

Spring Chinook Spawning Ground Surveys Upstream of Green Peter Reservoir

Contract W9127N24F0021



Prepared for:

Steven Sachs
Fisheries Field Unit
U.S. Army Corps of Engineers, Portland District

Prepared by:

Hans Berge, Ryan Flaherty, and Bret Fessenden
Cramer Fish Sciences
Fish Ecology Lab
7725 Ambassador Pl, Suite C
Portland, OR 97220

March 2025

TABLE OF CONTENTS

Table of Contents	2
Table of Figures	3
Table of Tables	4
Introduction.....	5
Methods and Materials.....	6
Spatial and Temporal Scope	6
Spawning Surveys.....	9
Adults	10
Carcasses	10
Redds.....	11
Results.....	12
Temperature and Flow	12
Adult Observations	16
Carcass Recoveries	18
Redd Enumeration	21
Discussion	24
Survey Effort.....	24
Carcass Recoveries	24
Redd Distribution and Abundance.....	25
References.....	27

TABLE OF FIGURES

Figure 1. Project Study Area. Quartzville Creek (QV) and Middle Santiam River (MS).	7
Figure 2. Daily maximum and minimum water temperatures (grey ribbon) and daily mean temperature (black line) recorded by USGS gage #14185900 in the Quartzville 4 survey reach. Colored points indicate water temperatures measured at the start of each survey.	13
Figure 3. Mean daily discharge at USGS Stream Gauge 14185900 on Quartzville Creek near Cascadia, Oregon, during the 2024 survey period.	14
Figure 4. Daily maximum and minimum water temperatures (grey ribbon) and daily mean temperature (black line) recorded by USGS Stream Gage #14185800 on the Middle Santiam River near Cascadia, Oregon, during the 2024 survey period.	15
Figure 5. Mean daily gauge height at USGS Stream Gauge #14185800 on the Middle Santiam River near Cascadia, Oregon, during the 2024 survey period.	16
Figure 6. Quartzville Creek Chinook salmon adult observations by statistical week and reach.	17
Figure 7. Distribution of Chinook carcasses recovered during the 2024 Quartzville Creek spawning surveys, by reach and statistical week.	19
Figure 8. Map of redds per 100 meters in Quartzville Creek.	22
Figure 9. Map of redds per 100 meters in the Middle Santiam River.	23

TABLE OF TABLES

Table 1. Quartzville Creek survey reaches and estimated lengths. Reaches are oriented from upstream to downstream, with Quartzville 1 being the uppermost reach.....	8
Table 2. Sampling weeks and number of surveys reaches completed by week at time of reporting. Note that the hatchery adult Chinook salmon were released on September 24th.	8
Table 3. Middle Santiam spawning survey reach names and approximate lengths.....	9
Table 4. Middle Santiam River survey reaches completed by statistical week.	9
Table 5. Metrics collected during Quartzville Creek and Middle Santiam spawning surveys 2024.....	10
Table 6. Redd age classifications from Gallagher and Gallagher 2005.....	12
Table 7. Quartzville Creek Chinook salmon adult observations by statistical week and reach.	17
Table 8. Distribution of Chinook salmon carcasses recovered during the 2024 Quartzville Creek spawning surveys, by reach and statistical week.	18
Table 9. Fork lengths (mm) of Chinook salmon carcasses from the 2024 Quartzville Creek spawning surveys, by reach and sex, showing minimum, mean, and maximum values for females, males, and unknown-sex individuals, with sample sizes (n) included.....	20
Table 10. Pre-spawn mortality estimates for female Chinook salmon carcasses recovered during the 2024 Quartzville Creek spawning surveys.	20
Table 11. Distribution of Chinook salmon carcasses recovered during the 2024 Middle Santiam River spawning surveys, by reach.	21
Table 12. Middle Santiam River recovered carcasses condition.	21
Table 13. Distribution of Chinook salmon redds observed during the 2024 Quartzville Creek spawning surveys, by reach and statistical week.	22
Table 14. Distribution of Chinook salmon redds observed during the 2024 Middle Santiam River spawning survey, by reach.....	23

INTRODUCTION

In the Pacific Northwest, Pacific salmon (*Oncorhynchus* spp.) are an important economic, biological, and cultural resource that embodies the values of the region. Habitat degradation and fragmentation coupled with harvest and hatchery practices have led to an acute decline in the abundance of Pacific salmon, culminating in several listings under the U.S. Endangered Species Act (ESA) (Nehlsen et al. 1991; Huntington et al. 1996; Gregory and Bisson 1997; Myers et al. 1998; Lichatowich 1999; Bradford and Irvine 2000; Blumm 2002). In response to this precipitous decline, the National Marine Fisheries Service (now NOAA Fisheries) identified over 50 Evolutionarily Significant Units (ESUs) for salmon and steelhead throughout the Pacific Northwest (California, Washington, Oregon, and Idaho) to evaluate individual populations that are reproductively isolated from adjacent ESUs and represent an important segment of the evolutionary legacy of the species (Good et al. 2005). This includes the Upper Willamette River (UWR) Spring Chinook salmon ESU.

In its 2008 Biological Opinion (BiOp) for the Willamette River Basin Flood Control Project, NOAA Fisheries identified the lack of fish passage at project dams as a major limiting factor to the viability of UWR spring Chinook salmon (NMFS 2008). The BiOp directed actions to identify, address and reduce impacts from existing dam passage conditions for adult and juvenile Chinook salmon, including continued trap, transport, and release of adult salmon into riverine habitats upstream (Reasonable and Prudent Alternative [RPA] 4.1), along with studies to investigate the feasibility of improving downstream fish passage at Project dams for juvenile Chinook salmon (RPA 4.12) (NMFS 2008). These combined actions are intended to re-establish viable populations of naturally spawning UWR spring Chinook salmon in their historical habitats above Willamette Project dams.

On September 1, 2021, the U.S. District Court for the District of Oregon issued an Interim Injunction that directs USACE to implement interim injunction measures intended to improve conditions for fish passage and water quality in the Willamette Valley Project (WVP) to avoid irreparable harm to ESA listed salmonids during the interim period until the completion of the reinitiated consultation. These measures must be carried out “to the greatest extent practicable under existing hydrologic conditions and necessary flood control operations” while making “every effort to comply with the various water quality standards governing the WVP.” One important requirement of the Injunction was: “Within one year of this Interim Injunction, the USACE shall begin outplanting adult UWR Chinook salmon above Green Peter Dam.” Since 2022, USACE has been outplanting up to 800 fish above Green Peter Reservoir during the summer

and early fall. Of those 800 fish, 200 fish are allocated to Quartzville Creek and 600 fish are allocated to the Middle Santiam River. The primary objective of this project is to monitor the distribution of those individuals and to describe the spatial and temporal distribution of any redds that they build in Quartzville Creek, The Middle Santiam River, and major tributaries thereof, from their mouths to the first natural barrier to upstream migration.

In response to those directives, the USACE contracted with Cramer Fish Sciences (CFS) through contract W9127N24F0021 to monitor the spawning success of approximately 600 spring Chinook released into the Middle Santiam River in July of 2024 and 200 spring Chinook salmon released into Quartzville Creek in September of 2024. The two main objectives of monitoring were:

1. Document the spatial and temporal distribution of spring Chinook salmon redds constructed in the Middle Santiam River, Quartzville Creek and their tributaries.
2. Locate and sample spring Chinook salmon carcasses to provide estimates of length, sex, age, pre-spawn mortality, and life history type (i.e., hatchery vs. adfluvial), and to recover any active or passive tags.

METHODS AND MATERIALS

With a reintroduction program upstream of Green Peter Dam in Quartzville Creek and the Middle Santiam River, there is a need to understand the success of these efforts. To evaluate the spawning success of adult spring Chinook we conducted surveys of the spawning grounds in Quartzville Creek and the Middle Santiam that included live counts of adults, redd enumeration, and carcass surveys in the fall of 2024. Adult Chinook released into Quartzville Creek and the Middle Santiam were marked with individual Floy T-bar “spaghetti” tags anterior to the dorsal fin.

Spatial and Temporal Scope

Spawning ground surveys in 2024 took place in Quartzville Creek and Middle Santiam River. In each system we divided the survey area into sampling reaches to communicate results clearly and better understand spawning site selection within each system (Figure 1).

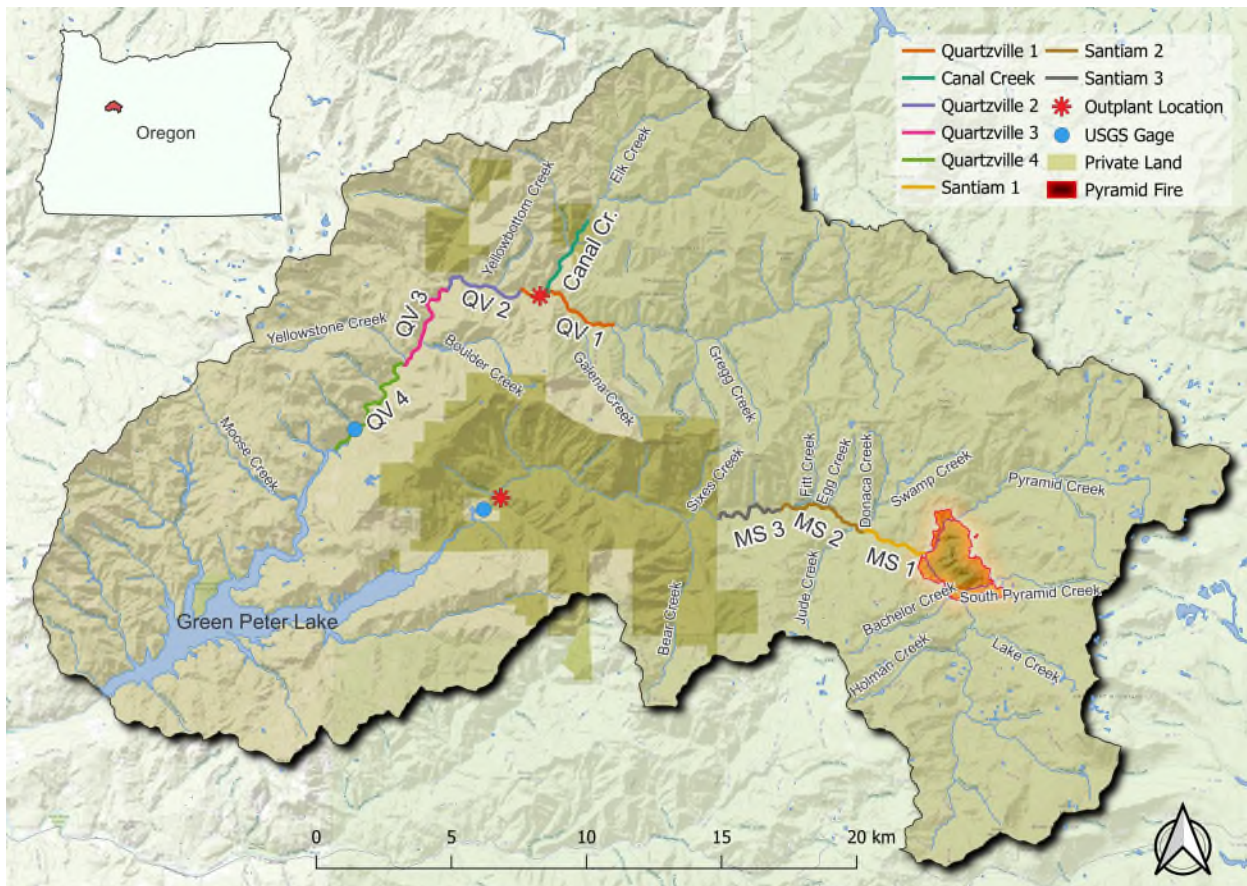


Figure 1. Project Study Area. Quartzville Creek (QV) and Middle Santiam River (MS).

Quartzville Creek

The Quartzville Creek study area extends from the creek's confluence with Green Peter Reservoir upstream to an anadromous fish barrier at upstream extent of Quartzville Reach 1 (Figure 1). The Quartzville Creek study area included any tributaries with suitable spawning habitat. Consistent with previous years, the study area was divided into five survey reaches: four on Quartzville Creek and one on Canal Creek (Table 1). Additional tributaries, such as Galena Creek and Boulder Creek had low stream discharge throughout the survey period, which likely prevented Chinook salmon from accessing these tributaries.

Table 1. Quartzville Creek survey reaches and estimated lengths. Reaches are oriented from upstream to downstream, with Quartzville 1 being the uppermost reach.

Reach Name	Length (km)
Quartzville 1	4.4
Canal Creek	3.3
Quartzville 2	3.7
Quartzville 3	3.9
Quartzville 4	5.3

On September 24th, 2024, USACE and Oregon Department of Fish and Wildlife (ODFW) released 200 adult spring Chinook salmon into Quartzville Creek (Figure 1). Spawning surveys commenced the following day, September 25th 2024. Following the release, the entire spatial extent of the Quartzville Creek study area was sampled weekly (Table 2) including Canal Creek.

Table 2. Sampling weeks and number of surveys reaches completed by week at time of reporting. Note that the hatchery adult Chinook salmon were released on September 24th.

Week	Date Range	Survey Reaches Completed
39	Sep 25 - Sep 27	5
40	Sep 30 - Oct 4	5
41	Oct 7 - Oct 11	5*
42	Oct 14 - Oct 17	5
43	Oct 21 - Oct 24	5

Middle Santiam River

The original spatial extent of the Middle Santiam River study encompassed the area from the boundary between private land and U.S. Forest Service (USFS) land upstream to the confluence of Bachelor Creek, including Pyramid Creek. Initially, the study was planned to begin on August 1, 2024 to evaluate pre-spawn mortality and the distribution of live adults and was scheduled to end after all spawning activity had ceased, no later than mid-November.

Between July 10 and July 23, 2024, the USACE and ODFW released 600 adult spring Chinook salmon into the Middle Santiam River (Figure 1). However, on July 17, 2024, the Pyramid Fire ignited near the eastern boundary of the Middle Santiam study area, altering both the spatial and temporal scope of the study. The fire prompted road closures by USFS, including Forest Service Road 2041, which served as the primary access route to the study area and the entire Middle Santiam study reach was closed to all

access do to active fire. These closures prevented Cramer Fish Sciences from accessing the Middle Santiam River survey area for much of the spawning season, significantly disrupting survey efforts.

On October 11, near the end of the spawning season, CFS and USACE received approval from the USFS to use Forest Service Road 2041 to access a portion the Middle Santiam River below its confluence with Pyramid Creek. Consequently, in 2024, the survey area for this portion of the project was restricted to the section from the confluence with Pyramid Creek to the western boundary of the Middle Santiam Wilderness area (Figure 1). This reduced survey area was divided into three reaches, with Santiam Reach 1 being the most upstream reach (Figure 1; Table 3). Reach boundaries were selected to ensure surveys could be completed within daylight hours; however, late-season timing limited opportunities to establish more scientifically rigorous reach breaks.

Table 3. Middle Santiam spawning survey reach names and approximate lengths.

Reach Name	Length (km)
Santiam 1	2.6
Santiam 2	4.0
Santiam 3	3.2

Overnight access to the wilderness area was granted by USFS on October 22 and 23, allowing CFS to survey halfway into Santiam Reach 2 and a complete survey in Santiam Reach 3. Over three survey days—October 16, October 17, and October 23—one full spawning survey of the study area was successfully completed (Table 4)

Table 4. Middle Santiam River survey reaches completed by statistical week.

Week	Date Range	Surveyed Reaches
42	Oct 16 - Oct 17	2
43	Oct 23	1

Spawning Surveys

Spawning surveys were conducted on both Quartzville Creek and the Middle Santiam River by a team of two trained individuals. Surveys were generally conducted in a downstream direction, with the exception of two surveys on the Middle Santiam River conducted upstream. Data collected during these surveys included counts of Chinook salmon adults, carcasses, and redds, following established protocols from Crawford et al. (2007) and Gallagher and Gallagher (2005). For each protocol, specific metrics were collected to provide information on the success of spawning Spring Chinook (Table 5).

Table 5. Metrics collected during Quartzville Creek and Middle Santiam spawning surveys 2024.

Survey Variables	Redd Variables	Carcass Variables	Adult Variables
Survey ID	Survey ID	Survey ID	Survey ID
Date	Redd ID	Carcass ID	Adult ID
Start Time	Redd Number	Unit Type	Unit Type
End Time	Unit Type	Carcass Lat/Lon	Adult Lat/Lon
Stream Name	Redd Lat/Lon	Adipose Fin Presence	Number Observed
Reach Name	Species	Floy Tag	Activity
Discharge	Visit Type	Fork Length	Sex
Weather	Redd Age	Post-Orbital Hypural Plate Length	Size Class
Water Visibility	Pot Length (m)	MEPS Length	Adipose Fin Presence
Surveyor 1	Pot Width (m)	Species	Photo ID
Surveyor 2	Pot Depth (m)	Sex	Notes
Air Temperature	Pot Substrate (mm)	Egg Retention %	
Water Temperature	Tail Spill Length (m)	Carcass Condition	
Start Lat/Lon	Tail Spill Width 1 (m)	Scavenge Status	
End Lat/Lon	Tail Spill Width 2 (m)	Scale Sample ID	
Start Photo	Tail Spill Depth (m)	Otolith Sample ID	
End Photo	Tail Spill Substrate (mm)	Fin Clip ID	
Notes	Fish on Redd?	Carcass Photo ID	
	Photo ID	Carcass Lat/Lon	
	Unit Type	Notes	
	Notes		

Adults

All live adult Chinook salmon observed during the surveys were counted. To enhance visibility, polarized glasses with yellow or amber lenses were used to aid in the detection of adults and redds. Water visibility was characterized by crews at the start of each spawning survey as Good (greater than 1 meter), Fair (0.5 – 1.0 meters) or Poor (less than 0.5 meters). All surveys conducted in 2024 were characterized as good visibility. For each observed adult Chinook, the following data were recorded: approximate GPS location, a photograph, the number of fish, the channel unit type (e.g., pool, riffle), and their current activity (holding, migrating, or spawning). Additionally, sex and adipose fin presence were documented when possible.

Carcasses

CFS conducted carcass surveys alongside live fish and redd surveys to assess spawning success, spawn timing, and the spatial distribution of the outplanted adults. Carcasses were examined for fin clips and external tags, and all biological metrics were recorded using an electronic tablet (Table 1). Gonads were inspected to determine sex, and for females, the proportion of eggs remaining in the skeins was estimated.

Female Chinook carcasses retaining 50% or more of their eggs were classified as pre-spawn mortality (PSM), consistent with methodologies from Sharpe et al. (2017) and Lindsey et al. (2019). Scales, otoliths, and fin clips were collected from carcasses lacking a tag or those with an adipose fin. Carcass sample quality was recorded for all collected fish and categorized as excellent, good, fair, poor, or dry. Samples were not collected from carcasses categorized as poor or dry. All carcasses were photographed, and their locations were recorded via GPS. Sampled carcasses were cut in half to mark them as processed.

Redds

CFS survey crews were trained in redd identification and enumeration. Individual redds were identified, and their locations were recorded. Test redds were distinguished from complete redds using the redd age classifications outlined in Gallagher and Gallagher (2005) (Table 6). To be classified as a complete age 2 redd, the presence of an observable pit, sorted tailspill, and new clean gravel was required. All observed complete redds were counted and assigned a unique redd identification number (redd ID). Test redds were marked electronically but were not marked with survey ribbon. For each complete redd, a labeled marker was attached to the nearest solid object upstream of the pit and in the vicinity of the redd. The unique redd ID, date of visit, visit type, redd age, whether the redd had been measured, and its location relative to the marker were recorded on the flag and in the electronic record. Redd locations were captured using a high-accuracy GPS unit (Bad Elf Mini Flex GNSS Surveyor) tethered via bluetooth to the data collection tablet.

For each complete redd, the following measurements were taken during the first survey in which the redd was observed and no adult Chinook were present: pit length, pit width, pit depth, tailspill length, tailspill width, tailspill depth, pit substrate size, and tailspill substrate size. A photograph of each redd was also taken, along with documentation of the channel unit type in which the redd was built (e.g., pool tail, glide, riffle).

Table 6. Redd age classifications from Gallagher and Gallagher 2005.

Age	Classification	Description
1	Test redd or redd in progress	Newly created, often with little to no visible features
2	New redd	Fresh and clean, no signs of periphyton or fine sediment accumulation
3	Older, darker redd	Shows signs of deterioration, such as periphyton growth or flattening tailspill
4	Highly degraded redd	Hard to distinguish, with excessive periphyton growth and loss of pit and tail definition
5	Abandoned redd	No visible redd, only flagging used to locate the previous site

RESULTS

Temperature and Flow

Gages operated by the USGS in Quartzville Creek (14185900) and Middle Santiam (14185800) provide data on water temperature, discharge (Quartzville) and river stage (Middle Santiam).

Quartzville Creek

Between the release of adult fish on September 24, 2024, and the conclusion of surveys on October 24, 2024, the mean water temperature recorded at USGS gage 14185900 on Quartzville Creek was 11.9°C, with temperatures ranging from 9.2°C to 16.2°C. Stream temperatures declined steadily following the release through October 5, 2024. A slight warming trend was observed between October 6 and October 16, 2024, after which temperatures steadily declined for the remainder of the study period. Water temperatures measured at the start point of each survey day indicated that the upper reaches of the study area (e.g., Quartzville 1 and Canal Creek) were consistently cooler than downstream sections (Figure 2).

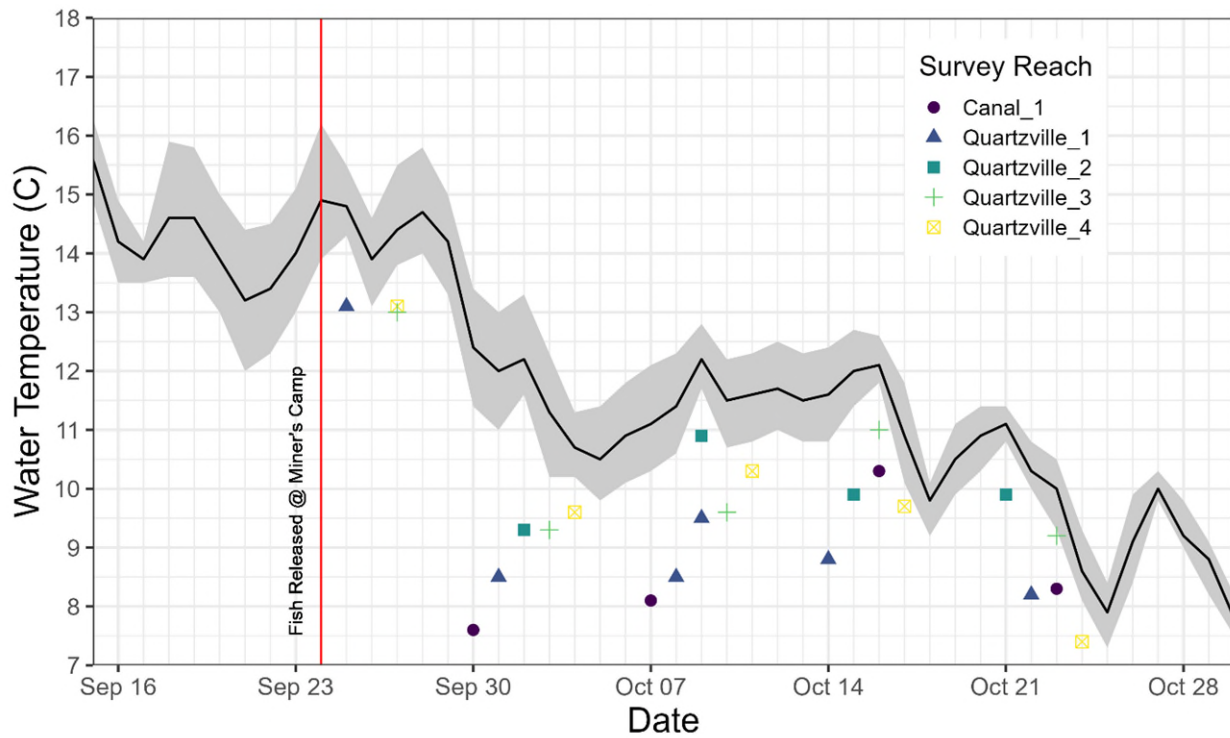


Figure 2. Daily maximum and minimum water temperatures (grey ribbon) and daily mean temperature (black line) recorded by USGS gage #14185900 in the Quartzville 4 survey reach. Colored points indicate water temperatures measured at the start of each survey.

The minimum mean daily flow was 17.5 cfs, the mean for the season was 24.3 cfs, and the maximum was 60.4 cfs. These flow conditions allowed the CFS crew to safely survey all reaches in the study area each week and provided good water visibility conditions during all surveys (Figure 3).

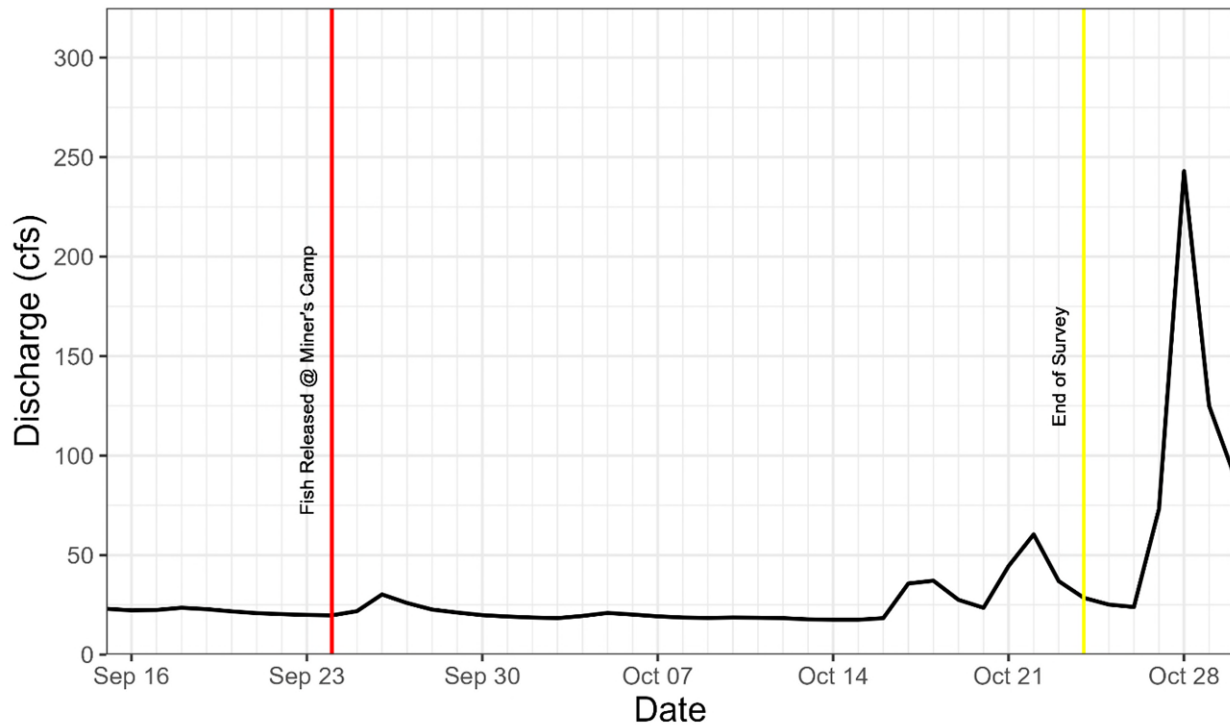


Figure 3. Mean daily discharge at USGS Stream Gauge 14185900 on Quartzville Creek near Cascadia, Oregon, during the 2024 survey period.

Middle Santiam River

The mean water temperature recorded at USGS gage 14185800 from July 10, 2024 (the release date of the first group of fish), through October 31, 2024, was 15.4°C, with a range of 8.2°C to 22.8°C. The maximum temperature of 22.8°C was recorded on August 2, 2024. The seven day average daily maximum temperature (7DADM) exceeded 18° C a total of 57 days and exceeded 20° C a total of 27 days. Exceeding these temperature thresholds has been identified as potentially stressful to adult Chinook salmon (McCullough et al. 2001, Richter and Kolmes 2005)(Figure 4).

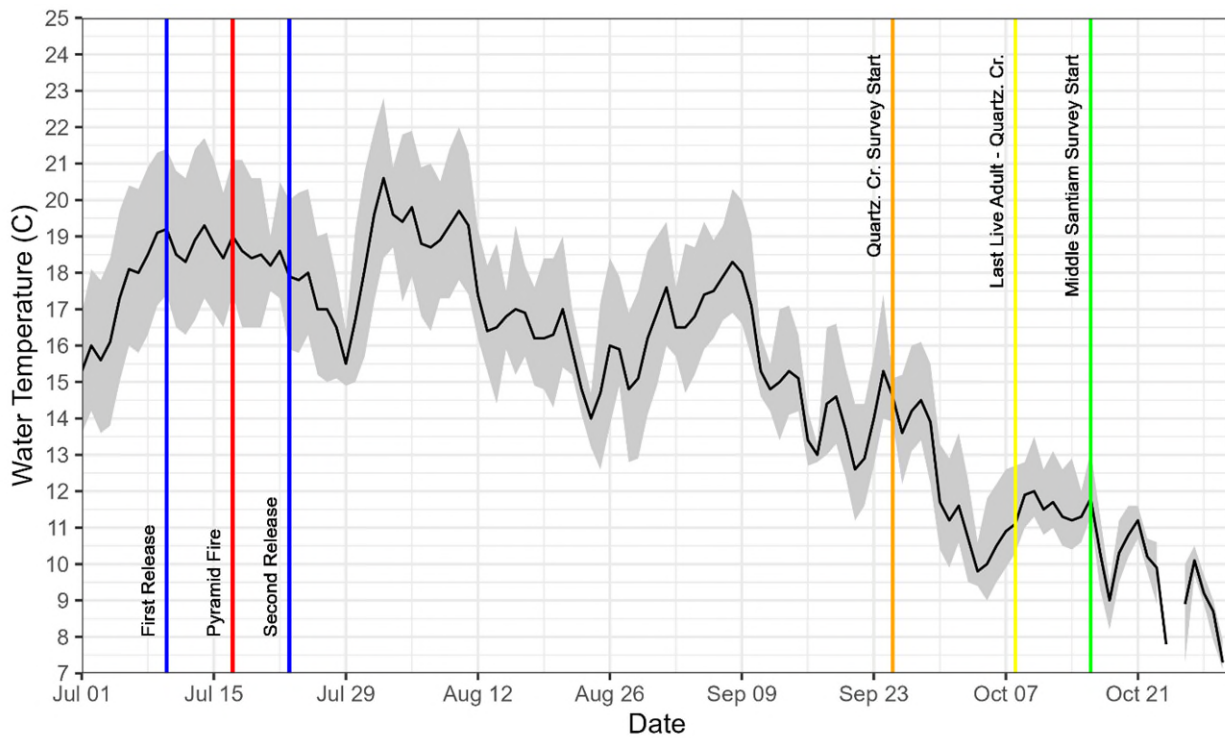


Figure 4. Daily maximum and minimum water temperatures (grey ribbon) and daily mean temperature (black line) recorded by USGS Stream Gage #14185800 on the Middle Santiam River near Cascadia, Oregon, during the 2024 survey period.

From the initial release of adult fish into the Middle Santiam River on July 10 through the conclusion of the study period on October 24, gauge height measurements ranged from a minimum of 0.8 ft to a maximum of 1.41 ft, with a mean gauge height of 1.0 ft (Figure 5). Visibility conditions were classified as 'good' (exceeding 1 meter) during all survey dates.

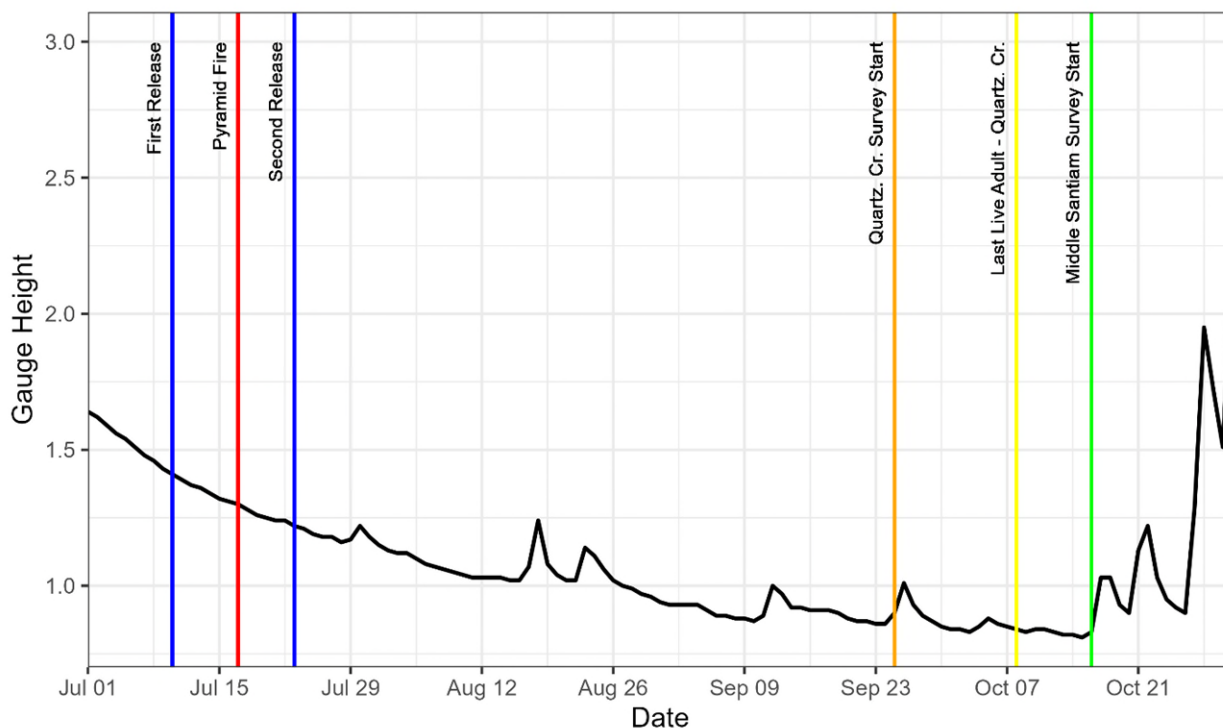


Figure 5. Mean daily gauge height at USGS Stream Gauge #14185800 on the Middle Santiam River near Cascadia, Oregon, during the 2024 survey period.

Adult Observations

As part of the spawning ground surveys, the location and number of live adult Chinook salmon encountered were recorded to evaluate their distribution and abundance throughout the study area. The following section details the observations made in Quartzville Creek and the Middle Santiam River, highlighting spatial and temporal trends in adult Chinook salmon presence during the 2024 survey season.

Quartzville Creek

A total of 154 live Chinook salmon were observed during the 2024 Quartzville Creek spawning surveys (Table 7 and Figure 6). The majority of live fish sightings (86.2%, $n = 131$) occurred in the Quartzville 1 reach. The highest number of observations occurred during Week 39 (September 25–27), with 102 adults observed, representing 66.2% of all adult observations for the 2024 season. Following the first week of surveys, adult observations declined rapidly. During Week 40 (September 30–October 4), 51 adults were observed, with 48 located in Quartzville 1 and three in Quartzville 2. Week 41 (October 7–11) marked the final week of live fish observations, with only one adult recorded in Quartzville 1. No fish were observed in Canal Creek during the survey period, despite the absence of apparent migration barriers. This absence was notable compared to previous survey periods, with 51 adults observed in 2022 and 19 in 2023. The consistent trend across the 2022, 2023, and 2024 seasons has been a concentration of adult observations

in Quartzville 1, with the majority occurring during the first full survey week following release (CFS 2023; EAS 2024).

Table 7. Quartzville Creek Chinook salmon adult observations by statistical week and reach.

Week	Quartzville 1	Quartzville 2	Quartzville 3	Quartzville 4	Canal 1	Total Observations
39	82	14	1	5	0	102
40	48	3	0	0	0	51
41	1	0	0	0	0	1
42	0	0	0	0	0	0
43	0	0	0	0	0	0
Total	131	17	1	5	0	154

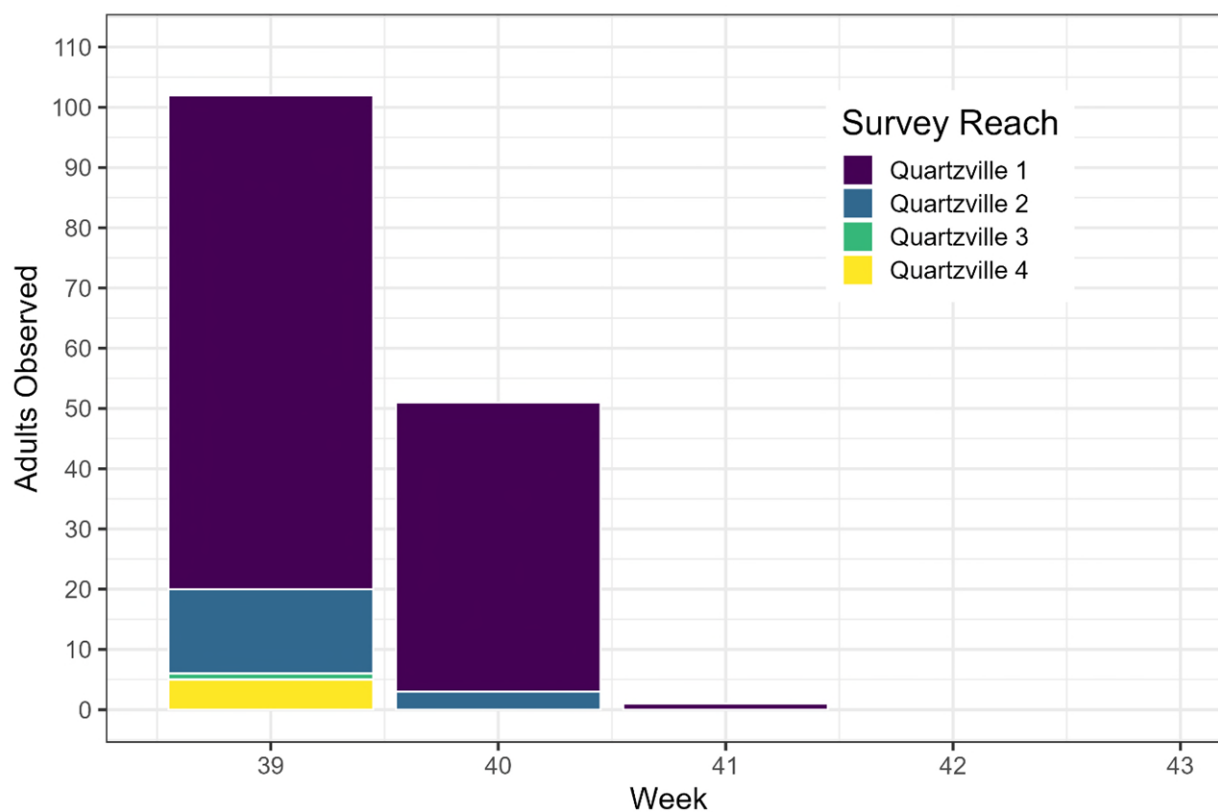


Figure 6. Quartzville Creek Chinook salmon adult observations by statistical week and reach.

Middle Santiam River

No live adult Chinook salmon were observed during the 2024 spawning surveys in the Middle Santiam River. This absence is likely attributable to the late timing of the surveys, which were conducted during statistical weeks 42 and 43. For comparison, surveys in Quartzville Creek yielded only one live adult observation during statistical week 41 and no observations during weeks 42 and 43 (Table 7).

Carcass Recoveries

Carcass surveys for spring Chinook salmon were conducted in Quartzville Creek and the Middle Santiam River during the 2024 season. These recoveries are critical for estimating pre-spawn mortality rates, particularly among females, and provide valuable data on length frequencies, sex ratios, and spatial distribution. Additionally, carcasses enable the collection of biological samples (e.g., fin clips for parentage analysis and scales or otoliths for age determination) enhancing our understanding of population dynamics. Prompt recovery is essential, as scavengers often remove carcasses shortly after senescence, potentially biasing data if collection is delayed.

Quartzville Creek

A total of 106 Chinook salmon carcasses were recovered during the 2024 spawning season in Quartzville Creek, representing 53% of the total fish released (Table 8; Figure 7). The majority of carcasses (86%, $n = 91$) were recovered within Reach 1. Carcass recovery began during the first week of surveys (Week 39), with 13 fish collected, peaked during Week 40 (44 carcasses), and declined steadily through the remainder of the sampling season, with only six carcasses recovered during each of Weeks 42 and 43 (Table 8). Minimal carcass recoveries occurred in Quartzville 2 ($n = 14$) and Quartzville 3 ($n = 3$), while no carcasses were recovered in Quartzville 4 or Canal 1.

Table 8. Distribution of Chinook salmon carcasses recovered during the 2024 Quartzville Creek spawning surveys, by reach and statistical week.

Reach	Week					Total
	39	40	41	42	43	
Quartzville 1	11	37	33	5	5	91
Quartzville 2	2	7	3	1	1	14
Quartzville 3	0	1	0	0	0	3
Quartzville 4	0	0	0	0	0	0
Canal 1	0	0	0	0	0	0
Total	13	44	36	6	6	106

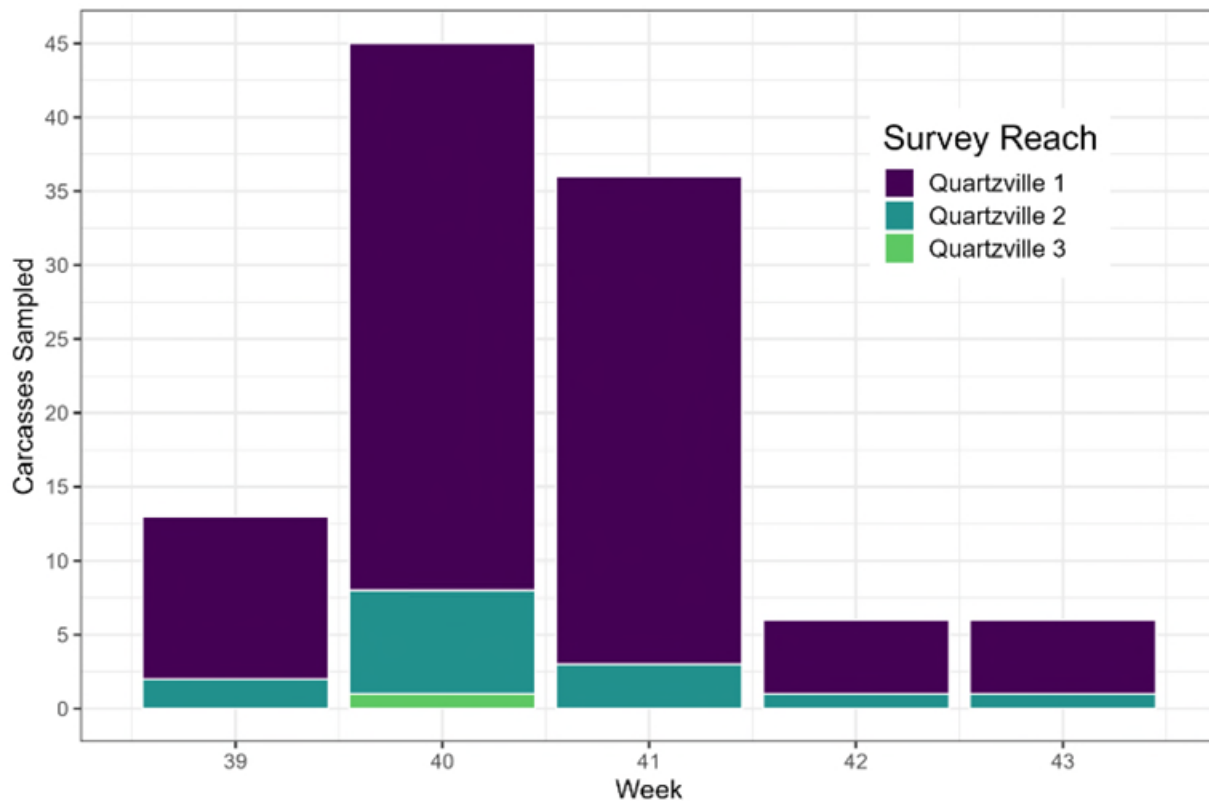


Figure 7. Distribution of Chinook carcasses recovered during the 2024 Quartzville Creek spawning surveys, by reach and statistical week.

The overall sex ratio of recovered carcasses was nearly 1:1, with 46 females and 51 males identified (nine carcasses were too degraded for sex determination; Table 9). Sex ratios varied between reaches, with a slightly higher proportion of females in Quartzville 1 (43 males females, 42 males) and a higher proportion of males in Quartzville 2 (3 females, 8 males). Fork lengths ranged from 620–890 mm for females and 640–925 mm for males. Carcasses recovered in Quartzville 1 had an average fork length of 764 mm while those in Quartzville 2 averaged 796 mm.

Table 9. Fork lengths (mm) of Chinook salmon carcasses from the 2024 Quartzville Creek spawning surveys, by reach and sex, showing minimum, mean, and maximum values for females, males, and unknown-sex individuals, with sample sizes (n) included.

Reach	Sex	n	Carcass Fork Length (mm)		
			Minimum	Mean	Maximum
Quartzville 1	Female	43	620	759	890
Quartzville 1	Male	42	640	770	925
Quartzville 1	Unknown	6	700	725	750
Quartzville 2	Female	3	820	847	870
Quartzville 2	Male	8	620	777	920
Quartzville 2	Unknown	3	NA	NA	NA
Quartzville 3	Male	1	840	840	840

Of the 46 female carcasses, 10 retained at least 50% of their eggs, resulting in an estimated female pre-spawn mortality rate of 21.7% (Table 10).

Table 10. Pre-spawn mortality estimates for female Chinook salmon carcasses recovered during the 2024 Quartzville Creek spawning surveys.

Egg Retention %	Yes	No	Pre-spawn mortality %
> 50	10	36	21.7

No adfluvial Chinook were observed during the season. Of the 106 carcasses recovered, 18 were missing tags. Biological samples (fin clips, otoliths, or scales) were collected from 10 of these 18 untagged carcasses; the remaining eight were too degraded for sample collection.

Middle Santiam River

A total of 37 Chinook salmon carcasses were recovered in the Middle Santiam River survey area during the 2024 season, representing 6% of the total fish released (Table 11). The majority of carcasses were recovered in the Santiam 1 reach and the upper half of the Santiam 2 reach. Approximately midway through Santiam 2, the riparian corridor transitions from a low-gradient, unrestricted valley to a high-gradient, restricted canyon. Notably, 92% (33/36) of carcasses were located in the upper, unrestricted valley section, with only one carcass found in the restricted canyon.

Table 11. Distribution of Chinook salmon carcasses recovered during the 2024 Middle Santiam River spawning surveys, by reach.

Reach	Carcasses
Santiam 1	19
Santiam 2	15
Santiam 3	2
Total	36

Due to the late timing of the surveys, carcass conditions were generally poor. Many carcasses were reduced to skeletal remains with no flesh remaining (Table 12). Intact carcasses were rare and typically covered in fungus or severely deteriorated. While skeletal remains are typically excluded from carcass surveys, they were recorded in this study to provide spatial distribution data for Chinook salmon, as this area had not been surveyed earlier in the season. Additionally, three tags were recovered without associated fish or remains and were counted as carcasses. Of the 36 carcasses, only four were in sufficient condition to measure fork length, and five were intact enough for sex determination, representing less than 1% of all outplanted adult Chinook salmon.

Table 12. Middle Santiam River recovered carcasses condition.

Carcass Condition	Total Number
Dry	4
Poor	29
Tag Only	3

Redd Enumeration

Redd surveys for spring Chinook salmon were conducted during the 2024 spawning season in Quartzville Creek and the Middle Santiam River, with redd locations recorded whenever observed. Identified redds (substrate disturbances forming a pot, mound, and tailspill; Bjornn and Reiser 1991) serve as key indicators of spawning activity and habitat selection. These observations provide insight into timing, distribution, and physical characteristics of spawning sites, and reproductive success and habitat preferences across the surveyed reaches.

Quartzville Creek

A total of 27 Chinook salmon redds were observed during the 2024 spawning season in Quartzville Creek (Table 13). Consistent with patterns observed in adult and carcass distributions, the majority of redds (92.5%, $n = 25$) were constructed within the Quartzville 1 reach (Figure 8). Redd construction began

almost immediately, with 10 redds completed on September 25th, approximately 24 hours after the release at Miner Camp. Spawning activity peaked during Weeks 39 and 40, with 10 redds constructed in each week, and concluded by Week 41 (Table 13). No redds were observed in Quartzville 3, Quartzville 4, or Canal 1, mirroring the absence of adult observations in these reaches.

Table 13. Distribution of Chinook salmon redds observed during the 2024 Quartzville Creek spawning surveys, by reach and statistical week.

Reach	Week					Total Redds
	39	40	41	42	43	
Quartzville 1	10	10	5	0	0	25
Quartzville 2	2	0	0	0	0	2
Quartzville 3	0	0	0	0	0	0
Quartzville 4	0	0	0	0	0	0
Canal 1	0	0	0	0	0	0
Totals	12	10	5	0	0	27

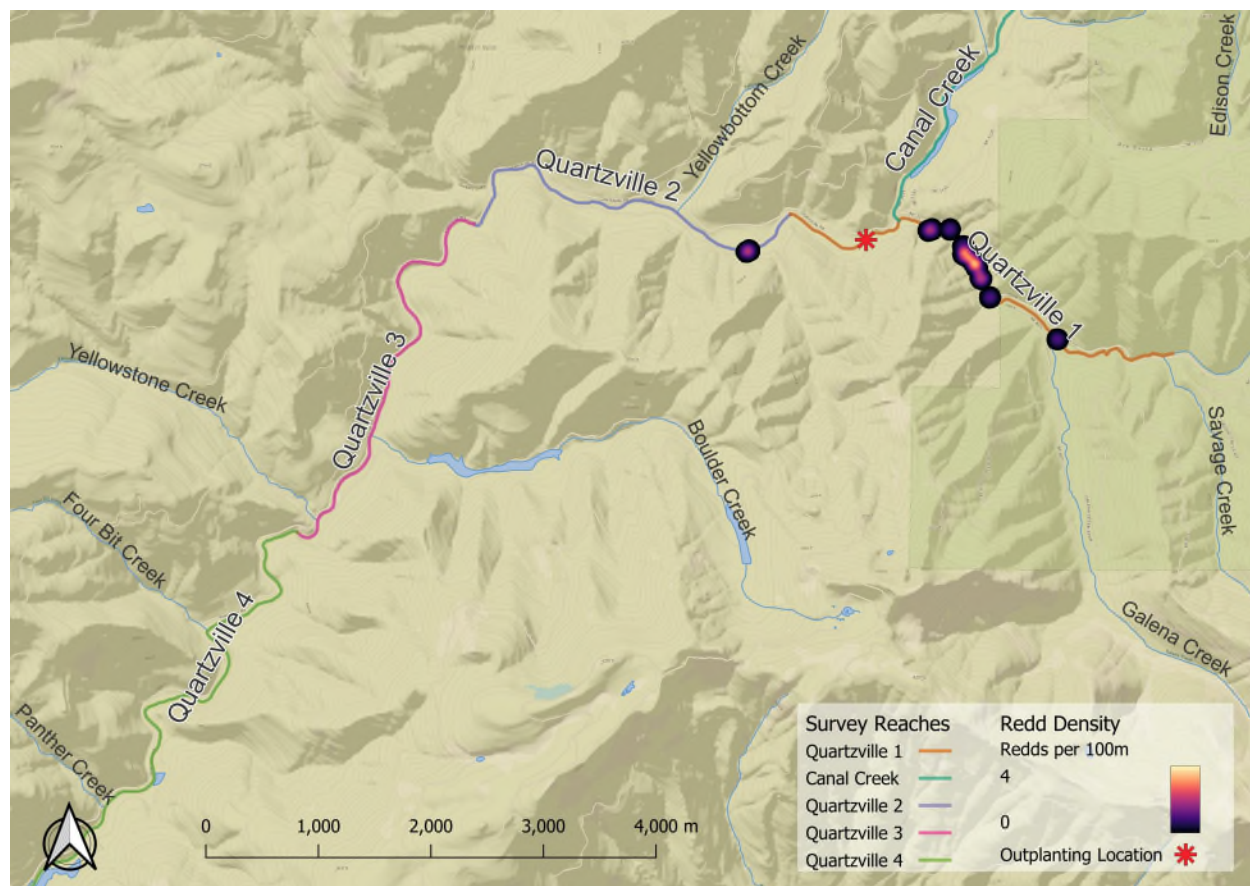


Figure 8. Map of redds per 100 meters in Quartzville Creek.

Middle Santiam River

A total of 17 Chinook salmon redds were observed during the single complete survey of the Middle Santiam River in 2024, conducted over three days across three reaches (Table 14). The majority of redds ($n = 8$) were located in Santiam 1, followed by Santiam 2 ($n = 5$) and Santiam 3 ($n = 4$) as illustrated in Figure 9. The distribution of redds across reaches suggests that spawning activity was concentrated in Santiam 1, with progressively fewer redds observed in downstream reaches.

Table 14. Distribution of Chinook salmon redds observed during the 2024 Middle Santiam River spawning survey, by reach.

Reach	Redds
Santiam 1	8
Santiam 2	5
Santiam 3	4
Total	17

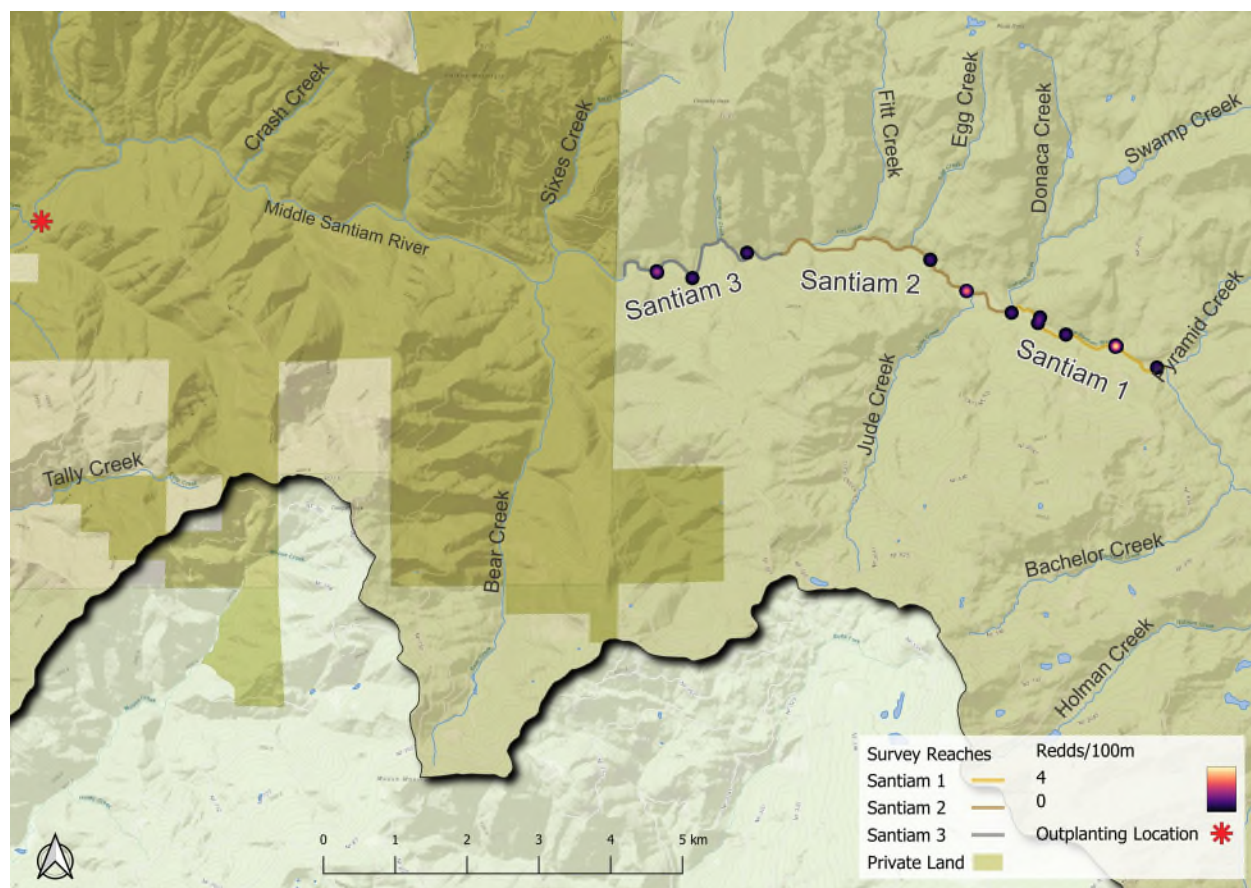


Figure 9. Map of redds per 100 meters in the Middle Santiam River.

DISCUSSION

Survey Effort

Survey effort in Quartzville Creek was not impacted by adverse weather or high stream flows during the 2024 spawning season. Stream flows remained low throughout the survey period, similar to conditions observed during the 2022 spawning season. This contrasts with the 2023 season, when a significant storm event on October 12th caused flows to exceed 1,400 cfs, necessitating adjustments to survey methods and timing (CFS 2023; EAS 2024). The consistently low flows in 2024 facilitated uninterrupted survey efforts and allowed for data collection across the entire season.

In contrast, survey efforts in the Middle Santiam River were severely impacted by the Pyramid Fire, which ignited on July 17th, just days after the first release of adult Chinook salmon on July 10th. A second release occurred on July 23rd, but surveys planned to commence in August were delayed due to fire-related access restrictions. Surveys did not begin until October 16th, by which time all spawning activity in the accessible areas had concluded. Additionally, the spatial scope of the surveys was significantly reduced; Pyramid Creek and the Middle Santiam River above its confluence with Pyramid Creek were inaccessible. It is highly probable that these limitations resulted in an underestimation of spawning activity and carcass recovery in the Middle Santiam River, as the delayed and restricted surveys precluded the observation of peak spawning events and the collection of biological data.

Carcass Recoveries

A total of 106 Chinook salmon carcasses were recovered in Quartzville Creek during the 2024 spawning season, representing 53% of the total fish released (Table 8). Consistent with findings from previous survey years (2022 and 2023), the majority of carcasses were recovered in Quartzville 1, while significantly fewer carcasses were found in downstream reaches, including Quartzville 2, Quartzville 3, and Quartzville 4. Notably, no carcasses were recovered in Canal Creek during the 2024 season, a departure from the previous two years when adults, carcasses, and redds were observed in this reach. Spawning activity and carcass distribution were heavily concentrated in Quartzville 1, likely due to a combination of factors such as outplanting release timing, release location, river conditions, and reach-specific habitat characteristics.

Pre-spawn mortality in Quartzville Creek appeared elevated this year, with 10 of 46 recovered females exhibiting greater than 50% egg retention, corresponding to a rate of 21.7%. This is notably higher than the rates observed in previous years: 11% in 2022 and 8% in 2023. The increased pre-spawn mortality

may be attributable to the low flow conditions experienced during the migration period, which creates stressful conditions for females attempting to reach suitable spawning sites.

In contrast with Quartzville Creek, only 37 Chinook salmon carcasses were recovered in the Middle Santiam River survey area during the 2024 season, representing 6% of the total fish released. The late timing and reduced spatial scope of the Middle Santiam River surveys, necessitated by the Pyramid Fire, severely limited our ability to recover carcasses. The majority of carcasses we did recover were reduced to skeletal remains or were severely deteriorated, with only four carcasses intact enough to measure fork length and five suitable for sex determination. The majority of carcasses were recovered in Santiam 1 and the upper, unrestricted valley section of Santiam 2, with only one found in the restricted canyon section of Santiam 2. This pattern indicates that spawning activity was likely concentrated in lower-gradient, unrestricted valley habitats, which may offer better conditions for spawning and carcass retention. Future surveys in the Middle Santiam should prioritize defining survey reach boundaries based on geomorphic features rather than daily survey duration or logistical constraints.

Redd Distribution and Abundance

In Quartzville Creek, 2024 spawning activity was limited to Quartzville Reach 1 and Quartzville Reach 2, with no redds observed in downstream reaches or tributaries, including Canal Creek. Most spawning occurred in Quartzville Reach 1, consistent with patterns observed in 2022 and 2023, when the majority of redds were also in Reach 1. However, in 2022 and 2023, redds were documented in Canal Creek (9 and 12, respectively), and in 2022, two redds were recorded in Quartzville Reach 4. Two factors likely explain the interannual variation in redd distribution. First, adult outplant timing differed: fish released in 2023 (September 26) and 2024 (September 25) were closer to spawning readiness than those released in 2022 (September 8), reducing post-release dispersal time. Second, stream discharge between outplanting and spawning cessation varied notably across years. Mean daily discharge during the period of new redd construction was 30.2 cfs in 2022, 111 cfs in 2023, and 20 cfs in 2024. Low flows in 2024 likely restricted downstream movement through shallow bedrock sections and step-pool sequences, while also limiting access to tributaries with steep alluvial fans and slot canyon features at their confluence. For instance, Canal Creek's confluence with Quartzville Creek includes a 200-meter section of narrow slot canyons and shallow step pools, which may have impeded upstream migration despite no absolute barriers.

In 2024, 27 unique Chinook salmon redds were documented in Quartzville Creek, matching the count recorded by CFS in 2022 but representing a substantial decline from the 89 redds reported by EAS in 2023. Assuming a 1:1 female-to-male spawning ratio, the 2024 redd total corresponds to an estimated 54

successfully spawning adults (27% of the outplanted population). This interannual variability is partially explained by hydrologic differences: the elevated base flows in 2023 likely expanded available spawning habitat and reduced competition for spawning sites, while 2024's low-flow conditions restricted habitat availability. Our crews identified 12 test redds in 2024. Under a hypothetical scenario where all test redds were misclassified and represent completed spawning activity, the adjusted 2024 total rises to 39 redds (78 spawners). Incorporating the observed 21.7% pre-spawn mortality rate and assuming equal sex distribution, approximately 44 individuals died prior to spawning. This yields a potential spawning population of 156 adults, suggesting a maximum spawning success rate of 50% (78/156) under optimal assumptions. Future studies examining how flow regimes affect spawning habitat availability could clarify differences in spawning success across years.

Stream temperatures in the Middle Santiam River likely influenced migration behavior and spawning success of outplanted adult Chinook salmon in 2024. Outplanting occurred on days when daily maximum stream temperatures exceeded 20°C. Following the first release, the 7-day average daily maximum temperature exceeded 20°C for 27 days in the vicinity of the releases, with the mean daily temperature falling just below. Such temperatures are known to affect adult Chinook salmon, potentially inhibiting upstream migration and prompting fish to seek cold-water refugia. For instance, one outplanted adult was later captured in research nets in Green Peter Reservoir, indicating downstream movement, possibly to escape thermal stress after release. Additionally, Bowerman et al. (2017) found that pre-spawn mortality in Upper Willamette River Spring Chinook salmon females exceeded 80% annually when maximum temperatures surpassed 20°C and hatchery-origin fish comprised over 80% of spawners, though mortality rates typically declined at higher elevations. Future outplanting efforts should consider water temperature at release and forecasted conditions to optimize adult survival and spawning success.

In the Middle Santiam River, 17 Chinook salmon redds were documented during a single three-day survey across three accessible reaches. Survey efforts were severely constrained by logistical challenges: access to downstream sections was restricted due to landowner permissions, while upstream areas above the Middle Santiam-Pyramid Creek confluence remained inaccessible because of post-Pyramid Fire hazards. These limitations confined surveys to <50% of potential spawning habitat, excluding critical reaches that may have harbored additional redds. Despite these constraints, the observed redd distribution suggested preferential use of habitats with lower gradient and wider valley-bottoms. Future surveys should prioritize expanded spatial coverage, particularly in fire-affected upstream reaches and downstream sections currently under private ownership, as well as multiple assessments through time to describe peak spawn

timing in this system. Concurrently, post-fire habitat evaluations would be useful to quantify impacts such as sedimentation rates, large wood recruitment, and substrate embeddedness, which may influence future spawning success.

The 2024 spawning surveys above Green Peter Dam documented Chinook salmon spawning activity in Quartzville Creek and the Middle Santiam River, despite challenges from low flows and the Pyramid Fire's disruption. The work highlighted how habitat access, stream conditions, and outplant timing shape redd distribution and adult survival in these reintroduction areas. In Quartzville Creek, spawning was confined to upstream reaches, while in the Middle Santiam, fire-related access issues limited our understanding of broader habitat use. Future efforts could expand surveys to fire-affected and restricted zones, refine release timing to match fish readiness and ideal environmental conditions, and explore how flow and temperature regimes influence spawning success to support long-term population recovery.

REFERENCES

- Bjornn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-138.
- Blumm, M. C. 2002. Sacrificing the Salmon: A legal and policy history of the decline of the Columbia River salmon. Beverly Hills, FL: Book World Publications.
- Bowerman, T., A. Roumasset, M.L. Keefer, S.S. Sharpe, and C.C. Caudill. 2018. Prespawn mortality of female Chinook salmon increases with water temperature and percent hatchery origin. Transactions of the American Fisheries Society. 147:31-42
- Bradford, M. J. and J. R. Irvine. 2000. Land use, fishing, climate change and the decline of Thompson River, British Columbia, coho salmon. Can. J. Fish. Aquat. Sci. 57: 13-16.
- Cramer Fish Sciences. 2023. 2022 Spring Chinook Salmon Spawning Surveys in Quartzville Creek. Prepared for the United States Army Corps of Engineers, Portland District.
- Crawford, B., T.R. Mosey, and D.H. Johnson. 2007. Carcass Counts. Pages 59-86 in D.H. Johnson, B.M. Shrier, J.S. O'Neal, J.A. Knutzen, X. Augerot, T.A. O'Neil, and T.N. Pearsons. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.
- Environmental Assessment Services. 2024. 2023 spring Chinook salmon spawning surveys in Quartzville Creek. Prepared for the United States Army Corps of Engineers, Portland District.

- Good, T. P., R. S. Waples, and P. Adams (editors). 2005. Updated status of federally listed
Seuss of West Coast salmon and steelhead. U.S. Dept. Commer., NOAA Tech. Memo.
NMFS-NWFSC-66, 598 p.
- Gallagher, S.P. and C.M. Gallagher. 2005. Discrimination of Chinook salmon, coho salmon, and
steelhead redds and evaluation of the use of redd data for estimating escapement in several
unregulated streams in Northern California. *North American Journal of Fisheries Management*.
25:284-300.
- Gregory, S. V., and P. A. Bisson. 1997. Degradation and loss of anadromous salmonid habitat
in the Pacific Northwest. pp 277-314 in D. J. Stouder, P. A. Bisson, and R. J. Naiman,
editors. *Pacific salmon and their ecosystems*. Chapman and Hall, New York.
- Huntington, C. W.; W. Nehlsen; J. Bowers. 1996. A survey of healthy native stocks of
anadromous salmonids in the Pacific Northwest and California. *Fisheries*. 21(3): 6-15.
- Lichatowich, J. A. 1999. *Salmon without rivers: a history of the Pacific Salmon crisis*. Island
Press, Washington, D. C. 333 pp.
- Lindsey, C., Morasch, M. and Paulsen, M., 2019. Spring Chinook Salmon Spawning Surveys in the
Upper Willamette River Basin in 2018.
- McCullough, D.A., Bartholow, J.M., Jager, H.I., Beschta, R.L., Cheslak, E.F., Deas, M.L., Ebersole,
J.L., Foott, J.S., Johnson, S.L., Marine, K.R., Mesa, M.G., Petersen, J.H., Souchon, Y., Tiffan,
K.F., Wurtsbaugh, W.A., 2009. Research in thermal biology: burning questions for coldwater
stream fishes. *Rev. Fish. Sci.* 17, 90–115.
- Myers J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grand,
F. W. Waknitz, K. Neely, S. T. Lindley, R. S. Waples. 1998. Status review of Chinook
salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech
Memo. NMFS-NWFSC-35, Seattle, WA.
- National Marine Fisheries Service (NMFS). 2008. Endangered Species Act Section 7(a)(2) Consultation
Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential
Fish Habitat Consultation: Consultation on the Willamette River Basin Flood Control Project,
Oregon. NMFS Consultation Number: NWR-2000-02117. Northwest Region, Portland, OR.
- 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*. 16(2): 4-21.
- Richter, A., & Kolmes, S. A. 2005. Maximum temperature limits for Chinook, coho, and chum salmon,
and steelhead in the Pacific Northwest. *North American Journal of Fisheries Management*, 25(1),
275–278.
- Sharpe, C.S., Mapes, R.L., Cannon, B., Olmsted, P., Sinnott, M., DeBow, B., Bailey, E., Hoblit, T. and
Friesen, T.A., 2017. Abundance, distribution, diversity and survival of adult spring Chinook
salmon in the Upper Willamette River: 2015 and 2016. Prepared for the US Army Corps of
Engineers, Portland District, Task Orders: W9127N-12-2-0004-4009 and W9127N-10-2-0008-
0036, p.141.