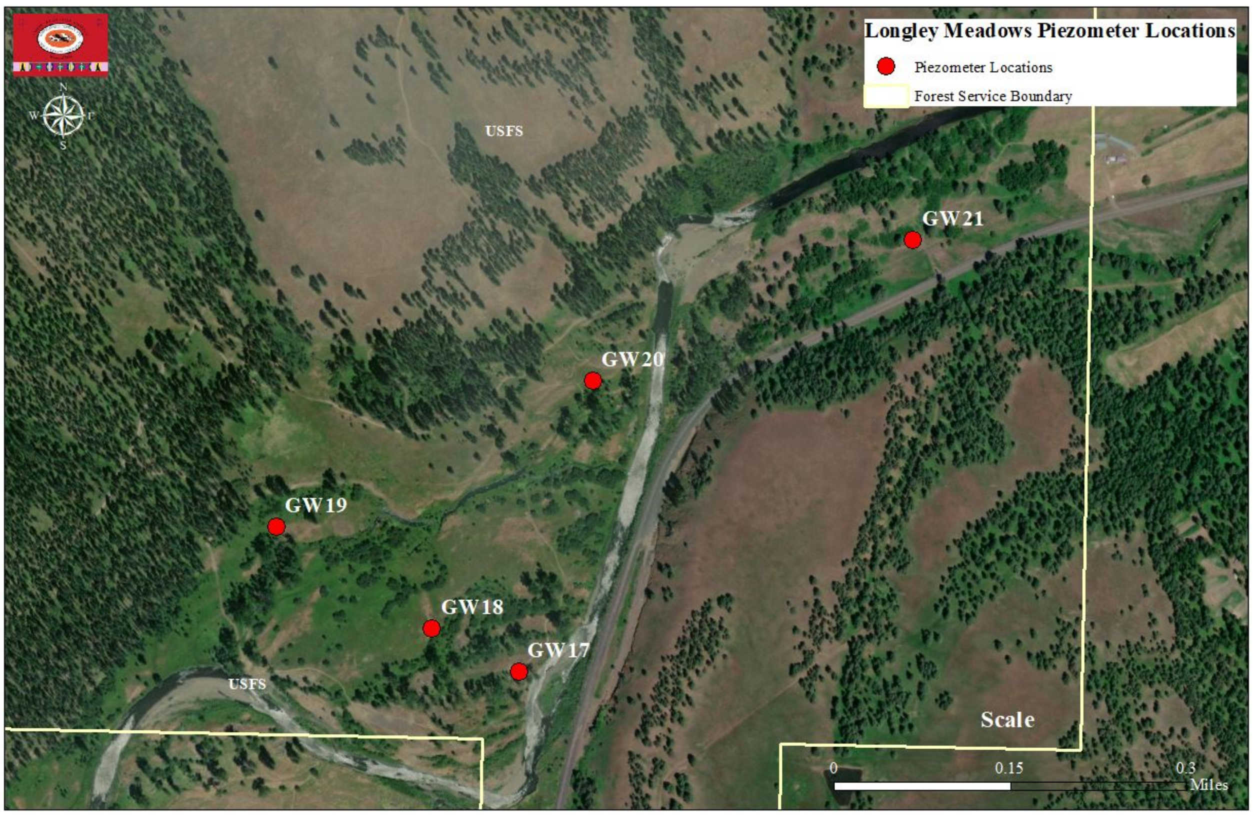


FIGURE 14 MAP OF GROUNDWATER WELLS IN THE LONGLEY MEADOWS PROJECT AREA

Results

Average daily flucutions in water level were ploted against real-time discharge data from the gauge located near Perry, Oregon, operated by the Oregon Water Resource Department for the period between January-2018 to March-2021. Additionally, monthly water levels were graphed with corresponding groundwater temperatures measured over the same period. In order to stay consistent, well data are reported in metric units of Celsius and meters. For the purposes of this initial evaluation and clarity, well data were grouped by proximity and project area, although it should be noted there may be many ways to interpret the following data, which will be available through the CDMS website operated by the CTUIR.

Bird Track Springs

The following graphs are organized with Bird Track Springs project wells 1-11, followed by Longley Meadows project wells 17-21. There are data patterns in common with all well sites that will be mentioned briefly, followed by a more detailed discussion of smaller groups of wells at each project site. Peaks in the average daily discharge measured at the Perry stream gage site correspond to increases in water elevation at all well sites for both project sites. However, there is a difference in the range and amplitude following the peaks in discharge between individual wells and project sites. The duration of increased water level elevation (shallow) occurs between January and June with the lowest elevations (deep) being observed from July to December. Groundwater temperatures are inversely related to water elevations, with lowest temperatures occuring during the highest water elevations and the highest water temperatures occuring in the lowest water elevations.

It is important to point out that groundwater data collected from Bird Track Springs wells 1-11 between 2018-2019 may exhibit anomolies influenced by certain project construction activities. Year 2 construction began in early May 2019 and ended in November. Activities such as bypass channel activation, channel de-watering and reclaimation, or pumping water out onto the floodplain could account for some wells exhibiting noticable fluctuations in groundwater elevation otherwise unassociated with any natural surface flow events.

The first three wells (GW 1-3) are in the upper portion of the Bird Track Springs project area in the vicinity of side channel 1 & 2 (Figure 12). The two grey columns in the data plot represent in-water construction windows during 2018 and 2019. GW 3 (blue) has the lowest groundwater elevation of this group during 2018 and most of 2019, but quickly rises to the surface beginning late summer 2019 where it remains the highest groundwater elevation well in this group to present. The sudden increase and persistance in elevation coorelates to GW 3 proximity to side channel 2, which was not fully activated during 2018-2019 construction until September 2019, precisely when we see a near-vertical 0.5 meter uptick towards ground surface elevation. The greatest range in seasonal max-min temperature was also observed at GW 2 (18°C in Aug-19 down to 2°C in Feb-20 (Figure 13). Proximity to side channel 2 may explain the extreme temperature range due to a shorter sub-surface distance between the well and seasonally-influenced surface water. The two remaining wells (GW 1 and 3) are further from main channel or side channels and exhibit more muted temperature extremes, possibly due to a greater buffering distance of sub-surface substrate between these two wells and surface water. The Grande Ronde River near Perry, OR reached just over 8000 cfs (226 cms) on April 7, 2020 and then topped out again at 9000 cfs (255 cms) on May 21, 2020. The groundwater elevations for these three wells show an almost instantaneous increase response to the river's peak flows. As the river receded following peak flows in May so did the groundwater elevations at these three well locations. Following the first surge in 2020 there were multiple small increases in main channel surface discharge leading up to the second high water event that correspond with subtle increases in groundwater elevations. Furthermore, as main channel flows drop to summer base flow levels, groundwater elevations at these three locations seem to hold steady throught the remainder of the year.

GW wells 4-7 represent a north south transect with the new channel alignment wrapping around the transect (Figure 14). Additionally, GW 6-7 exist within a lowland swale network that is charged with groundwater through a blind channel diversion from the right bank of side channel 2 just upstream from where it rejoins the main channel. This may be a good area to direct attention for a more intensive thermal refugia study proposed by BOR given the potential to alter the groundwater table and how the new channel alignment and off channel swale networks may influence the transect. GW 4 has the highest water elevation between 2018-present despite it being farther away from the existing channel (Figures 14 & 15). It is possible that the majority of groundwater at GW 4 location originates from a small draw that drains the north face of a large hill within Bird Track Springs Campground, south of highway 244. Compared to GW 5-7, GW 4 does not seem to respond to April-May 2020 peak discharges with similar groundwater elevation increases; it appears it maxes out at 0.5 m below ground surface. On another interesting note, when comparing neighboring GW 4 and GW 5 after peak flows decline into May is the large difference in groundwater elevations (approximately 1.25 m difference) when geographically these wells are the closest to each other among all BTS wells. Similarly to the observed increase in groundwater elevation at GW 3 following side channel 2 activation, GW 6 also exhibits a sharp increase in groundwater elevation corresponding to the Oct-19 activation of the blind channel swale network that envelops this well location. GW 6 had the greatest range in temperature beginning with Aug-19 maximum, decreasing 14°C into Feb-20, then climbing again to the same average max temperature in Aug-20 (2.2-16.1°C-Figure 15). Similarly to GW 3, the seasonal temperature swings may be due to increased interaction with surface water from side channel 2 that is diverted into the blind channel swale complex.

Wells 8-11 represent the downstream portion of the project area and have the most sustained high water elevation of the Bird Track Springs wells, only briefly dropping below 1.5 m below ground surface elevation (Figure 16). Each of these three wells exhibited instantiations increases in groundwater elevation during peak surface flow events. GW 10 groundwater elevations have remained above those at GW 8 and 11 since wells were installed in 2017. Its location lies just behind the main channel bank at a sharp 90 degree meander bend in line with thalweg trajectory. The relatively high groundwater elevations recorded at GW 10 may be the result of main channel surface water encountering the sudden change in river direction and continuing on straight into the sub-surface substrate of the bank. Average temperature min-max range is the greatest at GW 10 (2.5-17°C Feb-20 to Aug-20) suggesting that groundwater in this location may originate from nearby hyporheic exchange with seasonally-influenced main channel surface water. Construction activities such as dewatering, channel reclamation, bypass channel construction, and pumping water onto floodplain associated with construction in the summer and fall of 2019 appears to have affected some readings at GW 8 & 11 (Figure 16). However, GW 10 exists in close proximity to a 2018 completed project reach and therefore exhibits a relatively stable and predictable groundwater fluctuation regime while 2019 construction activities were happening elsewhere.

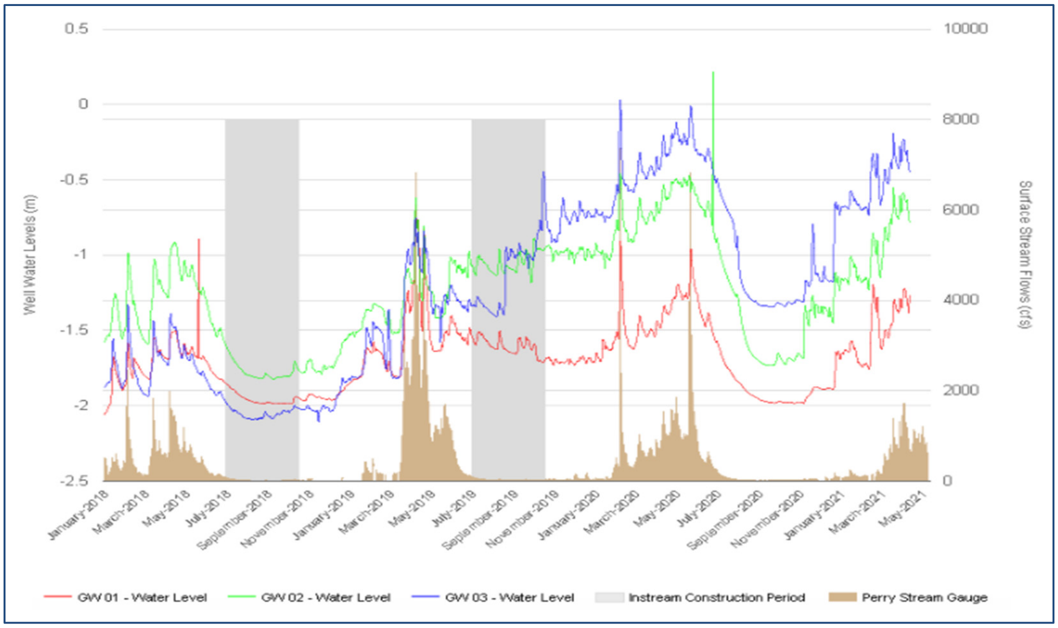


FIGURE 15 AVERAGE DAILY GROUND WATER LEVELS FOR WELLS 1-3 AT BIRD TRACK SPRINGS AND DISCHARGE AT THE PERRY GAUGE, JANUARY-18 TO MARCH-21

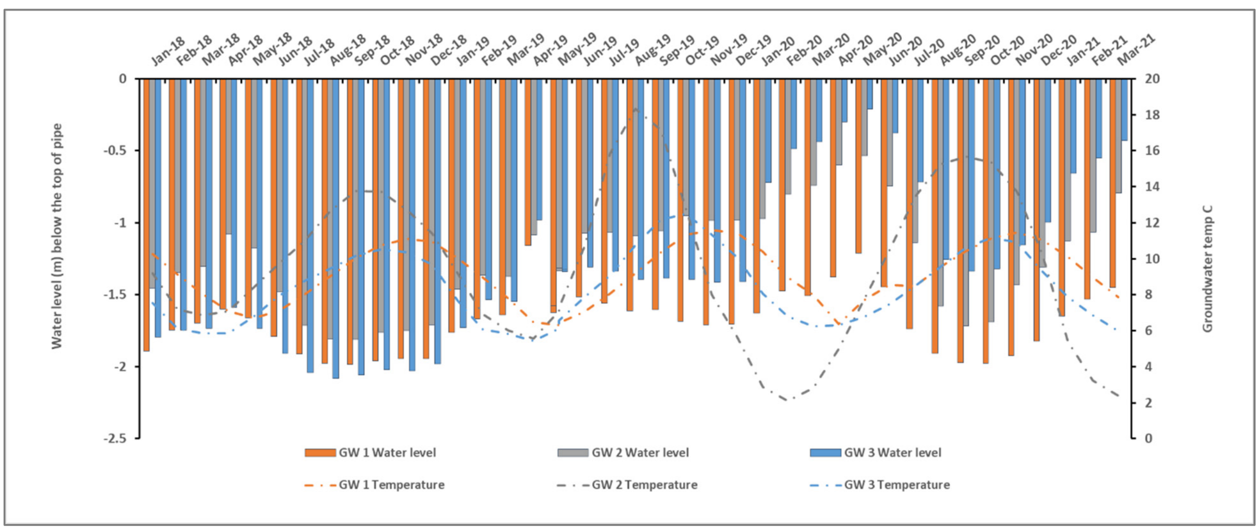


FIGURE 16 MONTHLY AVERAGE GROUNDWATER LEVELS FOR WELLS 1-3 AT BIRD TRACK SPRINGS AND CORRESPONDING GROUNDWATER TEMPERATURES, JANUARY-18 TO MARCH-21. COLORS FOR GROUNDWATER TEMPERATURES AND LEVELS ARE MATCHING

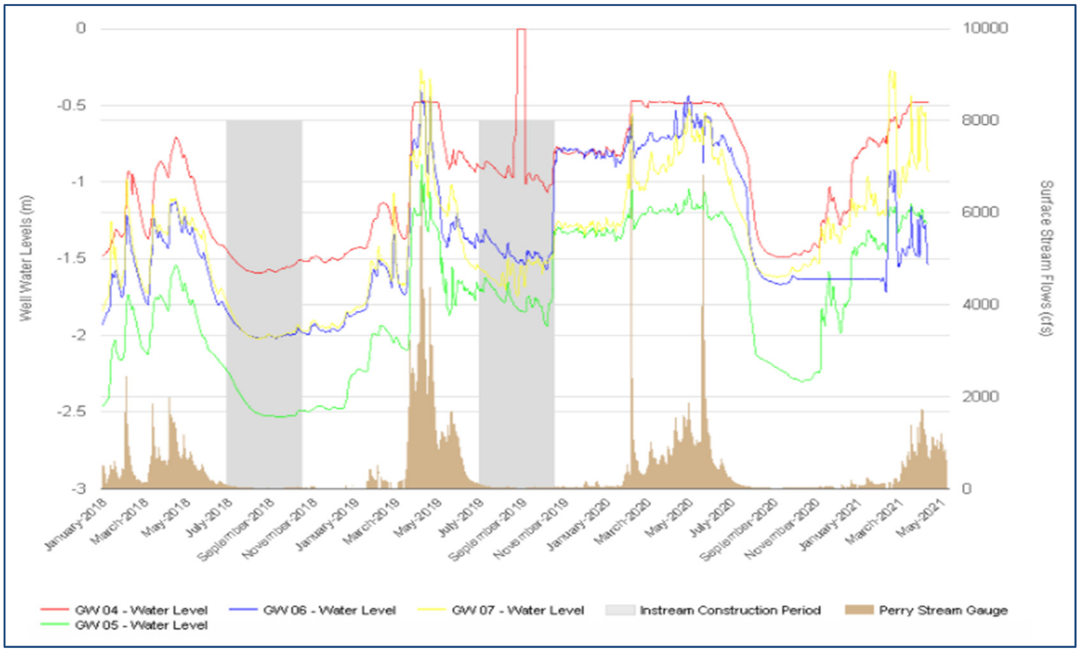


FIGURE 17 AVERAGE DAILY GROUND WATER LEVELS FOR WELLS 4-7 AT BIRD TRACK SPRINGS AND DISCHARGE AT THE PERRY GAUGE, JANUARY-18 TO MARCH-21.

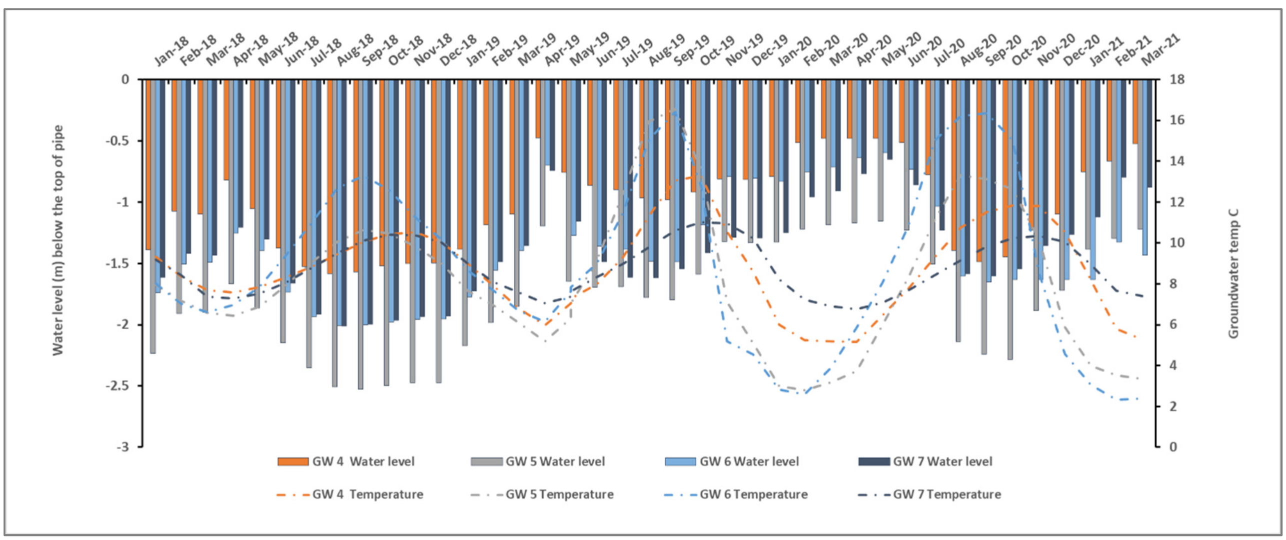


FIGURE 18 MONTHLY AVERAGE GROUNDWATER LEVELS FOR WELLS 4-7 AT BIRD TRACK SPRINGS AND CORRESPONDING GROUNDWATER TEMPERATURES, JANUARY-18 TO MARCH-21. COLORS FOR GROUNDWATER TEMPERATURES AND LEVELS ARE MATCHING

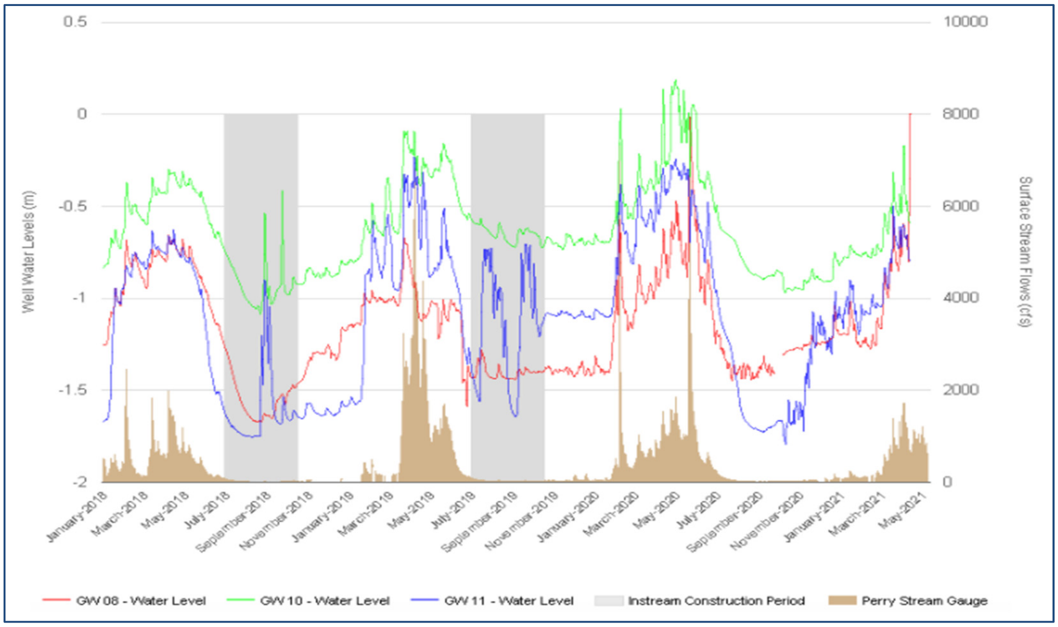


FIGURE 19 AVERAGE DAILY GROUND WATER LEVELS FOR WELLS 8-10 AT BIRD TRACK SPRINGS AND DISCHARGE AT THE PERRY GAUGE, JANUARY-18 TO MARCH-21.

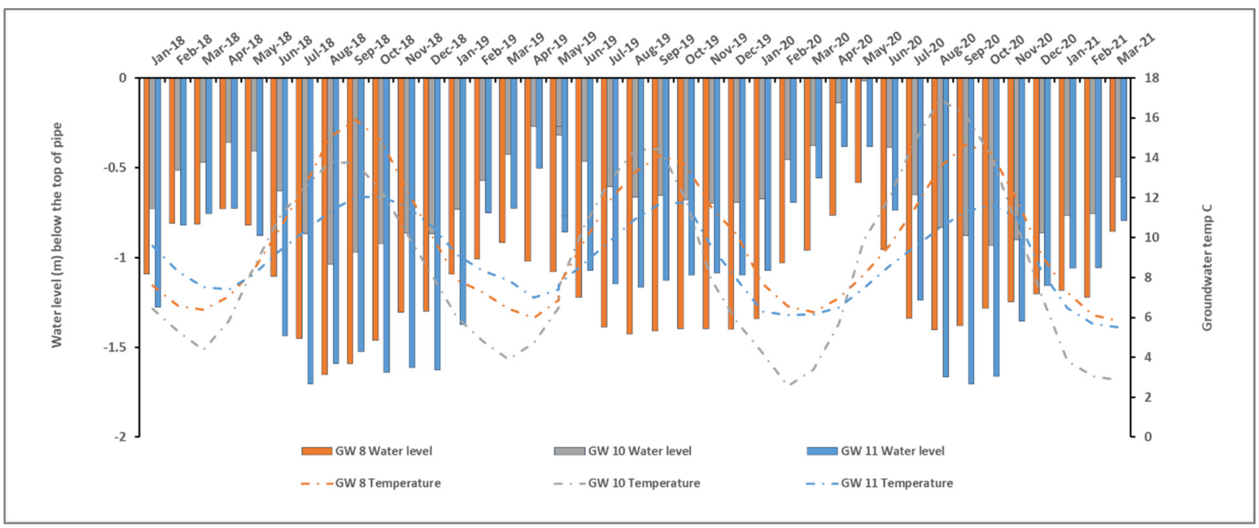


FIGURE 20 MONTHLY AVERAGE GROUNDWATER LEVELS FOR WELLS 8-10 AT BIRD TRACK SPRINGS AND CORRESPONDING GROUNDWATER TEMPERATURES, JANUARY-18 TO MARCH-21. COLORS FOR GROUNDWATER TEMPERATURES AND LEVELS ARE MATCHING

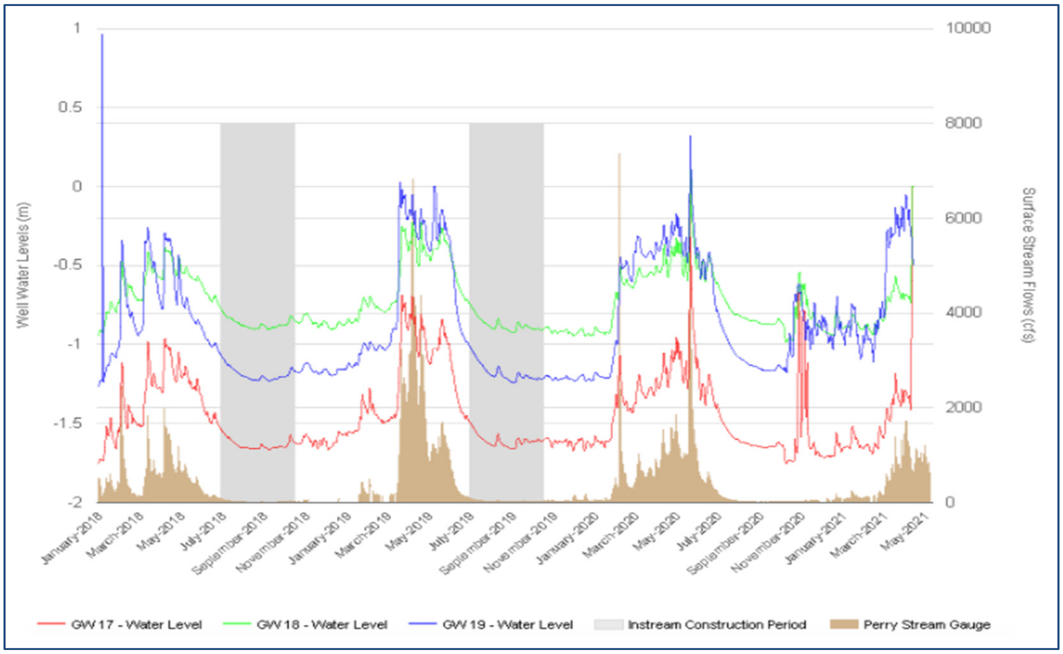


FIGURE 21 AVERAGE DAILY GROUND WATER LEVELS FOR WELLS 17-19 AT LONGLEY MEADOWS AND DISCHARGE AT THE PERRY GAUGE, JANUARY-18 TO MARCH-21.

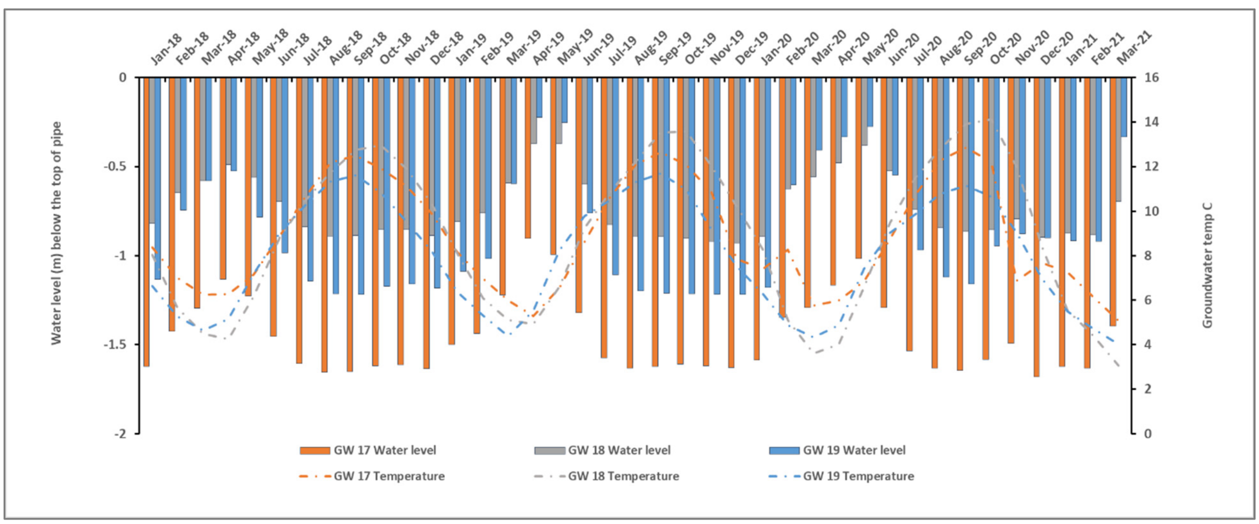


FIGURE 22 MONTHLY AVERAGE GROUNDWATER LEVELS FOR WELLS 17-19 AT LONGLEY MEADOWS AND CORRESPONDING GROUNDWATER TEMPERATURES, JANUARY-18 TO MARCH-21. COLORS FOR GROUNDWATER TEMPERATURES AND LEVELS ARE MATCHING

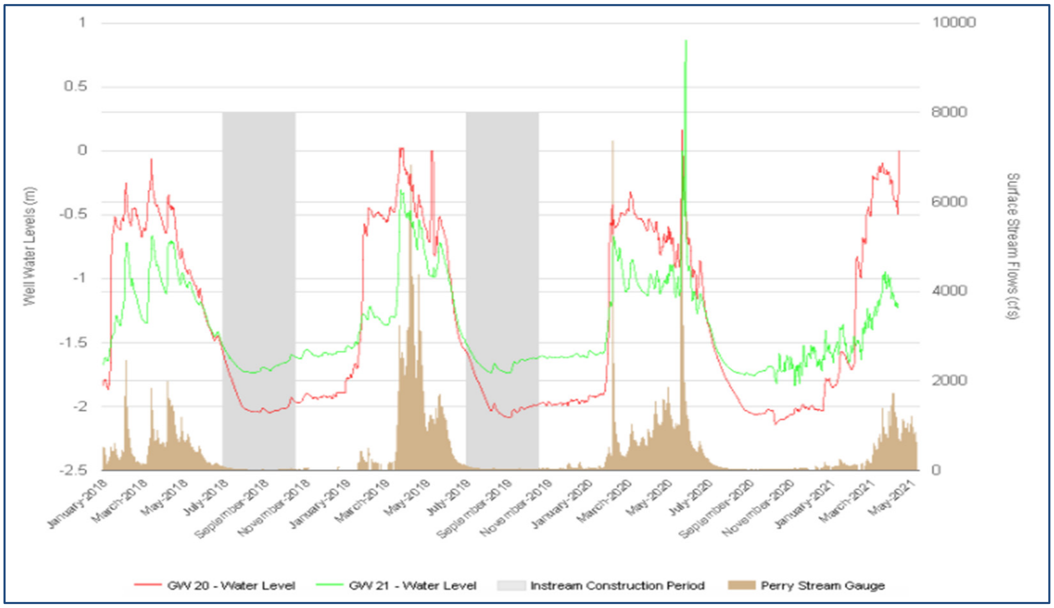


FIGURE 23 AVERAGE DAILY GROUND WATER LEVELS FOR WELLS 20-21 AT LONGLEY MEADOWS AND DISCHARGE AT THE PERRY GAUGE, JANUARY-18 TO MARCH-21.

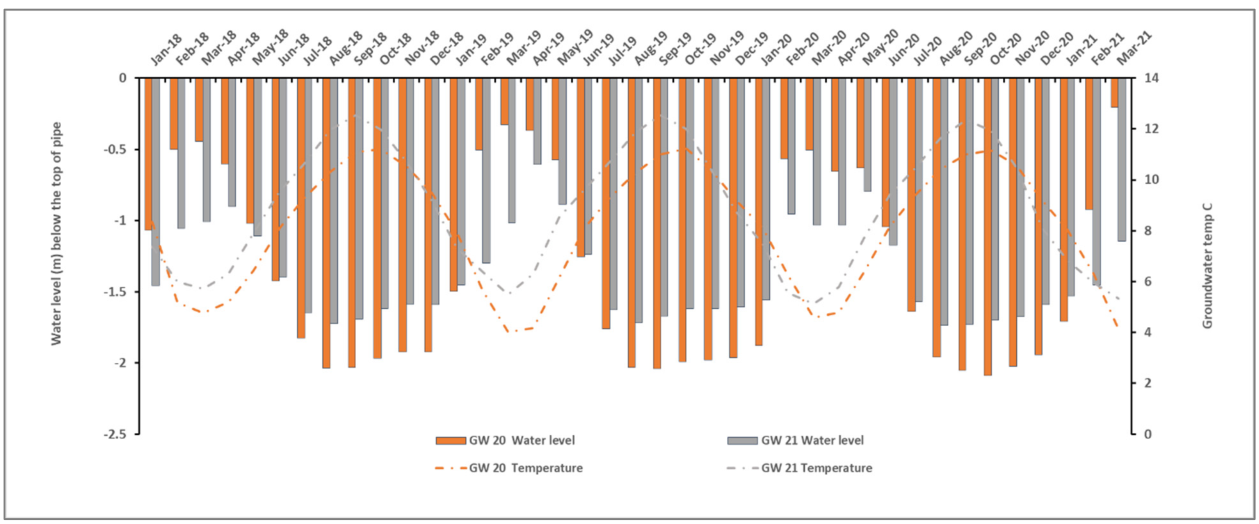


FIGURE 24 MONTHLY AVERAGE GROUNDWATER LEVELS FOR WELLS 20-21 AT LONGLEY MEADOWS AND CORRESPONDING GROUNDWATER TEMPERATURES, JANUARY-18 TO MARCH-21. COLORS FOR GROUNDWATER TEMPERATURES AND LEVELS ARE MATCHING

Longley Meadows

Wells 17-18 represent the upstream portion of Longley Meadows Fish Habitat Enhancement Project, orientated in a northwest transect (Figure 18). Interestingly, the closest well to the river (GW 17) exhibits the lowest water elevation, and the well furthest from the river (GW 18) recorded the highest groundwater elevation (Figure 18). In fact, GW 18 water elevation leading up to peak flows in spring 2018 and 2019 was the same distance below the meadow surface as GW 17 reached at its peak. Groundwater data collected from these three wells in fall of 2020 appears to have been influenced by Longley Meadows Fish Habitat Enhancement Project - Phase I construction activities. Prior to installation of main channel large wood bank structures a large volume of water was pumped out of deep main channel pools and onto the floodplain in the vicinity of GW 17 and 19. Records from GW 17 during this time exhibit an upward surge of approximately 1.5 m groundwater elevation, whereas groundwater elevation increased about 1 m at GW 19 during the fall 2020 construction window. In 2018 and 2019 GW 18 maintained a fairly steady groundwater elevation around -0.8 m in relation to meadow surface, whereas groundwater elevation at GW 19 hovered around -1.25 m below meadow surface, about 0.5 m lower than water level at GW 18. Interestingly, the amplitude of groundwater elevation increase during spring peak flows is greater for GW 19 in relation to GW18 and exhibits a higher maximum peak elevation at or slightly above (overland flow) the meadow surface. Overall, these three wells exhibit fairly similar average monthly seasonal temperature ranges, with GW 18 having experienced a slightly greater range of temperature between winter lows and summer highs (approximately 4.0-14.0°C) (Figure 19).

The downstream portion of Longley meadows has two wells (GW 20-21; Figure 20). Groundwater at GW 20 during spring-summer-fall months maintains a fairly steady elevation around -2.0 m relative to meadow surface, whereas groundwater elevation at GW 21 was perched slightly higher around -1.65 m during the same time span. When the Grande Ronde River experiences peak spring flows groundwater elevation at GW 20 exhibits a higher corresponding amplitude surge and maximum elevation (-2 m to 0 m) compared to GW 21 (-1.65 m to -0.25 m). Groundwater temperature measured at GW 21 consistently ranges from a seasonal low of around 5°C in February up to a summertime high around 12°C in August for years 2018-2020 (Figure 21). Spring-summer groundwater temperatures at GW 20 are consistently about 1-2°C cooler compared to GW 21. During fall-winter months groundwater temperatures at these two wells are about the same. Seasonal max-min temperatures at GW 21 exhibit a slight lag of about 2 weeks relative to summertime highs and winter low temperatures at GW 20.

Discussion

Some GW data recorded during 2018-2019 from the Bird Track Springs project area was influenced by two seasons of nearby construction activity, including dewatering, channel reclamation, bypass channel construction, and pumping water out of work areas onto the floodplain. Groundwater records collected during 2020 represent the first entire year of uninterrupted data since project completion. Conversely, GW data recorded from the Longley Meadows project area was unaltered by BTS construction activities 2018-2019 but show signs of construction influence during Phase I activities which began in summer 2020.

Understanding groundwater data is complicated by several variables such as geology and hydrology, and often monitoring wells may be inadequate in number or location. However, groundwater wells also provide measurable outcomes for how stream restoration projects can influence groundwater elevation and temperature. Increasing the amplitude and duration of cold water elevations and corresponding influence of temperature is a desired outcome for fish habitat restoration activities. Combined with monitoring surface water elevation, discharge and stream temperatures, we may be able to gather a more complete picture of how stream restoration techniques can influence thermal refuge in terms of volume and capacity for aquatic organisms.

Photo Point Monitoring

Photo points are an effective monitoring method used to document morphological changes on restoration projects. Representative photos are taken at intervals throughout each project, the number being determined by the project size and complexity (Figure 22). A master photo point notebook is used to align each subsequent year's photo with the image taken the previous year. Ideally, images are captured in the exact location as the earlier image, with landmarks (trees, hillsides, etc.) used to align the photo. Images are taken during midday for optimal lighting conditions and jpeg images are saved into a master photo point file. Aerial photos and videos are also taken at varying intervals along several project locations using a UAV operated by the Grande Ronde Model Watershed. A summary of photo point highlights can be viewed by following the link:
GR Habitat Photo Point Album

During 2020 photo points were taken at 4 separate projects. A total of 76 photos were taken, and GPS coordinates were recorded at each photo point site. Each photo point site is marked with a green T-133 post or a 1 foot rebar stake. Photo points are located at sites along project reaches with good visibility of stream-bank vegetation and areas where morphological changes are likely to occur. Photo points are typically taken every year; however, some project photo points are taken every other year. 16 photo points were taken at CC 44 Southern Cross, McCoy Creek, Meadow Creek, and McCoy/Meadow Creek enclosures.

Representative samples are provided below. Of particular note are stark differences in recruitment of riparian vegetation between enclosed and exposed areas in the McCoy Creek/Meadow Creek complex. This project is subject to intense browsing pressure from wild ungulates resulting in extremely limited release of riparian vegetation in untreated areas. This contrast is readily seen when comparing photo points of protected and unprotected areas of the project (Figures 29 and 30).

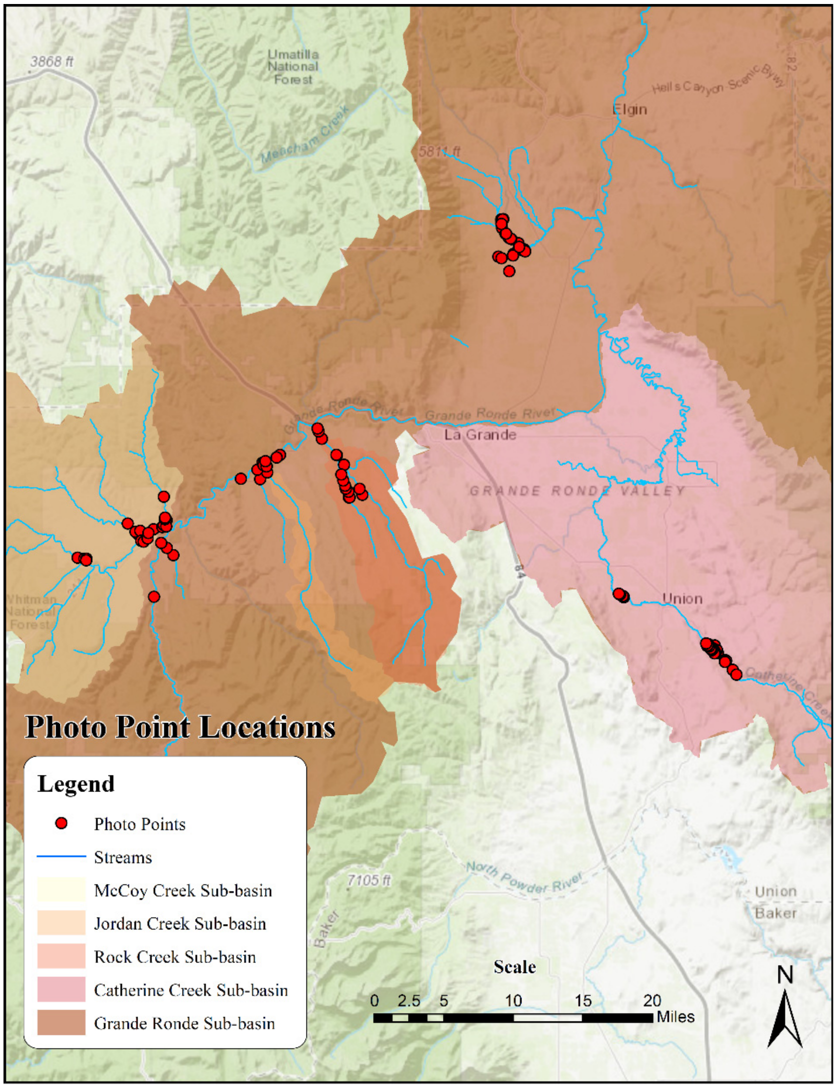


FIGURE 25 GRANDE RONDE WATERSHED PHOTO POINT MAP

FIGURE 26 ROCK CREEK PHASE 3 AERIAL PHOTO POINT 8 – 4/24/2018

FIGURE 27 ROCK CREEK PHASE 3 AERIAL PHOTO POINT 8 – 4/9/2019

FIGURE 28 BIRD TRACK SPRINGS AERIAL PHOTO POINT 6 - 5/15/2018

FIGURE 29 BIRD TRACK SPRINGS AERIAL PHOTO POINT 6 - 5/15/2018

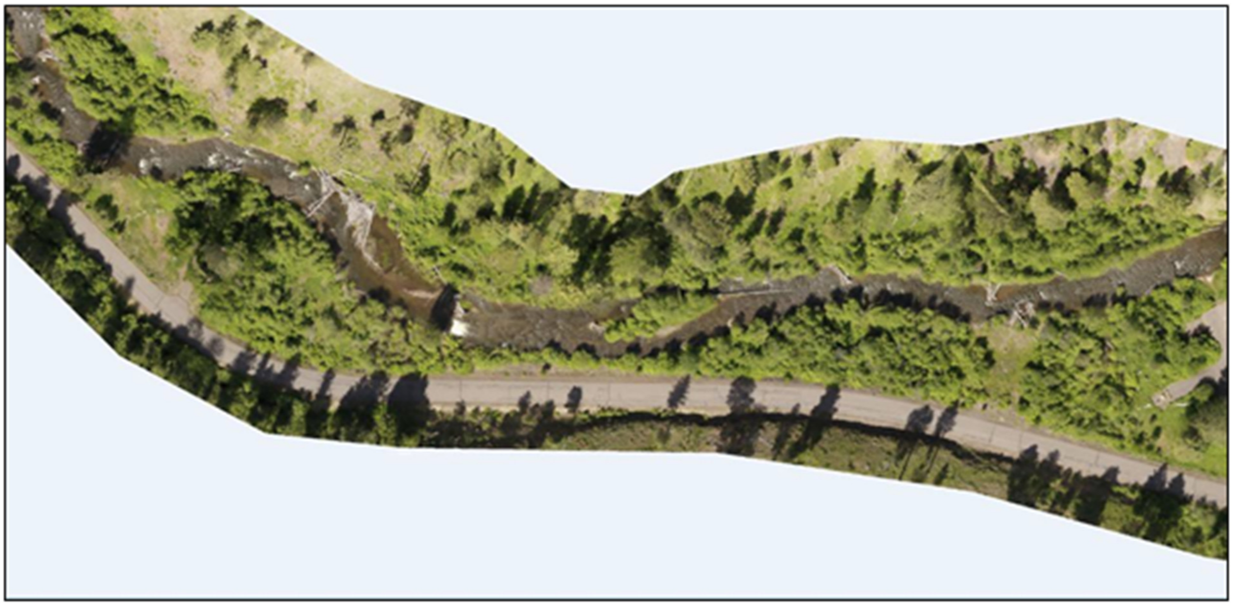


FIGURE 30 MIDDLE UPPER GRANDE RONDE RIVER PHOTO POINT 2 – 6/14/2017

FIGURE 31 MIDDLE UPPER GRANDE RONDE RIVER PHOTO POINT 2 – 7/16/2019

FIGURE 32   UNPROTECTED REACH ON MCCOY CREEK, JULY 2017

FIGURE 33   PROTECTED ELK ENCLOSURE ON MCCOY CREEK AND RECENT BEAVER ACTIVITY, DECEMBER, 2018

2020 Water Temperature Monitoring

Introduction

Thermal regimes in river and stream ecosystems are vital for fish and other aquatic organisms because most are ectotherms with physiologic processes controlled by temperatures of the ambient environment (Neuheimer and Taggart 2007). Temperature dictates the distribution and abundance of individual species across many spatial and temporal scales. Temperature also affects the limnological process, specifically, the rate of decomposition of organic material and the saturation concentration of dissolved oxygen. Unfortunately, as anthropogenic climate change advances and temperatures warm, aquatic communities in rivers and streams will be altered and forced to find thermally suitable habitat. Linear networks such as streams and rivers are often fragmented by anthropogenic perturbations, which greatly impacts aquatic communities (Isaak et al. 2012). Thus, the need for floodplain and stream restoration, especially thermal (Johnson 2004). Thermal restoration is dependent on restoring floodplain hydrology and channel morphology that promotes water storage, hyporheic functions, and restoration of riparian and wetland vegetation. Floodplain attenuation contributes to hyporheic lag, providing cold water refuge during summer and warm water refuge during winter.

It is important for fisheries managers to have a better understanding of thermal regimes in river and stream networks. Understanding the temperature variability in river streams will allow managers to evaluate changes in water temperature on habitat restoration projects. The CTUIR efforts include thermal dynamics associated with floodplain reconnection, restoration of natural channel morphology, and riparian and wetland communities. The goal of the temperature monitoring effort is obtain data and to assess whether restoration actions are improving the summer and winter altered thermal regime.

Methods

36 TidbiT Waterproof Data Loggers temperature were deployed within the Grande Ronde Basin and its tributaries (Rock Creek: 5 probes, mainstem Grand Ronde: 15 probes, Dark Canyon: 2 probes, Meadow Creek: 1 probe, and Catherine Creek: 13 probes). See Figure 31 for an overview of monitoring locations. Pendant 64K probes are housed in a metal tube that is anchored to the streambed and cabled to a post or tree on the bank, while Tidbit v2 probes can be installed in the aforementioned manner or housed in a PVC bushing and cap and installed with underwater epoxy.

Data loggers are programmed to record at one-hour intervals with a ± 0.2° C over 0°C to 50°C (±0.36°F over 32°F to 122°F) level of accuracy, and are deployed early summer depending on flows and are left within their monitoring location until early winter. The CTUIR focuses on having a consistent monitoring period from early June to end of October. This monitoring period will monitor crucial summer temperatures and early winter temperatures and will provide the CTUIR data to assess if restoration efforts are improving the summer and winter thermal regime.

Temperature data is transferred to the Central Data Management System (CDMS), which gives the CTUIR natural resources staff a single place to house various data types. Within CDMS, temperature data is QA/QC'd and then exported to .csv files for data analysis using R-Programming.

We conducted basic exploratory data analysis to look at the distribution of data, mean, min, and max for each monitoring probe. Summary statistics were calculated for each probe that include number of days deployed, max temperature, hours of exceedance of the Department of Environmental Quality's (DEQ) lethal limit of 25°C, and the preferred salmonid core cold temperature range of 10°C to 15.6°C, which is also the preferred temperature range for juvenile Chinook salmon. In the subsequent tables, cells are highlighted with a light red color to show time spent in the lethal limit temperature range, a burnt orange to show a decrease in core-cold temperatures from 2019 to 2020, and a green color to show an increase in core-cold temperatures.

Diurnal fluctuations in water temperature were also plotted to show the variability in temperatures. We plotted the seven day average maximum (7DADM) for selected probes that bracket stream restoration project areas. For both Catherine Creek and Bird Track Springs t-tests were run to evaluate stream temperatures before and after project completion. This inferential statistic allows us to determine if there is a significant difference between the means of two groups (pre-restoration vs. post-restoration). We also can determine restoration effectiveness by assessing if there is a reduction of the number of hours under the 25°C (lethal limit), and increasing number of hours within the 10°C and 15.6°C (core cold temperatures for salmonids).
.

Temperature Monitoring Maps

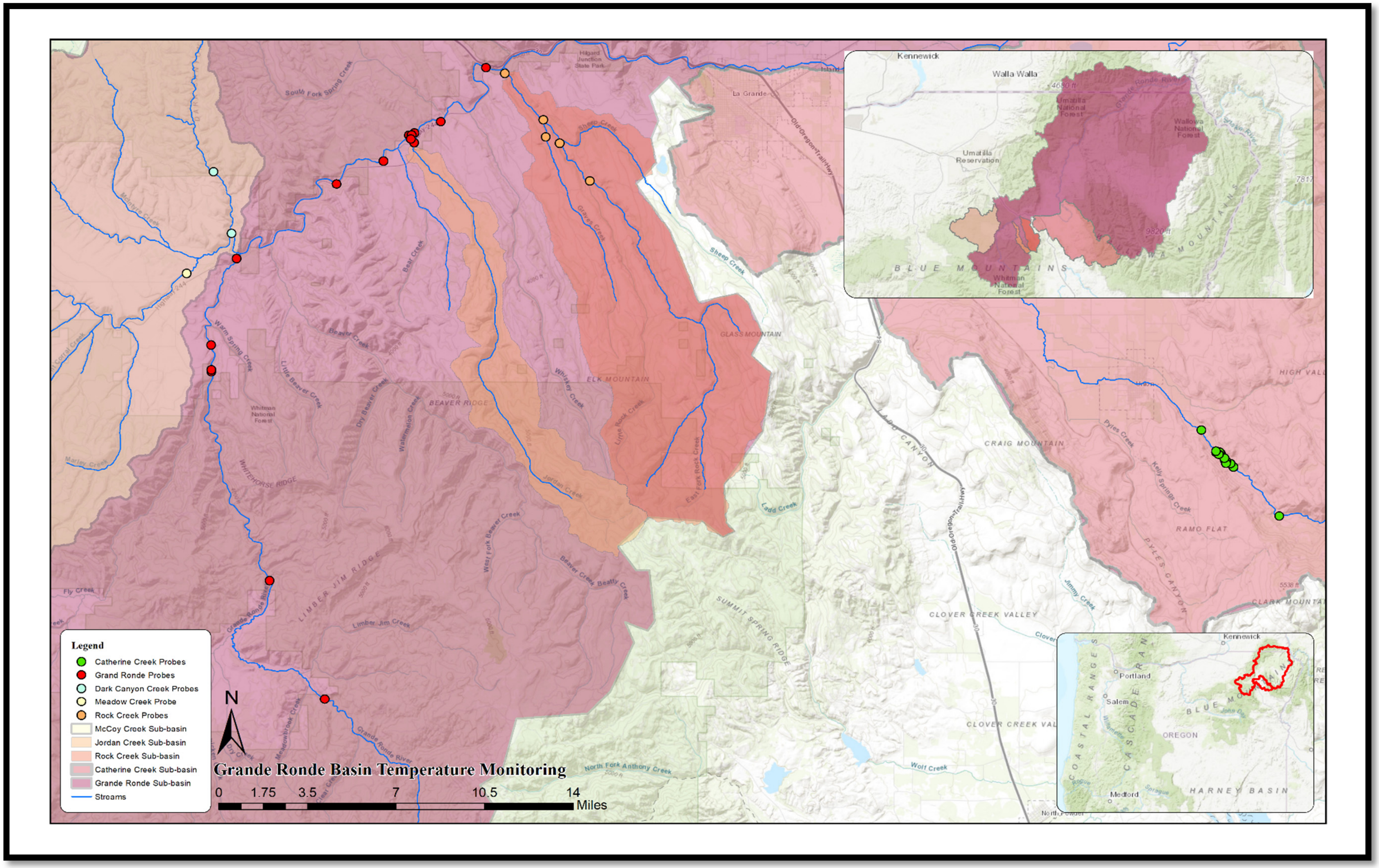


FIGURE 34 OVERVIEW MAP OF THE TEMPERATURE PROBES IN THE GRANDE RONDE BASIN

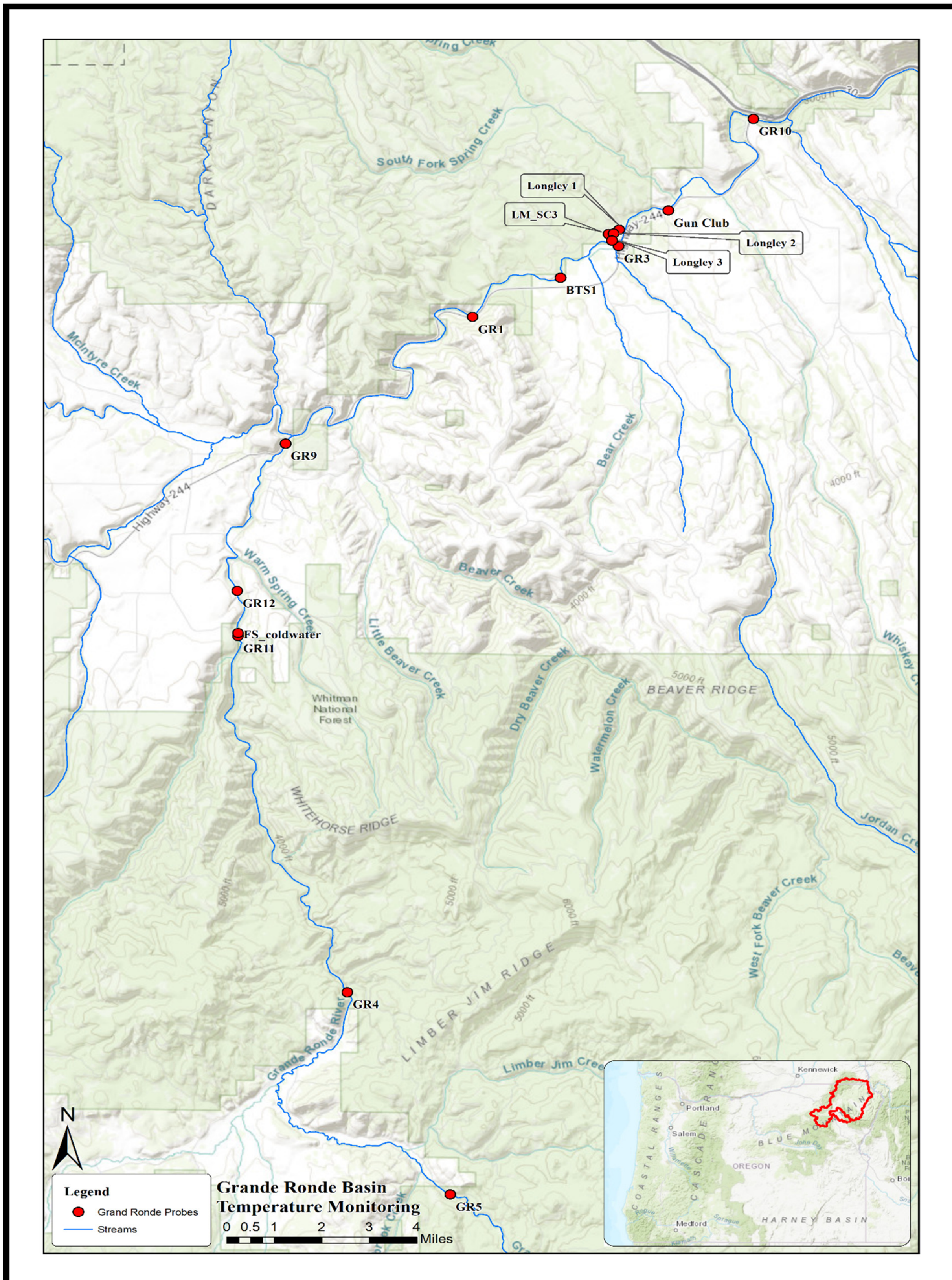


FIGURE 35 OVERVIEW MAP OF THE GRANDE RONDE RIVER PROBES

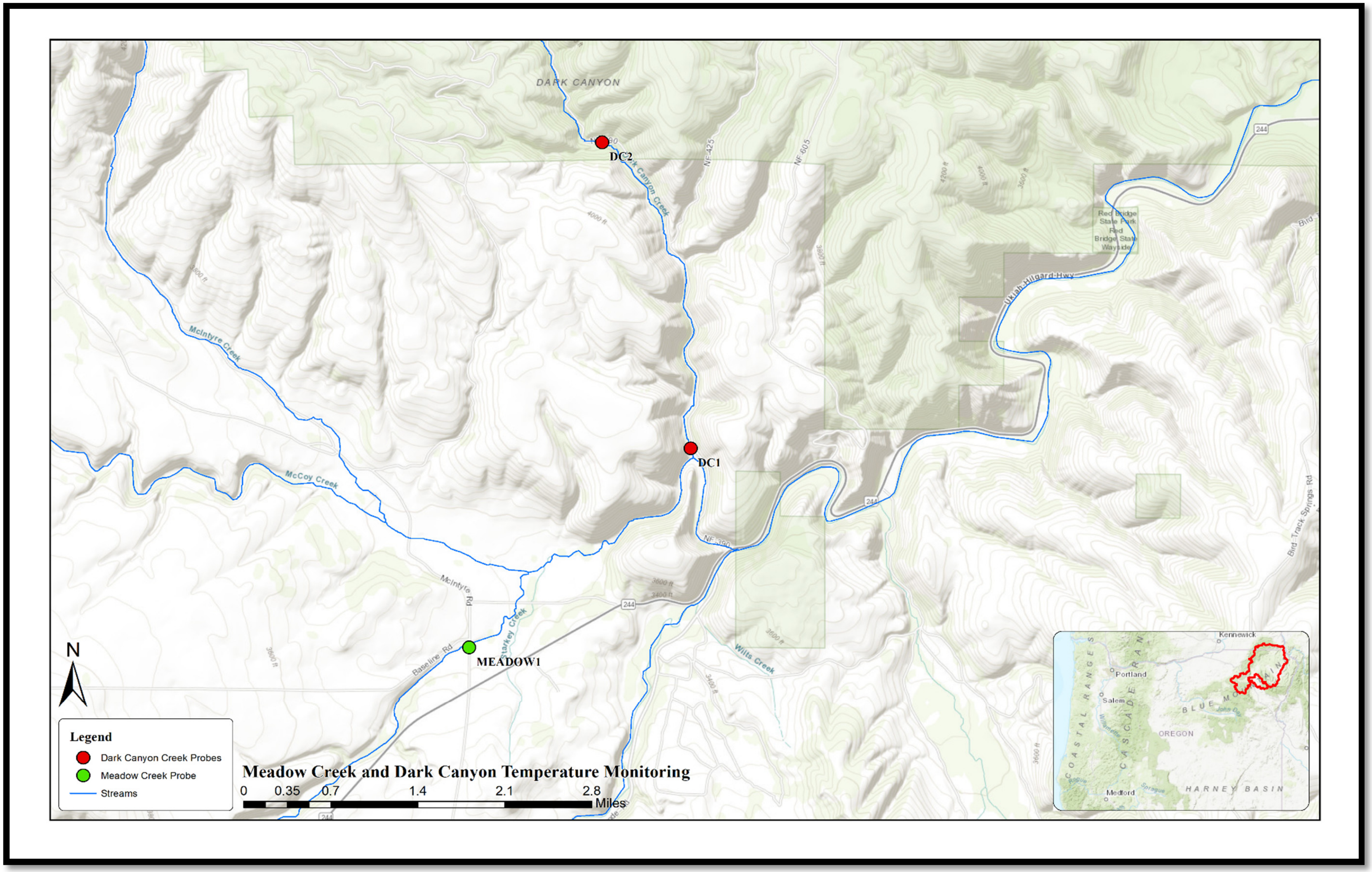


FIGURE 36 OVERVIEW MAP OF THE MEADOW CREEK AND DARK CANYON PROBES

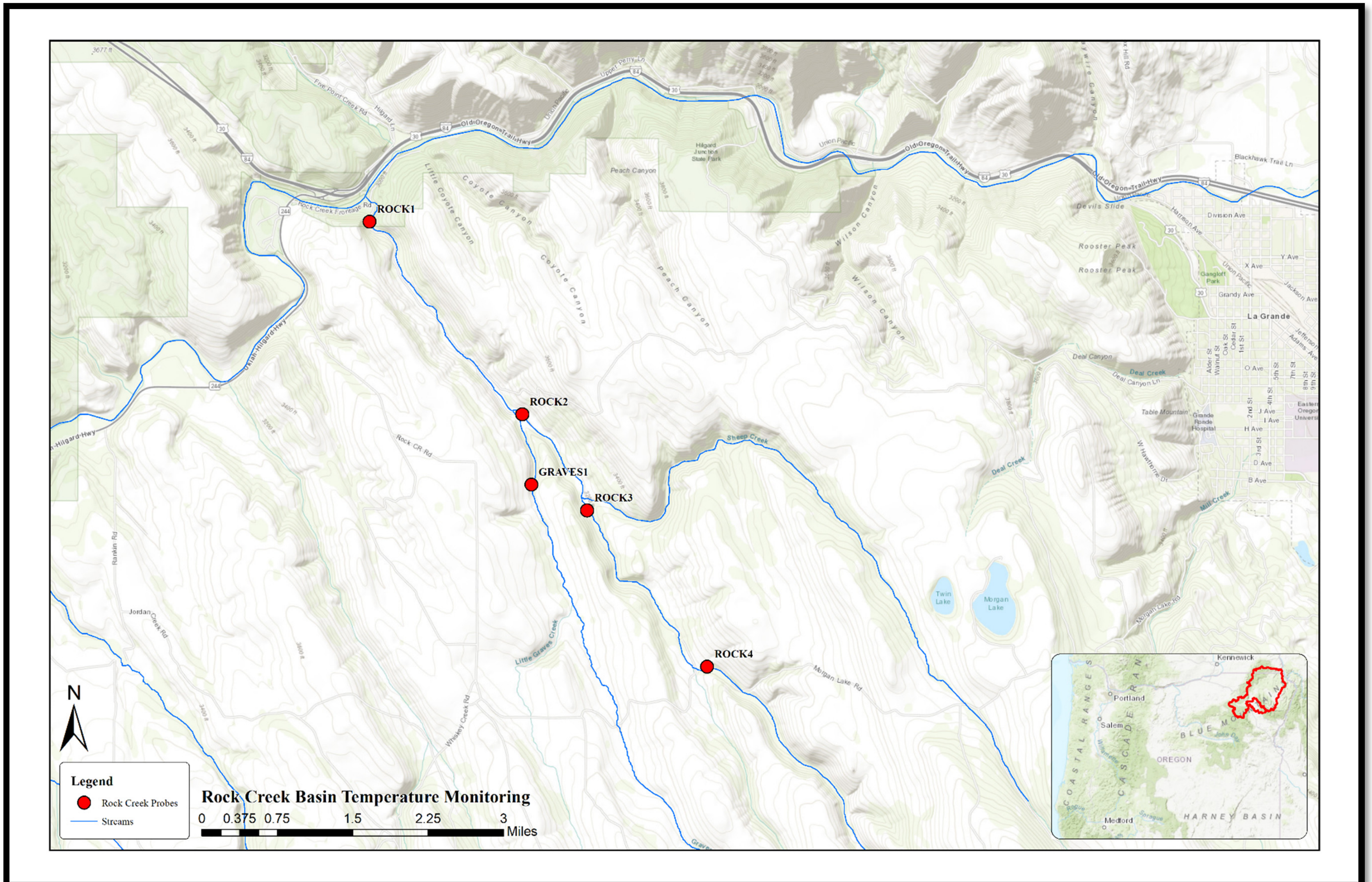


FIGURE 37 OVERVIEW MAP OF ROCK CREEK PROBES

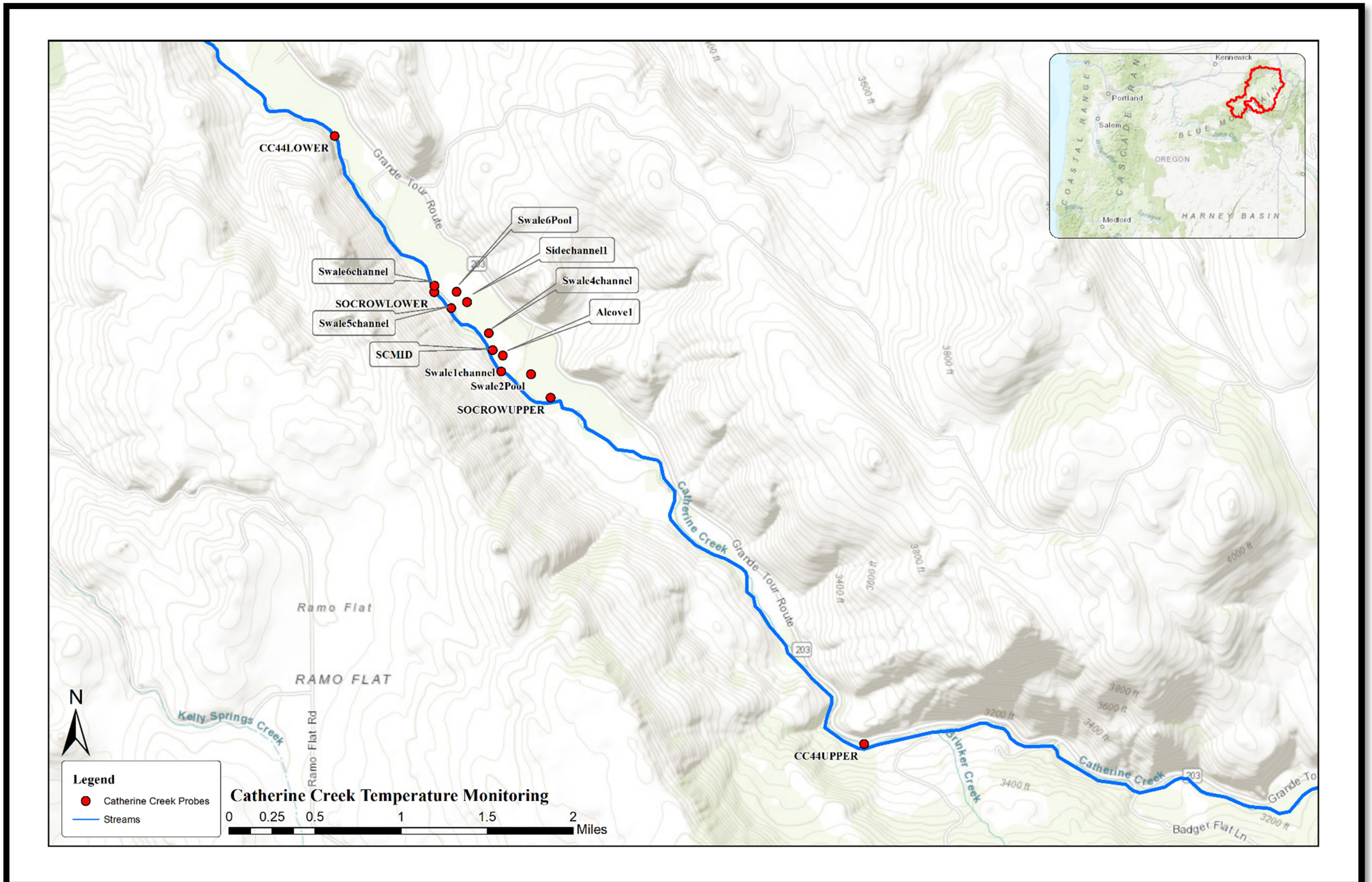


FIGURE 38 OVERVIEW MAP OF CATHERINE CREEK PROBES

Results

Exploratory Data Analysis

Data was QA/QC'd within CDMS, and checked for normality and outliers were removed from any analyses within R and CDMS. Outliers that were removed were those that recorded temperatures while out of water during low flows, temperature recordings that were erroneous due to some technological error or washed away during high flows. There was no need to transform the time-series data since the data when plotted met the assumption of normality and transformations did not improve data distributions.

Monitoring

Recently, we have used alternative methods to detect change, support project design and project locations. This has been done through a combination of, 1) using existing temperature probes in the Grande Ronde basin that bracket project areas, 2) documenting cold water habitat in the Grande Ronde basin and off channel habitats with additional temperature probes, 3) geospatial longitudinal temperature profile figures, and 4) deployment of novel loggers following completion of a restoration project.

Grande Ronde

The CTUIR and Grande Ronde Basin partners implemented fish habitat improvements along the Grande Ronde River (Bird Track Springs) on private and public land river mile (RM) 142-164.2. One of the primary objectives of fish habitat enhancement projects is to restore thermal heterogeneity to stream temperatures within project reaches, resulting in an improved altered summer and winter thermal regime. Traditionally, this has been monitored by installing temperature loggers upstream and downstream of a project reach and monitoring pre and post project construction to detect changes in stream temperatures related to restoration activities and to see if the thermal regime is improving for fish populations.

TABLE 5 SUMMARY STATISTICS FOR GRANDE RONDE PROBES

Site	River Mile	# of Days Deployed	Max Temperature (°C)	2019 Hours >=25 °C	2020 Hours >=25 °C	>=25 °C Percent Increase/ Decrease	2019 Hours between 10 and 15.6 °C	2020 Hours between 10 and 15.6 °C	10 and 15.6 °C Percent Increase/ Decrease	% at 10-15.6 °C	Mean Daily >=17.78 °C (# days)
Alcove_RM183.24	183.24	315	21.127	0	0	NA	3646	3330	-8.67	44.12	0.75
04 Grande Ronde River	194.23	160	26.769	14	13	-7.14	1388	1342	-3.31	36.88	23
05 Grande Ronde River	199.75	315	19.603	0	0	NA	1543	1449	-6.09	25.47	0
09 Grande Ronde River	182.5	315	27.677	66	46	-30.30	1410	1741	+23.48	27.56	35
10 Grande Ronde River	169.6	316	29.115	0	130	NA	264	1753	+564.02	25.31	62
11 Grande Ronde River	186.6	315	25.841	0	3	NA	1435	1763	+22.86	28.61	23
12 Grande Ronde River	186	315	25.963	0	3	NA	1414	1769	+25.11	28.45	26
250 Grande Ronde River 01	176.2	197	18.461	81	0	-100	1117	848	-24.08	21.69	0.75
252 Grande Ronde River 03	174.7	197	22.202	11	0	-100	1067	870	-18.46	22.38	7
BTS1	169.3	316	27.801	46	53	+15.22	1132	1789	+58.04	26.97	52
FS cold-water	186.49	269	16.677	0	0	NA	2902	2086	-28.12	32.73	0
LM_SC3_RM143.3	143.3	316	16.415	0	0	NA	3209	2462	-23.28	32.52	0

Longley 1	168.08	316	20.722	0	0	NA	1208	3267	+170.45	43.4	0
Longley 2	NA	155	21.795	0	0	NA	2856	1535	-46.25	41.57	33
Longley 3	NA	316	15.27	0	0	NA	325	3116	+858.77	41.22	0
Gun Club	166.69	316	18.866	0	0	NA	2724	2839	+4.22	34.47	1

We plotted the 7DADM for two probes that bracket the recently completed fish habitat enhancement improvements. From the upstream probe (250 Grande Ronde River 01) to the downstream probe (BTS1) there are 6.9 RMs between the two. The upstream probe was removed prematurely because of recording malfunction and there are no records after mid-late July. BTS1 recorded 53 hours of temperatures >=25°C, which is up 15.2% from 2019's 46 hours.

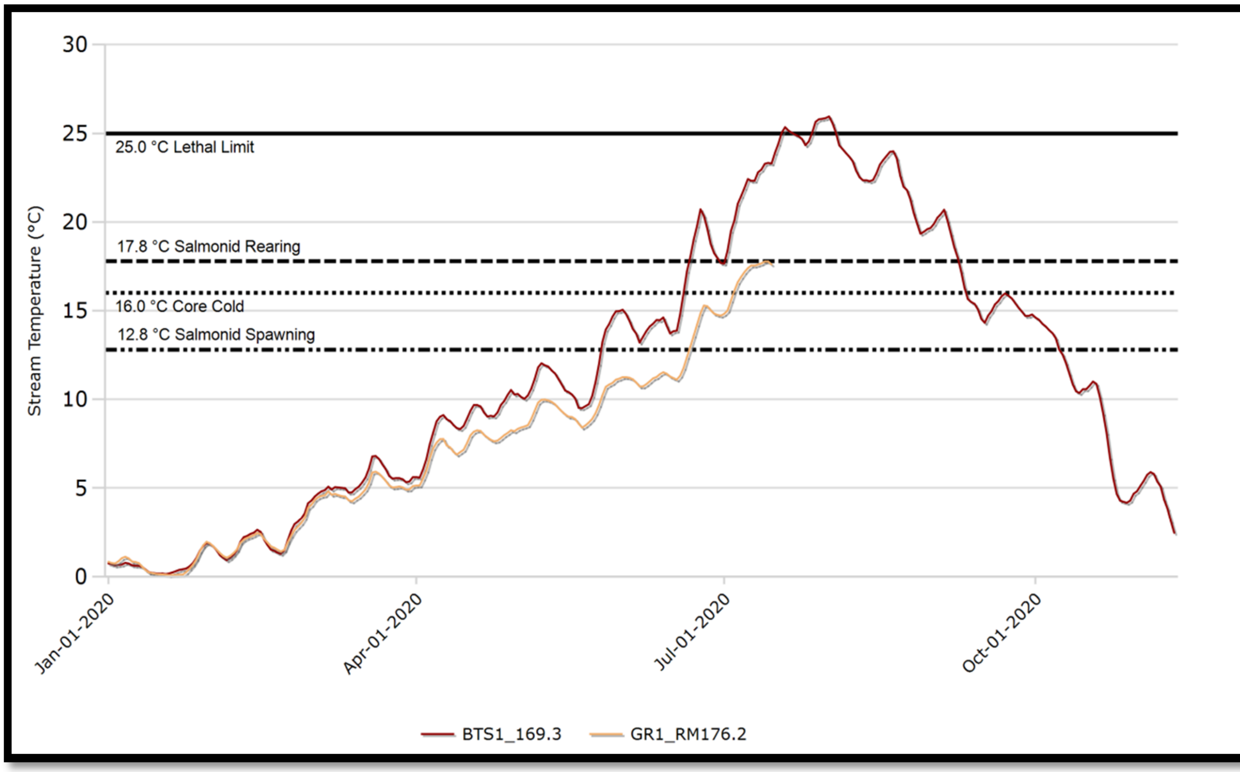


FIGURE 39 7DADM FOR GRANDE RONDE RIVER WITH PROBES BRACKETING THE BIRD TRACK SPRINGS RESTORATION PROJECT

Table 6 below shows results from a Welch's Two Sample t-test, which does not have the assumption of equal variance, however, still has the assumption of normality. Water temperature recorded at the selected sites from 2016 (pre-restoration) and 2020 (two years post-restoration) were used to test if there was a significant difference in water temperatures from 2016-2020 at the two given probes. The results show that mean temperature has decreased 0.267°C in five years, with a 95% confidence interval ± 0.441, p-value = 0.018.

TABLE 6 WELCH'S TWO SAMPLE T-TEST FOR MAINSTEM GRANDE RONDE PROBES

Welch Two Sample t-test		
Data	2016 temp and 2020 temp	
Locations	250 Grande Ronde River 01 and BTS1	
t = 2.3732	df = 11086	p-value = 0.01765
Alternative hypothesis	true difference in means is not equal to 0	
95% confidence interval	0.04651463	0.48803467
Sample estimates (temperature)	14.31664	14.04937

Since 2018, Figure 37 shows probes that bracket the fish habitat enhancement project and the seasonal oscillation with a downward trend. The key takeaway from the figure is the downward trend of the summer time temperature peaks (7DADM) have decreased with the amount of time spent above the 25°C lethal limit.

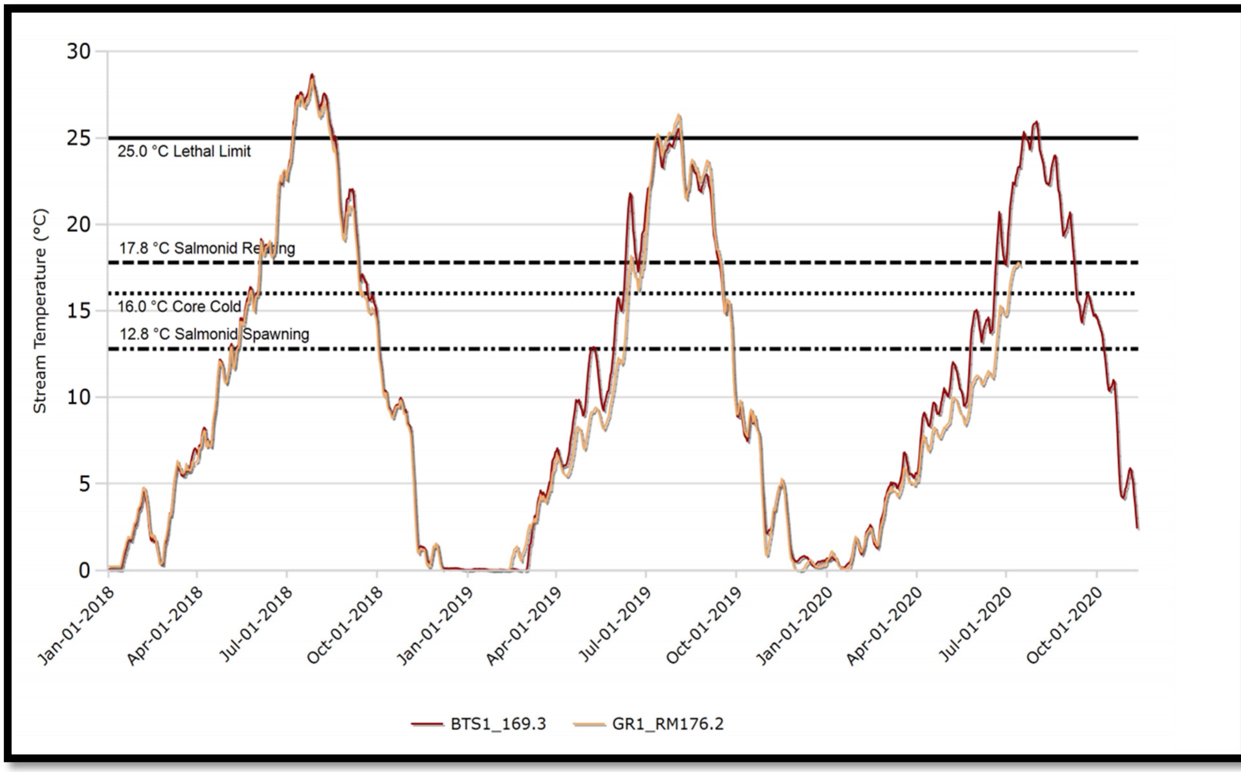


FIGURE 40 2018-2020 7DADM FOR GRANDE RONDE RIVER (BIRD TRACK SPRINGS) BRACKETED RESTORATION PROJECT

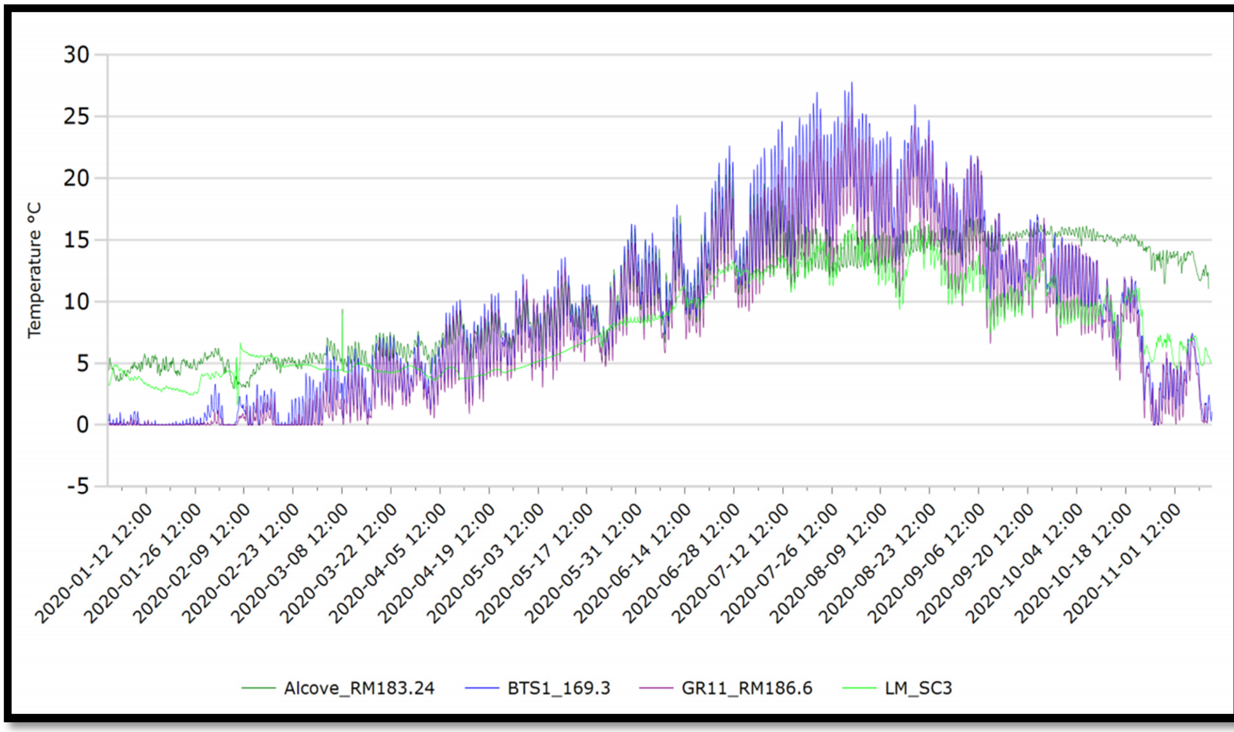


FIGURE 41 DIURNAL FLUCTUATIONS AT PROBES THAT BRACKET THE BIRD TRACK SPRINGS AND LONGLEY MEADOWS PROJECTS

Figure 33 shows diurnal fluctuations for a mainstem Grande Ronde River probe and two probes placed in off-channel areas. Both off-channel probes account for 35.52% and 44.12% of recorded hours in core-cold salmonid temperatures. Neither of the off-channel probes recorded temperatures within the lethal limit. The importance of these areas are vital because they provide thermal refuge for fish within the basin.

Meadow Creek and Dark Canyon

TABLE 7 SUMMARY STATISTICS FOR MEADOW CREEK AND DARK CANYON PROBES

Site	River Mile	# of Days Deployed	Max Temperature (°C)	2019 Hours >=25 °C	2020 Hours >=25 °C	>=25 °C Percent Increase/Decrease	2019 Hours between 10 and 15.6 °C	2020 Hours between 10 and 15.6 °C	10 and 15.6 °C Percent Increase/Decrease	% at 10-15.6 °C	Mean Daily >=17.78 °C (# days)
01 Dark Creek	0.06	197	22.537	0	0	NA	231	2232	+866.23	47.66	3
02 Dark Creek	1.9	197	23.184	NA	0	NA	NA	1684	NA	39.61	8
01 Meadow Creek	2.9	316	29.115	118	157	+33.05	1415	1794	+26.78	28.78	56

In 2020, Dark Canyon Creek probes maintained productive temperatures for fish with 2,232 hours within the 10°C -15.6°C core-cold range, which is an 866% increase from 2019. Meadow01 saw an increase of 33.05% in lethal limit recorded temperature, however, also saw a 26.78% increase in 10°C -15.6°C temperatures.

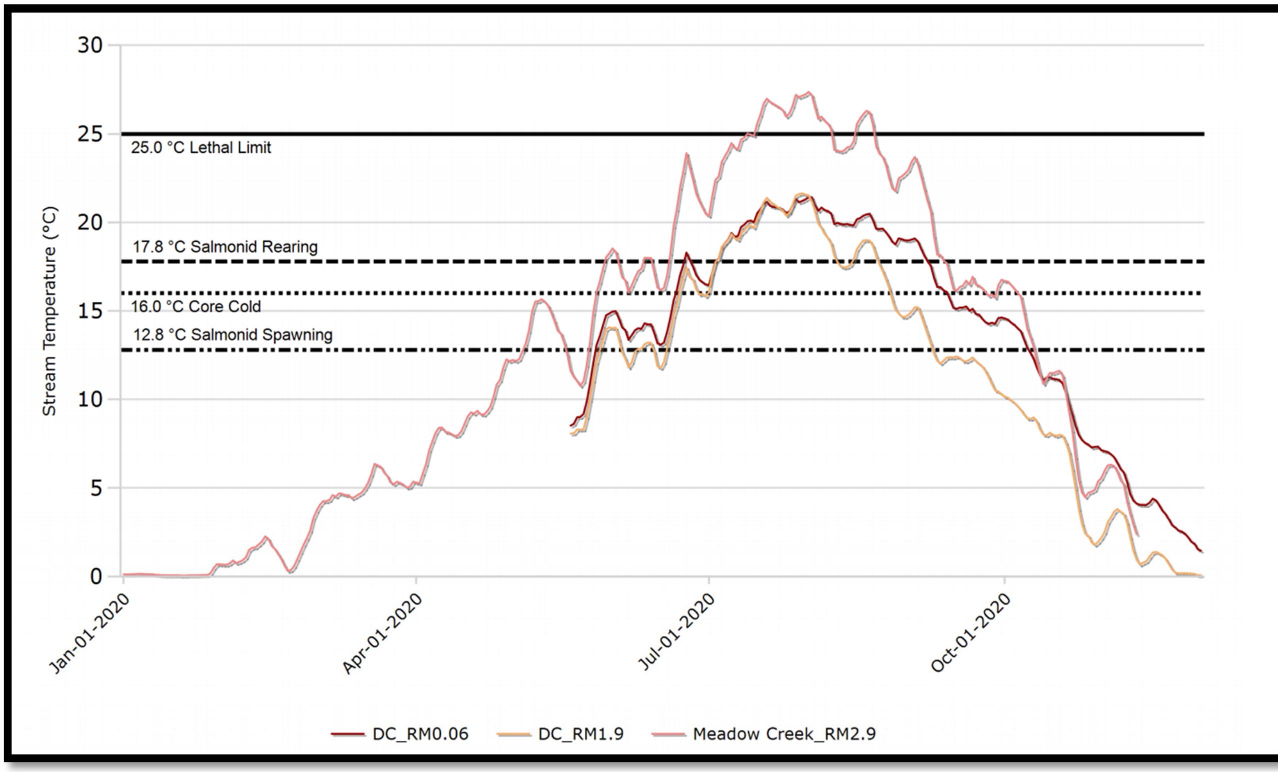


FIGURE 42 2020 7DADM FOR DARK CANYON AND MEADOW CREEK PROBES

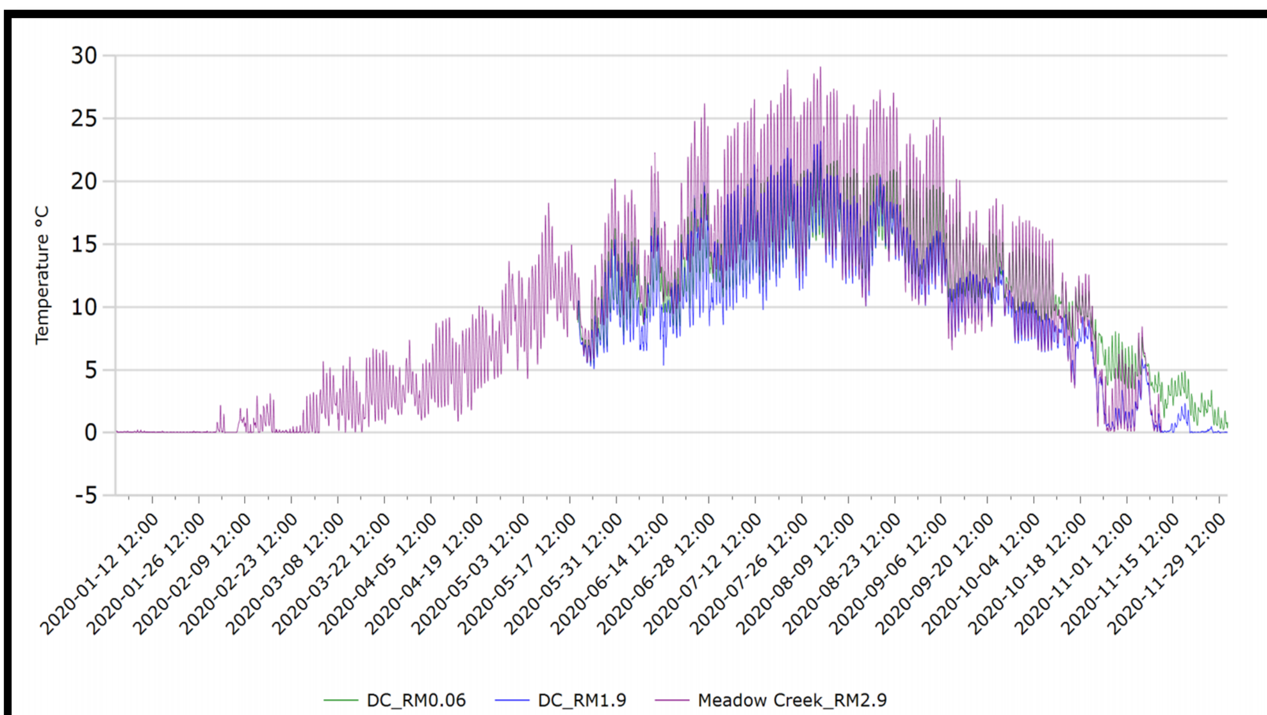


FIGURE 43 2020 DIURNAL FLUCTUATIONS FOR DARK CANYON AND MEADOW CREEK PROBES

Rock Creek

TABLE 8 SUMMARY STATISTICS FOR ROCK CREEK PROBES

Site	River Mile	# of Days Deployed	Max Temperature (°C)	2019 Hours >=25 °C	2020 Hours >=25 °C	>=25 °C Percent Increase/ Decrease	2019 Hours between 10 and 15.6 °C	2020 Hours between 10 and 15.6 °C	10 and 15.6 °C Percent Increase/ Decrease	% at 10-15.6 °C	Mean Daily >=17.78 °C (# days)
01 Graves Creek	0.05	146	23.857	3	0	-100	2889	1188	-58.88	34.12	11.46
01 Rock Creek	0.23	146	29.315	NA	97	NA	NA	1115	NA	32.07	42.96
02 Rock Creek	1.7	146	24.46	21	0	-100	1371	1031	-24.80	32.36	38.96
03 Rock Creek	3	97	25.72	0	5	NA	1402	484	-65.48	54.5	6
04 Rock Creek	4.5	146	22.992	1	0	-100	2565	1200	-53.22	42.81	5

Rock Creek probes are generally improving with lethal limit temperatures being reduced. However, core cold salmonid temperatures have also decreased. The summer of 2020 was a particualry warm, dry year, with little precipiation. Furthermore, spring runoff was quick and abrupt with multiple rain on snow events.

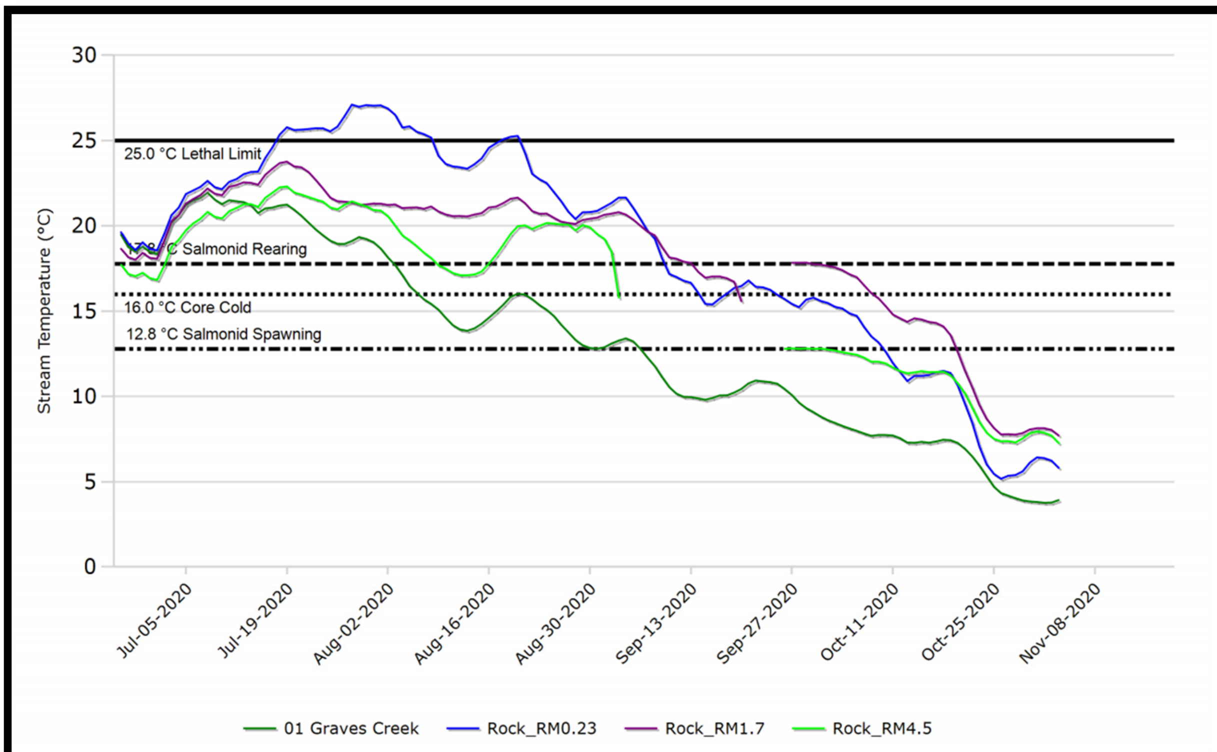


FIGURE 44 2020 7DADM FOR ROCK CREEK BASIN PROBES

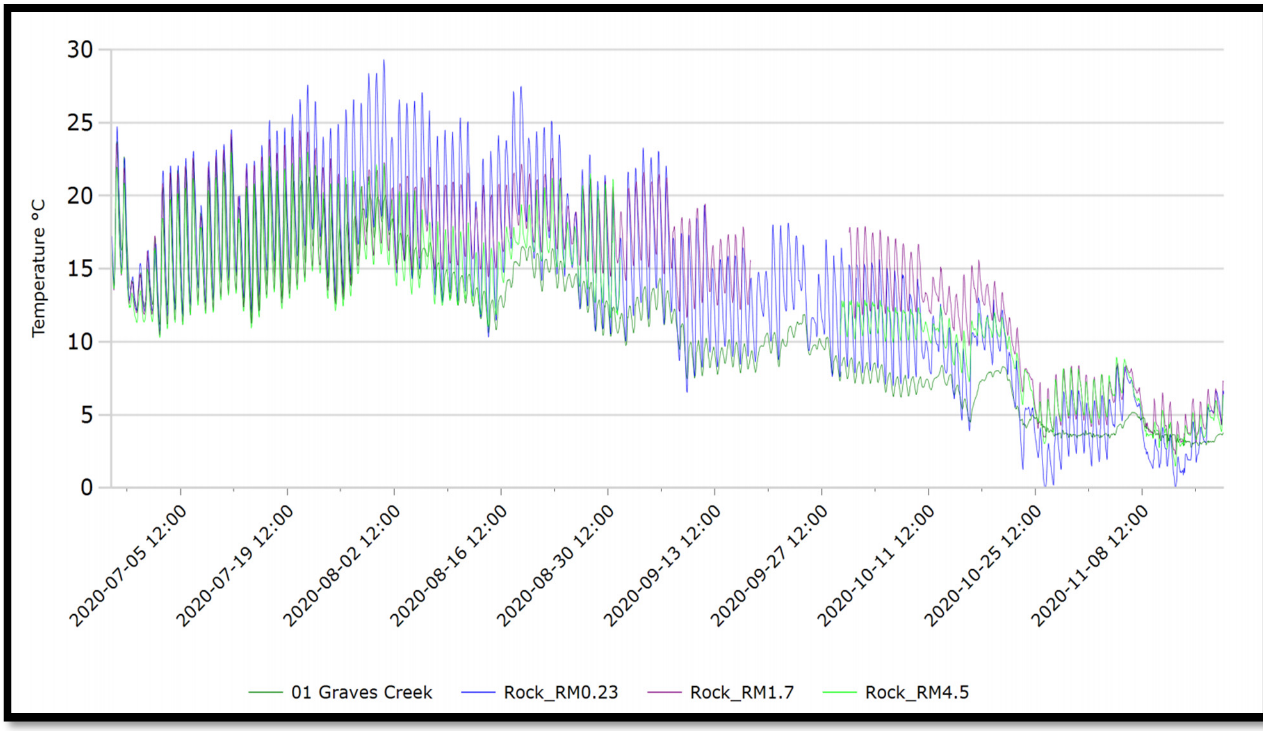


FIGURE 45 2020 DIURNAL FLUCTUATIONS FOR ROCK CREEK PROBES

Catherine Creek

TABLE 9 SUMMARY STATISTICS FOR CATHERINE CREEK PROBES

Site	River Mile	# of Days Deployed	Max Temperature (°C)	2019 Hours >=25 °C	2020 Hours >=25 °C	>=25 °C Percent Increase/ Decrease	2019 Hours between 10 and 15.6 °C	2020 Hours between 10 and 15.6 °C	10 and 15.6 °C Percent Increase/ Decrease	% at 10-15.6 °C	Mean Daily >=17.78 °C (# days)
44 Catherine Creek Lower	40	117	22.992	0	0	0	1382	1207	-12.66	43.91	11
44 Catherine Creek Upper	44	71	18.866	0	0	0	153	613	+300.65	38.12	0
Alcove1	41.28	120	16.034	0	0	0	2241	2415	+7.76	84.26	0
SCMID	41.23	120	23.04	0	0	0	1411	1246	-11.69	44.18	9
SideChannel1	41	120	23.497	0	0	0	1551	1462	-5.74	50.98	11
Southern Cross Lower	NA	120	23.136	0	0	0	1406	1244	-11.52	44.08	10
Southern Cross Upper	NA	120	22.968	0	0	0	1433	1247	-12.98	44.2	8
Swale1channel	41.41	50	28.345	16	31	+93.75	644	143	-77.80	29.55	9.21
Swale2Pool	41.39	120	20.579	0	0	0	1743	1340	-23.12	46.74	7
Swale4channel	41.14	120	19.318	104	0	0	823	1435	+74.36	50.05	4
Swale5channel	40.93	120	19.579	0	0	0	63	1827	+2800.00	63.7	0
Swale6channel	40.84	120	31.153	226	187	-17.26	1315	961	-26.92	33.51	38
Swale6Pool	40.96	120	19.46	0	0	0	1295	1416	+9.34	49.37	8

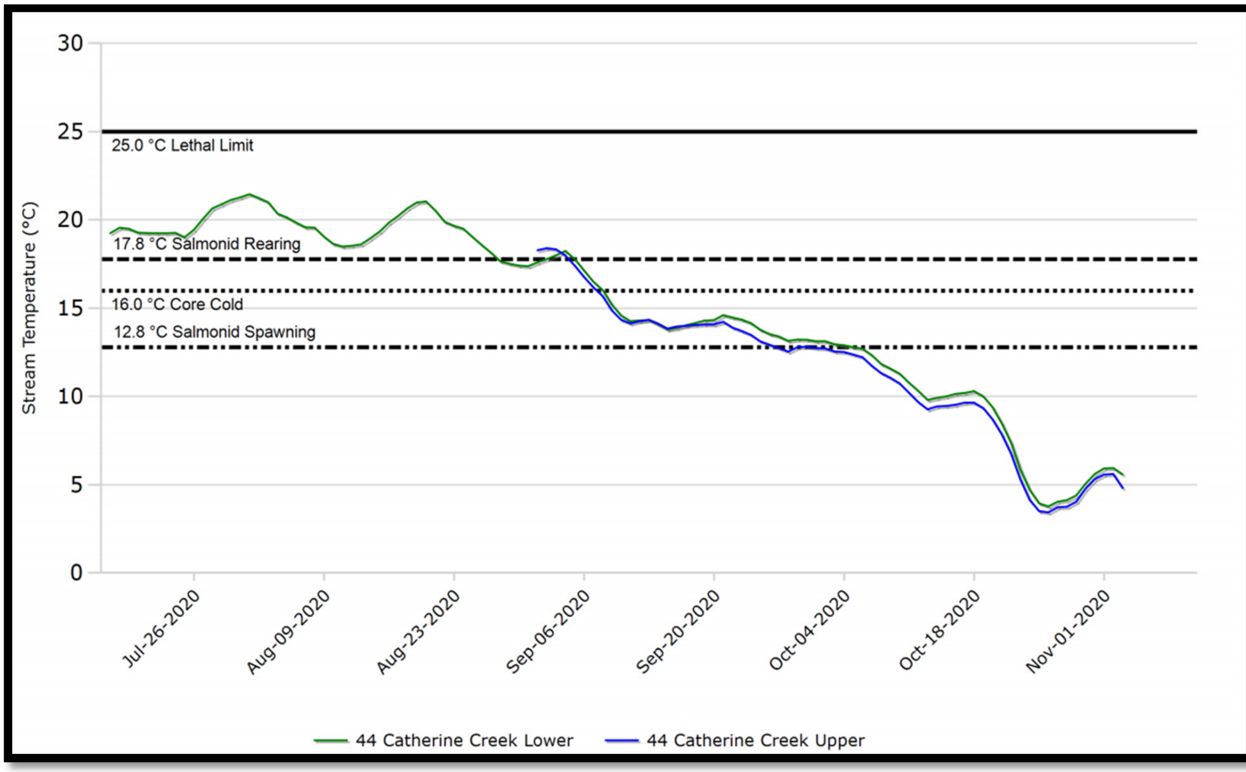


FIGURE 46 2020 7DADM FOR CATHERINE CREEK BRACKETED RESTORATION PROJECT

Table 10 below shows results from a Welch's Two Sample t-test for Catherine Creek. This type of inferential statistic does not have the assumption of equal variance, however, still has the assumption of normality. Water temperature recorded at the selected sites from 2016 (pre-restoration) and 2020 (four years post-restoration) were used to test if there was a significant difference in water temperatures from 2016-2020 at the two given probes. The results show that mean temperature has decreased 1.399°C in five years, with a 95% confidence interval ± 0.34, and p-value = <0.01.

TABLE 10 WELCH'S TWP SAMPLE T-TEST FOR 2016 VS. 2020 DATA

Welch Two Sample t-test		
Data	2016 temp and 2020 temp	
Locations	44 Catherine Creek Upper, 44 Catherine Creek Lower	
t = 16.154	df = 7373.5	p-value = <0.01
Alternative hypothesis	true difference in means is not equal to 0	
95% confidence interval	1.229143	1.568658
Sample estimates (temperature)	12.29926	10.90036

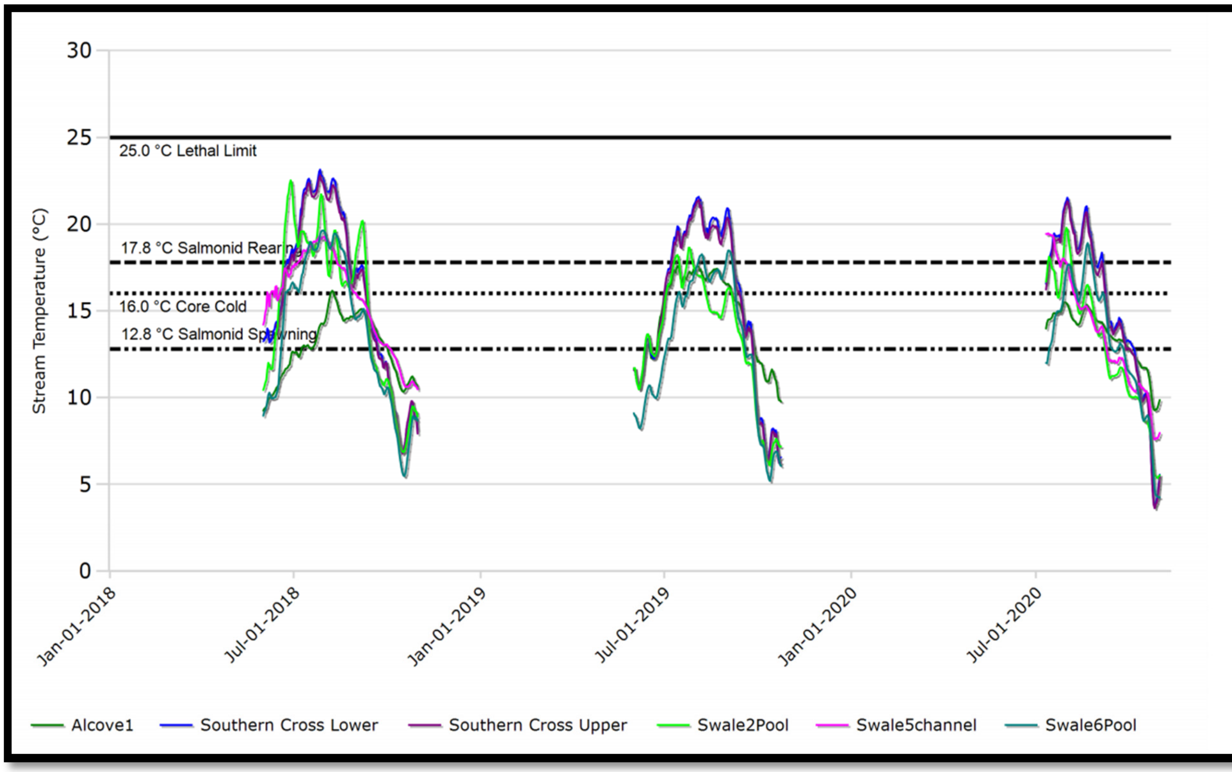


FIGURE 47 7DADM FOR THREE YEARS FOR PROBES ALONG CATHERINE CREEK

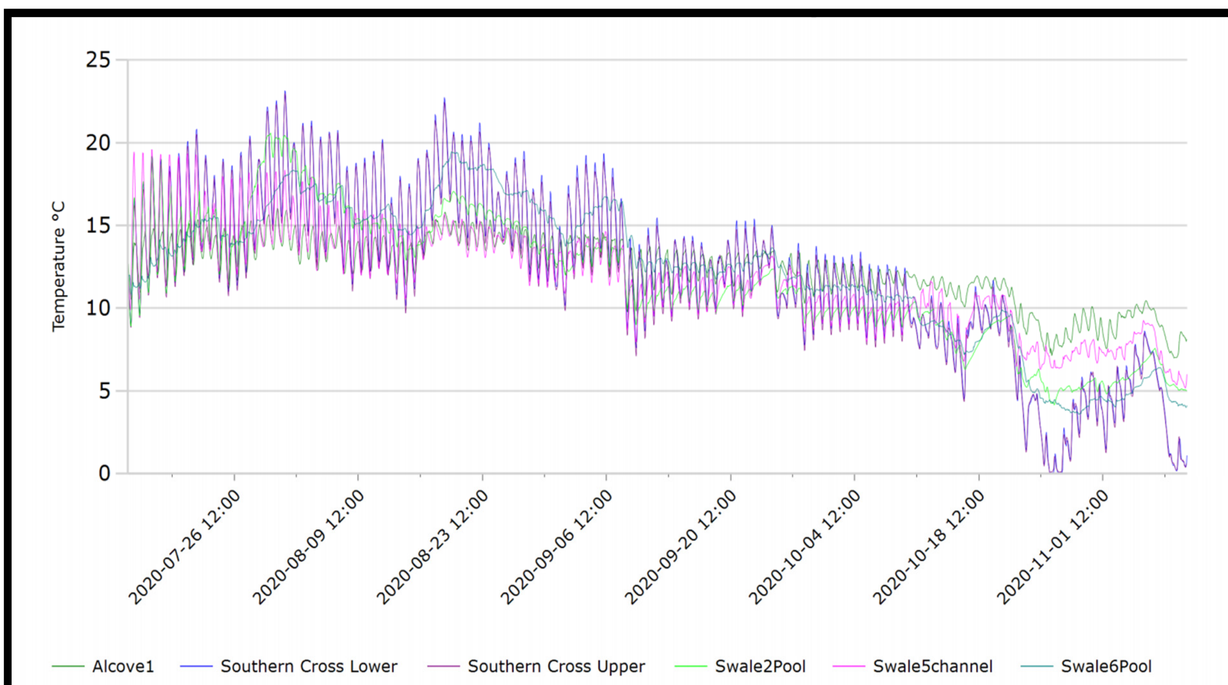


FIGURE 48 CATHERINE CREEK DIURNAL FLUCTUATIONS FOR TWO MAINSTEM PROBES (SOUTHERN CROSS LOWER AND SOUTHERN CROSS UPPER) AND FOUR OFF-CHANNEL HABITAT PROBES.

Figure 45 shows diurnal fluctuations for a mainstem Catherine Creek probe and two probes placed in off-channel areas. Both off-channel probes account for 7.76% to 9.34% of recorded hours in core-cold salmonid temperatures. Neither of the off-channel probes recorded temperatures within the lethal limit.

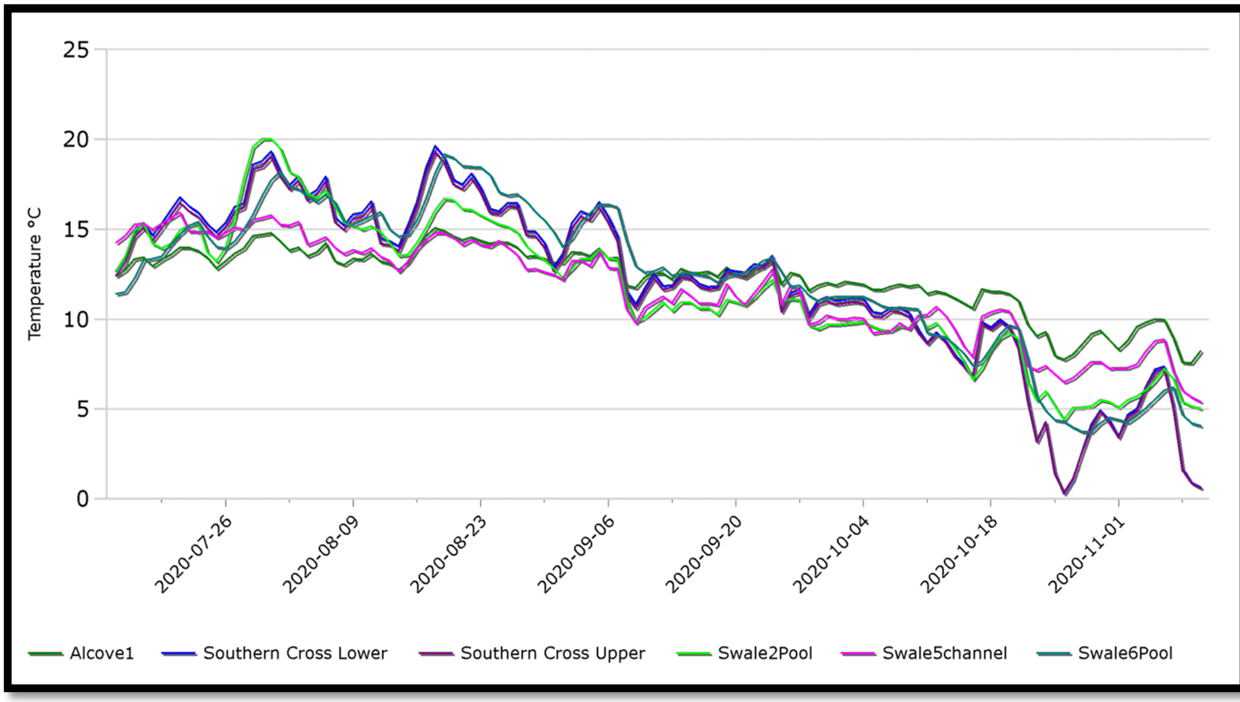


FIGURE 49 AVERAGE DAILY TEMPERATURES FOR MAINSTEM PROBES VS FLOODPLAIN FEATURES.

Discussion

Grande Ronde River

There were 15 temperature probes deployed along the Grande Ronde River in the year 2020. Temperature probes along the Grande Ronde River generally showed an increase in hours of core cold temperatures of 10°C and 15.6°C, however, seven probes had the core cold salmonid temperatures decrease throughout the monitoring period. Four probes saw a decrease in lethal limit temperatures (Table 11)

The three year 7DADM (Figure 46) shows promising results that temperatures are decreasing along the mainstem Grande Ronde River, and is further supported by the t-test that was used to determine if there was a significant difference from 2016 temperatures and 2020 temperatures at the given probes.

There still is a fair amount of noise with the mainstem diurnal fluctuations of temperature. However, plotted against the mainstem probe are two off-channel probes that demonstrate the importance of access to off-channel habitats because of the thermal refugia they provide for salmonids.

Meadow Creek and Dark Canyon
Three probes were deployed within the Meadow Creek and Dark Canyon basins in 2020. Meadow Creek and the lower Dark Canyon (01 Dark Canyon) probes both increased significantly in hours spent within the core cold temperatures for salmonids (Table 7). However, the amount of the time the 01 Meadow Creek probe recorded lethal limits, significantly increased by +33.04%. Meadow Creek has been heavily altered by anthropogenic perturbations throughout its history and because of that, temperatures have been negatively impacted. Thus, from assessing surface water temperatures alone, there is strong supporting evidence that restoration work is needed in the near future to improve the thermal regime.

Since August 2009, the CTUIR has monitored water temperature at two locations within Dark Canyon Creek – an upper probe site (DC2) at river mile 1.9 and a lower probe site (DC1) at river mile 0.06. Dark Canyon has consistently been a thermal refuge for fish because of inputs from cold-water seeps, a shallow ground water elevation, and increasing hyporheic exchange with the river water column. Because of this, it is and has been heavily used by juvenile salmonids because of its cooler temperatures than the mainstem Grande Ronde Probe 01 Dark Canyon, particularly within the summer months.

Rock Creek
The lower 3 miles of Rock Creek was historically channelized by draw bottom road construction, installation of levees and utilities (power lines, gas pipelines, fiber optics), and agriculture. Alternations have contributed to floodplain confinement, channel entrenchment, increased slope, coarsened streambed sediment and loss of spawning habitat, streambank erosion, loss of wetland and riparian plant communities, poor thermal diversity, high water temperatures and homogenized and degraded fish habitat.

Restoration work was completed in 2018 along Rock Creek that aimed to remedy the impacts mentioned above. Restoration work included, enhancing in-stream structural diversity, complexity, and geomorphic stability by installing large wood and riffle-boulder complexes to provide roughness, overhead cover, and attenuate velocities. Water quality was addressed by increasing channel and floodplain interactions to diversify hyporheic exchange, by facilitating preferential flow from hillside cold water spring seeps into alcoves, side channels, and the main channel, promoting vegetative cover and shade, and decreasing channel width-to-depth ratios to lower summer stream temperatures and increase winter temperatures.

In 2020, there were five probes that record temperature data within the Rock Creek basin. Four of the five probes within the basin saw a decrease in cord cold water temperatures ranging from a -24.80% to a -64.48%. Graves01 has provided interesting insight for the CTUIR. At this probe location, flows go sub-surface and you can see a dramatic decline in water temperatures during summer months. Although, not valuable for buffering surface water temperatures, this occurrence shows the important of facilitating hyporheic interactions to buffer summer and winter stream temperatures.

Catherine Creek
There were 13 temperature probes deployed along the mainstem and off-channel habitats of Catherine Creek in the year 2020. Temperatures along Catherine Creek were variable. One probe (Swale1channel) saw in increase of 93.75% in core cold temperatures recorded (Table 9). The three year 7DADM (Figure 47) shows promising results that temperatures are trending downward. 44 Catherine Creek Lower was left in and was malfunctioning, which explains the straight line from mid-late October 2019 to August 2020. The 7DADM was also supported by a t-test with significant results in temperatures from 2016-2020 (Table 10).

There still is a fair amount of noise with the mainstem diurnal fluctuations of temperature along Catherine Creek. However, similar to the mainstem Grande Ronde and its off-channel habitats, when plotting the mainstem probe against two off-channel probes, it demonstrates the importance of access to off-channel habitats because of the thermal refugia they provide for salmonids (Figure 49).

Monitoring Conclusion

Restoration actions since 2014 in the Grande Ronde basin has resulted in reconnecting 455 acres of floodplain habitat, protection of 1,083 acres of floodplains, uplands, and riparian areas through permanent and term conservation easements, 157 acres of floodplain and riparian habitat planted with over 47,000 native trees and shrubs, 13.5 miles of main channels restored or enhanced, eight miles of side channels constructed, 147 large main channel pools created or enhanced, 74 side channel pools created or enhanced, and 589 large wood structures installed. Overall, restoration practitioners are putting forth a great amount of effort to restore natural processes in the basin, however, from the temperature results above suggests that there are confounding factors that are not captured with data that was plotted or analyzed.

The relationship between stream and air temperatures is a key variable that would facilitate more in depth statistical analyses. With the increasing air temperature that is being seen across watersheds, if timed appropriately with the increasing stream temperatures such as increasing nighttime lows more than daytime highs, aquatic species, especially salmonids will be greatly impacted.

Results suggest that further restoration work within the Grande Ronde basin is still needed to facilitate temperatures optimal for salmonid productivity and to improve the summer and winter altered thermal regime. Furthermore, our findings have several limitations that hinder a robust analysis to draw stronger conclusions from and will be addressed in future monitoring efforts. Limitations are; 1) inconsistent probe deployment and removal, 2) varying probe locations, and 3) single water quality parameter collection.

We will work internally to improve deployment of probes and will install them in locations that are able to provide more detail on thermal loadings in the basin, specifically within deep pools of restoration projects, and will look for funding to potentially deploy other monitoring probes to collect other parameters such as ambient air, dissolved oxygen (DO), and/or potential of hydrogen (pH).

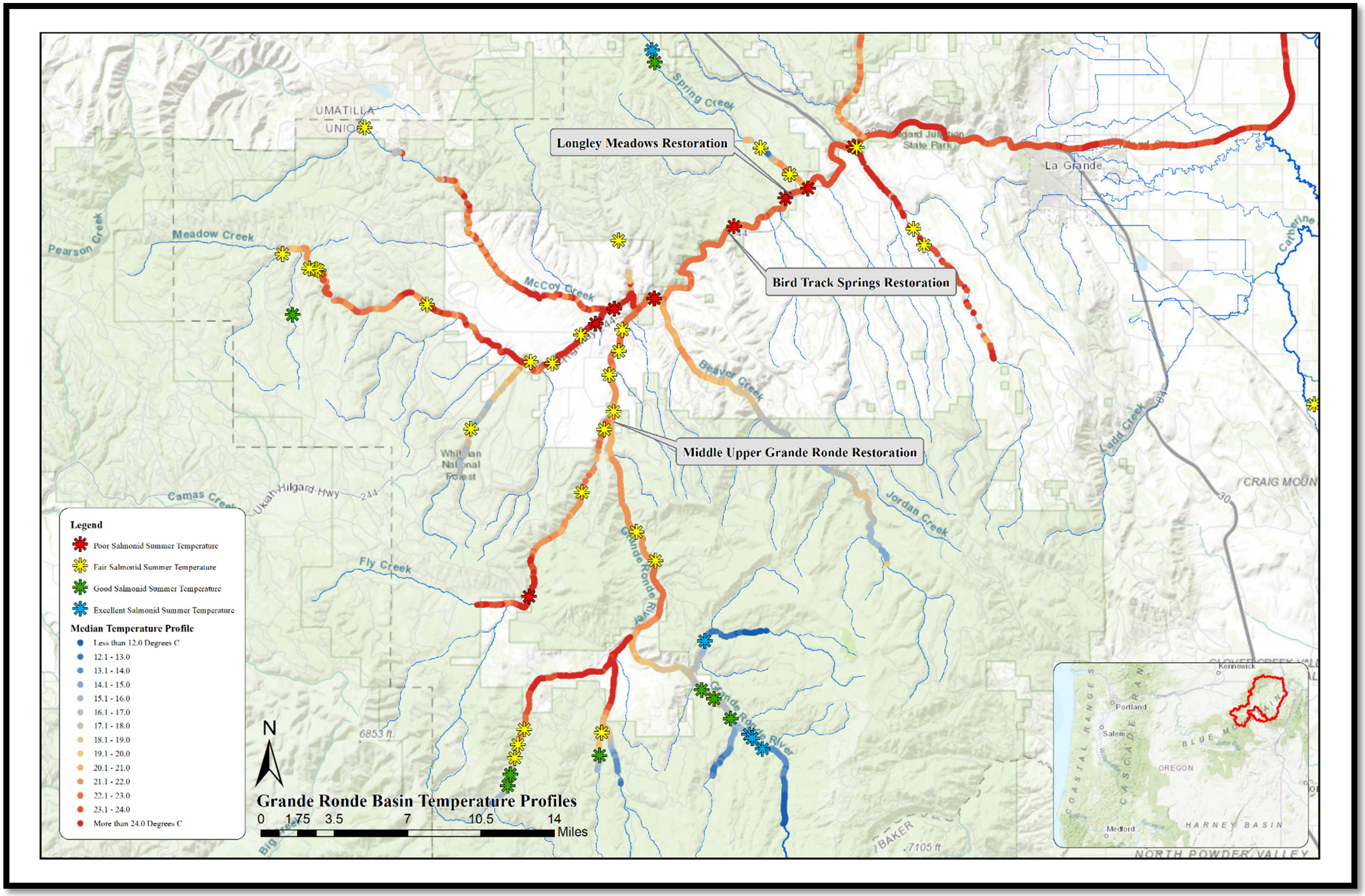


FIGURE 50 MEDIAN TEMPERATURE PROFILE MAP AND SUMMER SALMONID SUITABLE TEMPERATURE ASSESSMENT

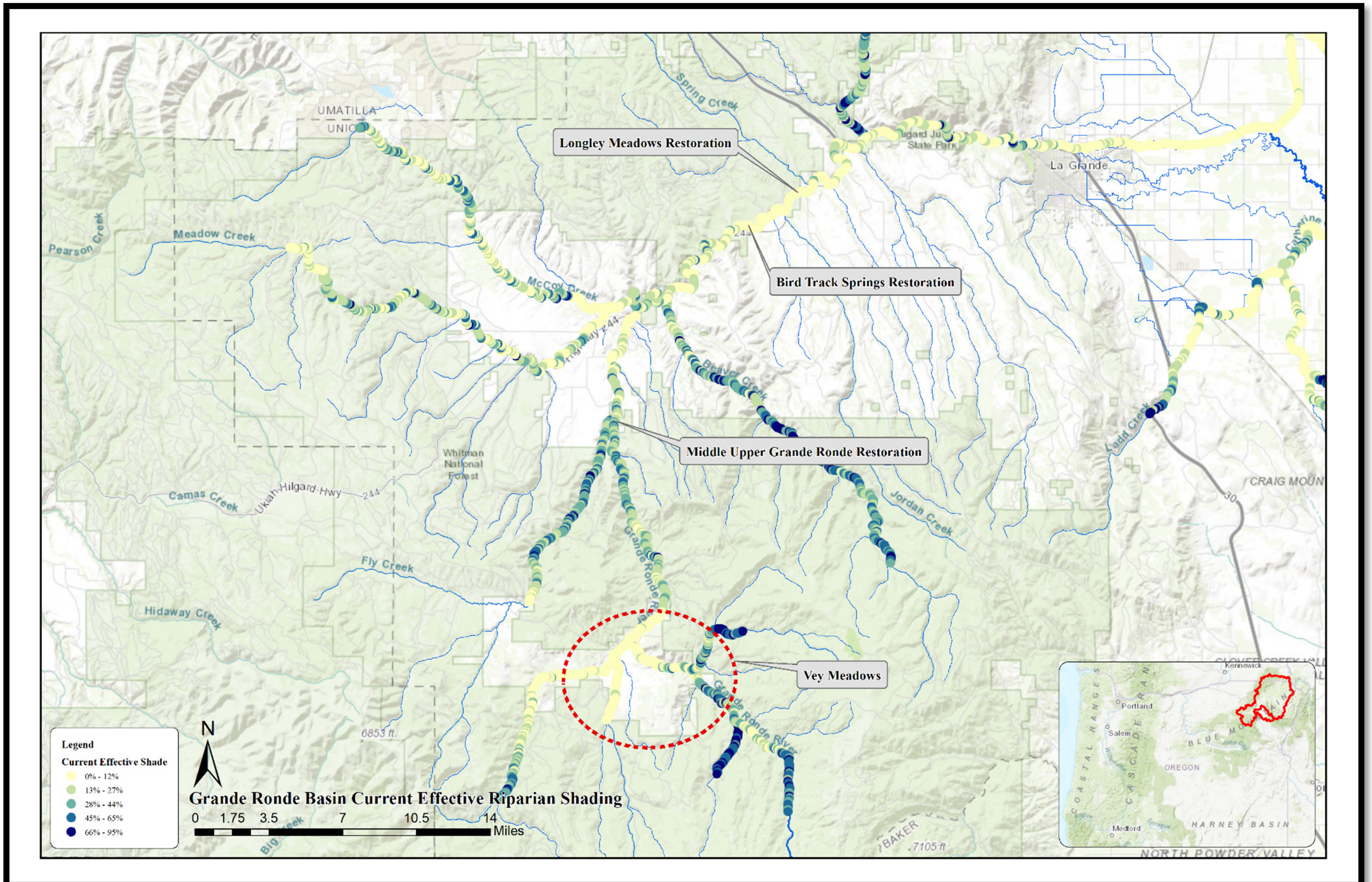


FIGURE 51 CURRENT EFFECTIVE SHADING ALONG THE GRANDE RONDE RIVER

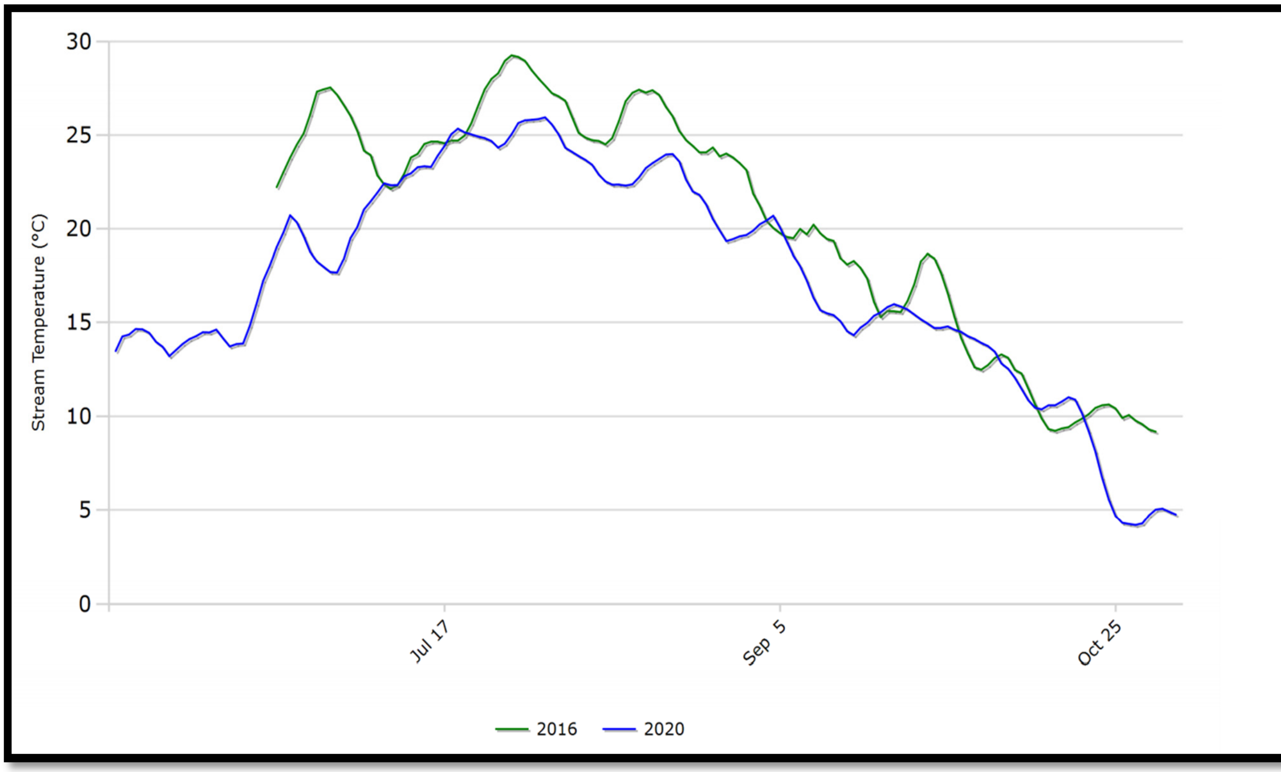


FIGURE 52 BEFORE AND THREE YEARS AFTER PROJECT 7DADM FOR MAINSTEM GRANDE RONDE PROBE (BTS1_RM169.3), BELOW BIRD TRACK SPRINGS FISH HABITAT ENHANCEMENT PROJECT.

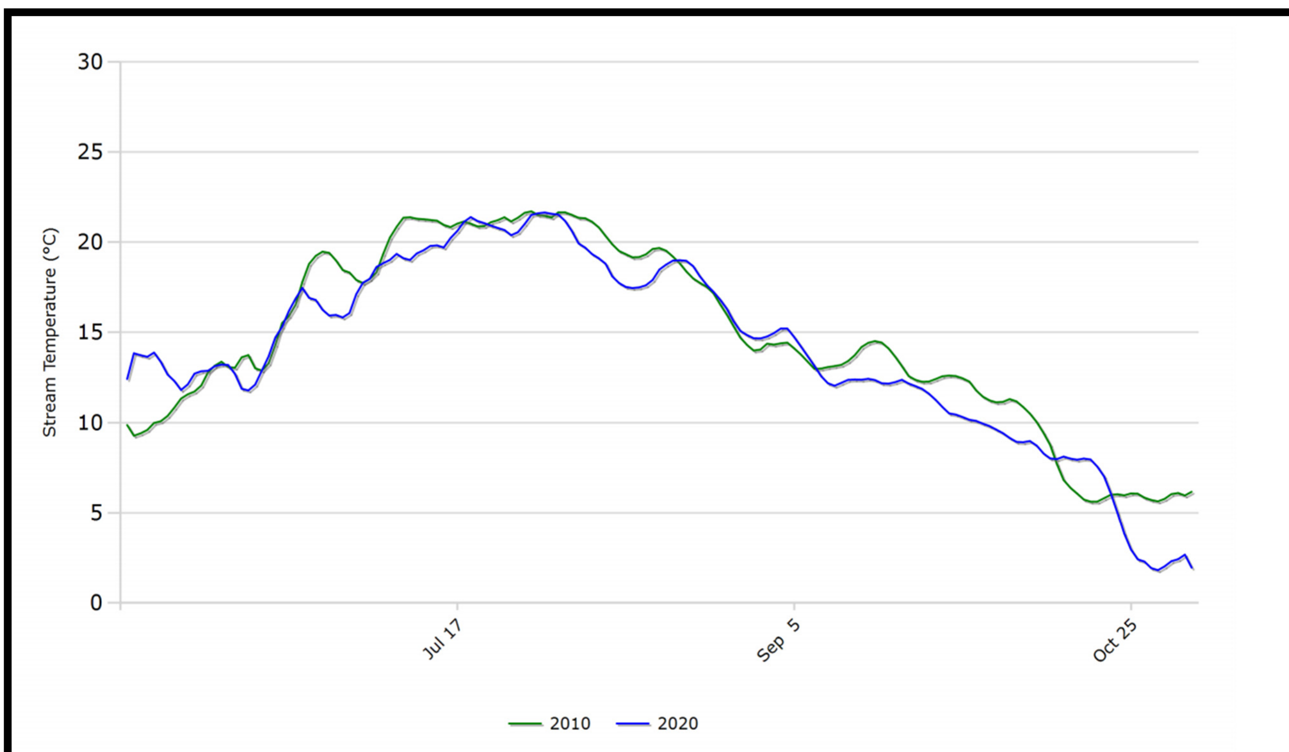


FIGURE 53 MIDPOINT 7DADM FOR UPPER DARK CANYON PROBE (DC_RM1.9)

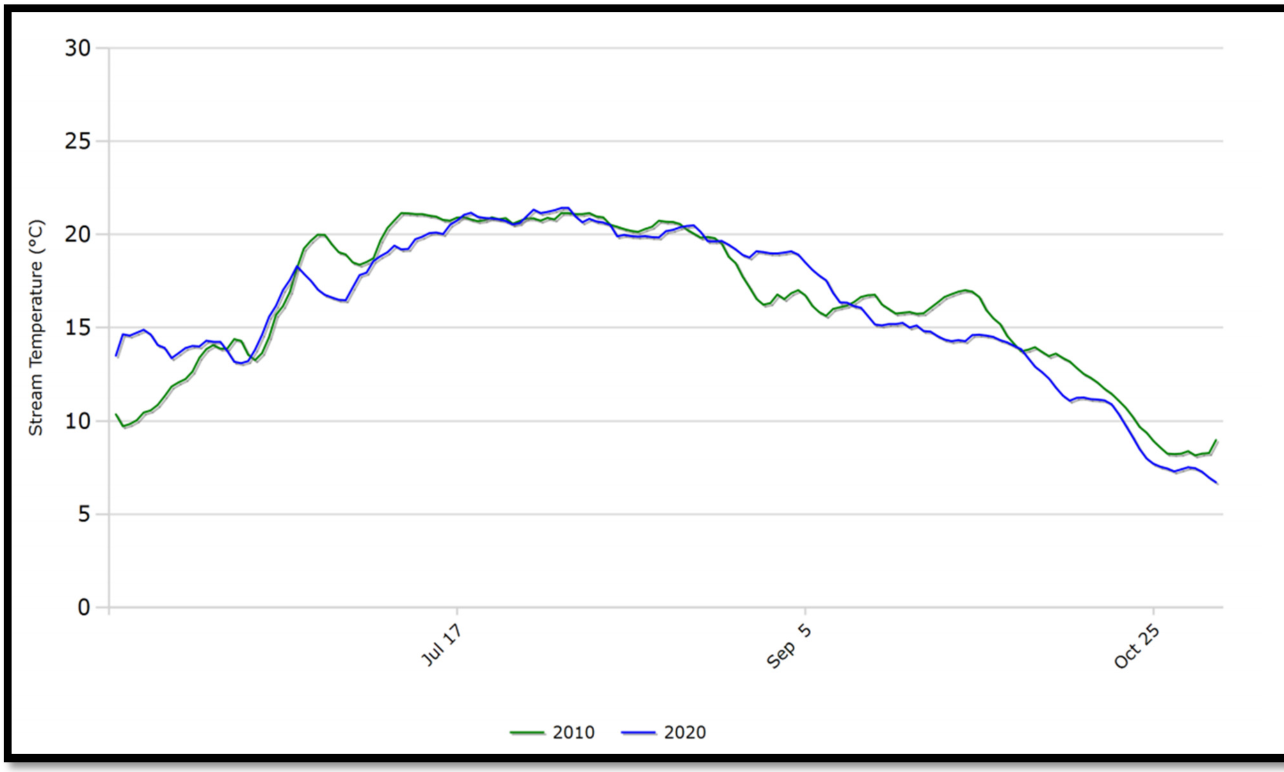


FIGURE 54 MIDPOINT 7DADM FOR LOWER DARK CANYON PROBE (DC_RM0.6)

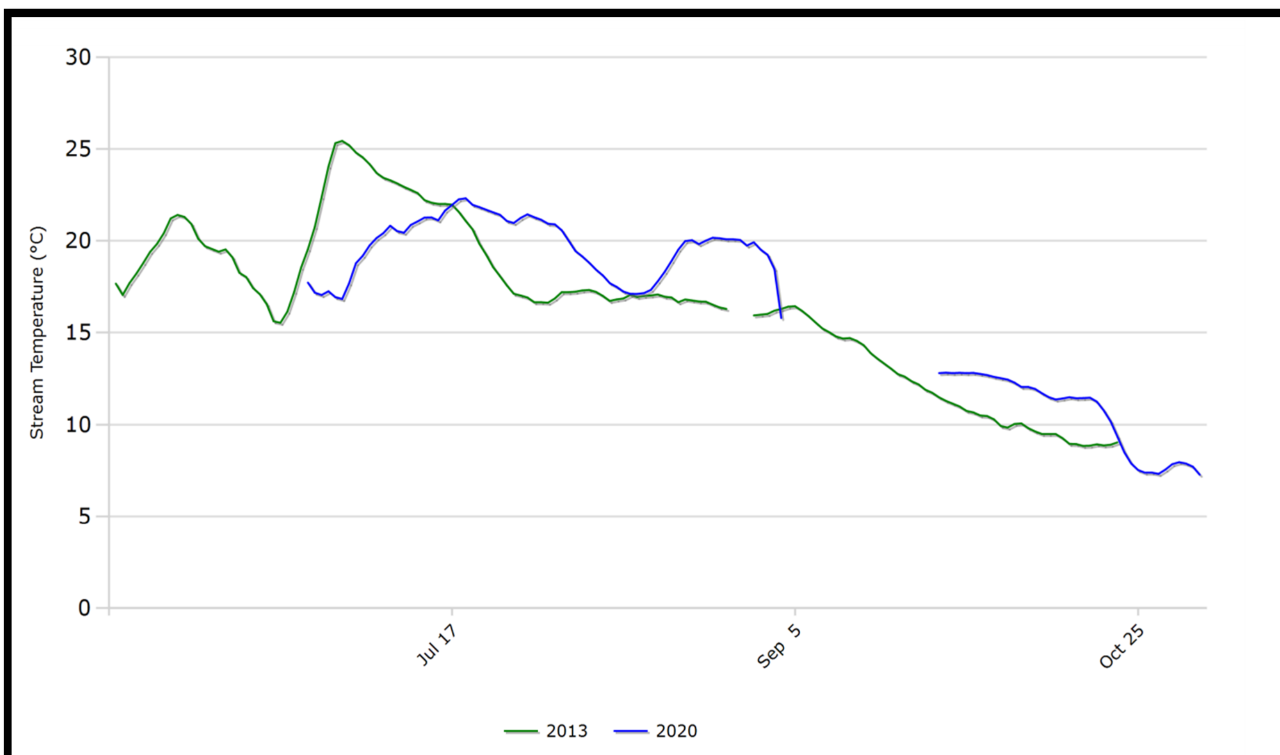


FIGURE 55 BEFORE AND THREE YEAR AFTER MIDPOINT 7DADM FOR ROCK CREEK UPPER PROBE (ROCK_RM4.5), ABOVE RESTORATION. MISSING DATA DUE TO MALFUNCTION

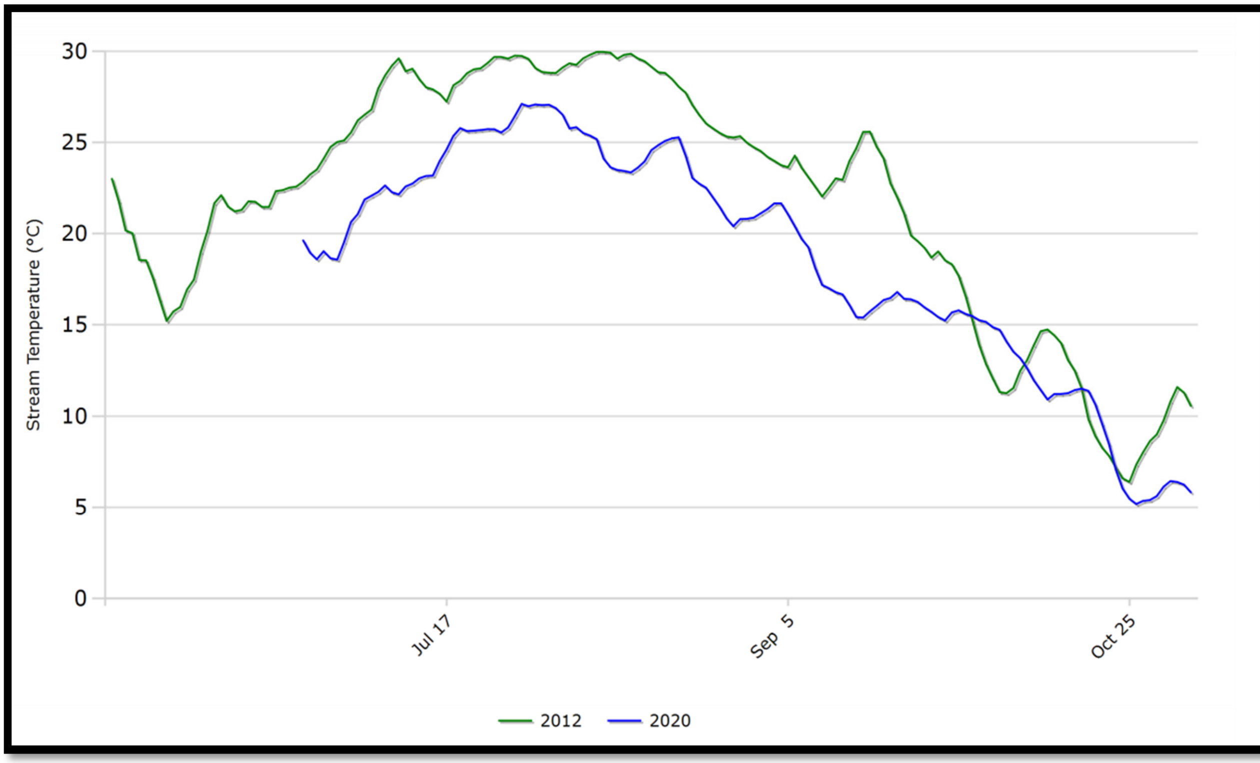


FIGURE 56 MIDPOINT 7DADM FOR ROCK CREEK LOWER PROBE (ROCK_RM0.23)

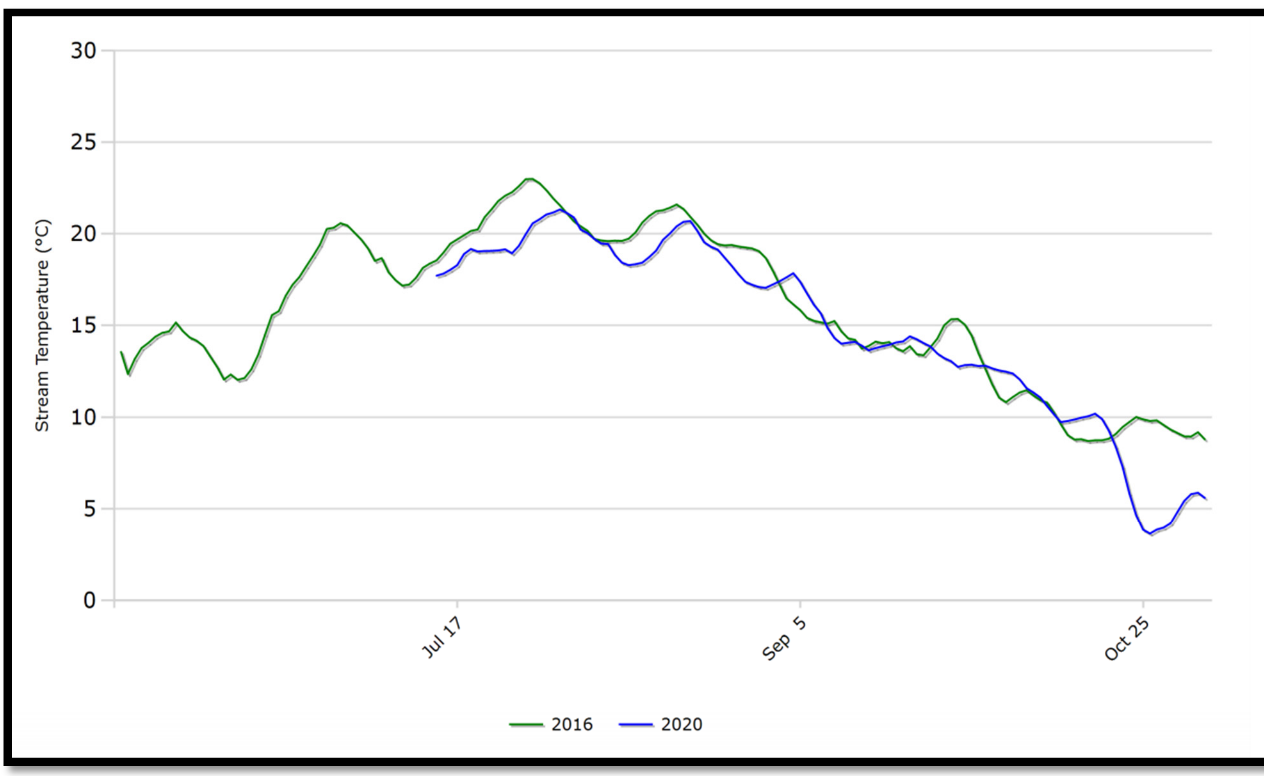


FIGURE 57 MIDPOINT 7DADM FOR SOUTHERN CROSS UPPER PROBE

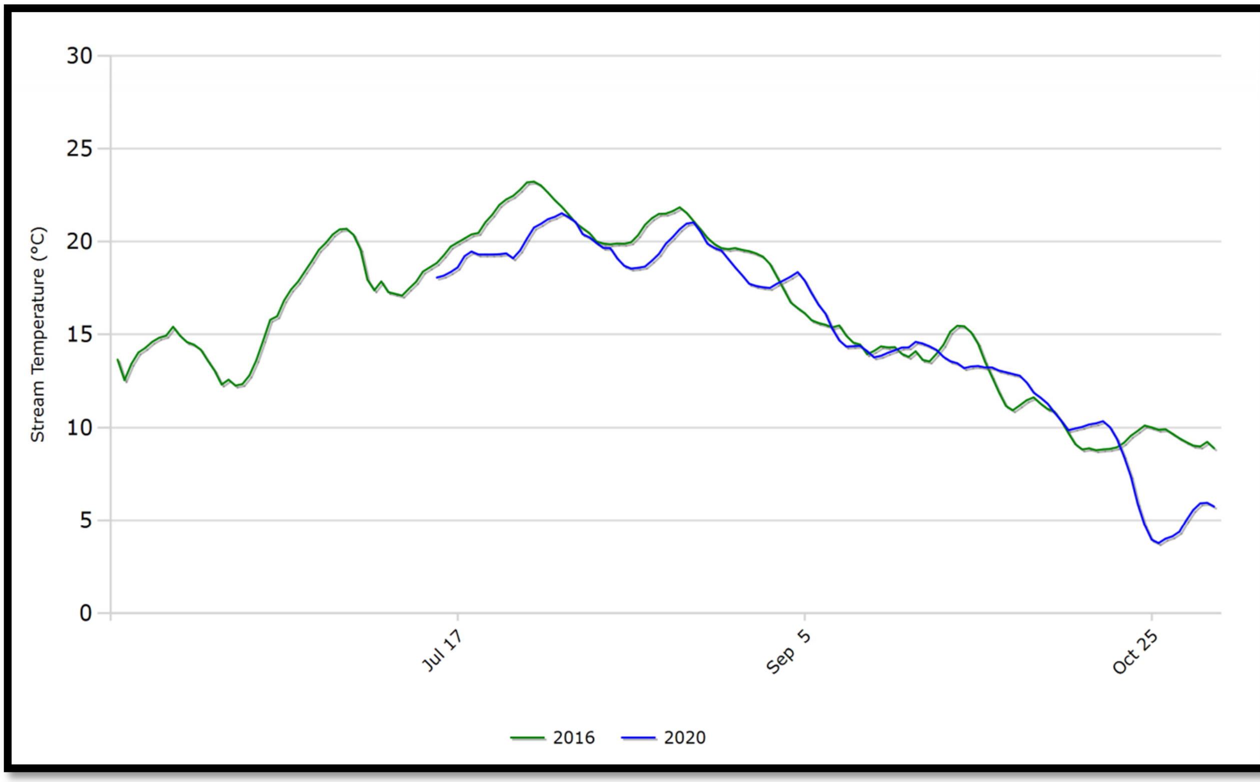


FIGURE 58 MIDPOINT 7DADM FOR SOUTHERN CROSS LOWER PROBE

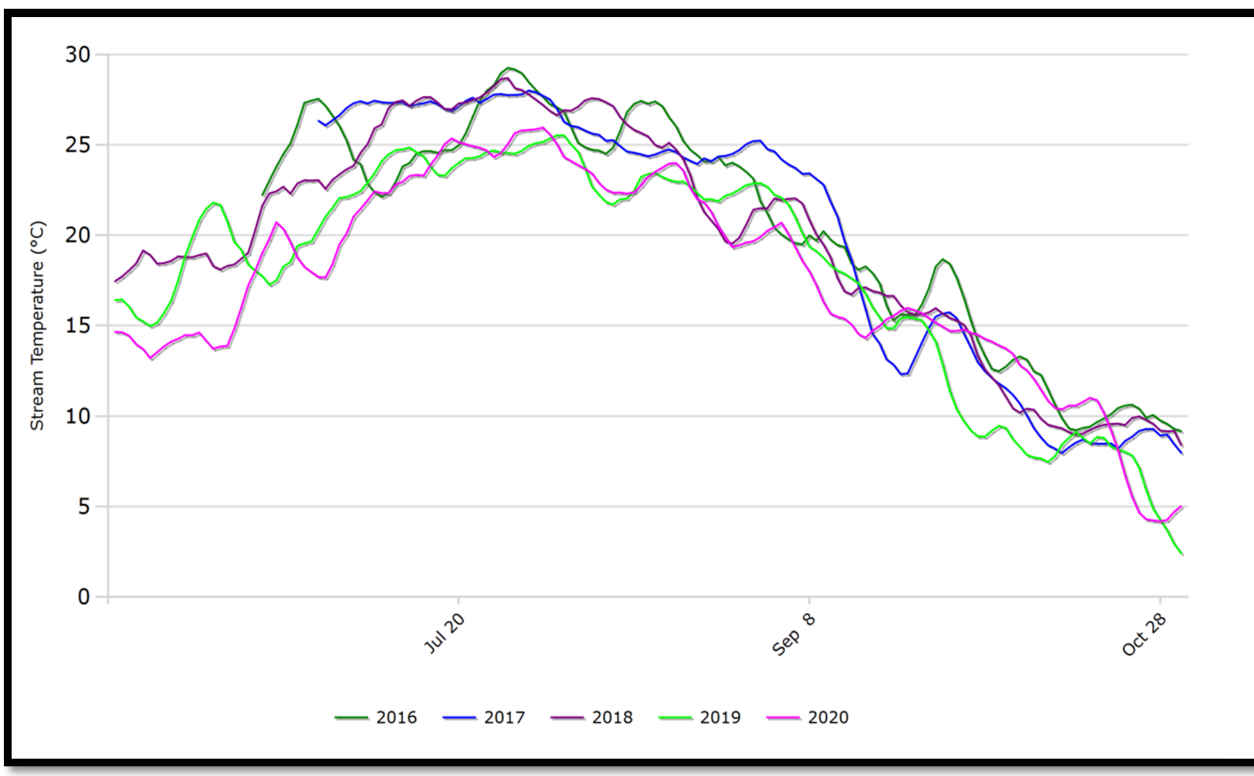


FIGURE 59 MULTI YEAR MIDPOINT 7DADM FOR GRANDE RONDE RIVER PROBE BTS1_RM169.3, BELOW RESTORATION

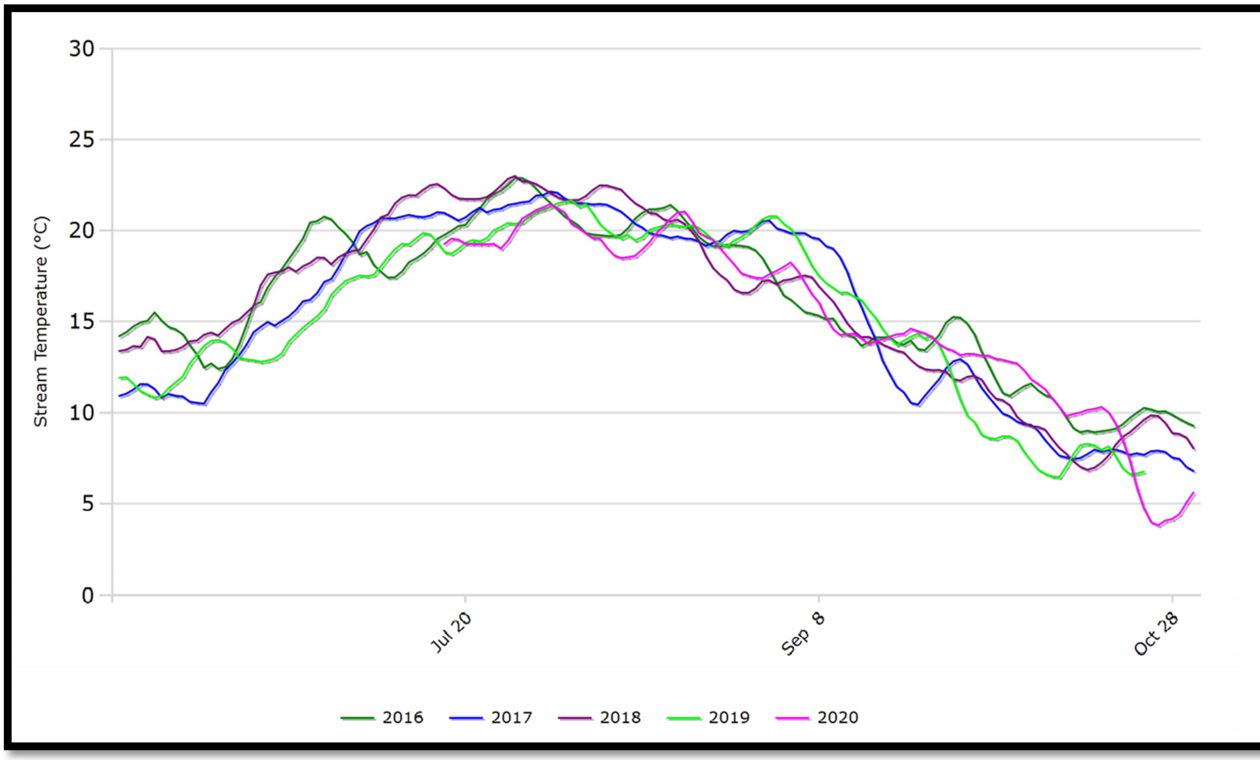


FIGURE 60 MULTI YEAR MIDPOINT 7DADM FOR CATHERINE CREEK PROBE 44 CATHERINE CREEK LOWER, BELOW RESTORATION

Long-term Analysis and Looking Forward

Oregon Department of Fish and Wildlife's Aquatic Inventory (AQI) and the Columbia Habitat Monitoring Program (CHaMP) developed a temperature/habitat ranking for steelhead and Chinook for various life stages and Watershed Sciences developed a median temperature profile of 266 river miles of the Grande Ronde River using a FLIR camera. Overlaid on each other gives insight to suitable salmonid temperatures within the basin. As seen in Figure 47, there is rapid heating from the headwaters of the Grande Ronde River as it flows through and downstream of Vey Meadows. There is increased thermal loading associated with decreases in elevation and subsequent increased in ambient air temperature, and the direct exposure to the sun as surface water flows through Vey Meadows, which has roughly 12% - 28% riparian shading (Figure 48). Downstream from Vey Meadows through the canyon there is a reduction in water temperature, and this is where most of the CTUIR is focusing current restoration actions.

The CTUIR developed a multiple year 7DADM to assess thermal regimes within the basin and determine if temperatures are improving with the restoration efforts being employed. CTUIR plotted 7DADM for the most recent restoration projects displaying the results of before and after restoration. The multiple year 7DADM focuses on the summer month period because during these times is when the most pronounced changes in stream temperatures are observed and when salmonids are heavily stressed with temperature fluxes. The multiple year 7DADM report was developed within the CDMS and provides the CTUIR a useful tool to analyze longer term datasets and draw conclusions from to assess restoration project effectiveness.

Figure 49 shows a five year 7DADM for probe BTS1_RM169.3. This probe is located at downstream end of the Bird Track Springs restoration project that concluded in 2018. The restoration project is the ideal approach restoration practitioners should aim for because of the ecological benefits that have been documented within this reach. Two years after construction the 2020 7DADM has a noticeably cooler trend than previous years. Figure 49, also illustrates the importance of floodplain restoration and the effect it has on stream metabolism, especially the buffering of water temperatures. The CTUIR is continuing to monitor water temperatures within this site and have provided permission to the University of Idaho to study the thermal dynamics of this this project as well.

Focusing on the July to September period on Figures 49-57, the 2020 temperature trend line has improved. Although, there are multiple variables that influence stream temperature, floodplain restoration is a key tool to improve overall ecosystem function because of the increased groundwater or hyporheic exchange that leads to reduced water temperatures. Increased hyporheic flow exchange has been shown to increase thermal complexity through the emergence of upwelling cool patches, especially during summer months (July to September). Implementation of large wood (LW) facilitates cooling as well because as water flows around the LW instream structures, hydraulic forces drives water into the benthic substrate increasing hyporheic exchange and promoting thermal heterogeneity (Clark et al. 2021). The CTUIR will continue to work with partners and will meticulously design and place structures at the best configuration so that optimal hyporheic exchange is achieved and that stream temperatures are buffered.

In conclusion, across the west, climate change models indicate that stream temperatures within the Columbia Basin will increase significantly in the next 50-years, specifically eastern Oregon and within the Grande Ronde basin. As water moves down the basin temperature trends increase due to global climate change and anthropogenic perturbations including, water abstraction, and reduction in stream side vegetation, resulting temperatures will be inhospitable for salmonid fishes (Clark et al. 2021). Restoration will need to persist to remedy the impacts on streams and will need to be implemented methodically through the GRMW project prioritization atlas basin to ensure vital areas are restored first. The CTUIR will continue to put forth their efforts to restore the Grande Ronde basin to warrant the continuance of the CTUIR's First Foods and River Vision.

Biological Monitoring

The CTUIR Grande Ronde RM&E Project (#2009-014-00) monitors fish response to habitat actions within the Grande Ronde Basin. The focus of the Grande Ronde RM&E Project is to monitor Grande Ronde Restoration projects at a scale larger than than that currently used by the CHaMP and AEM programs (Naylor, et al., 2019). This monitoring effort follows the guidelines laid out in the Physical Habitat Monitoring Strategy - PHaMS (Jones, et al., 2015) and by the monitoring plan prepared by Stillwater Sciences for CTUIR (Stillwater Sciences, 2012). The overall habitat monitoring goal of the Grande Ronde RM&E Project is to provide empirical data to restoration managers on fish responses/use of restoration structures and new channels, and on changes in morphological (habitat) features as a function of the restoration actions. Monitoring objectives include: 1) provide restoration managers with information about fish response/use of different types of habitat structure or constructed channel segments; 2) provide empirical data on changes in thermal refugia associated with the restoration project, and 3) provide empirical data on morphological changes within shorter (200 m) sites nested within the larger restoration area.

Responses are measured by:

- Determining whether juvenile and adult fish responses are positively affected within the project area, post-restoration compared to pre-restoration levels (such as increased juvenile densities, relative abundance and increased spatial distribution of juveniles and redds).

- Determine fish use of restoration structures, such as large wood sites, constructed pools, side channels, alcoves, floodplains etc.

- Mapping thermal refugia within the project area pre- and post-restoration.

- Recording existing or pre-project physical habitat attributes and compare them with post-restoration attributes.

Monitoring activities provide information to restoration managers on existing fish use and response within project areas and these data will be utilized when designing habitat-enhancing projects in the future. Data will also be used as a baseline for comparison with post-restoration surveys when evaluating the effectiveness of projects in meeting their objectives. Habitat and morphology surveys follow protocols detailed in the Columbia Habitat Monitoring Protocol (CHaMP) methodology (CHaMP, 2015) using biomonitoring protocol #1955 (www.monitoringmethods.org) and are reported separately by the CTUIR Biomonitoring Project (BPA Project # 2009-014-00.

Methods

Evaluating the effectiveness of these habitat enhancement efforts is done by physical and biological sampling using regionally standardized habitat and biotic monitoring protocols and methods (Gallagher, et al., 2007; Nelle & Moberg, 2009; White, et al., 2011; Stillwater Sciences, 2012; CHaMP, 2015; Justice, et al., 2015; Bonneville Power Administration, 2016). Data collected by the CTUIR Biomonitoring Project and Grande Ronde RM&E are now stored on the CTUIR Central Database Management System (CDMS).

Spawning surveys

Steelhead - (Nelle & Moberg, 2009) Steelhead spawning surveys are conducted from March to June and are typically carried out 4 to 5 days per week, with repeat surveys for each restoration project occurring every 10 to 14 days until the spawning season is complete. Metrics collected include:

- Site ID (name of the reach surveyed)
- Stream name
- Survey date
- GPS number
- Start/End time
- Crew
- Survey direction (up or downstream)

- Air temperature at start
- Water temperature at start and end
- Lower end point coordinates
- Upper end point coordinates
- Weather conditions
- Water clarity
- Flow estimate (dry/low/moderate/high/flood)

Coordinates of all redds are recorded on a hand held GPS unit and the redd is flagged with the date, redd number, and surveyors initials on the flagging.

Chinook - (Gallagher, et al., 2007) Chinook spawning surveys are carried out late August to mid-September. A detailed description of the survey method for Lookingglass Creek that includes scale sample protocol, carcass metrics collected, and genetic sample protocol is given in (Crump & Van Sickle, 2016) published on Monitoringresources.org as Protocol #1843.

Snorkel surveys

Snorkel surveys follow the protocols outlined by White et al 2011, and the BPA Action Effectiveness Monitoring Program (White, et al., 2011; Bonneville Power Administration, 2016) and are typically undertaken in daylight hours. Surveys are conducted during daytime hours for logistical and safety reasons after comparing day and night survey results in 2016 on the Catherine Creek Southern Cross Restoration Project (Costi, et al., 2016). Surveys use a one pass, open population (no block nets) sampling design in order to not inhibit movement of ESA species between habitats.

In addition to recording observed fish species and their size, habitat data for each channel unit snorkeled is collected including:

- GPS point for downstream end of snorkeled channel unit
- Channel unit type (riffle, pool, side channel, etc.)
- Length in meters
- Mean width in meters (measurements taken at 25%, 50%, and 75% of channel unit)
- Mean depth in meters (measurements taken at 25%, 50%, and 75% of channel unit)
- Maximum depth in meters
- Ambient and minimum temperature in degrees centigrade (Justice, et al., 2015).

Radio Tracking

The Upper Grande Ronde stock of spring Chinook salmon migrate into the upper reaches of the Grande Ronde River beginning in early May and continue to move into the spawning grounds through August (McLean, et al., 2016). There is a weir and trap located at river mile 153.5 (Figure 45) operated by the CTUIR. The weir is designed to capture broodstock and enumerate upstream migrating salmon and has been in operation since 1997 (McLean, et al., 2016). The migration of Grande Ronde adults in the lower Columbia River system has been well documented (Keefer, et al., 2004; Keefer, et al., 2008). The movement and habitat use of adult Chinook in other basins has also been studied (Conder, et al., 2008), including within the Grande Ronde Basin on the Lostine River (Harbeck, et al., 2014). However, the migration patterns and stream reach use prior to spawning of the Upper Grande Ronde stock is unknown once returning adults are captured and released above the weir. In most years, the habitat in the Upper Grande Ronde River is plagued by low stream flows and high stream temperatures throughout the summer (Nowack, 2004; Justice, et al., 2017).

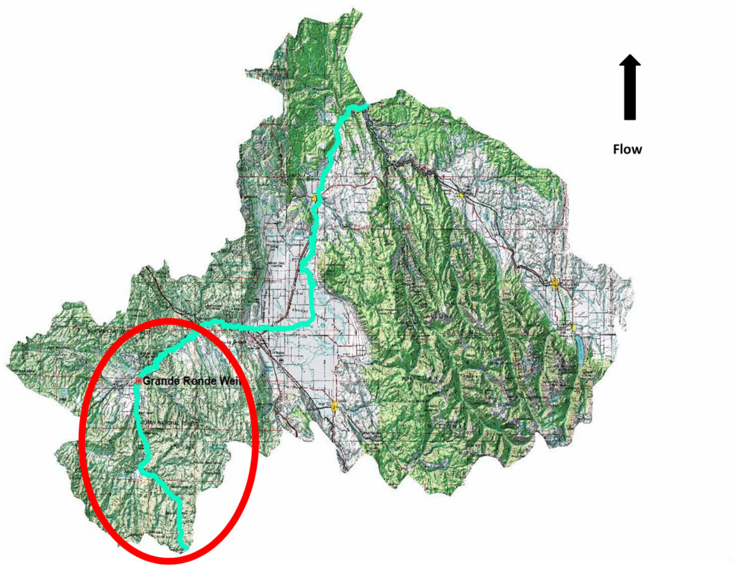


FIGURE 61 UPPER GRANDE RONDE WEIR LOCATION

Discovering where the salmon hold and how long they choose to stay in those areas may help in understanding which stream reaches and habitat types need to be protected or enhanced. Radio telemetry is a common technique that has been used to document the movement of fish and other animals within their habitat (Contor, C.R., 2010, 2014; Harbeck, et al., 2014) and we are able to handle a percentage of the run at the weir each year. There is also a large portion of the upper river (Vey Meadows, 6.5 river miles) that is under private ownership and currently access has not been granted. By using radio telemetry methods and staying within the boundaries of the National Forest it is possible document when fish enter and leave the area without having to enter the property.

Historically, when access was regularly granted to the meadow area (1986 to 1993), an average of 43% of the total redds for the Upper Grande Ronde River were counted there, with an average of 49% of redds counted in the section above the meadow to the top of the spawning area (4.2 river miles) (Tranquilli, et al., 2001). Current redd distribution information is unknown for this reach and understanding usage of this historical spawning area before/after habitat restoration actions upstream and downstream is important for understanding the population dynamics of this ESA species. During recent years there has been high pre-spawning mortality observed in the Upper Grande Ronde, but with the majority of carcasses only being recovered upstream of the private land (Joseph Feldhaus, ODFW unpublished data 2018), it is still unclear how much the section of stream within private land or downstream of the meadow is being used.

In 2019 a three year pilot study was initiated by the CTUIR to radio tag adults after broodstock needs were met to better understand where the salmon might be holding and what habitat types are important for survival prior to spawning. Information gained from this study could help guide future pre-spawning mortality surveys, understand habitat needs of adults during holding and spawning in this critical area, and identify areas of use that may influence in-stream habitat work in the future. Details of the sampling design for the monitoring proposal are uploaded to Pisces as "Migration Patterns and Stream Reach Usage of Adult Spring Chinook salmon in the Upper Grande Ronde River" under BPA contract # 73928 REL 87 (Naylor, et al., 2018).

Catherine Creek – Floodplain Restoration Monitoring

During steelhead spawning surveys in spring 2017, project biologists noted large groups of juvenile Chinook within the floodplain swales, alcoves, and blind channels (perennial spring fed channels connected to the main channel at the downstream end but only connected at the upstream end in high flows). The first observations saw very few fish in late April when the main channel was running at an estimated 350 cfs (9.9 m/s) – based on the Oregon Water Resources flow gauge near Union, approximately 2.6 miles (4.1 km) downstream of the site (station # 13320000). However, as the hydrograph increased so did the observations of juvenile Chinook, and underwater videos as the hydrograph peaked at 900 cfs (25.4 m/s) provided qualitative evidence of the floodplain utilization by young-of-the-year Chinook (Naylor, et al., 2017).

The approach taken to restoring floodplain connectivity at the Southern Cross site is providing ephemeral and perennial off-channel habitat for juvenile salmonids that had not previously been available within the simplified channel. We know from the literature that floodplain access can have significant growth benefits for juvenile Chinook, but questions remain about the effectiveness of the Southern Cross project because currently we do not possess quantitative data of Chinook and O. mykiss abundance, density, or growth at this site. Nor are we able to provide information to the restoration implementers on what habitats within the floodplain are being used by these juveniles so that they can mimic them at their next floodplain projects.

This monitoring project is designed to quantify salmonid use of the newly restored floodplain habitat within the Catherine Creek – Southern Cross – restoration project so that restoration implementers can re-create the preferred floodplain habitat in future projects. To do this the CTUIR proposed to document habitat characteristics and estimate juvenile salmonid abundance and densities within these floodplain habitats and compare these with marginal (edge) habitat within the main channel at different flow events. For this annual report we will provide an overview of the work undertaken in 2019. A detailed report will be uploaded to Pieces after the completion of the monitoring period in 2022.

Discussion

Dark Canyon Creek has seen a decline in the number of juvenile Chinook and O. mykiss over the past 5 years that may be confounded by low adult returns throughout the Basin rather than indicative of poor habitat quality within the restoration project as a whole. The pool habitat between the two survey reaches were similar in area and depth for within year comparisons, but between-year comparisons showed that the lower reach had shallower and longer pools in 2019 compared to 2018. Whether this is a shift in the channel morphology in this section will be remain unclear until these habitat variables are measured for several more years. The abundance of O. mykiss was similar in both reaches in 2019, however, adding a survey of 670 meters between these two reaches showed a larger number of fish using this section.

For McCoy Creek it appears that overall the pool habitat in the most downstream reach has not changed significantly in area over the 8 year period of monitoring, has been greater in length in some years compared to the upstream reaches, but has been similar in mean pool area compared to the other reaches, it has not varied in max depth each year of survey, has been cooler than the other reaches in most years, has dissolved oxygen levels tolerable for salmonid species and similar to the upstream reach, has the most steelhead redds, but has had the lowest abundance of juvenile salmonids in most years. It appears that even though spawning occurs within this reach, when adult returns are higher, O. mykiss are not rearing here. Similar to Dark Canyon Creek the declining numbers of salmonid species may be reflective of Basin wide trends. The habitat variables we measured indicate that our hypothesis was incorrect and pool rearing habitat does not appear to be highly variable within the restoration area.

On Rock Creek, the availability of late summer habitat has been demonstrated to be an important factor in salmonid rearing (Polivka, et al., 2015) and is likely still a limiting factor. While this habitat appears to be persistent within the lower section of Rock Creek (Reach 1) each year post construction there is up to 800 meters of channel upstream of this reach which is not. These two section had very different habitat restoration work implemented due to infrastructure concerns on the upper reach. These limitations on Reach 2 may have been enough to render this reach unsuccessful in maintaining late season rearing habitat. It should be pointed out that while this may be true for late summer rearing it is not for early summer rearing as Reach 2 does provide a large section of stream habitat at this time. Fish salvage operations before the 2014 restoration work have shown that this reach can have a large abundance of O. mykiss with 2,185 juveniles captured that year in just 24 sites covering approximately 818 m2. As with other restoration project monitoring it appears that the habitat is available but the poor adult return numbers and lack of redds is leading to a shift in juvenile age structure away from being dominated by young-of-the-year to older juveniles and a reduction in the overall abundance of salmonids.

Plantskydd® application and monitoring

Riparian habitat restoration is an important component of fisheries habitat restoration projects (Averett, et al. 2017). Riparian vegetation provides shading that reduces solar input and lowers stream temperature, traps sediment on the floodplain, reduces stream turbidity, provides terrestrial nutrients, stabilizes stream banks and limits erosion (Jones, et al. 2008; Averett, et al. 2017). Riparian vegetation has been highlighted as an important element in ESA species recovery in the Grande Ronde Basin (Justice, et al. 2017). Restoring riparian vegetation is a key functional component in the CTUIR River Vision that promotes dynamic rivers and provides first foods to tribal members (Jones, et al. 2008). However, several complications arise when attempting to establish native vegetation following habitat restoration work including; adequate watering, invasive vegetation control and protection from browsing (Trent, Nolte and Wagner 2001; Ward and Williams 2010; Averett, et al. 2017). The costs associated with the purchase of plants, planting labor and measures to ensure plant survival represent a large portion of the overall cost of stream restoration projects. Therefore, investments in plant growth, survival and protection are valuable until the vegetation reaches a state that is sustainable and resilient to natural disturbance regimes further increasing the success of restoration projects.

In order to measure the effectiveness of using Plantskydd® to deter elk and deer browse, we undertook a study on the CTUIR Southern Cross property which includes about 0.80 miles of mainstem Catherine Creek and approximately 65 acres of riparian management zone, located at River mile 43 (Figure 62). The property was acquired by Western Rivers Conservancy, Bonneville Power Administration, and the CTUIR with the intent of restoring a fully functional floodplain complete with a diverse native riparian community (Table 12) Within the riparian management zone, over 22,000 plants, trees and willow cuttings were planted and 800 pounds of native grass seed were used to revegetate the site. Grazing from Rocky Mountain Elk (*Cervus Canadensis nelsoni*), white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*) was evident before planting was completed (Figure 2). Large investments in time in money were made in revegetating the Southern Cross riparian corridor through design, planning and training. These costs included: plants/seed, planting labor and machine rentals and were nearly 20% of the overall restoration work. In addition to these costs, there is considerable time involved in monitoring survival, controlling invasive weeds and preventing herbivores from depredation, following initial planting efforts.

FIGURE 62 MAP OF CTUIR PROPERTY, SHOWING TREATMENT AND CONTROL PLOTS AS WELL AS EXCLOSURES WITHIN THE RESTORED PROJECT REACH OF CATHERINE CREEK, OR.

FIGURE 63 TOP TWO PHOTOS, ROCKY MOUNTAIN ELK, BOTTOM LEFT, MULE DEER AND BOTTOM RIGHT WHITE-TAILED DEER AT THE SOUTHERN CROSS FISH HABITAT ENHANCEMENT PROJECT. NOTE THE ANIMALS UTILIZING NOCTURNAL BEHAVIOR.

Study Design

Given the large investment in time and money to design, implement and monitor plant survival and the benefit of revegetating restoration projects, protection from grazing is a vital step to restoration success. Various methods exist to protect plants from browsing, including: chemical repellents, fencing and lethal control (Trent, Nolte and Wagner 2001; Ward and Williams 2010). Complete exclosure fencing for large ungulates such as elk can cost as much as $50,000 per mile, requires annual maintenance and is not aesthetically pleasing (Platz 2015). Results from chemical animal repellents vary according to manufacuturer and application rate, with 2 out of three studies demonstating some level of effectiveness using sulfur-based repellents such as the Plantskydd® brand (Trent, Nolte and Wagner 2001; Arjo, et al. 2005; Ward and Williams 2010). Additionally, local and regional results indicated favorable results from application of Plantskydd® repellent (J. Staldine, personal communication, April 20, 2016; Platz 2015).

Results from Plantskydd® treatments to exposed plants on a stream restoration effort covering 7.5 miles demonstrated 20% browse on new plantings in the upper Grande Ronde basin compared to 73% browse on untreated plants in Meadow Creek (Platz 2015). These findings suggest using Plantskydd® on newly established riparian vegetation could offset growth reductions found in Averett et al. (2017) study, potentially releasing plants to mature above browse height.

Chemical repellents and strategically located fence exclosures were selected to control ungulate browse on the Southern Cross property because they are cost effective and have been shown to reduce or eliminate unwanted grazing (Trent, Nolte and Wagner 2001; Arjo, et al. 2005; Ward and Williams 2010). Among the chemical repellents, Plantskydd® was chosen to assess the efficacy of reducing browse by asking the following questions:

1. Does applying Plantskydd® to newly established vegetation in stream restoration projects promote overall growth, measured as the height of the tallest living portion of the plant?

2. Will Plantskydd® application increase the survival of newly planted vegetation in stream restoration projects? And,

3. How will applying Plantskydd® effect the severity of browse on newly planted vegetation in stream restoration projects?

Methods

In order to test the efficacy of Plantskydd® on our riparian planting zone, we used 13 fence exclosures as postive controls (Ward and Williams 2010) that received no grazing pressure (Figure 3). The exclosures were various sizes, constructed with 10 ft t-post and 4 ft tall hog panels wired together and stacked on one another for a total height of 8 feet, totaling 2,941 sq ft (273 sq m) of enclosed space (Figure 3). There were 211 plants in the exclosures, with 6 different plant species. Approximately 70%,or 45 acres (18 hectares) of the 65 acres (26 hectares) of the riparian management zone were planted with a variety of native tree and shrub species (Table 1). Densities and species varied by planting zone. Overall, 14,289 containerized plants and 5,700 willow cuttings were planted.

In addition to the exclosures, sixteen circular plots were established, each with 30 foot radius (9 m) and stratified by 8 treatment and 8 control. The location of the plots were randomized within riparian planting polygons in the planting plan, totaling 2,827 sq ft area (263 sq m). Randomization was accomplished in ArcMap by selecting the most densely planted polygons in the planting plan and using the create random points feature. The center of plots were selected in the field from a table of random points generated in ArcMap. Treatment plots received Plantskydd® applications while control plots did not receive Plantskydd®. The circular plots did not have any form of exclosures and will also be used to evaluate the effectiveness of Plantskydd®. The remaining planted vegetation on the stream restoration project had Plantskydd® applied with the same methodology.

Plantskydd® concentrate powder was mixed according to the manufacturers specifications (2.2 lb concentrate to 2.5 gallons of water) in a 5 gallon bucket with a cordless drill and paint-stirring drill bit. Anti-foaming agents were also used in the Plantskydd® mixture in 2018 to reduce wasted product and increase efficiency. Application was done using a diaphragm style backpack pump sprayer with a 4 gallon capacity. One full pump sprayer treated around 1440 plants. Application of Plantskydd® began in Spring and were repeated at three months intervals, followed by a winter onset application (Ward and Williams 2010). In 2018, a conversation with a Tree World Plant Care Products representative, lead to a rapid re-application technique that involved a diluted concentration applied after the first treatment by two to three weeks and when the plants began to cure. The cost of one 22 lb box of soluble powder concentrate is $349.95 and treats 9000 plants at 1 ft in height (Tree World Plant Care Products Inc. 2018). Applicators used handheld GPS units to track area and time spent applying the product.

We used a pre and post treatment monitoring design that allowed for a temporal assessment of browse effects. Monitoring occurred prior to the initial application to establish baseline information, before each new application, as well as following the final application. Monitoring consisted of a visual estimation of browse at the end of the growing season, using a variation of the ocular estimation techniques described in (USDA 1996; Figure 68). Survival estimates were calculated by dividing post counts into pre survey counts and the average height of the tallest living part of the plant was measured to the nearest half centimeter for each species using a Keson folding ruler. Statistical analysis were done in JMP software, version 8.01, SAS institute Inc. Unequal variance were checked and either a students t, Tukey HSD (honestly significant difference) test or a Welch's test were used to test for significant differences between groups at 0.05 alpha level. Photo points were established in control and treatment plots as well as enclosures.


FIGURE 64 DIFFERENT EXCLOSURES TYPES-8'X8' SQUARE ON LEFT AND 8'X8'X8' TRIANGLE ON RIGHT.

TABLE 11 FUNCIONAL FLOODPLAIN NATIVE RIPARIAN COMMUNITY SPECIES.

Species list	Common name	ALPHA code (first two letters of genus and species)
Alnus incana	Mt. Alder	ALIN
Amelanchier alnifolia	Serviceberry	AMAL
Betula occidentalis	Western Water Birch	BEOC
Cornus sericea	Red Osier Dogwood	COSE
Crataegus douglasii	Black Hawthorn	CRDO
Frangula purshiana	Cascara	FRPU
Philadelphus lewisii	Mock Orange	PHLE
Physocarpus malvaceous	Ninebark	PHMA
Pinus ponderosa	Ponderosa pine	PIPO
Populus trichocarpa	Black Cottonwood	POTR
Prunus virginiana	Chokecherry	PRVI
Ribes aureum	Golden Currant	RIAU

Rosa spp	Wood and Nutka Rose	RO
Salix spp	Willow species	SA
Sambucus cerulea	Blue Elderberry	SACE
Symphoricarpus albus	Snowberry	SYAL

Results

Average heights of the tallest living leaders of the plants were enumerated by species in both control and treatment plots as well as within exclosures. Willow species, Coyote (Salix exigua) and Peachleaf (Salix amygdaloides) as well as Black cottonwood (Populus balsamifera ssp trichocarpa) were the primary focus of this section given the relatively high numbers of plants for comparison (Hoag et al., 2008). Furthermore, both species of willow were not identified to species and will hence forth be referred to commonly as Salix spp. to describe both Coyote and Peachleaf varieties.

Mean plant heights were also evaluated for containerized plants following all three treatments using a box plot displaying, median, 25th and 75th percentiles for Mountain Alder (Alnus incana), Western Water Birch (Betulus occidentalis), Redosier Dogwood (Cornus serciea), Black Hawthorn (Crataegus douglasii), and Black cottonwood (Populus balsamifera ssp trichocarpa) in treatment plots, control plots and exclosures (positive control), (Randall et al., 1994; Hoag et al., 2008).

There was no difference in mean plant heights between treatment and both control types for Mountain Alder for both years (Tukey-Cramer HSD, p-value > 0.05; Figure 4). However, it should be noted that the treatment and control group in 2018 had a p-value of 0.06 and there were small sample sizes for both years (2017-control, n=3, positive control, n=8, treatment, n=15; 2018-control, n=6, positive control, n=8, treatment, n=16). Water Birch also showed no significant difference between mean plant heights for control groups and the treatment group (Tukey-Cramer HSD, p-value > 0.05; Figure 4), although sample size was also low for this species (2017-control, n=5, positive control, n=6, treatment, n=17; 2018-control, n=3, positive control, n=3, treatment, n=4).

Redosier Dogwood were significantly taller in the positive control group compared to both the treatment and control plots (p-value < 0.0001), yet not different between the control and treatment groups in 2017 (p-value > 0.05). Redosier dogwood were significantly taller in the positive control group compared to the treatment group in 2018 (p-value < 0.0001). Black Hawthorn positive control showed greater mean heights compared to either the control or treatment plots (p-value < 0.0001), and not significantly different between treatment or control plots (p-value > 0.05) in 2017. This pattern repeated itself in 2018 for black hawthorn with positive control being significantly different compared to both treatment and control groups (p-values 0.0017 and 0.0587 respectively). Black Cottonwood also followed the same pattern, displaying significant differences between the positive control and treatment and control plots for both years (2017-p-value 0.0003 and 0.0192 respectively) and (2018-p-value < 0.0001 and 0.0142 respectively; Figure 65).

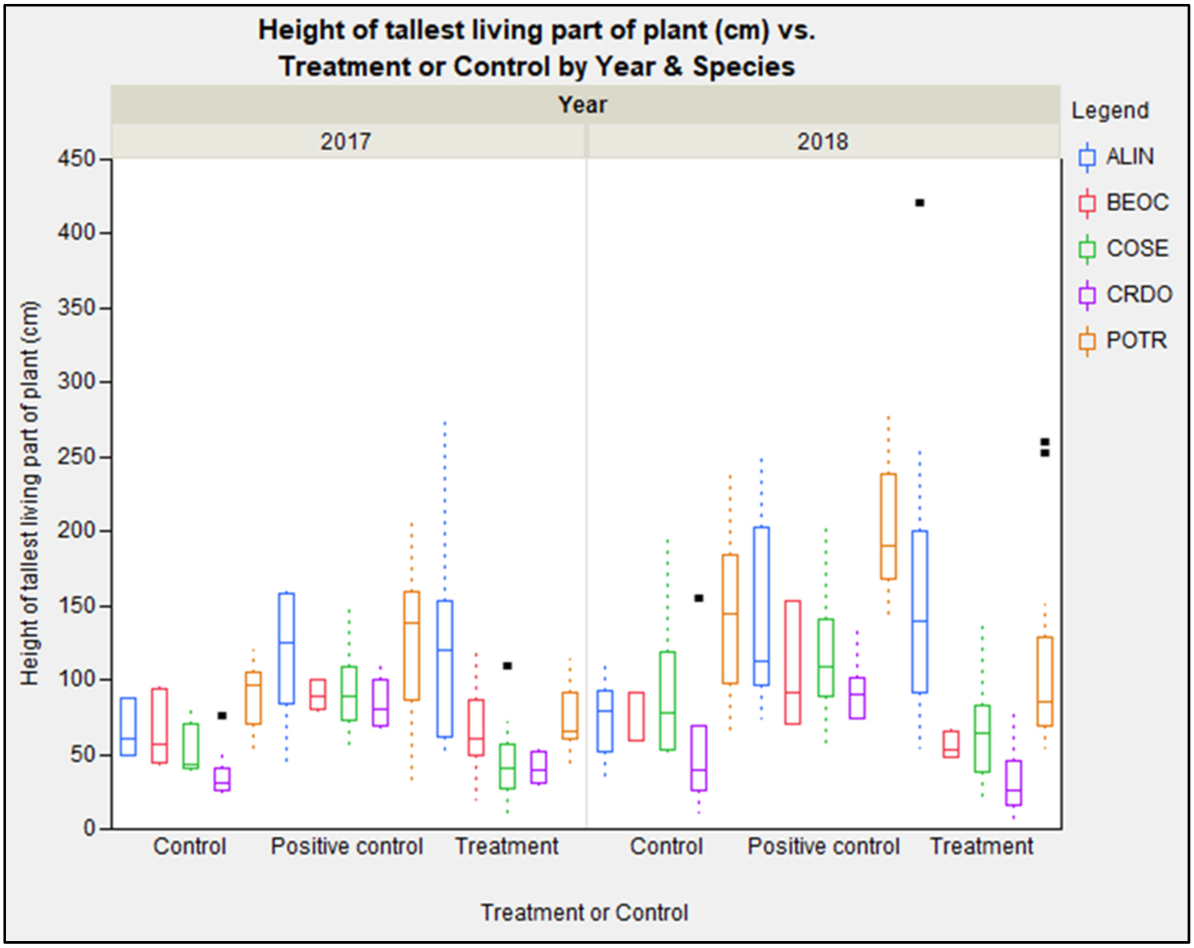


FIGURE 65 MEDIAN PLANT HEIGHTS FOR ALIN (ALNUS INCANA-MOUNTAIN ALDER), BEOC (BETULUS OCCIDENTALIS- WESTERN WATER BIRCH), COSE (CORNUS SERCIEA-REDOSIER DOGWOOD), CRDO (CRATAEGUS DOUGLASII-BLACK HAWTHORN), POTR (POPULUS TRICHOCARPA-BLACK COTTONWOOD) IN TREATMENT AND CONTROL PLOTS AS WELL AS EXCLOSURES (POSITIVE CONTROL) FOR 2017 AND 2018.

Control and treatment groups of plots for Black cottonwood and Salix spp were evaluated for a difference in average height (i.e. growth) for 2017 and 2018 growing cycles. Results showed a 24 cm positive difference in the average growth for the control group compared to the treatment group for Black Cottonwood in 2017, while the Salix spp. treatment group had a 5.6 cm positive difference in average growth compared to the control group in 2017 (Figure 5). The difference in average growth was more pronounced in the control group for Black cottonwood in 2018 (73.3 cm), compared to a positive difference of 12.5 cm in Salix spp. The difference in average heights is consistently higher for Black cottonwood across both years, although it should be noted that the late season measurements of Cottonwood were low (n=26 in 2017 and n=4 in 2018) and relatively high for Salix spp. (n=206 in 2017 and n=154 in 2018).

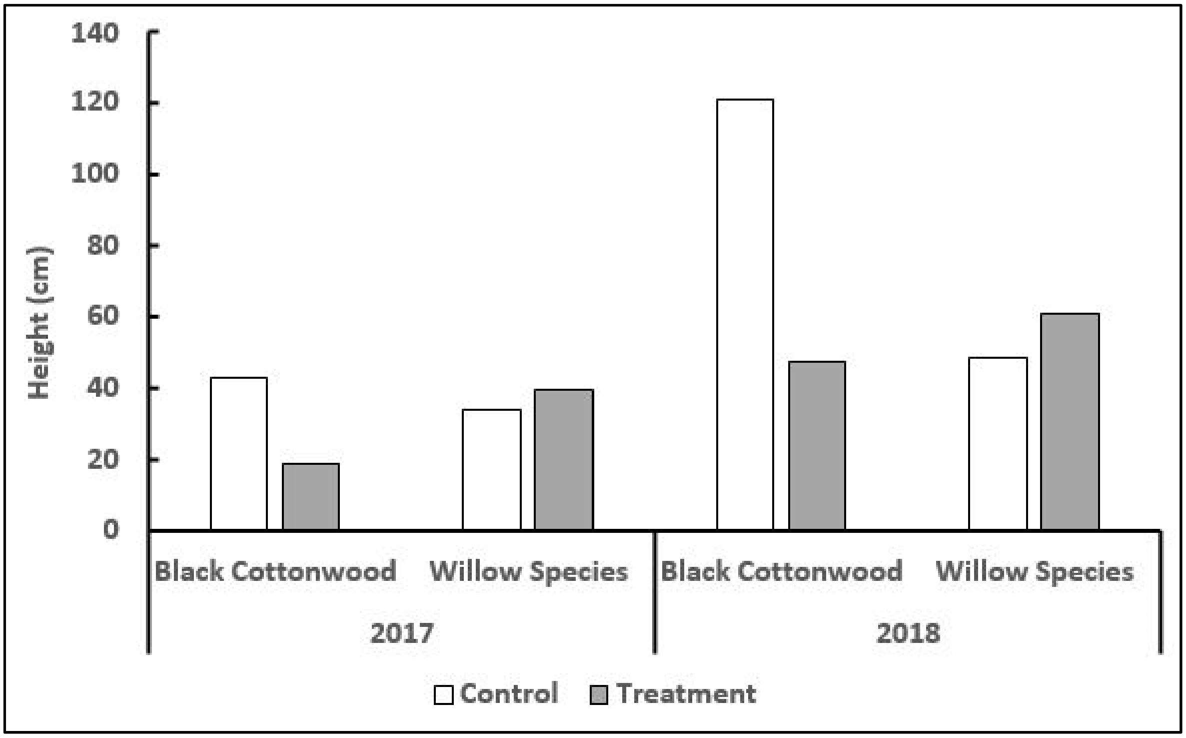


FIGURE 66 DIFFERENCE IN AVERAGE HEIGHTS (I.E. GROWTH) OF BLACK COTTONWOOD AND SALIX SPP. FOR TREATMENT AND CONTROL GROUPS DURING 2017 AND 2018 GROWING SEASON. THE CONTROL PLOTS DID NOT INCLUDE EXCLOSURES.

Survival

Survival was evaluated for Black cottonwood and Salix spp. with treatment groups for both species and years having higher survival compared to control groups (Figure 6). The Black cottonwood treatment groups had 28 % greater survival compared with the control groups, while the Salix spp. had a 8% higher survival when compared to the control group in 2017 (Figure 6). In 2018, Black cottonwood treatment groups had a 40% higher survival compared to the control group, while Salix spp. had a 39% higher survival when compared to the control (Figure 6). It is worth noting that there were only 4 Black cottonwoods for the 2018 measurement in the control group. Interestingly, the Black cottonwood treatment group had higher survival, yet lower average heights (Figure 66). This may be a reflection of container size at planting and growing site condition (e.g., soil and soil moisture?) and not a function of the treatment. Observations following planting indicate that larger potted plants demonstrated better growth compared to the same species planted with smaller pots.

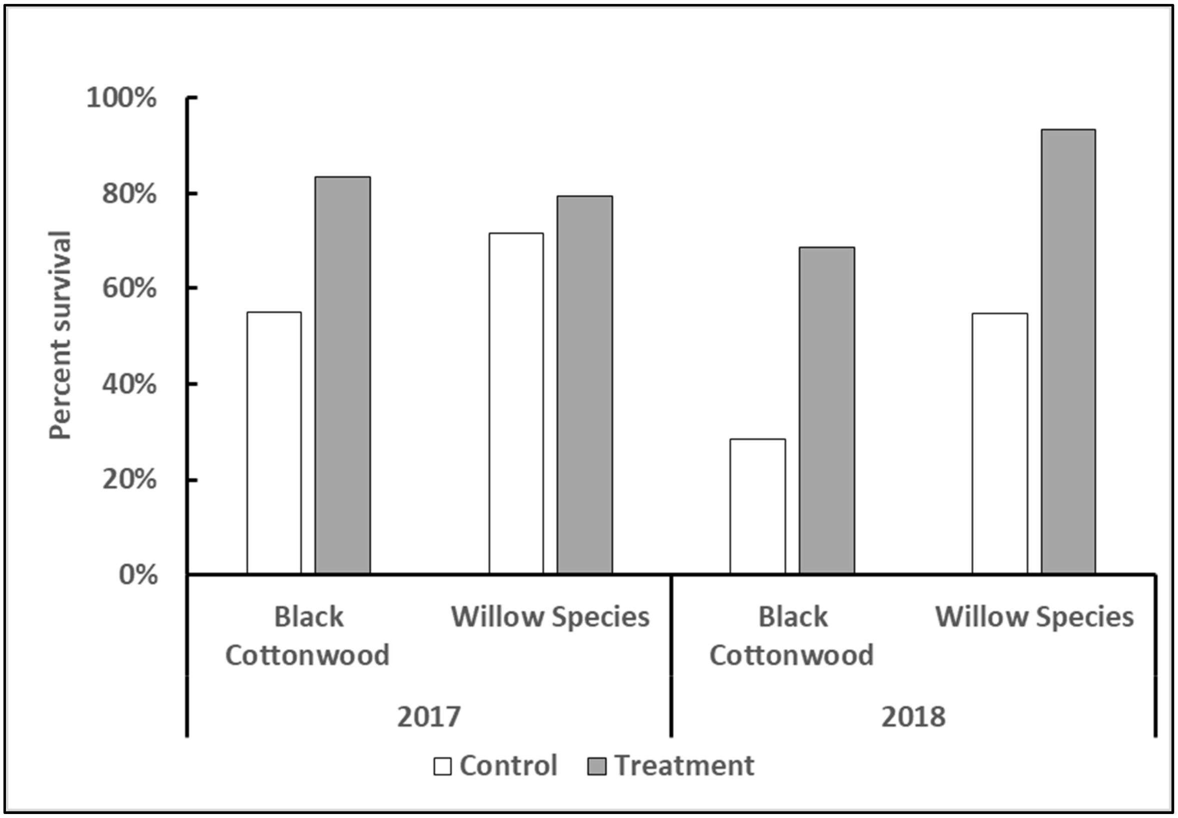


FIGURE 67 DIFFERENCE IN AVERAGE HEIGHTS (I.E. GROWTH) OF BLACK COTTONWOOD AND SALIX SPP. FOR TREATMENT AND CONTROL GROUPS DURING 2017 AND 2018 GROWING SEASON. THE CONTROL PLOTS DID NOT INCLUDE EXCLOSURES.

Ocular Utilization

Only willow species were evaluated for the effects of browse using the ocular utilization estimates because of low numbers of other species. The browse classes described in (USDA 1996) were grouped in categories of light-0-20% (no to light use), medium-21-60% (obvious to uniform use) and heavy-61- 81+% (complete to repeated use) utilization (Table 2). Proportions of each utilization group were compared for overall browse effect (Figure 8). There was no difference in the light utilization for control and treatment groups in 2017, however there was a greater portion of the treatment group utilized in 2018 (Figure 8). The medium browse class was 14% more utilized in the treatment group compared to the control group in 2017 and there was not enough plants in 2018 for a medium bin analysis (Figure 8). There was a greater portion of plants that were heavily utilized in the control groups for both years (13% > 2018 and 30% > 2018; Figure 8). These results were also noteworthy because there was no difference in the light utilization group in 2017 yet more plants that were lightly browsed in 2018 and a consistent pattern of heavier utilization of control groups across both years (Figure 8). However, sample size for the medium control browse class was low (n=10), compared to the other control groups, n= 17 for 0-20 browse class, and n=51 for 61-81+ browse class in 2017. The treatment sample sizes were greater (n= 27 for 0-20 browse class, n= 34 for 21-60 browse class and n=67 for the 61-81+ browse class for 2018). Sample sizes for 2018 were: n=17 for 0-20 and n= 20 for 61-81+ control groups and n=85 for 0-20 and n=27 for 61-81+ for treatment groups). This suggests that while the results are not as expected, there may be a benefit to using Plantskydd® to prevent severe browse on willow species, despite the fact that heavier browse was evident in both treatment and control groups and there is higher proportion of willows that were lightly utilized.

Classes show relative degrees of use of available current year's growth (leaders) of key browse plants (willow, trees, shrubs, etc.).

No Use (0%-5%) No evidence or negligible appearance of grazing.

Slight (6%-20%) Browse plants have the appearance of very light use. The available leaders of key browse plants have the appearance of very light use. The available leaders of key browse plants are little disturbed.

Light (21%-40%) Obvious evidence of leader use. The available leaders appear cropped or browed in patches and 60% to 80% of the available leader growth of the key browse plants remain intact.

Moderate (41%-60%) Browse plants appear rather uniformly utilized and 40% to 60% of the available leader growth of key browse plants remain intact.

Heavy (61%-80%) The use of the browse gives the appearance of complete search. The preferred browse plants are hedged and some plant clumps may be slightly broken. Nearly all available leaders are used and few terminal buds remain on key browse plants. Between 20% to 40% of the available leader growth of the key browse plants remain intact.

Severe (81%+) There are indications of repeated coverage. There is no evidence of terminal buds and usually less than 20% of available leader growth on the key browse plants remain intact. Some, and often much, of the second and third year's growth has been utilized. Hedging is readily apparent and the browse plants are more frequently broken

FIGURE 68 DIFFERENCE IN AVERAGE HEIGHTS (I.E. GROWTH) OF BLACK COTTONWOOD AND SALIX SPP. FOR TREATMENT AND CONTROL GROUPS DURING 2017 AND 2018 GROWING SEASON. THE CONTROL PLOTS DID NOT INCLUDE EXCLOSURES.

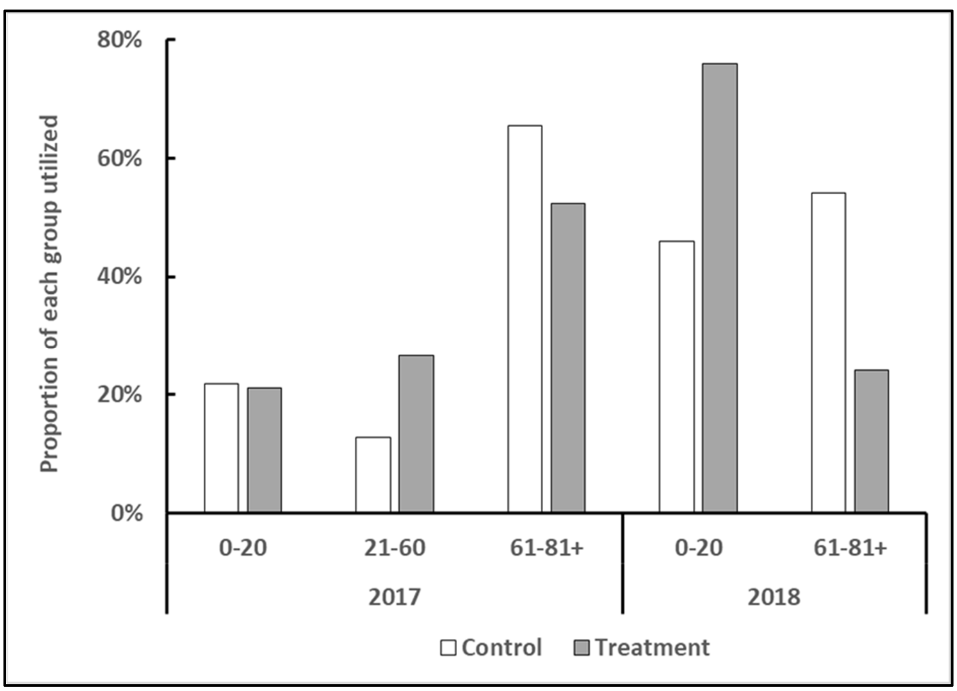


FIGURE 69 BROWSE UTILIZATION OF WILLOW SPECIES FOLLOWING FINAL PLANTSKYDD® APPLICATION AT SOUTHERN CROSS STREAM RESTORATION PROJECT FOR YEARS 2017 AND 2018. CATEGORIES OF BROWSE ARE CLASSIFIED AS: LIGHT-0- 20% (NO TO LIGHT USE), MEDIUM-21-60% (OBVIOUS TO UNIFORM USE) AND HEAVY-61-81+% (COMPLETE TO REPEATED USE) UTILIZATION.

Discussion

Establishing a robust experimental design on the effects of animal deterrents proves challenging when concurrent revegetation goals are to promote maximum survival, growth and protection from browse. Future studies should account for adequate sample size for species of interest, site conditions and a time scale appropriate to address research questions for a better understanding of Plantskydd® as a viable alternative to protecting and promoting growth on plants in stream restoration projects.

Even though this study was limited in the species evaluated for Plantskydd® effectiveness, we were able to demonstrate greater average growth for willow species, greater survival for Black cottonwood and willow species as well as less severe browse on willow species. In addition, we were able to confirm the effectiveness of complete exclusion of browse on several key species using fenced exclosures. These may be important factors to consider when weighing alternative plant protection following stream restoration vegetation management, especially when considering willow species, which can often represent an important component of revegetation plans.

Around 28% of the planting plan for the Southern Cross revegetation plan consisted of willow species collection and planting, which constitutes a significant portion of the revegetation budget. Reductions to browse that promote survival and growth can play an important role in establishing riparian vegetation following stream restoration projects. Following the second year of application in this study, benefits were realized across both years, warranting further application until plants are above browse height. Other concurrent studies involving Plantskydd® in the Grande Ronde Basin will be evaluated for future use of Plantskydd®. Additional alternatives such as complete exclusion of browse in the form perimeter fencing or floodplain connection should not be ruled out to either exclude browsing for a period of time or promote natural recruitment when considering revegetation plans.

Action Effectiveness Monitoring (AEM)

The following reporting of Action Effectiveness Monitoring (AEM) efforts within the Grande Ronde River and Catherine Creek watersheds comes from Cramer Fish Sciences 2019 annual report to Bonneville Power Administration (Roni et al. 2020).

The Bonneville Power Administration (BPA) and its partners have funded thousands of riverine restoration actions across the Columbia River Basin to improve habitat for anadromous fish as part of the Northwest Power and Conservation Council's Fish and Wildlife Program. The Action Effectiveness Monitoring (AEM) Program was developed to address the pressing need for a programmatic approach to project-level effectiveness monitoring in the Columbia River Basin. The goals of the AEM Program are to quantify improvements in localized habitat and fish abundance as a function of restoration actions implemented in the Columbia River Basin and to help guide future restoration and improvement efforts to ensure the BPA is investing in effective restoration techniques. Specifically, AEM is designed to programmatically evaluate projects across the interior Columbia River Basin to determine the effect of different action categories on juvenile Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* and habitat at the reach scale, why some projects within an action type are more effective than others, and whether there are differences in project effectiveness among regions (salmon evolutionary significant units or ESUs).

The AEM Program was designed in 2013 and implemented in 2014 to provide both short-term and long-term results for previously completed (prior to 2015) and newer salmon and steelhead habitat restoration and improvement projects. A multiple before-after control-impact (MBACI) design is used to evaluate a subset of new actions and an extensive post-treatment (EPT) design for previously completed actions. The MBACI design includes collection of data in paired treatment and control reaches two years before and in years 1, 3, and 5 after restoration project implementation. In contrast, the EPT design requires the collection of data only post-treatment at paired treatment and control reaches.

At its inception, the AEM Program was split into two separate contracts with the EPT design implemented by Cramer Fish Sciences and the MBACI design being implemented by a different contractor. Cramer Fish Sciences took over the entire AEM Program in 2018 and conducted a systematic and detailed review of all MBACI data collection, monitoring methods, site selection, and data management and met with project sponsors.

Riparian Vegetation Monitoring – Extensive Post-Treatment (EPT) study design.

Active restoration and enhancement of riparian areas is one of the most widespread habitat improvement techniques in the Columbia River Basin and throughout the United States for the benefit of listed Pacific salmon *Oncorhynchus* spp. and steelhead *O. mykiss* (Pollock et al. 2005; Kondolf et al. 2007; Hillman et al. 2016).

Short-term monitoring (e.g., two to five years post implementation) of riparian planting and other riparian restoration projects has found promising results, including high plant survival and improved vegetation structure and cover, as well as reduced instream temperatures and sediment loads, reduced bankfull width to depth ratios, and improved water quality (Feld et al. 2011; Conley and Lindley 2012; González et al. 2015; Hall et al. 2015). Results from riparian restoration actions vary and appear to depend upon whether underlying processes, such as hydrologic connectivity, predation, and competition, were addressed during restoration (Emmingham et al. 2000; Hall et al. 2011; Lennox et al. 2011; González et al. 2015). Moreover, the responses to restoration differ by ecoregion and there have been relatively few studies that have been conducted within the Columbia River Basin (Roni et al. 2014a; Hillman et al. 2016). Additionally, many studies have focused on monitoring the short-term (<5 years) response to riparian restoration (Roni et al. 2008; Kettering and Adams 2011; Lennox et al. 2011; González et al. 2015). Long-term monitoring of these riparian projects provides valuable insight into riparian habitat response to various restoration strategies which can inform future riparian restoration projects. It is important to continue to monitor key restoration metrics (e.g., species diversity, structure, and shade) for extended periods post-implementation (5-25 years) to better understand what factors influence long-term success of riparian plantings (González et al. 2015; Hillman et al. 2016; Roni et al. 2019).

The primary goal of the AEM Program monitoring effort for riparian projects is to determine their effectiveness at improving riparian conditions. A secondary goal is to determine if there are characteristics of the project design (e.g., type of planting, use of tree shelters) or project location (e.g., evolutionary significant unit [ESUs], ecoregion, elevation) that influence project success. Specifically, we address the following questions:

1. Did treatment (planting and invasive vegetation removal) lead to increases in native species abundance and diversity?
2. Did treatment lead to increased cover of native woody plant species?
3. Did treatment lead to increased riparian condition (e.g. structure, shade)?
4. Has riparian vegetation structure changed?

Reach lengths were determined by 20 times bankfull width, with a minimum length of 150 m and a maximum of 600 m, as measured at the thalweg (Roni et al. 2014b). Average bankfull width was taken from five equally spaced measurements across the reach. If restoration plots exceeded our site length (20 times bankfull width), a treatment reach was delineated within the project boundary that was representative of the project as a whole, as opposed to the area with the highest density of plantings. If all other minimum survey requirements were met, due to the limited number of sites that qualified to be included in the monitoring program, sites were surveyed as long as they were 150 m in length, regardless of their bankfull width calculated site length.

Surveys were conducted using two-meter wide belt transects equally spaced across reaches and oriented perpendicular to the active channel (Gregory et al. 1991; Parkyn et al. 2003; Harris 2005; Lennox et al. 2011; Merritt et al. 2017). Site layout at control reaches mimicked the layout of their paired treatment reach. Twenty percent of the reach length was used to determine the number of two-meter wide belt transects to be surveyed (Lennox et al. 2011; Gornish et al. 2017). For example, for a site length of 150 m, 30 m (20%) would be sampled, which is 15 equally spaced two-meter wide transects (i.e., 15 transects at 2 m wide equals 30 m total). Therefore, given our site length requirements, a minimum of 15 and a maximum of 60 transects were surveyed (Kaufmann 1999). Transects were delineated by running a meter tape from the active channel boundary to the outer boundary of the riparian planting (Merritt et al. 2017). The tape denoted the middle of the belt transect and surveys extended one meter on both sides of the tape. Transect lengths were determined by the extent of the planting but were a minimum of 5 m and a maximum of 20 m (Kaufmann 1999; Harris 2005).

Species composition, vegetation cover, and canopy cover were measured within each belt transect. All woody plants were identified to species except for willows, which were identified to genus *Salix* spp., woods and Nootka rose, which were grouped as Rosa *spp.* and sagebrush species, which were identified as *Artemisia* spp. For each species, the height and location (meter tape distance) were recorded. Species were classified based on height as herbaceous (<1 m), shrub (1–5 m), or tree (>5 m). Bud browse, beaver damage, living or deceased condition, and evidence of planting (tubes, markers, mulch, or cages) were recorded for each woody species. The Shannon-Weiner diversity index (*H*) and the Simpson diversity index (1-*D; D* = Simpson's diversity) were calculated for native woody species using richness and abundance data.

Riparian surveys were conducted on six restoration projects within the Grande Ronde and Catherine Creek watersheds. The following describes the project areas by their monitoring type, reach length, number of transects, transect length, and number of years since project implementation that the site was last surveyed. The CTUIR sponsored or contributed to the implementation of all but one (Meadow Creek) of the six projects listed below.

CC-37 (Upper Catherine Creek HUC-10 basin)
Riparian vegetation monitoring - EPT design
6 years since project (visited 2018)
Site length – 220 m
Transects – 22
Transect length – 15 m

End Creek (Willow Creek HUC-10 basin)
Riparian vegetation monitoring - EPT design
13 years since project (visited 2019)
Site length – 150 m
Transects – 15
Transect length – 6.3 m

McCoy Creek (Meadow Creek HUC-10 basin)
Riparian vegetation monitoring - EPT design
8 years since project (visited 2018)
Site length – 150 m.
Transects – 15
Transect length – 9.3 m

Meadow Creek (Meadow Creek HUC-10 basin)
Riparian vegetation monitoring - EPT design
5 years since project (visited 2019)
Site length – 150 m
Transects – 15
Transect length – 17.7 m

Oregon Ag Foundation (Willow Cr HUCK-10 basin)
Riparian vegetation monitoring - EPT design
11 years since project (visited 2018)
Site length – 150 m
Transects – 15
Transect length – 5 m

Southern Cross (Upper Catherine Cr HUC-10 basin)
Riparian vegetation monitoring – EPT
Physical habitat & biological monitoring – MBACI
2 years since project (visited 2018)
Site length – 272 m
Transects – 27
Transect length – 14.8 m

TABLE 12 SPECIES ABUNDANCE, DETERMINED BY THE NUMBER OF INDIVIDUAL TARGET PLANT SPECIES WITHIN TREATMENT (T) AND CONTROL (C) REACHES.

Year surveyed	Site name	Black cottonwood		Black hawthorn		Common snowberry		Red alder		Red-osier dogwood		Rose spp.		Willow spp.	
		T	C	T	C	T	C	T	C	T	C	T	C	T	C
2018	CC37	-	147	8	-	-	1	-	-	2	3	-	6	85	63
2019	End Cr	-	-	1	-	-	-	1	-	1	-	6	-	35	-
2018	McCoy	-	-	-	-	-	138	4	19	-	-	-	-	16	6
2019	Meadow Cr	-	-	3	-	-	7	-	-	-	-	-	-	259	574
2018	OAF	-	-	-	-	-	-	-	-	-	-	-	78	73	20
2018	Southern Cross	26	89	8	11	-	-	21	-	33	1	42	1	108	16
Total idividuals **T**	Total individuals **C**	26	236	20	11	0	146	26	19	36	4	48	85	576	679
732	1180														

Overall abundances for target planting species show that there were significantly more plants observed within the control reaches compared to their treatment counterpart. However, the species Black hawthorn, Red alder, and Red-osier dogwood counted in treatment reaches outnumbered those found in control reaches. No snowberry individuals were observed in treatment reaches in any of the six monitored restoration projects, compared to 146 plants counted in control reaches, with all but one found within the McCoy and Meadow Creek project areas. Willows were found at every treatment and control site except within the End Creek control reach. Willows also represent the majority of counted individual plants overall (65.6%), and were approximately evenly dispersed between treatment and control reaches.

TABLE 13 SPECIES RICHNESS AND ABUNDANCE. HERBACEOUS (WOODY SPECIES <1 M), SHRUBS (WOODY SPECIES 1-5 M), TREES (WOODY SPECIES> 5 M). STEM COUNT REFERS TO OVERALL WOODY PLANT ABUNDANCE OF ALL THREE HEIGHT CLASSES COMBINED. SHANNON INDEX (H) AND SIMPSON INDEX OF DIVERSITY (1-*D; D*= SIMPSON'S DIVERSITY).

Year surveyed	Site name	Richness		Stem count		Herb		Shrub		Tree		*H*		1-*D*	
		T	C	T	C	T	C	T	C	T	C	T	C	T	C
2018	CC37	3	6	95	222	41	88	54	43	0	91	0.4	0.9	0.2	0.5
2019	End Cr	5	0	44	0	32	0	12	0	0	0	0.7	0.0	0.3	0.0
2018	McCoy	3	4	23	164	6	163	17	1	0	0	0.8	0.5	0.5	0.3
2019	Meadow Cr	6	5	290	616	280	604	5	8	5	4	0.5	0.3	0.2	0.1
2018	OAF	2	3	76	134	68	117	8	17	0	0	0.2	1.0	0.1	0.6
2018	Southern Cross	9	8	266	145	179	67	87	51	0	27	1.7	1.2	0.8	0.6
	Averages	4.7	4.3	132.3	213.5	101.0	173.2	30.5	20.0	0.8	20.3	0.7	0.7	0.4	0.4

Overall species richness was slightly higher at treatment versus control reaches among the six monitored sites in the Grande Ronde Subbasin during 2018 and 2019 site visits, with an average of 4.7 species observed at treatment reaches and 4.3 species observed at control reaches. The Southern Cross project supported nearly twice the species richness in both treatment and control sites (9 and 8, respectively) compared to overall subbasin average. There was significantly higher overall woody plant abundance (all three height classes combined) in control versus treatment reaches. Overall average herbaceous and tree abundance was also significantly higher in control reaches compared to treatment reaches, with shrubs found within treatment sites outnumbering those found in their control counterparts. Using the two diversity indices (Shannon's *H* and Simpson's *D*) we are shown that average species diversity is equal between overall treatment and control reaches, however overall species diversity was higher in treatment reaches within End Creek, McCoy Creek, Meadow Creek, and Southern Cross project areas. Southern Cross project also exhibited the highest species diversity in both treatment and control sites compared to the other five study areas monitored within the subbasin.

Riparian planting projects sometimes include other restoration actions that may influence recovery of riparian conditions. Floodplain restoration projects often involve a large amount of riparian disturbance prior to restoration planting and therefore take longer for riparian areas to return to pre-restoration conditions even with substantial planting efforts (Morley et al. 2005). Control reaches were selected to match treatment reaches pre-restoration implementation condition, and therefore control reaches for floodplain enhancement projects sometimes contained more riparian vegetation than their paired restored treatment reach, likely confounding results. Therefore, given the level of riparian disturbance and the time needed for the riparian area to match pre-restoration conditions for floodplain enhancement projects, these projects should be evaluated separately when examining the success of riparian planting efforts in future monitoring programs. In addition, positive responses in cover and shading were not detected likely due to lack of elapsed time since project completion, and interactions with predation, watering, and terrace height.

Physical Habitat Tables

TABLE 14 BANKFULL WIDTH TO DEPTH RATIO, SINUOSITY, TOTAL COUNT OF BANKFULL SIDE-CHANNEL JUNCTIONS, AND SIDE-CHANNEL RATIO FOR SOUTHERN CROSS PROJECT.

Site name	Year collected	Year code	BF W/D ratio		Sinuosity		BF side-channel junctions (#)		Side-channel ratio	
			T	C	T	C	T	C	T	C
Southern Cross	2014	Yr -2	20.1	30.2	1.06	1.11	0	0	0	0
	2015	Yr -1	18.8	30.4	1.04	1.09	0	0	0	0
	2017	Yr +1	21.3	33.4	1.23	1.11	6	0	2.16	0
	2019	Yr +3	18.0	29.1	1.27	1.08	11	0	3.43	0

Pre-project bankfull width to depth ratio ranged from 18.8 to 20.1 in the treatment reach, and 30.2 to 30.4 in the control reach. One year after project completion the treatment width to depth ratio increased to 21.3 but then decreased to 18.0 when surveyed again three years post-project. Width to depth ratio in the control reach increased to 33.4 one year after project completion, but decreased to 29.1 when measured again three years post-project.

Average pre-project sinuosity was 1.05 in the treatment reach and 1.10 in the control. Measurements form the +1 and +3 year surveys post-project give us an average sinuosity of 1.25 at the treatment site (0.2 increase) and remained essentially the same in the control reach at 1.09.

Bankfull side-channel junctions and side-channel ratios were null during the two years surveyed pre-project due to no side channels existing within the Southern Cross project area before restoration actions occurred in 2016. The number of bankfull side-channel junctions ranged from 6-11 in the treatment reach during the three years after project completion. During this same time period post-project side-channel ratios ranged from 2.16-2.43 in the treatment reach. In the control reach bankfull side-channel junctions and side-channel ratios did not exist post-project.

TABLE 15 POOL TO RIFFLE RATIO, PERCENT SLOW WATER, AND RESIDUAL POOL DEPTH (M) AT SOUTHERN CROSS PROJECT.

Site name	Year collected	Year code	Pool/riffle ratio		Slow water (%)		Residual pool depth (m)		Habitat Diversity (H)		RCI		LWD (volume / 100 m)	
			T	C	T	C	T	C	T	C	T	C	T	C
Southern Cross	2014	Yr -2	0.33	2.00	28	25	0.40	0.22	1.00	1.17	0.40	0.36	4.5	12.8
	2015	Yr -1	0.40	2.00	48	52	0.29	0.22	1.03	1.36	0.40	0.35	0.7	21.7
	2017	Yr +1	1.25	2.33	60	31	0.55	0.27	1.16	1.20	0.40	0.36	133.2	17.0
	2019	Yr +3	1.00	0.80	72	51	0.62	0.22	1.10	1.33	0.40	0.35	110.9	31.6

Pool/riffle ratio was 2.00 in the control reach during each of the two surveys conducted the two years prior to project implementation. The pool/riffle ratio ranged from 0.33-0.40 in the treatment reach during the same two surveys. During post-project surveys pool/riffle ratio in control reach ranged between 0.80 and 2.33. Pool/riffle ratio in the treatment reach increased to between 1.00 and 1.25 post-project.

The post-project treatment reach consisted of between 60-72% slow water, up from 28-48% during pre-project measurements. The control reach remained nearly unchanged with 25-52% slow water pre-project compared to 31-51% post-project.

Residual pool depth within the treatment reach increased in depth from 0.29-0.40 m pre-project to 0.55-0.62 m post-project. The control reach pool depth remained nearly unchanged at approximately 0.22 m before and after project implementation.

Habitat diversity increased slightly in the treatment reach from an average of 1.015 pre-project up to 1.13 post-project. Within the control reach average habitat diversity remained unchanged pre/post-project at 1.27.

A significant increase in post-project LWD/100 m. was observed in the treatment reach of the Southern Cross restoration project, averaging 2.6 LWD volume/100 m. pre-project compared to 122.1 post-project. The pre-project control reach contained an average of 17.25 LWD volume/100 m. compared to 24.3 averaged between the two post-project surveys.

TABLE 16 THE D_{50} AND D_{84} BY SIZE RANGE (MM) AND POOL TAIL FINES (%) FOR SUBSTRATE COLLECTED AT SOUTHERN CROSS PROJECT.

Site name	Year collected	Year code	D_{50} (mm)		D_{84} (mm)		Pool tail fines (%)	
			T	C	T	C	T	C
Southern Cross	2014	Yr -2	64 - 90	45 - 64	128 - 180	90 - 128	9	13
	2015	Yr -1	45 - 64	32 - 45	128 - 180	64 - 90	7	6
	2017	Yr +1	45 - 64	45 - 64	128 - 180	64 - 90	10	8
	2019	Yr +3	45 - 64	32 - 45	90 - 128	90 - 128	10	15

D_{50} substrate size surveyed in the treatment reach pre-project ranged between Gravel-Very Coarse 2 (45-64 mm) to Cobble-Small 1 (64-90 mm) but remained in the 45-64 mm category when surveyed one and three years after project completion. The control reach contained D_{50} substrate sizes that ranged from Gravel-Very Coarse 1 (32-45 mm) to Gravel-Very Coarse 2 (45-64 mm) both before and after project area restoration.

D_{84} substrate size in the treatment reach fell within the Cobble-Large 1 (128-180 mm) category pre-project, and ranged between 90-180 mm post-project. The control site averaged D_{84} substrate within the range of 64-128 both pre and post-project.

The average percent of pool tail fines observed in the treatment reach pre-project was 8% and increased to 10% in the years surveyed after project completion. In the control reach an average of 9.5% pool tail fines were observed, compared to 11.5% post-post project.

The table below contains snorkel survey total count of juvenile Chinook and steelhead, water temperature, and discharge from Southern Cross project.

TABLE 17 SNORKEL COUNT OF JUVENILE CHINOOK AND STEELHEAD, WATER TEMPERATURE, AND DISCHARGE FROM SOUTHERN CROSS PROJECT.

Site name	Year collected	Year code	Chinook		Steelhead		Temperature (C)		Discharge (cfs)	
			T	C	T	C	T	C	T	C
Southern Cross	2014	Yr -2	26	235	49	275	13.7	18.7	29.5	28.8
	2015	Yr -1	169	357	189	205	20.2	14.2	24.0	16.0
	2017	Yr +1	90	504	62	166	17.3	17.0	24.0	23.9
	2019	Yr +3	138	99	4	163	17.6	16.3	24.2	44.1

Juvenile Chinook and steelhead snorkel surveys were conducted before and after Southern Cross restoration project implementation. Two years prior to project construction the treatment reach contained 26 juvenile Chinook and 49 steelhead, while the control reach contained 235 chinook and 275 steelhead. Surveyed again one year pre-project snorkelers observed 169 juvenile chinook in the treatment reach and 189 steelhead. During this time the control reach contained 357 Chinook and 205 steelhead juveniles. One year following project construction activities the treatment reach contained 90 juvenile Chinook and 62 steelhead while the control reach contained 504 Chinook and 166 steelhead. The paired treatment-control reaches were surveyed again three years post-project. At this time the treatment reach contained 138 Chinook and 4 steelhead juveniles while snorkelers counted 99 Chinook and 163 steelhead in the control reach.

Lessons Learned/Adaptive Management

The Grande Ronde Subbasin is one example of efforts to learn and adapt management programs through time. Historically, basin partners developed projects in an opportunistic approach. Projects were largely identified and developed with willing landowners based on coarse scale planning established through the Grande Ronde Subbasin plan completed in 2004. In 2013, basin partners initiated a strategic planning process (ATLAS) for Catherine Creek and the Upper Grande Ronde watershed based on salmon and steelhead life history requirements and geomorphic potential to stratify individual watershed by biological significant reaches, assign relative importance of limiting factors, define key actions to address limiting factors, and develop a ranking and prioritization system to clearly identify geographic and reach priorities and both short and long term strategies to focus watershed restoration actions in areas with the most biological need and the highest probability of benefit.

The process engaged multiple basin partners and leveraged the best available science and local expertise available to develop a road map that all partners can utilize to identify, develop, and implement strategic watershed and fish habitat restoration and enhancement projects. Transitioning opportunistic to strategic planning may be one of the most important adaptive management changes employed in the basin for prioritizing and strategizing work in Catherine Creek and the Grande Ronde river to address survival gaps for Snake River Spring-Summer Chinook and Summer Steelhead populations in the Grande Ronde Subbasin.

Additionally, the CTUIR Grande Ronde Fish Habitat Project continues to monitor and evaluate performance of projects and conservation measures developed to improve watershed and fishery resources in the Grande Ronde Subbasin. Post project construction and monitoring data, along with staff experience and collaboration with basin partners, collectively informs and helps improve our understanding of how different techniques and approaches to watershed and habitat restoration respond as well as develop new and innovative approaches to addressing habitat limiting factors for salmon and steelhead populations.

Adaptive management and project adjustment derived from evaluation of older in-basin projects, regional project tours and reviews, and collaboration with regional and local habitat biologists and researchers continues to be an important part in the progression and evolution of floodplain and habitat restoration techniques and design features, including:

1. Hydro geomorphology and hyporheic processes and functions to promote summer and winter refuge. The CTUIR Hyporheic Flow Assessment in Columbia River Tributaries project (#2009-014-00) provides valuable insight into floodplain design and restoration of groundwater

and hyporheic process and function. Examples include promoting floodplain inundation, increasing the River Complexity Index (RCI), promoting multi-thread/anastomosing channel networks, restoring sinuosity, and forcing hydrologic head through meanders to create and restore diverse flow paths.

2. Habitat suitability and juvenile life stage habitat selection (Favrot and Jonasson 2018): Local Basin research informs importance and prioritization of zero velocity and forced pool habitats. Locally derived suitability indices for depth and velocity inform habitat suitability modeling which is used in channel and floodplain design. Achieving velocity requirements during spring and early summer flows shown to be difficult to achieve without diverse floodplain and off channel habitat (low gradient swales, side channels and alcoves). Forced pool habitat design requires short radius and support complex "catcher mitt" large wood structure design with overhead cover, mimicking natural pool logjams.

3. Beaver habitat and restoration. Floodplain projects and the associated disturbance regime provide multiple ecological benefits, including restored hydrology, erosion and deposition, and support of riparian and wetland vegetation colonization. Beaver benefit from restored hydrology and the associated vegetation response that improve beaver habitat suitability indices, including a yearlong food supply, and dam and lodging materials. Degraded floodplains exhibit simplified and xeric conditions with poor riparian condition that limit habitat suitability for multiple resources. Floodplain process restoration includes hydrology and a disturbance regime that supports wetland and riparian vegetation establishment and habitat suitability for both aquatic and terrestrial fish and wildlife.

Additionally, at the request of the NPCC, ISRP, and others regarding the need to address evaluation and adaptive management, BPA developed and initiated the Action Effectiveness Monitoring (AEM) Program as a cost-effective approach to evaluate reach-scale physical and biological effectiveness of a subset of habitat improvement (restoration) actions implemented and funded under the Council's F&W Program (NPCC 2012; Roni et al. 2015). The AEM Program has been evaluating a subset of barrier removal, wood placement, riparian planting, and floodplain restoration projects using two monitoring designs (before-after control impact for new projects and extensive post-treatment for previously completed projects). The Project has closely coordinated with the AEM Program to assist with identification of potential projects to monitor, provide critical information on project design, coordinate with landowners, and contribute data collection efforts on individual monitoring sites. Results to date from the AEM Program have demonstrated positive physical and biological success of large wood placement, barrier removal, and riparian planting projects. While only a portion of the restoration projects evaluated by AEM are in our ESU or project area (watershed), results to date have shown little differences in response among ESUs. Reports from the AEM project have provided project design guidance for habitat complexity (large wood), barrier removal, and riparian planting projects both within and across ESUs, including:

Large wood placement
- Ensure the amount of "in-channel wood" is closer to historical targets
- Increase the amount of functional large wood (i.e., creating pools)
- Place more large wood in the thalweg or spanning channel, not on margins

Barrier removal

- Prioritize for target species as many remaining barriers are in small streams
- Document Chinook and steelhead use in order to assist with prioritization

Riparian

- More emphasis on design for site conditions (climate, channel incision, browse protection, watering/maintenance)
- Prioritize projects so they are less opportunistic

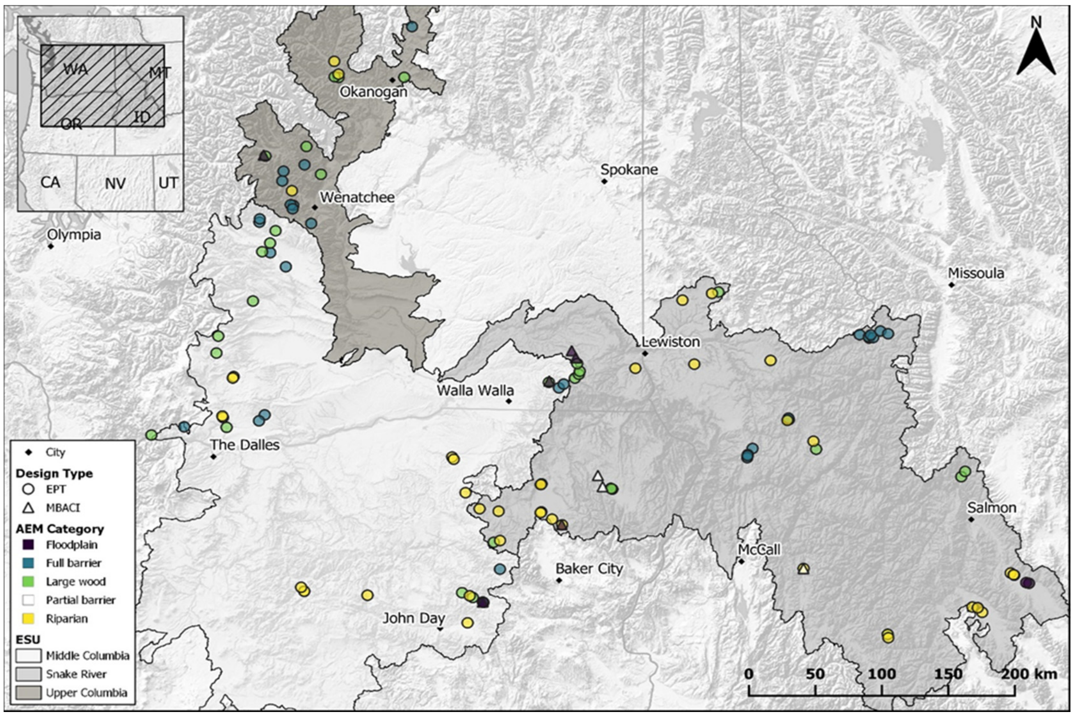


FIGURE 70 **MAP OF 118 AEM PROJECTS SAMPLED (2014 TO 2021). IN 2021 AND 2022, ADDITIONAL FLOODPLAIN PROJECTS NOT SHOWN WILL BE SAMPLED USING AN EPT DESIGN. EPT = EXTENSIVE POST-TREATMENT, MBACI = MULTIPLE BEFORE-AFTER CONTROL-IMPACT.**

These results and recommendations from AEM are relatively recent (Roni et al. 2020, 2021), but we are using them to adaptively manage our project selection and restoration design process to improve success of current and future habitat projects. As additional results from AEM for floodplain projects become available, we will incorporate those into our restoration approaches and designs. In addition to objective-specific monitoring, project inspections including photo documentation are conducted annually. Pre and post-project monitoring is performed by various agencies including CTUIR, Reclamation, ODFW, USFS, GRMW, the Columbia River Intertribal Fish Commission (CRITFC), and independent contractors.

Literature Cited

Anderson, J.W., et al. 1992. Upper Grande Ronde River Anadromous Fish Habitat Protection, Restoration, and Monitoring Plan. USFS, PNWFRS, ODFW, CRITFC, CTUIR, NPT, OSU.

Arjo, W., Wagner, Chad D Richardson, and Dale L Nolte. 2005. "Use of Deer Repellants to Preserve Wildlife Food Plots For Game Birds." Proceedings of the11th Wildlife Damage Management Conference.

Averett, Joshua P, Bryan A Endress, Mary M Rowland, Bridget J Naylor, and Michael J Wisdom. 2017. "Wild ungulate herbivory suppresses deciduous woody plant establishment following salmonid stream restoration." Forest Ecology and Management 135-144.

Bjornn, T.C. and Reiser, D.W. (1991) Habitat Requirements of Salmonids in Streams. In: Meehan, W.R., Ed., Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats, American Fisheries Society Special Publication, 19, 83-138.

Bonneville Power Administration Action Effectiveness Monitoring Program - protocol for monitoring the effectiveness of off-channel habitat/floodplian enhancement projects [Report]. - Portland, Oregon : Bonneville Power Administration, 2016.

Brown, et al. Effects of high river flows on errors in modeled annual average Delta water temperatures. Davis, California, 2011.

CBFWA. 1990. Columbia Basin Fish and Wildlife Authority. Integrated System Plan for Salmon and Steelhead Production in the Columbia River Basin.

CHaMP Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program. [Report]. - [s.l.] : Columbia Habitat Monitoring Program., 2015.

Clark, C., Krall, M., Roni, P., & Ceder, K. 2021 Reach scale stream temperature response to large wood placement. *Restoration Ecology*.

Cluer, B., Thorne, C. A Stream Evolution Integrating Habitat and Ecosystem Benefits. River Research and Applications, 2013.

Conder, T., Hand, D., Olsen, D. & Lovtang, J., 2008. Distribution and Survival of Adult Hatchery Spring Chinook Salmon Radio-tagged and Released Upstream of Warm

Springs National Fish Hatchery in 2008, Vancouver, WA: U.S. Fish and Wildlife Service.

Conley, W., and D. Lindley. 2012. Klickitat watershed enhancement project. Report to the Bonneville Power Administration, Project No. 1997-056-00, contract No. 35988. Yakama Nation Fisheries Resource Management Program, Toppenish, Washington.

Contor, C.R., 2010. Umatilla Basin Natural Production Monitoring and Evaluation, 2009 Annual Progress Report, Portland, OR: Bonneville Power Administration.

Contor, C. R., 2014. Umatilla Basin Natural Production Monitoring and Evaluation, 2014 Annual Progress Report, Pendleton, Oregon: Confederated Tribes of the Umatilla Indian Reservation.

Costi K, Shippentower, G and A. Wildbill. 2016. Fish Habitat Enhancement Biological Effectiveness Monitoring 2016 Annual Report. Confederated Tribes of the Umatilla Indian Reservation. Project # 2009-014-00; BPA contract# 71934.

CRITFC. 1995. Wykan Ush Me Wa Kush, Spirit of the Salmon. Columbia River Basin Salmon Policy. Columbia River Inter-Tribal Fish Commission. Columbia Basin Salmon Policy, 1995.

Crump, C., Naylor, L. M., Van Sickle, A. & Startzel-Holt, B., 2018. Evaluation of Reestablishing Natural Production of Spring Chinook Salmon in Lookingglass Creek, Oregon FY 2018 Annual Report, Boise, Idaho: U.S. Fish and Wildlife Service Lower Snake River Compensation Plan.

CTUIR. 1983. Confederated Tribes of the Umatilla Indian Reservation. Summary Report: Salmon and steelhead habitat improvement initiatives--John Day, Umatilla, Grande Ronde and Imnaha drainages.

CTUIR. (2019, February 12). Retrieved from CTUIR GIS (Public) Geographic Information Systems: http://gis.ctuir.org/

Emmingham, W. H., S. S. Chan, D. Mikowski, P. Owston, and B. Bishaw. 2000. Silviculture practices for riparian forests in the Oregon coast range. Research Contribution 24, Forest Research Laboratory, Oregon State University, Corvallis.

Favrot, S. D. & Jonasson, B. C., 2016. Identification of Grande Ronde River Fall Migrant Juvenile Spring Chinook Salmon Overwinter Rearing Reaches, La Grande, Oregon: Oregon Department of Fish and Wildlife.

Feld, C., S. Birk, D. Bradley, D. Hering, J. Kail, A. Marzin, A. Melcher, D. Nemitz, M. Pedersen, F. Pletterbauer, D. Pont, P Verdonschot, and N. Friberg. 2011. From natural to degraded rivers and back again: a test of restoration ecology theory and practice. Advances in Ecological Research 44:119-209.

Gallagher S P, Hahn P K and Johnson D H Redd Counts [Journal] // American Fisheries Society. - 2007. - pp. 197-234.

González, E., A. A. Sher, E. Tabacchi, A. Masip, and M. Poulin. 2015. Restoration of riparian vegetation: a global review of implementation and evaluation approaches in the international, peer-reviewed literature. Journal of Environmental Management 158:85-94.

Gornish E. S., M. S. Lennox, D. Lewis, K. W. Tate, and R. D. Jackson. 2017. Comparing herbaceous plant communities in active and passive riparian restoration. PLoS ONE 12:e0176338.

Grande Ronde Model Watershed Program, et. al. 2004. Grande Ronde Subbasin Plan. Northwest Power Planning Council Fish and Wildlife Program.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41:540-551.

Hall, A., & Selker, J. S. 2021. High-resolution temperature modeling of stream reconstruction alternatives. *River Research and Applications*.

Hall, J., M. Pollock, and S. Hoh. 2011. Methods for successful establishment of cottonwood and willow along an incised stream in semiarid eastern Oregon, USA. Ecological Restoration 29:261-269.

Hall, J. E., M. M. Pollock, S. Hoh, C. Volk, J. Goldsmith, and C. E. Jordan. 2015. Evaluation of dryland riparian restoration with cottonwood and willow using deep-planting and herbivore protection. Ecosphere 6:1-12.

Harbeck, J. R., Wilson, I. P. & Maxwell, A., 2014. Migratory assessment of spring Chinook salmon in the Lostine River using radio-telemetry techniques. 2010 – 2012 Progress Report, s.l.: Oregon Watershed Enhancement Board.

Harris, R. R. 2005. Monitoring the effectiveness of riparian vegetation restoration. Report to the California Department of Fish and Game. College for Forestry, University of California, Berkeley Agreement No. 09219566. Berkeley.

Henjum, M. G., J.R. Karr, D. L. Bottom, D. A. Perry, J. C. Bennarz, S. G. Wright, S. A. Beckwitt and E. Beckwitt. 1994 Interim Protection for Late-Successional Forest, Fisheries, and Watersheds: National Forest East of the Cascade Crest, Oregon and Washington.

Hillman, T., P. Roni, and J. O'Neal. 2016. Effectiveness of tributary habitat enhancement projects. Report to the Bonneville Power Administration, Portland, Oregon.

Hoag, Chris, Derek Tilley, Dale Darris, and Kathy Pendergrass. 2008. Identification and Use of Common Riparian Woody Plants. Aberdeen: United States Department of Agriculture.

Huntington, C. H. 1993. Clearwater BioStudies. Final Report. Stream and Riparian Conditions in the Grande Ronde Basin. Grand Ronde Model Watershed Operations-Action Plan, Appendix A and B.

Independent Scientific Group. 1996. Return to the River: Restoration of Salmonid fishes in the Columbia River Ecosystem. September 1996.

Isaak, D. J., Horan, D.L and S.P.Wollrab. 2013. A simple protocol using underwater epoxy to install annual temperature monitoring sites in rivers and streams. Gen. Tech. Rep. RMRS-GTR-314. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 21 p.

Jakober et al. Role of Stream Ice on Fall and Winter Movements and Habitat Use by Bull Trout and Cutthroat Trout in Montana Headwater Streams American Fisheries Society, 1998. Biology Department, Fish and Wildlife Program. Montana State University, Bozeman, Montana.

Johnson D H [et al.] Salmonid Field Protocols [Journal] // American Fisheries Society. - 2007. - pp. 325-340.

Johnson, S. L. (2004). Factors influencing stream temperatures in small streams: substrate effects and a shading experiment. *Canadian Journal of Fisheries and Aquatic Sciences*, *61*(6), 913-923

Jones K. L. et al. Physical Habitat Monitoring Strategy (PHAMS) for reach-scale restoration effectiveness monitoring [Report] = PHAMS: Open-File Report 2015-1069 / U.S. Department of the Interior. - Reston, Virginia: U.S. Geological Survey, 2013.

Jones, K. L., Poole, G. C., Quaempts, E. J., O, D. S., & Beechie, T. (2008). The Umatilla River Vision. Mission: Confederated Tribes of the Umatilla Indian Reservation Department of Natural Resources.

Justice, C. et al. Protocol for Field Measurements of Cold-water Refuges [Report]. - Portland, Oregon : Columbia Inter Tribal Fish Commission, 2015.

Justice, C. et al., 2017. Can stream and riparian restoration offset climate change impacts to salmon populations? Journal of Environmental Management, pp. 212-227.

Kaufmann, P. R., P. Levine, E. G. Robison, C. Seeliger, and D. V. Peck. 1999. Quantifying physical habitat in wadeable streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.

Keefer, M. L., Caudill, C. C., Peery, C. A. & Boggs, C. T., 2008. Non-direct homing behaviours by adult Chinook salmon in a large, multi-stock river system. Journal of Fish Biology, Issue 72, pp. 27-44.

Keefer, M. L. et al., 2004. Stock-specific migration timing of adult spring-summer Chinook salmon in the Columbia River Basin. North American Journal of Fisheries Management, Issue 24, pp. 1145-1162.

Kettering, K. M., and C. R. Adams. 2011. Lessons learned from invasive plant control experiments: a systematic review and meta-analysis. Journal of Applied Ecology 48:970-979.

Knutson, M. and Fealko, J. Reclamation, September 2014. Pacific Northwest Region Resource & Technical Services Large Woody Material – Risk Based Design Guidelines. U.S. Department of the Interior, Bureau of Reclamation. Pacific Northwest Region, Boise, Idaho.

Kondolf, G. M., S. Anderson, R. Lave, L. Pagano, A. Merenlender, and E. S. Bernhardt. 2007. Two decades of river restoration in California: what can we learn? Restoration Ecology 15:516-523.

Lennox, M. S., D. J. Lewis, R. D. Jackson, J. Harper, S. Larson, and K. W. Tate. 2011. Development of vegetation and aquatic habitat in restored riparian sites of California's north coast rangelands. Restoration Ecology 19:225-233.

Lofy, P. T. & McLean, M. L., 1995. Lower Snake River Compensation Plan Confederated Tribes of the Umatilla Indian Reservation Evaluation Studies Annual Progress Report. 1 January-31 December 1994. Report to U.S. Fish and Wildlife Service, Boise, Idaho. Contract #14-48-0001-94517, s.l.: s.n.

Lyons, E., & McAfee, R. (2017). Work Plan for Field Exploration. Boise: Bureau of Reclamation.

Merritt, D. M., M. E. Manning, and N. Hough-Snee, editors. 2017. The national riparian core protocol: a riparian vegetation monitoring protocol for wadeable streams of the conterminous United States. General Technical Report RMRS-GTR-367. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Environmental Protection Agency 910-R-99-010.

McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wismar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Management history of eastside ecosystems: Changes in fish habitat over 50 years, 1935-1992. General Technical Report, PNW-GTR-321, Report. USDA, Forest Service.

McLean, M. L., Seeger, R. L. & Helwick, T., 2016. Grande Ronde Satellite Facility O&M Annual Report for 1 January-
31 December 2015, Portland, OR: Bonneville Power Administration.

Mobrand, L. and L. Lestelle. 1997. Application of the ecosystem diagnosis and treatment method to the Grande Ronde Model Watershed Project. BPA Task Order Number 95AT61148.

Mobrand, L. 2003. Application of the Ecosystem Diagnosis and Treatment Method to the Grande Ronde Subbasin.
https://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf

Morley, S. A., P. S. Garcia, T. R. Bennett, and P. Roni. 2005. Juvenile salmonid (*Oncorhynchus* spp.) use of constructed and natural side channels in Pacific Northwest rivers. Canadian Journal of Fisheries and Aquatic Sciences 62:2811-2821.

Naylor, L. M. et al. Monitoring and Evaluation of Supplemented Spring Chinook Salmon and Life Histories of Wild Summer Steelhead in the Grande Ronde Basin 2019 Annual Progress Report: Annual Report. - Portland Oregon : Bonneville Power Administration, 2019.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries Bulletin, American Fisheries Society, Bethesda, Maryland.

Nelle R D and Moberg J A Field Guide of Scientific Protocols for Steelhead Redd Surveys within the Upper Columbia Monitoring Strategy [Report]. - Wauconda, Washington : Terraqua, Inc, 2009.

Newbury, R., & Gasboury, M. (1994). Stream analysis and fish habitat design: A field manual. Gibson: Newbury Hydraulics LTD.

Newbury, R., Gaboury, M., & Bates, D. (1997). Restoring habitats in channelized or uniform streams using riffle and pool sequences. Canadian Ministry of Environment, Lands and Parks. Vancouver: Watershed Restoration Program.

NMFS. (1997). Snake River Salmon Recovery Plan (8/97 draft),. National Marine Fisheries Service.

NMFS. 1997. National Marine Fisheries Service. Snake River Salmon Recovery Plan (8/97 draft), Chap.4, pg. 61, 1997.

NMFS. 1995. National Marine Fisheries Service. Snake River Salmon Recovery Plan.

Noll, W., Williams, S., and R. Boycce. 1988. Grande Ronde river basin fish habitat improvement implementation plan. Oregon Department of Fish and Wildlife.

NOAA Fisheries. 2017. ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon (Oncorhynchus tshawytscha) & Snake River Basin Steelhead (Oncorhynchus mykiss).

Nowack, M. C., 2004. Grande Ronde Subbasin Plan, s.l.: Northwest Power Planning Council.

NPCC. 1994. Columbia River Basin Fish and Wildlife Program. Northwest Power Conservation Council.

NPPC. 2001. Grande Ronde River Subbasin Summary. Northwest Power Conservation Council.

NPCC. 2004a. Grande Ronde Subbasin Plan. Prepared for Northwest Power and Conservation Council by Grande Ronde Model Watershed Program. Pgs. 491. Available from www.nwcouncil.org/fw/subbasinplanning/granderonde/plan/

NPCC. 2004b. Imnaha Subbasin Plan. Prepared for Northwest Power and Conservation Council by Wallowa County Natural Resources Advisory Committee. Paged by section. Available from www.nwcouncil.org/fw/subbasinplanning/imnaha/plan/

NPCC. 2004c. Grande Ronde Subbasin Plan Supplement. Prepared for Northwest Power and Conservation Council by Grande Ronde Model Watershed Program. Pgs. 51. Available from www.nwcouncil.org/fw/subbasinplanning/granderonde/plan/

NPCC. 2004d. Imnaha Subbasin Plan Supplement. Prepared for Northwest Power and Conservation Council by Wallowa County Natural Resources Advisory Committee. Pgs. 20. Available from www.nwcouncil.org/fw/subbasinplanning/imnaha/plan/

NPPC. 2000. Columbia River Basin Fish and Wildlife Program. Portland, OR. Available from www.nwcouncil.org/library/2000/2000-19/Default.htm

NPCC (Northwest Power and Conservation Council). 2012. Review of research, monitoring and evaluation and artificial production projects: recommendations of the Council, June 2011 (with July 2011 addition of completed Part 4). Available at URL: https://www.nwcouncil.org/sites/default/files/2011_06decision.pdf.

NRC. 1996. Upstream. Salmon and society in the Pacific Northwest. National Research Council, Washington D.C. 452 pp.

ODEQ. 1999. Grande Ronde Section 319 National Monitoring Program Project. Temperature Monitoring Summary Report, 1993-1998. Oregon Department of Environmental Quality.

ODFW. (1990). Past and present abundance of Snake River sockeye, Snake River Chinook, and lower Columbia River coho salmon. A report prepared for Senator Mark Hatfield, U. S. Senate. Oregon Department of Fish and Wildlife.

ODFW, 1990. Oregon Department of Fish and Wildlife and four other agencies. 1990. Grande Ronde River Subbasin, salmon and steelhead production plan. Northwest Power Planning Council, Portland, Oregon.

ODFW, 1996. Oregon Department of Fish and Wildlife. 1996. Grande Ronde Basin Fish Habitat Enhancement Project. 1996 Annual Report.

OWRD. (2019, February 5). Near Real Time Hydrographics Data. Retrieved from Oregon Water Resource Deparment: https://apps.wrd.state.or.us/apps/sw/hydro_near_real_time/display_hydro_graph.aspx?station_nbr=13318960

Parkyn, S. M., R. J. Davies-Colley, N. J. Halliday, K. J. Costley, and G. F. Croker. 2003. Planted riparian buffer zones in New Zealand: do they live up to expectations? Restoration Ecology 11:436- 447.

Platz, Joe. 2015. "Plantskydd® Riparian Spray Project proposal." La Grande, Oregon: United States Forest Service, August 15.

Polivka, K. M., Steel, A. E. & Novak, J. L., 2015. Juvenile salmon and steelhead occupancy of stream pools treated and not treated with restoration srtuctures, Entiat River, Washington. Canadian Journal of Fisheries and Aquatic Science, Volume 72, pp. 166-174.

Pollock, M. M., T. J. Beechie, S. S. Chan, and R. Bigley. 2005. Monitoring restoration of riparian forests. Pages 67-96 in P. Roni, editor. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland.

Quaempts, E.J., Jones, K.L., O'Daniel, S.J., Beechie, T.J., and Poole, G.C.. 2018. Aligning environmental management with ecosystem resilience: a First Foods example from the Confederated Tribes of the Umatilla Indian Reservation, Oregon, USA. Ecology and Society 23(2):29. https://doi.org/10.5751/ES-10080-230229

Randall, Warren R, Robert F Keniston, Dale N Bever, and Edward C Jensen. 1994. Manual of Oregon Trees and Shrubs. Corvallis: Oregon State University.

Roni, P., C. Clark, M. Krall, S. Burgess, and K. Ross. 2020. Bonneville Power Administration Action Effectiveness Monitoring Program – 2019 Annual Report. Report to Bonneville Power Administration, Project Number 2016-001-00, Portland, Oregon.

Roni, et al. 2002. A Review of Stream Restoration Techniques and a Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds Northwest Fisheries Science Center, National Marine Fisheries Service, 2725 Montlake Boulevard East, Seattle, Washington 98112.

Roni, P., Hanson, K. and Beechie,T.J. 2008. Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. North American Journal of Fisheries Management 28, 856 – 890.

Roni, P. et al. Fish-habitat relationships and the effectiveness of habitat restoration [Report] : Technical Memorandum / U.S. Department of Commerce. - [s.l.] : NOAA, 2014. - NMFS-NWFSC-127.

Roni, P., T. Beechie, G. Pess and K. Hanson. 2014a. Fish-habitat relationships and effectiveness of habitat restoration. NOAA Technical Memorandum NMFS-NWFSC-127. Seattle, Washington.

Roni, P., J. O’Neal, and R. Scranton. 2014b. Study plan for programmatic approach to monitoring riparian actions. Prepared for the Bonneville Power Administration, Portland, Oregon.

Roni, P., M. Krall, C. Clark, and K. Ross. 2019. Salmon Recovery Funding Board reach-scale project effectiveness monitoring program: 2018 Final Report. Report to the Washington State Salmon Recovery Funding Board, Recreation and Conservation Office, Olympia.

Rosgen, D. 1996 Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Rosgen, D. 1998. The reference reach – a blueprint for natural channel design. Presented at the ASCE, Denver, Co

Stillwater Sciences Biological effectiveness monitoring and evaluation plan for fisheries [Report]. - Portland, Oregon: Stillwater Sciences, 2012.

Thurow, R.F. 1994. Underwater Methods for Study of Salmonids in the Intermountain West. General Technical Report. Ogden, UT: US Department of Agriculture, Forest Service, Intermountain Research Station.

Tranquilli, J. V., Keefe, M. L. & Carmichael, R. W., 2001. A compendium of Grande Ronde and Imnaha River basin spring chinook salmon spawning ground surveys conducted from 1948 through 1998, La Grande, OR: Oregon Department of Fish and Wildlife.

Tree World Plant Care Products Inc. 2018. Buy Plantskydd Deer Rabbit Vole Repellent. January 9. https://www.plantskydd.com/.

Upper Grande Ronde River Tributary Assessment, Grande Ronde River Basin
Tributary Habitat Program, Oregon. U.S. Department of the Interior Bureau of Reclamation Pacific Northwest Region. January, 2014.

U.S. Fish and Wildlife Service. 2014. Revised draft recovery plan for the coterminous United States population of bull trout (*Salvelinus Confluentus*). Portland, Oregon. Xiii + 151 pp.

USFS et. al. 1992. Upper Grande Ronde River Anadromous Fish Habitat Protection, Restoration, and Monitoring Plan, USFS, PNFRES, ODFW, CRITFC, CTUIR, NPT, OSU.

Warren D. R., C. J. Harvey, M. M. McClure & B. L. Sanderson. (2014) Use of an Ecosystem-Based Model to Evaluate Alternative Conservation Strategies for Juvenile Chinook Salmon in a Headwater Stream, North American Journal of Fisheries Management, 34:4, 839-852

White, S., C. Justice, and D. McCullough. 2011. Protocol for Snorkel Surveys of Fish Densities. A component of Monitoring Recovery Trends in Key Spring Chinook Habitat Variables and Validation of Population Viability Indicators. Columbia River Inter-Tribal Fish Commission, Portland, OR.

Wohl, E. 2021. An integrative conceptualization of floodplain storage. Reviews of Geophysics, 59, e2020RG000724. https://doi. org/10.1029/2020RG000724