Thompson Falls Hydroelectric Project
FERC Project No. 1869

Updated Study Report
Fish Behavior Study 2021-2022

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Table of Contents

Table of Contents ...... ES-i

Executive Summary ES-1
Fish Behavior Study Background ES-1
Methods ES-1
Results ES-2
Travel Time ES-2
Movement Patterns ES-3
Fish Passage Efficiency ES-3
Water Temperature in the ZOP ES-3
Fish Depth ES-3
Fish Swimming Abilities and CFD Modeling ES-4
Discussion ES-4
Effectiveness of Study Methodology ES-4
Fish Passage Conditions at Varying Flows ES-5
Location of Fish Passage Facility ES-5
Water Temperature Effects on Fish Migration ES-6
2023 Study Season ES-6

1. Introduction 1-1
1.1 Fish Behavior Study Background 1-1
1.2 Goals and Objectives of Study 1-3

2. Methods 2-1
2.1 Overview of Approach 2-1
2.2 Study Area 2-1
2.3 Tagging and Monitoring Equipment 2-3
2.4 Fish Collection 2-7
2.5 Training and Testing Procedures 2-7
2.6 Monitoring and Data Processing Procedures 2-8
2.7 Study Assumptions 2-8
2.8 Fish Behavior Data Analysis 2-9
2.9 CFD Modeling Data Analysis 2-9
2.10 Variances from the FERC-approved Study Plan 2-12

3. Results 3-1
3.1 Fish Collection and Tagging 3-1
3.2 River Conditions 2021 and 2022 3-2
3.3 Fish Telemetry Results 3-3
3.4 Travel Time 3-4
3.4.1 Travel Time from Release Location to Far Field 3-4
3.4.2 Travel Time from the Far Field to the Near Field 3-5

3.4.3 Travel Time from the Near Field to the Entrance of the Fish Passage Facility 3-6
3.5 Movement Patterns 3-7
3.5.1 Rainbow Trout 3-7
3.5.2 Brown Trout 3-13
3.5.3 Movement Patterns in the Far Field 3-21
3.5.4 Movement Patterns in the Near Field 3-23
3.5.5 Fish Passage Facility Entrances 3-27
3.5.6 Summary of Locations Where Fish Hold within the ZOP 3-28
3.6 Water Temperature Profiles 3-31
3.7 Fish Depth 3-35
3.8 Fish Swimming Abilities and CFD Modeling 3-37
3.8.1 Model Scenario: 200 cfs 3-38
3.8.2 Model Scenario: 2,000 cfs 3-42
3.8.3 Model Scenario: 25,000 cfs 3-54
3.8.4 Model Scenario: 37,000 cfs 3-58
3.8.5 Fish Behavior at Modeled Scenarios 3-65
3.8.6 Summary 3-66

4. Discussion 4-1
4.1 Effectiveness of Study Methodology 4-1
4.2 Fish Passage Conditions at Varying Flows 4-2
4.3 Velocity Barriers in the ZOP 4-3
4.4 Fish Passage Efficiency 4-4
4.5 Location of Fish Passage Facility 4-5
4.6 Water Temperature Effects on Fish Migration 4-5

5. 2023 Study Season 5-1

6. Literature Cited 6-1

List of Figures

Figure 1-1. Study Areas as Defined by the Zone of Passage Concept. 1-4
Figure 2-1. Prominent Features of the Study Area. 2-2
Figure 2-2. Fixed Station Locations and Detection Zones, 2021 and 2022 Seasons. 2-5
Figure 2-3. Average Annual Hydrograph. 2-10
Figure 3-1. Mean Daily Streamflow and Water Temperature Recorded March 1 to October 29, 2021. 3-2
Figure 3-2. Mean Daily Streamflow and Water Temperature March 1 to October 26, 2022. 3-3
Figure 3-3. Daily Detections of Rainbow Trout by the Fixed Station Receivers, Total Clark Fork River Spill, and Water Temperature During the 2022 Study Season. 3-8
Figure 3-4 Monthly Manual Tracking of 23 Rainbow Trout, March – June 2022. 3-11
Figure 3-5. Manual Tracking of 14 Individual Rainbow Trout that Entered the Fish Passage Facility and 9 Individual Rainbow Trout that Did Not Enter the Fish Passage Facility, March – October 2022. 3-12
Figure 3-6. Daily Detections of Brown Trout by the Fixed Receivers, Mean Daily Spill at the Main Dam, and Daily Water Temperature Measurements, during 2022 Study Season. 3-13

Figure 3-7. Monthly manual tracking Brown Trout, March – June 2022. Number of individual fish detected in the ZOP each month provided. 3-17
Figure 3-8. Monthly manual tracking Brown Trout, June – October 2022. Number of individual fish detected in the ZOP each month provided. 3-18
Figure 3-9. Manual tracking of 7 individual Brown Trout that entered the fish passage facility (left) and 8 individual Brown Trout that did not enter the fish passage facility (right), March – October 2022. 3-19
Figure 3-10. Summary of Daily Detections from the Powerhouse and High Bridge Fixed Receiver Stations of Rainbow and Brown Trout in the Far Field and Mean Daily Spill at the Main Dam, 2022. 3-21
Figure 3-11. The Percentage of Rainbow Trout Detected in the Far Field by Month, 2022. 3-22
Figure 3-12. The Percentage of Brown Trout Detected in the Far Field by Month, 2022. 3-23
Figure 3-13. Summary of Daily Detections from the MDR and MDL Fixed Receiver Stations of Rainbow and Brown Trout in the Far Field and Mean Daily Spill at the Main Dam, 2022. 3-24
Figure 3-14. Percentage of Rainbow Trout Detected in the Near Field by Month, 2022. 3-25
Figure 3-15. The Number of MDR and MDL Receiver Detections of Rainbow Trout by Month, 2022. 3-25
Figure 3-16. The Number of MDR and MDL Receiver Detections of Brown Trout by Month, 2022. 3-26
Figure 3-17. Percentage of Brown Trout Detected in the Near Field by Month, 2022. 3-27
Figure 3-18. Summary of Individual Radio Tagged Rainbow Trout and Brown Trout Entering the Fish Passage Facility and Mean Daily Streamflow, 2022. 3-28
Figure 3-19. Manual Tracking of 23 Individual Radio-Tagged Rainbow Trout and 15 Individual Radio-Tagged Brown Trout, 2022 Season. 3-29
Figure 3-20. Temperature Profile Locations and Fixed Station Detection Zones. 3-32
Figure 3-21. Temperature Profile at Prospect Hole, High Bridge, and Dollar Hole on July 28, 2022. 3-34
Figure 3-22. Temperature Profile at Prospect Hole, High Bridge, and Dollar Hole on August 9, 2022. 3-35
Figure 3-23. Temperature Profile at Prospect Hole, High Bridge, and Dollar Hole on August 31, 2022. 3-35
Figure 3-24. Daily Average Depth (ft from surface) of Rainbow Trout and Brown Trout Detected by the High Bridge Station, 2022. 3-36
Figure 3-25. Run 4: 200 cfs Flow Path Streamlines. 3-40
Figure 3-26. CFD Modeled Water Velocity at 2,000 cfs Spill. 3-44
Figure 3-27. Model Scenario, 2,000 cfs. Cross-section at High Bridge. 3-48
Figure 3-28. Model Scenario, 2,000 cfs. Cross-section at the Falls. 3-49
Figure 3-29. Model Scenario, 2,000 cfs. Cross-section at the Fish Passage Facility Entrance. 3-50
Figure 3-30. Velocities at Fish Passage Facility Entrance Area: 2000 cfs. 3-51
Figure 3-31 Flow Path Streamlines, 2,000 cfs at the Main Dam. 3-52
Figure 3-32. Flow Path Details at the Fish Passage Facility Entrance under Model Run for 2,000 cfs at the Main Dam (river flow approximately 25,000 cfs). 3-53
Figure 3-33. Run 2: 25,000 cfs Upstream Fish Passage Facility Entrance Details. 3-56
Figure 3-34. CFD Modeled Velocity at 37,000 cfs Spill. 3-58
Figure 3-35. Model Scenario, 37,000 cfs. Cross-section at High Bridge. 3-59
Figure 3-36. Model Scenario, 37,000 cfs. Cross-section at the Falls. 3-60
Figure 3-37. Model scenario, 37,000 cfs. Cross-section at the Falls. 3-61
Figure 3-38. Model Scenario, 37,000 cfs. Cross-section at the Fish Passage Facility Entrance. 3-62

Figure 3-39. Flow Path Streamlines, 37,000 cfs. 3-64
Figure 3-40. Flow Path Details at the Fish Passage Facility Entrance: 37,000 cfs. 3-65

List of Tables

Table 2-1. Properties of Lotek MCFT3 Radio Tags. 2-4
Table 2-2. Flow Scenarios Utilized In 3D Simulations to Evaluate River Channel Hydraulics. 2-11
Table 2-3. Velocity Categories, Grouped by Fish Swimming Abilities. 2-12
Table 3-1. Trout Collection Summary for 2021 and 2022. 3-1
Table 3-2. Summary of the Rainbow and Brown Trout Detected in 2021 and 2022. 3-3
Table 3-3. Travel Time from the Far Field to the Near Field in 2021 and 2022. 3-6
Table 3-4. Summary of Radio Tagged Fish that Traveled from the Near Field to the Fish Passage Facility Entrance, 2021 and 2022. 3-7
Table 3-5 Monthly Summary of the Number of Individual Rainbow Trout Detected *via* Manual Tracking in the ZOP, 2022. Detections at the Ladder Entrance Represent a PIT Tag Recording. 3-8
Table 3-6 Monthly Summary of the Number of Individual Brown Trout Detected *via* Manual Tracking in the ZOP and PIT tag array in the fish passage facility entrance. 3-14
Table 3-7 Summary of 2019 Water Temperature Data. 3-31
Table 3-8. Summary of Upper Limit of Adult Fish Swimming Abilities, Prolonged and Burst Speed. 3-38
Table 3-9. Percent of Wetted Area Available for Fish to Access Based on Swimming Abilities: 2,000 cfs Model Scenario. 3-46
Table 3-10 Percent of Wetted Area Available for Fish: 37,000 cfs Model Scenario. 3-63
Table 3-11. Summary of 2D Model Estimated Maximum Velocity Near the High Bridge, Falls, and the Fish Passage Facility Entrance. 3-66
Table 3-12. Percentage of Cross-Section with Velocity Less Than 14.1 FPS. 3-67
Table A-1. Trout Collection Sampling Dates, Method, Location, Water Temperature, Effort, and Catch Per Unit Effort in 2021. 1
Table A-2. Trout Collection Sampling Dates, Method, Location, Water Temperature, Effort, and Catch Per Unit Effort in 2022 2
Table A-3. Trout Tagged and Transported in 2021. 3
Table A-4. Trout Tagged and Transported in 2022. 4

List of Appendices

Appendix A 2021 and 2022 Fish Collection Details
Appendix B Travel Time for 2021 and 2022 Radio Tagged Trout

List of Abbreviations and Acronyms

~	approximately
%	percent
<	less than
>	greater than
°C	degrees Celsius
2D	two-dimensional
3D	three-dimensional
CFD	computational fluid dynamics
cfs	cubic feet per second
FERC	Federal Energy Regulatory Commission
fish passage facility	Thompson Falls Upstream Fish Passage Facility
Flatiron FAS	Flatiron Ridge Fishing Access Site
fps	feet per second
FSR	Final Study Report
FWP	Montana Fish, Wildlife and Parks
FWS	U.S. Fish and Wildlife Service
HB zone	High Bridge zone
HVJ	high velocity jet
ILP	Integrated Licensing Process
ISR	Initial Study Report
Licensee	NorthWestern Energy
ladder	Thompson Falls Upstream Fish Passage Facility
Main Dam	Main Channel Dam
MDL	Main Dam Left
MDR	Main Dam Right
MHz	megahertz
NorthWestern	NorthWestern Energy
PIT	passive integrated transponder
Project	Thompson Falls Hydroelectric Project
PSI	pound-force per square inch
Scientific Panel	Thompson Falls Scientific Review Panel
TAC	Technical Advisory Committee
TC	terms and conditions

Thompson Falls Project	Thompson Falls Hydroelectric Project
U.S.	United States
USFS	U.S. Forest Service
USGS	U.S. Geological Service
vs.	versus
ZOP	Zone of Passage

Executive Summary

The Thompson Falls Hydroelectric Project (Thompson Falls Project or Project) is located on the Clark Fork River in Sanders County, Montana. Non-federal hydropower projects in the United States (U.S.) are regulated by the Federal Energy Regulatory Commission (FERC) under the authority of the Federal Power Act. The current FERC License expires December 31, 2025.

This Fish Behavior Study – Updated Study Report has been prepared to comply with the requirements of NorthWestern Energy's (NorthWestern, Licensee) Revised Study Plan, filed April 12, 2021, as approved in FERC's Study Plan Determination (2021) and FERC's Determination on Disagreements/Amendment Requests (2022) (Modified Study Plan).

Fish Behavior Study Background

The Project is located on the lower Clark Fork River near the town of Thompson Falls, Montana in Sanders County. Between 2009 and 2010, the Licensee constructed the Thompson Falls Upstream Fish Passage Facility (fish passage facility or ladder) along the right abutment of the Main Channel Dam (Main Dam) designed to address upstream fish passage for the federally threatened Bull Trout (*Salvelinus confluentus*).

In compliance with FERC's Study Plan Determination (2021), this study focuses on Rainbow and Brown trout, which are important game fish in the study area and serve as surrogate species to better understand upstream fish passage efficacy for Bull Trout (Scientific Panel 2020).

The goal of this study is to evaluate upstream fish movement *via* radio telemetry[1] through the Project's zone of influence[2] which is defined by the Zone of Passage (ZOP) concept (FWS 2017). The ZOP concept defines discrete areas for analysis of the pathway fish use to move through the influence of the Project. These areas include far field, near field, entry, internal fish passage facility, exit, and upstream. The ZOP concept provides a method to measure passage effectiveness and identify attributing causes and influences (Project and non-project related) to upstream passage effectiveness. This study focuses on fish movement in the far field, near field, and fish passage facility entrance.

Methods

The evaluation of fish behavior in the study area was conducted through radio telemetry. Fixed receivers were installed to continuously monitor the movement of tagged fish. Then Rainbow and Brown trout were collected, anesthetized, and a radio tag inserted in the body cavity of each fish. The tagged fish were transported downstream to the Flatiron Ridge Fishing Access Site (Flatiron

[1] Radio telemetry uses individually coded tags which transmit radio waves which can be detected with receivers mounted on shore.

[2] Zone of Influence means an area within which there are positive or negative effects as a result of the Project.

FAS), 4 miles downstream of the study area, and released. Mobile tracking was also used to define specific locations where the tagged fish were located in the study area.

The data were analyzed to determine the travel time between key locations in the study area, the proportion of fish that entered the ZOP and specific locations within the ZOP, areas and water depths where fish hold in the ZOP.

The results from the Hydraulic Conditions Study were also evaluated to assess how velocities in the ZOP may influence upstream fish passage.

Results

In 2021, seven Rainbow Trout and six Brown Trout were radio tagged in June, and three Brown Trout were radio tagged in late September and early October, for a total of 16 radio tagged trout. In 2022, 29 Rainbow Trout and eight Brown Trout were radio tagged in March and 17 Brown Trout were radio tagged in September for a total of 54 trout tagged in 2022, and 70 fish tagged overall.

Travel Time

All but one radio tagged trout released at the Flatiron FAS were later detected in the ZOP. Both Brown Trout and Rainbow Trout demonstrated an ability to travel upstream rapidly, reaching the far field from the Flatiron FAS as quickly as 1 hour, and finding the fish passage facility entrance from the near field in as quickly as an hour.

Behavior of Brown Trout tagged in March 2022 was different than Brown Trout tagged in September 2022 (**Table EX-1**). Most notably, the travel time for spring-tagged Brown Trout from the far field to the fish passage facility entrance averaged 136 days, whereas Brown Trout tagged in September 2022 made the journey in an average of 0.08 days. It appears the majority of radio tagged Brown Trout enter the fish passage facility during the fall months regardless of the individual fish's ability to navigate upstream to the near field earlier in the spring.

In contrast, all Rainbow Trout movements into the near field were made in both March and April.

Table EX-1. Travel Time in Days for Fish Tagged in 2022.

	# Tagged	Flatiron FAS to Far Field days average (range)	Far Field to Near Field average (range)	Near Field to Fish Passage Facility Entrance average (range)
RB Tagged in March	28	2.6 (0.04–11.4)	7.3 (0.08–32.7)	8.2 (0.03-38)
LL Tagged in March	8	5.1 (0.7–16.1)	28.4 (1.1-102.9)	136 (112-172)
LL Tagged in September	17	1.8 (0.04–9.3)	14.4 (2.4-25.8)	0.08 (0.3-1.2)

Notes: LL = Brown Trout; RB = Rainbow Trout.

Movement Patterns

The two areas where Brown and Rainbow trout congregated the most were near the mouth of Prospect Creek and along the right side of the Main Dam, near the upstream fish passage facility. Most fish move up the main section of the channel did not concentrate near the Original Powerhouse or the New Powerhouse, although some fish were detected for short periods of time in these locations before moving further upstream.

Rainbow Trout were observed utilizing many locations in the ZOP, however in the near field, Rainbow Trout concentrated within the Main Dam Right (MDR) zone near the fish passage facility entrance during March and April. There were few detections of Rainbow Trout in the Main Dam Left (MDL) zone. Rainbow Trout presence in the ZOP was greatest during the spring months in both the far and near field before tapering off rapidly when runoff occurred in June and then with few detections into the summer and fall months.

There was no consistent holding area observed for Brown Trout in the ZOP during the spring and summer months. Peak activity in the ZOP and upstream movement into the fish passage facility occurred in the fall.

Fish Passage Efficiency

Of the 53 radio tagged trout detected entering the ZOP in 2022, 72 percent (25 Rainbow Trout and 13 Brown Trout) were detected in the near field. Of the 38 fish that were detected in the near field, just over half (14 Rainbow Trout and 7 Brown Trout) were detected entering the fish passage facility entrance. Therefore, proportion of fish that were detected in the far field and located the fish passage entrance was approximately 40 percent, 48 percent of Rainbow Trout and 29 percent of Brown Trout.

Water Temperature in the ZOP

NorthWestern water temperature monitoring of the Clark Fork River upstream and downstream of the study area shows that water temperatures in the summer are warm throughout the Clark Fork River system. There is no difference in temperature upstream and downstream of the Project.

Water temperature data collected in conjunction with the telemetry study allowed NorthWestern to examine thermal profiles in the study area. NorthWestern collected temperature profile data in both 2021 and 2022 at three locations downstream of the Main Dam: Prospect Hole, High Bridge, and Dollar Hole. In both years, all three sites showed distinct thermal stratification during the summer.

Fish Depth

During the summer months when the thermocline has been established, trout are more often found in deeper waters to access cooler water temperatures. During the spring and fall periods, trout are found primarily at shallower depths, but also venture into depths greater than those found in the summer months. The majority of Rainbow Trout remained within 2 to 8 feet of the surface until around July 10 when Rainbow Trout dispersed to different depths (maximum depth ~19 feet). Detections during peak summer temperatures were about 17 feet below the surface within the High Bridge zone. Detections stopped abruptly August 21 and Rainbow Trout were not detected again until the end of September and early October when there were a few fish at various depths.

Brown Trout showed a similar behavior to Rainbow Trout with regards to location in the water column during the spring. Brown Trout were limited in detections during the summer. In the fall, Brown Trout were observed mostly at depths ranging from 1 to 17 feet with the deepest recorded at 43 feet.

Fish Swimming Abilities and CFD Modeling

During the Hydraulic Modeling Study, two-dimensional (2D) modeling of spill discharge of 200, 2,000, 25,000, and 37,000 cubic feet per second (cfs) was conducted. The three-dimensional (3D) model was applied to the 2,000 and 37,000 cfs spill discharge.

The modeling showed that two locations (High Bridge and falls) present maximum velocities of 20 feet per second (fps) or greater at some flows, exceeding swimming abilities of local fish species. Based on the 3D modeling, the falls appear to be a challenging area for upstream fish passage during all flows. When spill is 37,000 cfs at the Main Dam, both the High Bridge and the falls have a maximum velocity of 20 fps. However, in the two high flow scenarios, the velocities near the fish passage facility entrance remain 7.0 fps or less and appear to be accessible to local fish species. Although maximum velocity at the fish passage facility entrance exceeds 7.0 fps at low flows, these maximum velocities represent attraction flow for fish.

At the lower flows modeled (200 and 2,000 cfs), discharges from the fish passage facility produce a significant portion of the flow in near field and most of the flow path streamlines are concentrated near the entrance of the fish passage facility, resulting in fish attraction flow to the fish passage facility entrance. At the higher modeled flows (25,000 and 37,000 cfs), there are limited flow path streamlines from the upstream fish passage facility, as the flow is quickly mixed with turbulence and flow from the radial gates. Velocities are relatively low (<5 fps) at the upstream fish passage facility, but the high velocity jet (HVJ) has limited influence on the resulting downstream velocity field.

Discussion

Effectiveness of Study Methodology

- The Scientific Review Panel recommended a minimum of 50 fish be used in the telemetry study. By the time the study is complete (July 2023), the sample size will be 100 fish and will meet the recommendations of the Thompson Falls Scientific Review Panel (Scientific Panel).

- To date, all but one of the 70 fish collected, tagged, and transported downstream for release at Flatiron FAS were later detected in the far field. These data indicate that handling or tagging mortality was low or none during the study, and also indicate that tagged fish were motivated, at some level, to move upstream.
- The study methodology was effective in generating information on fish movement in the study area.

Fish Passage Conditions at Varying Flows

- The data indicate that during spill at the Main Dam, the detection of fish in the ZOP was limited. Rainbow Trout were essentially absent from the ZOP once spill started at the Main Dam, and for the remainder of the season. Brown Trout that were present in the ZOP during the spring appeared to leave the ZOP during spill, and then returned in the fall.
- Past telemetry studies conducted in the study area from 2004-2006 also found that few fish were present in the study area during the peak of spring runoff.
- Velocities through much of the High Bridge and falls areas exceed the swimming ability for fish during spring flows, likely impeding fish access to upstream locations. Accessible areas for fish to move upstream during high flow are limited to the margins and bottom of the channel.
- The falls and High Bridge areas are natural features of the Clark Fork River.
- While the telemetry data indicate that many fish leave the study area during high flow, a few fish remain and manage to find the fish passage facility. Fish are known to ascend the fish passage facility in limited numbers during high flows when spill is exceeding design capacity (>25,000 cfs spill).
- Velocities near the fish passage entrance are within fish swimming abilities at all flow scenarios. There are no apparent velocity barriers near the fish passage facility entrance that would limit fish movement to entering the fish passage facility.
- At modeled flows of 200 cfs and 2,000 cfs, the flow path streamlines remain distinguishable near the fish passage facility entrance.
- As total spill increases and reaches 25,000 and 37,000 cfs, flow path streamlines from the fish passage facility entrance area are not as distinct and appear to be overwhelmed from flows at the radial gates and flow over the Main Dam.

Location of Fish Passage Facility

The efficacy of the fish passage facility was noted during the development of study plans as a potential concern due to its location. The data collected during this study supports that the fish passage facility was correctly sited for the following reasons:

- Telemetry shows that fish enter the near field and preferentially select the right bank.

- The left side of the near field (MDL) is generally more turbulent and violent at various spill regimes at the Main Dam.
- The results indicate that a fish passage facility located at the powerhouses or Dry Channel Dam would be less effective than the current passage facility location, as only small numbers of fish were detected in those areas, and only for a short duration, before making forays further upstream near the mouth of Prospect Creek, to the Main Dam, or to the fish passage facility entrance.

Water Temperature Effects on Fish Migration

- River temperature may be a contributing factor limiting salmonid movement during July and August when Clark Fork River temperatures tend to peak. Summer water temperature is consistent throughout the Project (upper river, in Thompson Falls Reservoir, and in the river downstream of the Project), except for areas at the mouth of cooler tributaries.

- During the hot summer season, few radio tagged salmonids were recorded at the fish passage facility. Radio-tagged fish were not present in the near field, and relatively few were detected in the far field, during the period of high-water temperatures.

- Prospect Creek provides a cooler water source and creates an area more tolerable for salmonids in the summer. Although thermal stratification was observed at the three deep water locations downstream of the Main Dam (Prospect Hole, High Bridge, and Dollar Hole), thermal conditions are likely more preferrable for salmonids at the Prospect Hole compared to the other two sites. This may explain observations of fish staying near the confluence of Prospect Creek during the summer compared to other areas in the ZOP.

This study and existing fish passage facility data provide evidence that fish move upstream to the ZOP and can accomplish this quickly, and often continue to the near field preferring the MDR area near the fish passage facility entrance.

2023 Study Season

The fish collection methods implemented in 2021 and 2022 are continuing in 2023 with emphasis on Rainbow Trout. NorthWestern tagged 30 Rainbow Trout during the spring 2023. These fish will be monitored until the end of July 2023.

Because the Draft License Application (DLA) is due in early August, the results from 2023 fish movements within the ZOP and travel time between the far and near fields will not be available in time for inclusion in the DLA but will be summarized in the Final License Application, consistent with the Modified Study Plan.

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1. Introduction

The Thompson Falls Hydroelectric Project (Thompson Falls Project or Project) is located on the Clark Fork River in Sanders County, Montana. Non-federal hydropower projects in the United States (U.S.) are regulated by the Federal Energy Regulatory Commission (FERC) under the authority of the Federal Power Act. The current FERC License expires December 31, 2025. As required by the Federal Power Act and FERC's regulations, on July 1, 2020, NorthWestern Energy (NorthWestern, Licensee) filed a Notice of Intent to relicense the Thompson Falls Project using FERC's Integrated Licensing Process (ILP). Concurrently, NorthWestern filed a Pre-Application Document.

The ILP is FERC's default licensing process which evaluates effects of a project based on a nexus to continuing Project operations. In general, the purpose of the pre-filing stage of the ILP is to inform Relicensing Participants[3] about relicensing, to identify issues and study needs (based on a project nexus and established FERC criteria), to conduct those studies per specific FERC requirements which are included in the FERC Study Plan Determination, issued May 10, 2021, and to prepare the Final License Application.

This Fish Behavior Study, Updated Study Report has been prepared to comply with the requirements of FERC's Determination on Disagreements/Amendment Requests (2022) (Modified Study Plan).

1.1 Fish Behavior Study Background

The Project is located on the lower Clark Fork River near the town of Thompson Falls, Montana in Sanders County. Between 2009 and 2010, the Licensee constructed the Thompson Falls Upstream Fish Passage Facility (fish passage facility or ladder) along the right abutment of the Main Channel Dam (Main Dam) designed to address upstream fish passage for the federally threatened Bull Trout (*Salvelinus confluentus*).

The siting and design of the fish passage facility were determined through consultation between the Licensee and the Thompson Falls Technical Advisory Committee (TAC), which includes representatives of NorthWestern, Montana Fish, Wildlife and Parks (FWP), U.S. Fish and Wildlife Service (FWS), U.S. Forest Service (USFS), and Confederated Salish and Kootenai Tribes. After a multi-year study process, the decision to install a full height fish ladder was made by consensus at a TAC meeting held in October 2006 (*see* Section 5.0 of the Upstream Fish Passage Alternatives Evaluation[4], GEI Consultants, Inc. 2007). In April 2007, the Licensee filed a Biological Assessment with FERC which included letters of support for the fish passage facility from FWS

[3] Relicensing Participants includes local, state, and federal governmental agencies, Native American Tribes, local landowners, non-governmental organizations, and other interested parties.

[4] Meeting notes from this meeting state that, "There was consensus that the right bank full height ladder was the preferred alternative. GEI engineers will begin final design on the right bank full height ladder."

and FWP. In October 2008, the FWS released a Biological Opinion which included non-discretionary terms and conditions (TC). TC 1(a) required the Licensee to, "During 2009 and 2010, [the Licensee] will construct a fish passage facility (permanent fishway) to provide timely and efficient upstream passage at the right abutment of the main dam, as agreed to by the Service and through oversight of the TAC (as provided for in the interagency Thompson Falls Memorandum of Understanding)" (FWS 2008).

The upstream fish passage facility was constructed as specified in the BO and has operated seasonally since 2011 recording over 37,000 fish representing 15 species (plus 3 hybrids), including 21 Bull Trout at the upstream fish passage facility (NorthWestern 2023a).

The goals and objectives of the fish passage facility were defined by the TAC. The TAC determined the highest priority for upstream fish passage are Bull Trout, followed by native species and non-native game fish such as Rainbow (*Oncorhynchus mykiss*) and Brown (*Salmo trutta*) trout. These goals and objectives have informed how the fish passage facility is operated (notch vs. orifice mode) and the seasonal timing of operation (March – October). Rainbow and Brown trout represent over 80 percent of the salmonids recorded at the fish passage facility over the last 12 years (NorthWestern 2023a).

In compliance with TC 1-h in the Biological Opinion (FWS 2008) and the License amendment approving construction of the fish passage facility (FERC 2009), NorthWestern, in collaboration with the TAC, formulated a scientific panel to evaluate the fish passage facility, with emphasis on Bull Trout. The Thompson Falls Scientific Review Panel (Scientific Panel 2020) identified a large volume of qualitative data gathered from the fish passage facility but noted a data gap when quantitatively evaluating the proportion of "motivated" fish entering the Zone of Passage (ZOP) and finding the fish passage facility entrance. The ZOP was defined by the Scientific Panel as shown on **Figure 1-1**. The Scientific Review Panel specifically suggested NorthWestern, "…initiate two parallel studies [telemetry and hydraulic modeling] to assist in the determination of the fish passage facility's attraction[5] and entrance efficiency." (Scientific Panel 2020). This study was developed to address the Scientific Panel's recommendation for a telemetry study. The Hydraulic Conditions Study was performed in parallel, and results are partially reported here, with detailed results available in the Final Study Report (FSR), Hydraulic Conditions Study (NorthWestern 2023b).

Following the recommendation of the Scientific Panel, and in compliance with the FERC's Study Plan Determination (2021), this study focuses on Rainbow and Brown trout. Rainbow and Brown trout are important game fish in the study area and serve as surrogate species to better understand upstream fish passage efficacy for Bull Trout (Scientific Panel 2020).

[5] Attraction flow means the flow that discharges from the fishway that attracts upstream migrating fish.

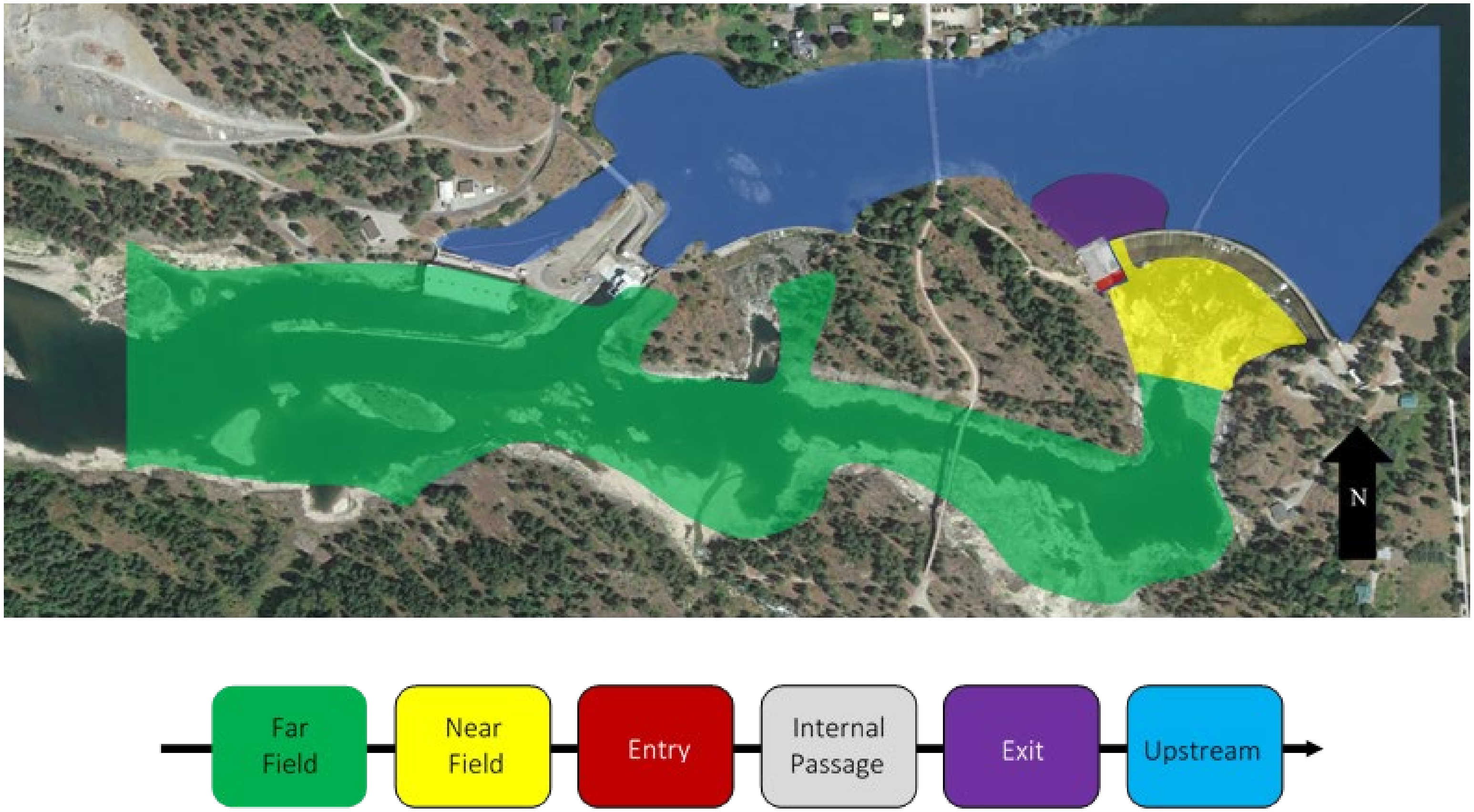
1.2 Goals and Objectives of Study

The goal of this study is to evaluate upstream fish movement *via* radio telemetry[6] through the Project's zone of influence[7] which is defined by the ZOP concept (FWS 2017). The ZOP concept defines discrete areas for analysis of the pathway fish use to move through the influence of the Project. These areas include far field, near field, entry, internal fish passage facility, exit, and upstream (*see* **Figure 1-1** for ZOP concept and definitions). The ZOP concept provides a method to measure passage effectiveness and identify attributing causes and influences (Project and non-project related) to upstream passage effectiveness. This study focuses on fish movement in the far field, near field, and fish passage facility entrance, as illustrated in **Figure 1-1**.

[6] Radio telemetry uses individually coded tags which transmit radio waves which can be detected with receivers mounted on shore.

[7] Zone of Influence means an area within which there are positive or negative effects as a result of the Project.

Figure 1-1. Study Areas as Defined by the Zone of Passage Concept.



Notes:

Figure not to scale.

Far Field = Downstream of fish passage facility/dam where the Powerhouse and spill serve as primary attraction to migrating fish.

Near Field =In proximity to fish passage facility where fish passage facility attraction flow may lure fish to entrance.

Entry = Immediately downstream of entrance channel/gate where fish passage facility discharge dominates hydraulics/velocity field/fish behavior.

Internal Passage = Hydraulics, structure, and fish movement with the fish passage facility (i.e., entrance channel, pools, trap, exit channel).

Exit = Immediate upstream of the fish passage facility exit gate/exit channel where inflow into fish passage facility dominates hydraulics/velocity field/fish behavior.

Upstream = Beyond the influence of the fish passage facility into the reservoir/impoundment.

Source: Scientific Review Panel 2020.

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The initial goals and objectives were to evaluate fish movement and behavior data from June through October 2021 (NorthWestern 2022b) and March through October 2022. The study will continue into 2023 with an additional study season, March through July 2023.

Due to the limited battery life in the radio tags, each year had separate group of fish being monitored. For example, fish sampled and tagged in 2021 were monitored in 2021 and fish sampled and tagged in 2022 were monitored in 2022. Results from 2021 are summarized in detail in the Fish Behavior Study – Initial Study Report (ISR) (NorthWestern 2022b) and results from the 2022 season are summarized in this study report. The results from 2022 are compared to the 2021 season where appropriate, such as when the seasonal monitoring periods overlap.

This study evaluates what proportion of radio tagged fish enter the ZOP and find the fish =passage facility entrance. The study measures the duration of time and pathway(s) of these movements during various flow conditions. This report does not evaluate movement of fish after entering the fish passage facility and details regarding internal fish passage ascents. Internal fish passage facility efficiency is evaluated *via* the remote passive integrated transponder (PIT)[8] arrays located in the ladder section of the fish passage facility; those data are reported in the 2021 Annual Report (NorthWestern 2022a) and 2022 Annual Report (NorthWestern 2023a) for each respective year. This study's primary objective is to assess ability of fish to move upstream through the ZOP and find the fish passage facility entrance.

This report includes a synthesis of upstream fish passage conditions downstream of the Main Dam based on the swimming abilities of fish, as described in NorthWestern (2022b); modeled flow velocities, as described in NorthWestern (2022c and 2023b), and trout radio telemetry tracking data (this report).

[8] A PIT tag is a small radio transponder that contains a specific code, which allows individual fish to be assigned a unique 10- or 15-digit alphanumeric identification number. They are "passive" and do not require a battery, which allows them to be smaller and last the life of the fish.

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2. Methods

2.1 Overview of Approach

The evaluation of fish behavior in the study area was conducted through radio telemetry. Fixed receivers were installed at four locations in the study area to continuously monitor the movement of tagged fish. Then Rainbow and Brown trout were collected, anesthetized, and a radio tag inserted in the body cavity. The tagged fish were transported downstream to the Flatiron Ridge Fishing Access Site (Flatiron FAS), 4 miles downstream of the study area and released.

Data from the fixed receivers was downloaded and entered into a database for analysis. Mobile tracking was also used to define specific locations where the tagged fish were in the study area.

The data were analyzed to determine the travel time between key locations in the study area, the proportion of fish that entered the ZOP and specific locations within the ZOP, areas and water depths where fish hold in the ZOP.

The results from the Hydraulic Conditions Study (NorthWestern 2023b) were also evaluated to assess how velocities in the ZOP may influence upstream fish passage.

Details of the study methodology are found in the following sections.

2.2 Study Area

This study focuses on evaluating Rainbow and Brown trout movement from the Thompson Falls original powerhouse upstream to the fish passage facility entrance at the Main Dam. This 0.75-mile section of the Clark Fork is further divided into the far field, near field, and fish passage facility entrance (*refer to* **Figure 1-1**).

NorthWestern developed a computational fluid dynamics (CFD) model of the area downstream of the Main Dam to about 500 feet downstream of the High Bridge. High velocity locations noted in the CFD modeling were areas of particular focus, as they potentially possess challenging conditions for upstream fish passage. The location of the falls and the high velocity area downstream of the High Bridge are shown in **Figure 2-1**. The falls is a naturally occurring bedrock feature downstream of the Main Dam (**Photos 2-1, 2-2,** and **2-3**).

In the ISR (NorthWestern 2022b), data were presented on thermal stratification at some of the deeper pools in the study area. These pools are known as the Dollar Hole, Prospect Hole, and High Bridge Hole (Figure 2-1). Thermal conditions in these pools were further investigated in 2022.

Fish movement was monitored in relationship to other prominent features of the study site, including the Dry Channel Dam, mouth of Prospect Creek, the new powerhouse, original (old) powerhouse, and wingwall (**Figure 2-1**).

Figure 2-1. Prominent Features of the Study Area.

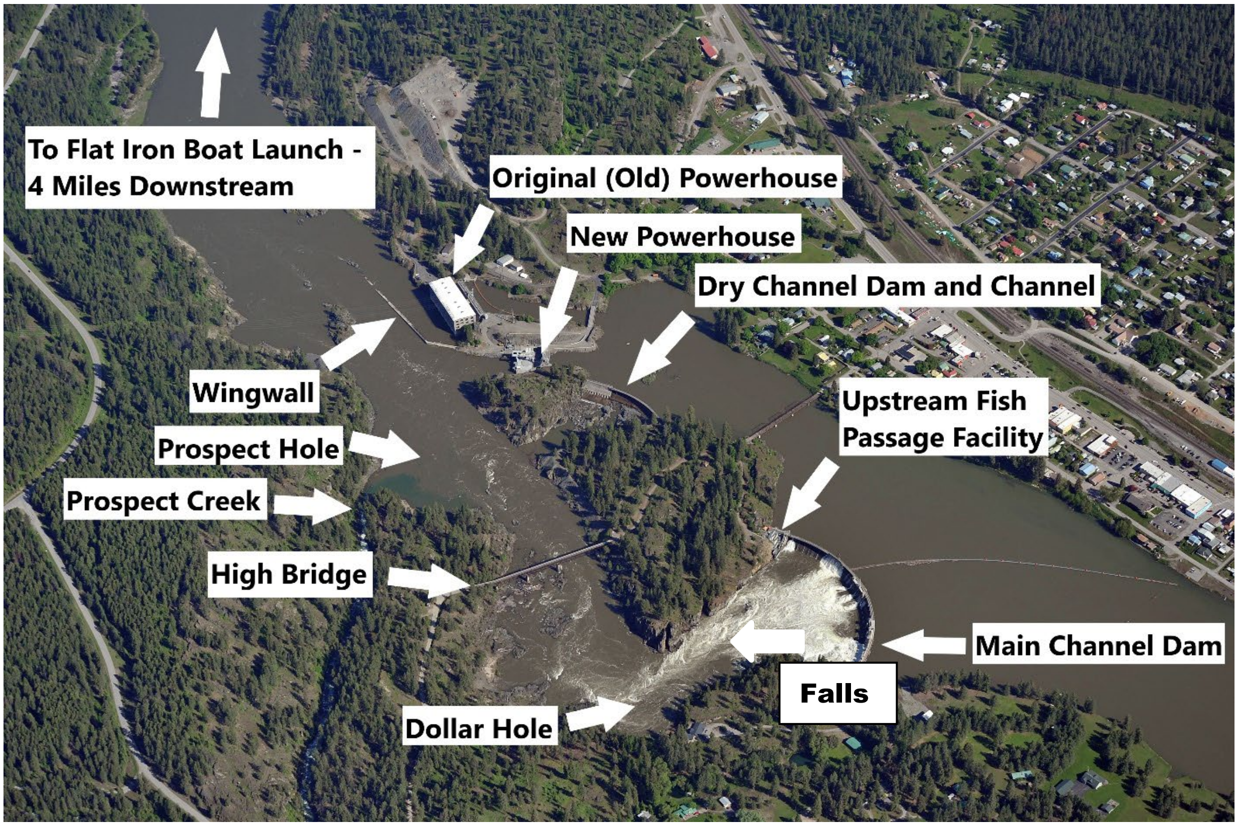


Photo 2-1. Clark Fork River at Thompson Falls, Prior to the Construction of the Thompson Falls Hydroelectric Project

Photo courtesy of the University of Montana Mansfield Library

Photo 2-2. Looking Upstream at the Falls, Clark Fork River at Thompson Falls, Prior to the Construction of the Thompson Falls Hydroelectric Project

Photo courtesy of the University of Montana Mansfield Library

Photo 2-3. Looking Upstream Towards the Main Channel Dam

Photo credit: Kim McMahon, Pinnacle Research, 2019.

2.3 Tagging and Monitoring Equipment

Tagging equipment included full-duplex PIT and radio transmitter tags. PIT tags are detected by a remote antennae array system operating in the two fish passage facility entrances. Radio tags were monitored by four fixed receiver stations and one mobile receiver.

The location of the four fixed receiver stations and estimated detection zone in the study area are illustrated in **Figure 2-3**. The Powerhouse and High Bridge fixed receiver stations recorded fish presence in the far field and the Main Dam Right (MDR) and Main Dam Left (MDL) recorded fish presence in the near field. The fish passage facility entrance is located along the right abutment of the Main Dam (**Figure 2-2**).

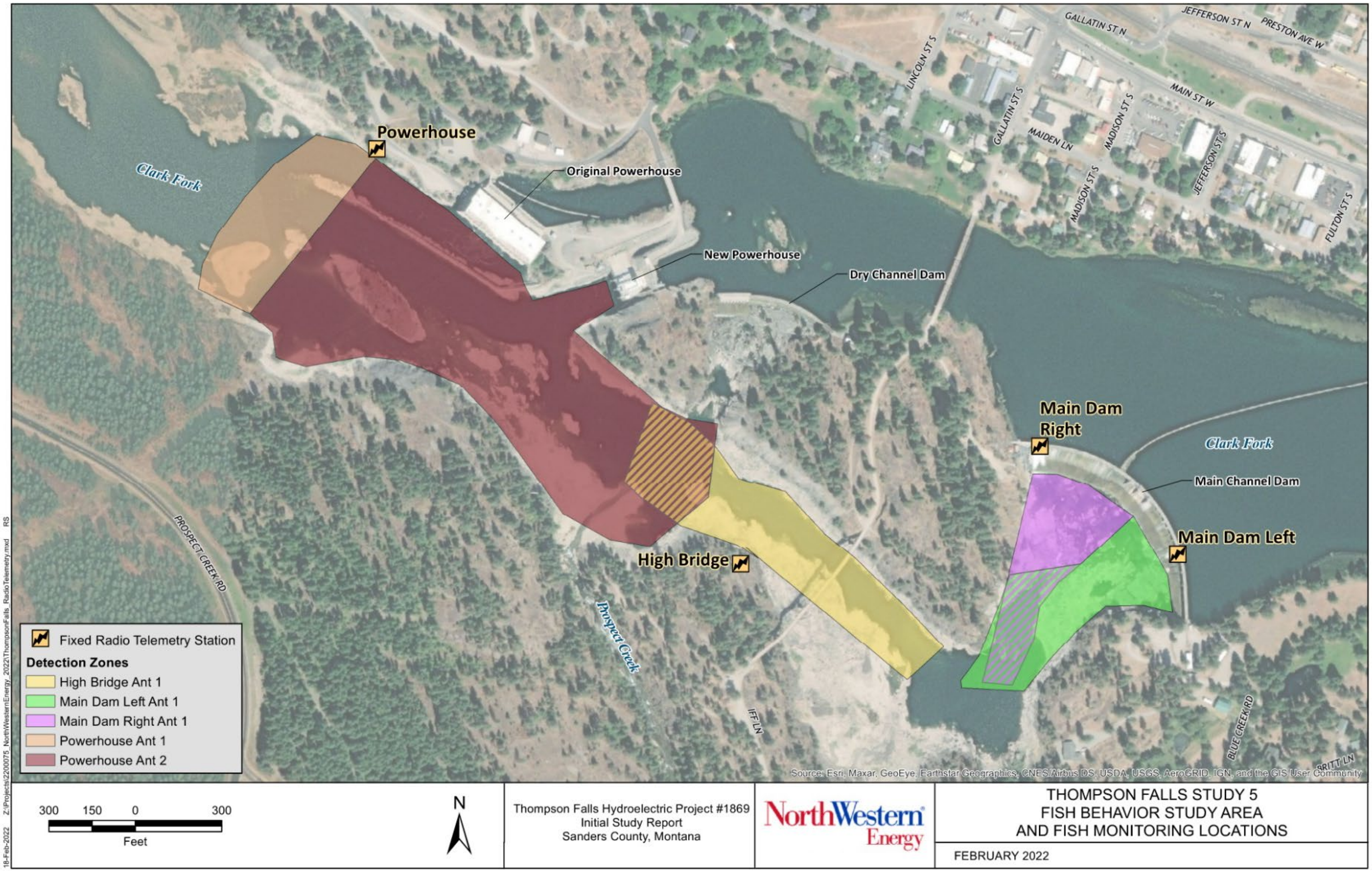
Each fixed station was set up with a Lotek SRX1200-D2 receiver along with a single 6-Element Yagi antenna, except for the Powerhouse, where two antennae were installed (Figure 2-3). The Powerhouse station had one 6-Element Yagi and one 4-Element Yagi antenna. The station on the left side of the Main Dam (MDL) was installed along the south side of the radial gate to shield it from duplicative detections with the right-side station (MDR). The Powerhouse and High Bridge stations were powered using a solar panel to charge a deep cycle battery, the two Main Dam stations were powered by a deep cycle battery charged by permanent AC power.

Radio transmitters were MCFT3 series tags manufactured by Lotek Wireless. MCFT3 tags were coded with the same frequency, 149.7 megahertz (MHz) and a unique code identification number. Radio tags were equipped with depth and activity sensors. A good faith effort was made to adhere to a 2 percent tag to body weight ratios (**Table 2-1**). Burst rates (length of time between transmissions) and battery life varied between the two sizes of tags (Table 2-1).

Table 2-1. Properties of Lotek MCFT3 Radio Tags.

	Large MCFT3 tag	Small MCFT3 tag
Frequency	149.7 MHz	149.7 MHz
Burst rate	5 seconds	10 seconds
Tag weight	11 grams	6.8 grams
Minimum Fish Weight	550 grams	340 grams
Battery Life	8 months	1.5 months
# Tags Deployed 2021	13	3
# Tags Deployed 2022	37	17

Figure 2-2. Fixed Station Locations and Detection Zones, 2021 and 2022 Seasons.[9]



[9] Detections zones are approximate based on testing and data collection.

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2.4 Fish Collection

Fish collection sites included (1) the mainstem Clark Fork River upstream of the Thompson Falls Project, (2) the lower section of the Thompson River (downstream of the confluence with West Fork Thompson River), and (3) the fish passage facility. Boat mounted electrofishing was used in the Clark Fork River to collect trout of suitable size for radio tagging. Angling was attempted in the Thompson River in 2021, but no fish of suitable size were collected. No angling attempts were made in 2022. Fish collection was contingent on accessibility of the sampling areas and water temperature necessary to allow for acceptable recovery of fish post-surgery. Fish collection, radio-tagging and transport occurred when water temperature was less than or equal to 16 degrees Celsius (°C), a standard established in collaboration with FWP for this study.

Tagged fish were transported by vehicle in an aerated tank to the Flatiron FAS, approximately 4 miles downstream of the Thompson Falls Dam. All but four fish were tagged and transported within a few hours of when each fish was captured. Four fish captured *via* electrofishing the night of September 28, 2022 were held overnight before being tagged and released the morning of September 29.

Radio tags were internally implanted through the intra-peritoneal (body cavity) following the methods described in Mizell and Anderson (2015). PIT tags (full duplex) were also implanted in each radio tagged fish in the muscle tissue ventral to the dorsal fin.

2.5 Training and Testing Procedures

On May 18, 2021, field crews received training and practiced radio tagging fish surgeries, including anesthetizing, surgery procedure, and recovery process for fish prior to transport and release.

Fixed receiver stations were installed, calibrated, and tested prior to fish collection activities in 2021 and 2022. Fixed receiver stations were tested to determine tag detection areas, and to ensure adequate power supply, data downloading, and quality assurance and quality control systems were in place. The zones of detection for each fixed station were determined by moving a submerged radio tag around the area and using the receiver to track when a signal was detected. Through trial and error with detections, associated signal strengths, and adjusting antenna positions, detection areas were determined for each fixed station. The zones of detection presented in **Figure 2-1** reflect the results obtained from testing and actual data collected (fixed station data correlated with manual data collection) during the season. A representative from the manufacturer, Lotek, was present in 2021, along with FWP and NorthWestern personnel to assist in setup and testing equipment.

2.6 Monitoring and Data Processing Procedures

The fixed telemetry stations recorded data continuously throughout the study season (June – October 2021 and March – October 2022). Data from the fixed receivers were downloaded weekly. Because of the large volume of data being collected in 5- or 10-second intervals, a database was developed to store all the information and provide a method to query and process data.

Manual tracking consisted of an individual walking along the bank, within the near and far fields, with a Lotek SRX1200-MD1 receiver and an H antenna 150 MHz. Once a tagged fish was detected, its location was triangulated, and applicable information recorded using a standardized data sheet with a georeferenced grid that was uploaded into a geographic information system (GIS).

The data were processed per consultation with Lotek. Fixed receiver data were filtered by a defined detection window to remove false detections. For example, an 11-gram MCFT3 tag is set on a 5-second transmission interval, the detection window requires a minimum of three detections per minute with a signal strength of 100 or greater. For the smaller 6.8-gram MCFT3 tag set on a 10-second transmission interval the smaller tag detection window required a signal strength of 100 or greater. Based on information provided by Lotek and review of the data, false detections were determined to be inconsequential for the smaller tags and supported the decision to modify the detection window criteria. For both tag sizes, a detection record that did not include a sensor (activity or pressure) was excluded from the analysis. False detections are often a result of environmental noise where a random noise or other factors produce a signal that is logged as a viable code. Areas around hydroelectric facilities with powerlines and operation of turbines and gates can increase the amount of environmental noise. The filters applied increase the confidence that detections are radio tagged fish of interest.

Manual radio telemetry monitoring efforts were implemented from June 3 through October 27, 2021, and March 23 through October 26, 2022. The frequency of manual tracking depended on fish detections in the ZOP and varied from multiple times a week, to daily, or multiple times a day. The goal of the manual tracking was to confirm locations of fish and provide higher resolution of the location for an individual fish within the ZOP. Manual tracking extended from Flatiron FAS (release site) upstream to Thompson Falls Project.

2.7 Study Assumptions

The study assumes each radio-tagged fish transported downstream and released at Flatiron FAS is motivated to return upstream. To reduce confounding factors, fish that were radio-tagged and then entered the fish passage facility, were not included in further analysis of travel time within the ZOP if detected later in the study season. For purposes of this report and study, fish entering the fish passage facility were considered to have completed the objective of the study, navigating the ZOP and locating the fish passage facility entrance. These assumptions were used to improve the consistency of data analysis and remove confounding factors or potential biases.

2.8 Fish Behavior Data Analysis

Fish movement data were analyzed to assess fish behavior through a range of flow conditions. The telemetry monitoring efforts evaluated fish movement behaviors with emphasis on attraction efficiency[10] (FWS 2017) by assessing the following:

- Travel time from the far field to the near field
- Travel time from the near field to the entrance of the fish passage facility
- Movement patterns (e.g., left bank, right bank) in the near field (Main Dam area)
- Proportion of fish that enter the ZOP and locate the entrance of the fish passage facility entrance
- Locations where fish hold within the ZOP

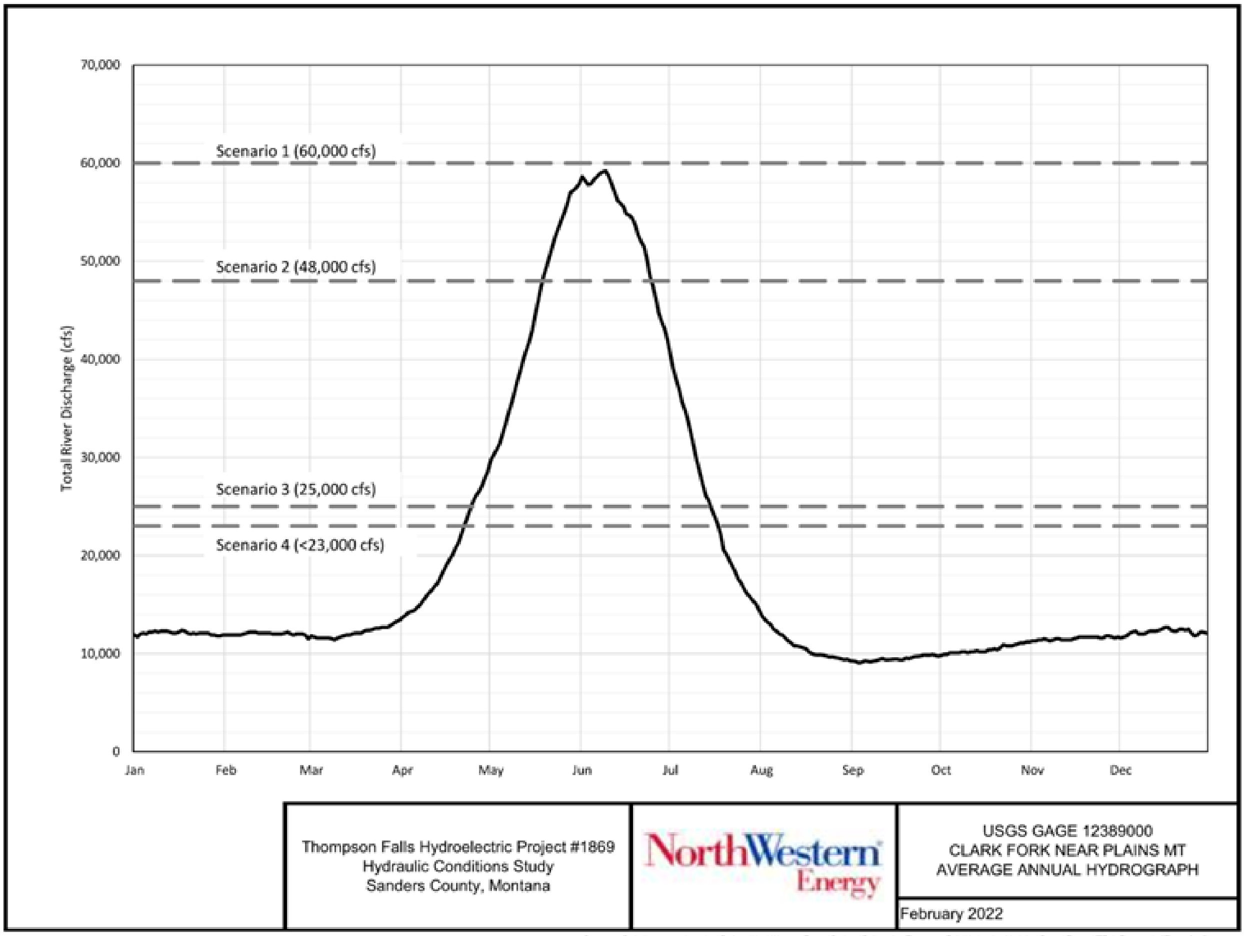
2.9 CFD Modeling Data Analysis

A CFD model was developed for the existing Main Dam and river approximately 500 feet downstream of the High Bridge using FLOW-3D software. Details of the CFD model development are provided in the FSR, Hydraulic Conditions Study (NorthWestern 2023b).

The Hydraulics Condition Study ISR (NorthWestern 2022c) provided an estimate of the hydraulic characteristics of the near field from the High Bridge upstream to the Main Dam and the resulting flow depths, velocities, and flow patterns for four flows scenarios over the Main Dam: Scenario 1: 37,000 cubic feet per second (cfs) spill; Scenario 2: 25,000 cfs spill; Scenario 3: 2,000 cfs spill; and Scenario 4: 200 cfs spill. **Figure 2-3** illustrates when these spill scenarios occur based on the average annual hydrograph for the Clark Fork River.

[10] Attraction efficiency is a measure of the proportion of the (motivated) population that is successfully attracted to the fishway; typically measured as a percentage of the motivated population that enters the fishway (FWS 2017). For this study, attraction efficiency is defined as fish moving from the far field to the entrance of the fish passage facility.

Figure 2-3. Average Annual Hydrograph.



Note: USGS Gage 12389000 Clark Fork River near Plains, Montana.

The FSR, Hydraulic Conditions Study (NorthWestern 2023b) includes 3D simulations providing detailed results of the river channel hydraulics at two specific flows **(Table 2-2)**. Scenario 1 was total river flow of 60,000 cfs and spill flow at the Main Dam of 37,000 cfs. Scenario 1 represents an intermediate flow during spill (within design capacity of the upstream fish passage facility). Scenario 3 was total river flow of 25,000 cfs and spill flow at the Main Dam of 2,000 cfs**.**

Table 2-2. Flow Scenarios Utilized In 3D Simulations to Evaluate River Channel Hydraulics.

Spill Scenario	Modeled Spill over Main Channel Dam (total river discharge)	Modeled Spill Represents	Representative Period When Modeled Spill is Observed	Dates Conditions Occurred in 2021, 2022
1	**37,000 cfs** (60,000 cfs)	Assess downstream flow conditions during the upper limit of Upstream Fish Passage Facility operations.	Spring Freshet. Average peak flow (60,000 cfs) typically occurs in May/June. Duration of flow at 60,000 cfs is brief (scale of hours/days).	June 5-6, 2021 June 7-10, 2022 June 29-July 2, 2022
3	**2,000 cfs** (25,000 cfs)	Assess downstream flow conditions at an intermediate typical flow rate	Ascending and descending limb of hydrograph. Brief period (scale of hours).	May 2, 2021 June 28, 2021 May 6, 2022 July 19, 2022

Note: cfs = cubic feet per second

This report utilizes the results of the CFD model (NorthWestern 2023b) to identify potential velocity obstacles under four flow scenarios from the High Bridge upstream to the Main Dam. Two of the flow scenarios (*refer to* **Table 2-2**) were modeled in greater detail using 3D methods for higher resolution.

The 3D simulation evaluated the vertical velocity distributions of flow downstream of Main Dam for each flow scenario. The simulated 3D flow velocity output was grouped in relation to fish swimming abilities from available published literature. Details of fish swimming abilities by species are provided in Section 3.4 of the Fish Behavior Report ISR (NorthWestern 2022b).

Velocity gradients were delineated into three categories (**Table 2-3**) to best compile and illustrate fish swimming abilities (Section 3, **Table 3-7**). The three velocity categories are generalized and not intended to reflect the swim speed capabilities of a specific fish species. The three groups were:

- Velocities of 7.0 feet per second (fps) or less, which encompasses the majority of the species swimming abilities for prolonged and burst speeds (green in figures)
- Velocities between 7.1 and 14.0 fps, the range of burst speeds for all the salmonid species (yellow in figures)
- Velocities exceeding 14.0 fps which is greater than all species prolonged and burst swimming abilities (red in figures)

The modeled velocity output illustrates these three velocity groups to identify areas in the near field, and the far field between the High Bridge and Main Dam, that could potentially present an obstacle to upstream fish passage.

Table 2-3. Velocity Categories, Grouped by Fish Swimming Abilities.

Velocity Categories	Velocity Gradient (fps)
Most Species - mix of Prolonged and Burst speeds	0-7.0
Many Species - Burst Speeds	7.1-14.0
Exceeds Burst Speeds	>14.0

Notes: > = greater than; fps = feet per second

The 3D model for a cross-section (or several cross-sections) provides a detailed assessment of the vertical distribution of flow velocities at the cross section. Based on the 3D modeling results, the percent of the cross-sectional area for each velocity category was calculated.

Cross-sections of the areas of concern or interest wereevaluated for the approximate area available for fish to navigate based on the swimming abilities (prolonged and burst speeds) identified from the literature and presented in the Fish Behavior Study ISR (NorthWestern 2022b). The cross-sections represent the portion of the area that appears to present the greatest velocities and potential obstacles for upstream fish movement. The configuration of each cross-section is delineated based on the mapping grid. In most instances, one line represents a cross-section for a specific site. At the fish passage facility, a vertical and horizontal cross-section were placed to evaluate velocities for fish approaching the fish passage facility entrance at different directions and provide a more descriptive depiction and assessment of velocities in the area. The falls area includes multiple segments to illustrate cross-sections when evaluating the 37,000 cfs spill scenario. Multiple segments were utilized to maintain precision of the model in an X or Y grid orientation, while attempting to evaluate a representative cross-sectional area of the falls location.

2.10 Variances from the FERC-approved Study Plan

There were no variances during the 2021 or 2022 study seasons from the FERC-approved Study Plan (NorthWestern 2021). In 2022, several agencies (FWP, FWS, USFS, and Confederated Salish and Kootenai Tribes) requested that the Fish Behavior Study be extended into a third year. NorthWestern agreed to modify the study plan to extend the study into a third study season. Data from the third study season will be analyzed and presented in the Final License Application. To allow for sufficient time to evaluate the third season of radio tagging data and incorporate the information into the Final License Application, NorthWestern plans to complete field data collection for the third season of the Fish Behavior Study by July 31, 2023.

3. Results

3.1 Fish Collection and Tagging

In 2021, spring fish collection occurred between June 2 and June 16 resulting in the tagging of 13 fish *via* electrofishing in the Clark Fork River. Water temperatures exceeded 16°C on June 17, halting fish collection efforts. Water temperature declined in the fall, and three Brown Trout were radio tagged at the fish passage facility on September 29 and October 1. Fish tagged in the spring received an 11-gram MCFT3 tag and fish tagged in the fall received a 6.8-gram MCFT3 tag.

In 2022, spring fish collection occurred between March 16 and March 29 resulting in the tagging of 28 fish at the fish passage facility workstation and nine fish *via* electrofishing in the Clark Fork River. All tagged fish received an 11-gram MCFT3 tag. Water temperatures declined in the fall, allowing for tagging of 17 Brown Trout (11 at the fish passage facility and 6 electrofishing upstream of the dam in the Clark Fork River) before the end of September. Brown Trout tagged in the fall received a 6.8-gram MCFT3 tag.

A summary of the fish collection efforts for each study season, including collection method, collection location, species, and tag size is provided in **Table 3-1**. **Appendix A** provides more details regarding each sampling event, including method, location, water temperature, effort, total catch, and catch per unit effort and individual fish tagged, including species, total length, weight, radio tag number, and PIT tag number for each study year and season. Monitoring data from 2021 and 2022 indicated no immediate mortalities from surgery.

Table 3-1. Trout Collection Summary for 2021 and 2022.

Season & Year	Method	Location	RB	LL	MCFT3 Tag size (g)	Total # Fish
June ‘21	Electrofishing	Clark Fork River	7	6	11	13
	Angling	Thompson River	-	-	-	-
Sept/Oct ‘21	Ladder[11]	Clark Fork River	-	3	6.8	3
2021 TOTAL			**7**	**9**		**16**
March ‘22	Ladder	Ladder	27	1	11	28
	Electrofishing	Clark Fork River	2	7	11	9
Sept ‘22	Ladder	Ladder		11	6.8	11
	Electrofishing	Clark Fork River		6	6.8	6
2022 TOTAL			**29**	**25**		**54**
		Grand Total	**38**	**34**		**70**

Notes: g = grams; LL = Brown Trout; RB = Rainbow Trout.

[11] Fish collected at the upstream fish passage facility.

3.2 River Conditions 2021 and 2022

A summary of 2021 and 2022 mean daily streamflow in the Clark Fork River near Plains, Montana (USGS gage #12389000) and a daily water temperature reading at Thompson Falls Dam upstream fish passage facility are shown in **Figures 3-1 and 3-2, respectively**. The red line depicted on Figures 3-1 and 3-2 shows the threshold (23,000 cfs) for when spill occurs at the Main Dam.

The Project's combined capacity of the seven generating units is approximately 23,000 cfs. When river inflows exceed this capacity, spill is initiated at the Main Dam spillway. In 2021, spill began at the Main Dam on May 2 and lasted 59 days (ending June 30). In 2022, spill began at the Main Dam on May 5 and lasted 77 days (ending July 21). In both years, spring flows increased in May, but due to a cooler and wetter spring in 2022, the duration of high spring flows was longer, and the peak flow was greater the second study season.

During the non-spill period, NorthWestern released approximately 200 cfs from the upstream fish passage facility and from the Main Dam to provide attractant flow for fish throughout the fish passage season.

Figure 3-1. Mean Daily Streamflow in the Clark Fork River near Plains (USGS #12389000), and Water Temperature Recorded at the Thompson Falls Fish Passage Facility, March 1 to October 29, 2021.

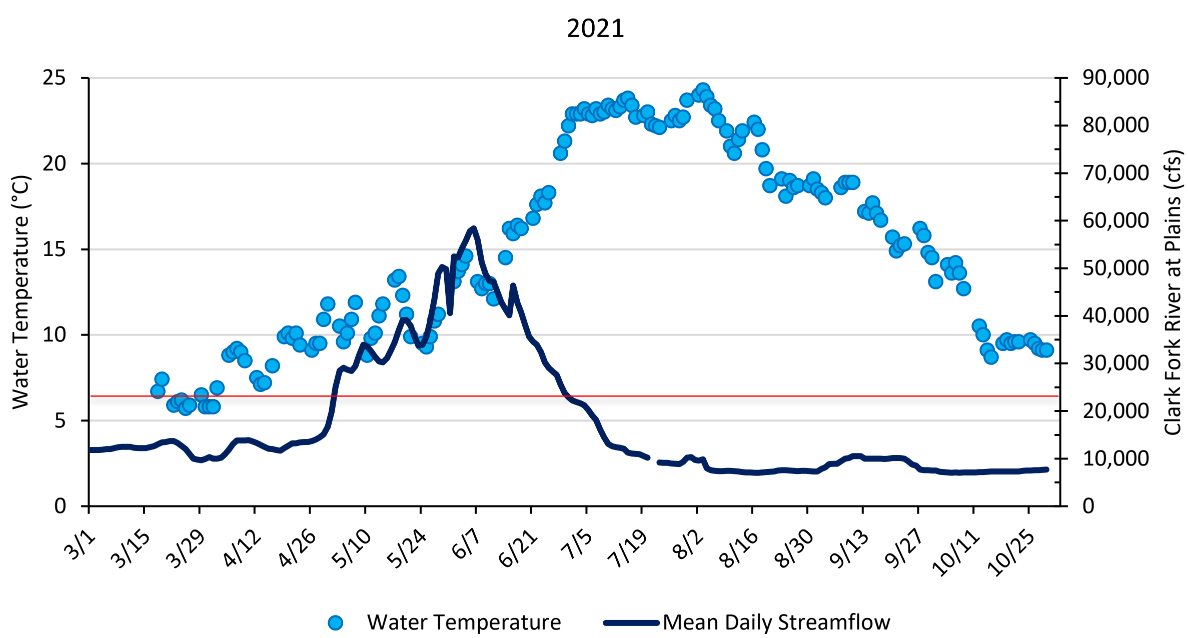
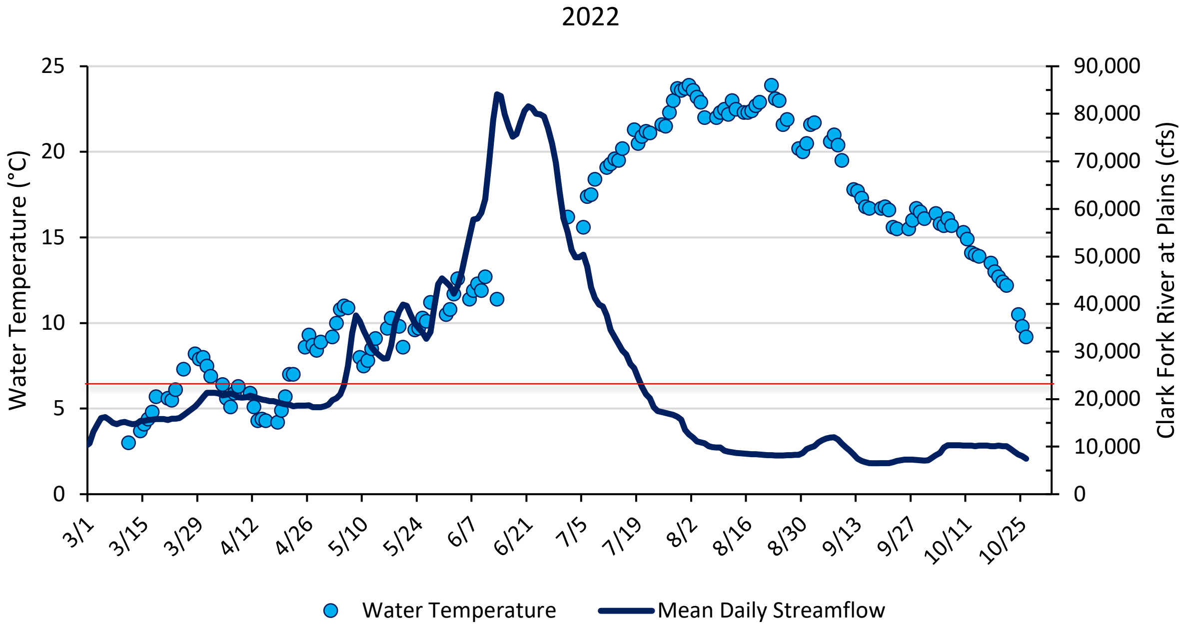


Figure 3-2. Mean Daily Streamflow in the Clark Fork River near Plains (USGS #12389000), and Water Temperature Recorded at the Thompson Falls Upstream Fish Passage Facility, March 1 to October 26, 2022.



3.3 Fish Telemetry Results

A summary of the fish studied in 2021 and 2022, including the month and year of tagging, species, total number radio tagged, percentage/number of radio-tagged fish detected in the far field, near field, and fish passage facility entrance, is provided in **Table 3-2**.

Table 3-2. Summary of the Rainbow and Brown Trout Detected in 2021 and 2022.

Collection Time	Species	Total Tagged	% (#) in Far Field	% (#) in Near Field	% (#) Ladder Entrance
June '21	RB	7	100 (7)	14 (1)	-
	.	6	100 (6)	50 (3)	33 (2)
Sept/Oct '21	LL	3	100 (3)	33 (1)	33 (1)
2021 Total		**16**	**100 (16)**	**31 (5)**	**19 (3)**
March '22	RB	29	100 (29)	86 (25)	48 (14)
	LL	8	100 (8)	88 (7)	38 (3)
Sept '22	LL	17	94 (16)	35 (6)	24 (4)
2022 Total		**54**	**98 (53)**	**70 (38)**	**39 (21)**
Total Both Years		**70**	**98 (69)**	**62 (43)**	**35 (24)**

Notes: % = percentage; # = number of fish detected; LL = Brown Trout; RB = Rainbow Trout.

Millions of records from the fixed receivers, representing movements of the 70 radio-tagged fish, were collected in both study seasons. Each year, the Powerhouse, High Bridge, MDR, and MDL stations ran continuously throughout the study season (March – October). All radio-tagged fish were detected entering the far field on the fixed receivers, except for one Brown Trout tagged in 2022. Collectively over the two study seasons, approximately 63 percent of the 70 tagged fish were detected by the fixed receivers in the near field, including 72 percent of the 36 tagged Rainbow Trout and 50 percent of the 34 tagged Brown Trout.

In 2021, fish were collected for radio tagging in June during spring runoff, thus no data on spring movement prior to that were collected. Early spring (March) fish collection in 2022 resulted in observations of Rainbow and Brown trout migration throughout the study season.

During the 2021 season, no radio-tagged Rainbow Trout entered the fish passage facility. However, one of the 2021 tagged Rainbow Trout entered the fish passage facility in March 2022. In 2022, fish collection occurred in March, and 48 percent (14 of 29) of the tagged Rainbow Trout entered the fish passage facility. Forty five percent (13 of 29) ascended the fish passage facility. All Rainbow Trout fish passage facility entries occurred during the spring months.

In 2021, 33 percent (3 of 9) of the tagged Brown Trout entered the fish passage facility and 22 percent (2 of 9) of the Brown Trout ascended the fish passage facility. Brown Trout were collected in spring and fall in 2022 and 28 percent (7 of 25) of the tagged fish entered the fish passage facility. Sixteen percent (4 of 25) ascended the fish passage facility. All but one Brown Trout fish passage facility entry occurred during the fall months.

Over the two years of study, 24 (35%) of the 70 radio tagged fish were detected at the fish passage facility entrance. Detections at the fish passage facility entrance were much higher in 2022 than in 2021, with 19 percent detected in 2021 and 39 percent detected in 2022.

3.4 Travel Time

3.4.1 *Travel Time from Release Location to Far Field*

The distance from the release location, Flatiron FAS, and the far field is approximately 4 miles. Travel time from the release location to the far field was calculated by duration between the date and time an individual fish was released at Flatiron FAS and the first detection date and time by the fixed receiver in the far field.

In 2022, the 29-tagged Rainbow Trout were released at Flatiron FAS between March 16 and March 29, and all fish were detected entering the far field of the ZOP. On average Rainbow Trout were detected entering the far field approximately 2.6 days (range 1 hour to 11.4 days) following release. The Rainbow Trout were detected entering the far field (Powerhouse and High Bridge fixed station receivers) starting March 19 through April 8. During this period there was no spill at the Main Dam and the mean daily streamflow in the Clark Fork River (USGS #12389000) ranged from 15,600 to 21,300 cfs and water temperatures were between 5.1 and 8.0°C.

Between March 16 and March 24, 2022, eight Brown Trout were transported and released at Flatiron FAS. All eight Brown Trout were detected entering the far field an average of 5.1 days (range 16.8 hours to 16.1 days) after their release, between March 19 and April 3. Mean daily stream flow and water temperatures were similar to conditions described for Rainbow Trout.

Between September 20 and September 29, 2022, an additional 17 Brown Trout were transported and released at Flatiron FAS. All but one of these Brown Trout were detected entering the far field an average of 1.8 days (range <1 hour to 9.3 days) between September 20 and October 2 following release. There was no spill at the Main Dam during this time and the mean daily streamflow in the Clark Fork River was between 6,530 and 7,240 cfs with water temperatures between 16.7 and 15.5°C.

Details on all tagged fish (2021 and 2022), including date of transportation and release at Flatiron FAS boat launch, the first date detected in the far field, near field, and fish passage facility entrance, and the travel time between locations, are summarized in **Appendix B**.

3.4.2 *Travel Time from the Far Field to the Near Field*

Travel time from the far field to the near field is equal to the number of days between the last date a fish was detected at the Powerhouse or High Bridge station and first date the fish was detected at the MDR or MDL station. A summary of the 2021 and 2022 seasons and fish travel time, including minimum and maximum time, mean time, and median time for Rainbow and Brown trout to travel from the far field to the near field is provided in **Table 3-3** (and Appendix B). Both species demonstrated the ability to migrate upstream from the far field to the near field within hours.

During the 2022 study, Rainbow Trout averaged about 1 week from their first detection in the far field and first detection in the near field. All movements into the near field were made in March and April. The two Rainbow Trout that were not detected in the near field were later detected in Prospect Creek or downstream, outside of the study area.

Brown Trout collected in the spring averaged about 4 weeks (range 1-103 days) and those collected in the fall averaged about 2 weeks (range 2-26 days) between their first detection in the far field and first detection in the near field. The initial movement to the near field appeared to depend on when the fish were collected. For the fish collected during the spring, migration to the near field occurred in March, April, May, and July. For fish collected during the fall, migration to the near field occurred in September and October. Some Brown Trout were later detected downstream near the release site and further downstream in other tributaries outside the study area.

Table 3-3. Travel Time from the Far Field to the Near Field in 2021 and 2022.

Collection Time	Species	Total # Detected in Near Field	Travel Time from the Far to Near Field (Days)			
			Average	Min	Max	Median
June '21	RB	1	36.6	36.6	36.6	36.6
	LL	3	71.7	0.05	114.1	100.8
Sept/Oct '21	LL	1	17.5	17.5	17.5	17.5
March '22	RB	25	7.3	0.08	32.7	4.9
	LL	7	28.4	1.1	102.9	10.1
Sept '22	LL	6	14.4	2.4	25.8	15.1

Notes: # = number of fish detected in near field; LL = Brown Trout; RB = Rainbow Trout.

3.4.3 *Travel Time from the Near Field to the Entrance of the Fish Passage Facility*

Travel time from the near field to the entrance of the fish passage facility is equal to the number of days between the date a fish is first detected by the MDL/MDR station and the date the fish is first detected by the PIT tag array in the fish passage facility entrance (**Table 3-4)**.

In 2022, there were 14 Rainbow Trout and seven Brown Trout that were detected at the entrance of the fish passage facility. The median travel time from first detection in the near field and first detection at the fish passage facility entrance for Rainbow Trout in 2022 was 1.8 days. (No Rainbow Trout were detected at the entrance of the fish passage facility during 2021 season.)

For Brown Trout, the travel time was separated into fish collected during the spring and fall months. In 2022, the median travel time was 123.9 days for Brown Trout collected in the spring and less than 1 day for Brown Trout collected in the fall. It appears the majority of Brown Trout entered the fish passage facility during the fall months regardless of the individual fish's ability to navigate upstream to the near field earlier in the spring.

A summary the 2021 and 2022 study seasons, including the number of fish by species, the average, minimum and maximum travel time (in days) from the near field to detection at the fish passage facility is provided in Table 3-4. Individual travel times are summarized in **Appendix B**.

Table 3-4. Summary of Radio Tagged Fish that Traveled from the Near Field to the Fish Passage Facility Entrance, 2021 and 2022.

Collection Time	Species	Total # Detected in Ladder Entrance	Travel Time from Near Field to Ladder Entrance (Days)			
			Average	Min	Max	Median
June '21	RB	-	-	-	-	-
	LL	2	6.1	2.4	9.8	6.1
Sept/Oct '21	LL	1	4.7	-	-	-
March '22	RB	14	8.2	0.03	37.7	1.8
	LL	3	136.0	112.6	171.6	123.9
Sept '22	LL	4	0.8	0.3	1.2	0.9

Notes: # = number of fish detected in ladder entrance; LL = Brown Trout; RB = Rainbow Trout.

Results and analysis of internal fish passage ascents is provided in the Thompson Falls Fish Passage Annual Reports (NorthWestern 2022c, 2023b). These reports provide an overview of all PIT tagged fish detections and ascents at the fish passage facility. Radio-tagged fish represent a small portion of the total number of tagged fish which are reviewed in the Annual Reports.

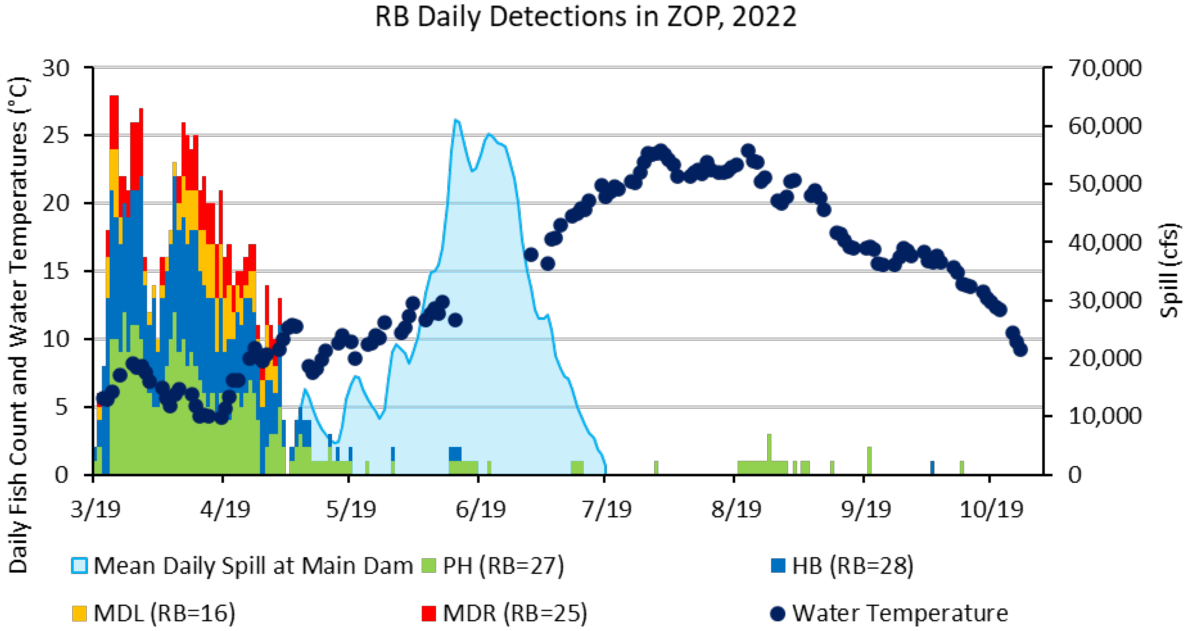
3.5 Movement Patterns

Data collected with both the fixed receivers, and with manual tracking, were used to assess trout movement patterns. The two types of data provide complimentary information about fish behavior. Manual tracking data was the primary tool used to identify specific locations where fish are located and to analyze potential holding patterns or locations in the ZOP. Fixed receivers operate 24 hours a day and thus capture continuous fish movements in the far and near fields. Because manual tracking occurs over a relatively short time period, representing one moment in time, manual tracking did not always locate all of the fish that were detected by fixed receivers, which operate continuously. Details of results of both manual tracking and fixed receivers are provided in the following sections for each species.

3.5.1 *Rainbow Trout*

In 2022, the fixed receivers detected Rainbow Trout presence in the ZOP was greatest during the spring months in both the far and near field before tapering off rapidly when runoff occurred in June and then with few detections into the summer and fall months (**Figure 3-3**). Fourteen Rainbow Trout entered the fish passage facility between March and May, leaving 16 Rainbow Trout present below the Main Dam for the remainder of the study season.

Figure 3-3. Daily Detections of Rainbow Trout by the Fixed Station Receivers, Total Clark Fork River Spill, and Water Temperature During the 2022 Study Season.



A summary of the monthly manual tracking detections of Rainbow Trout is shown in **Table 3-5**. Manual tracking detected 23 of the 29 tagged Rainbow Trout during the study. Of the 23 Rainbow Trout detected, 70 percent (16) moved into the near field and 61 percent (14) entered the fish passage facility entrance between March 23 and May 2. Manual tracking confirmed that the peak presence of Rainbow Trout in the ZOP and near field occurred during the spring months, March and April, during the ascending limb of the hydrograph and prior to spill at the Main Dam. No Rainbow Trout were detected manually between July and October. The locations for the monthly detections (March – June) are illustrated in **Figure 3-4**.

Table 3-5 Monthly Summary of the Number of Individual Rainbow Trout Detected *via* Manual Tracking in the ZOP, 2022. Detections at the Ladder Entrance Represent a PIT Tag Recording.

Month 2022	Individual Rainbow Trout Detected *via* Manual Tracking		
	ZOP	Near Field	Ladder Entrance
MAR	17	12	8
APR	12	10	4
MAY	5	2	2
JUN	1	0	0
JUL	-	-	-
AUG	-	-	-
SEP	-	-	-
OCT	-	-	-

Month 2022	Individual Rainbow Trout Detected *via* Manual Tracking		
	ZOP	**Near Field**	**Ladder Entrance**
Total	**23**[12]	**16**	**14**

Note: ZOP = Zone of Passage

In March, manual tracking detected 17 Rainbow Trout entering the ZOP with 70 percent (12) of those fish reaching the near field and over half of the fish (8) entering the fish passage facility entrance (*refer to* **Table 3-5**). Movement patterns show most detections in the falls and MDR zone in March and April.

In April fish appeared to be slightly more dispersed with most detections remaining in the MDR zone and the addition of fish detections downstream at the mouth of Prospect Creek and the Dry Channel Dam. Manual tracking detected 12 Rainbow Trout in the ZOP, four individuals were new, entering the ZOP for the first time. In the near field there were 10 individual Rainbow Trout detected in April, including one-third (4) of the fish detected earlier in March and six new fish. Four Rainbow Trout entered the fish passage facility. By the end of April, 12 of the 23 manually detected fish had entered the fish passage facility entrance leaving 11 fish in the ZOP.

In early May, detections of Rainbow Trout declined to five individual fish. During the first half of the month, two Rainbow Trout entered the fish passage facility entrance (in the first 2 days in May) and three Rainbow Trout were detected near the mouth of Prospect Creek. One Rainbow Trout was detected upstream in Prospect Creek by the remote PIT tag array system on May 4, a second Rainbow Trout was detected further downstream leaving the ZOP on May 13, and the third Rainbow Trout was last detected in the ZOP near the Prospect Creek mouth May 9. No new individual Rainbow Trout were detected moving upstream into the ZOP after May 13.

In June there was one individual Rainbow Trout detected in the far field after leaving the Prospect Creek drainage.

Four Rainbow Trout were detected in Prospect Creek between March 24 and May 4 *via* the remote PIT tag array. None of the Rainbow Trout that entered Prospect Creek were detected in the near field upstream of the falls.

Rainbow Trout detected in the far field near the original powerhouse and wingwall area were primarily located within the main river channel (*refer to* Figure 2-1). In April there were three detections representing three fish in the channel immediately downstream of the new powerhouse and along the inside of the wingwall of the original powerhouse. Two of these fish later continued upstream and were detected in the fish passage facility entrance. Movement patterns in 2022 showed Rainbow Trout either entered and ascended the fish passage facility during the spring,

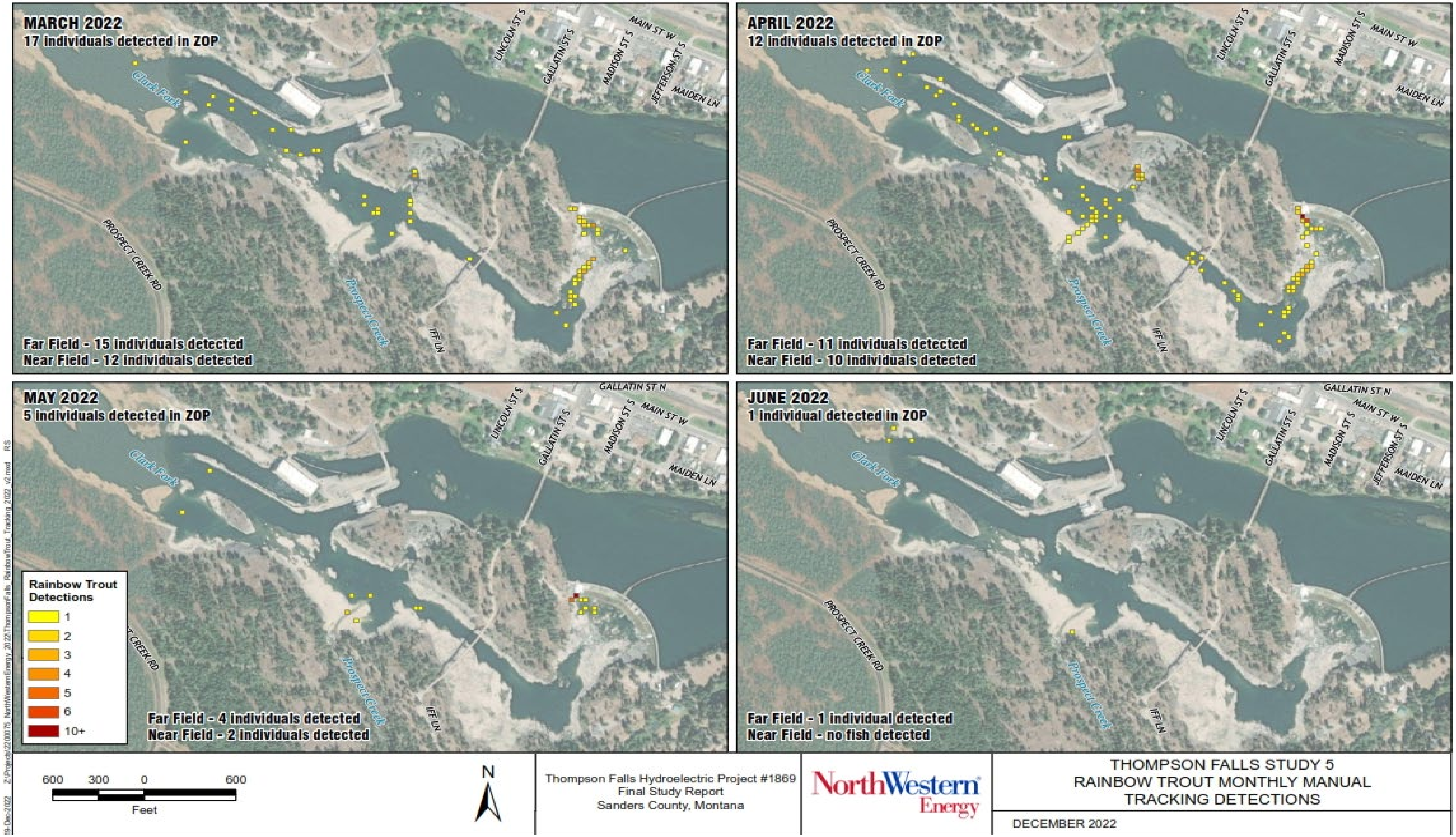
[12] Total number of separate, individual Rainbow Trout. Monthly numbers do not add to total because some Rainbow Trout detected in more than one month.

with a notable decline in detections in May and June, and no manual detections July through October (**Figure 3-4**).

The manual tracking illustrates Rainbow Trout explored and were recorded at similar locations within the ZOP regardless of whether the fish entered the fish passage facility. However, for the 14 Rainbow Trout that entered the fish passage facility, these fish were recorded more frequently at the falls and immediately outside of the fish passage facility entrance (MDR zone). In contrast, the nine Rainbow Trout that did not enter the passage facility appeared to remain further downstream and more oriented immediately below the High Bridge and near Prospect Creek outlet (**Figure 3-5**). Three of the nine Rainbow Trout that did not enter the fish passage facility were detected upstream in Prospect Creek by the remote PIT tag array during the spring (March, April, and May).

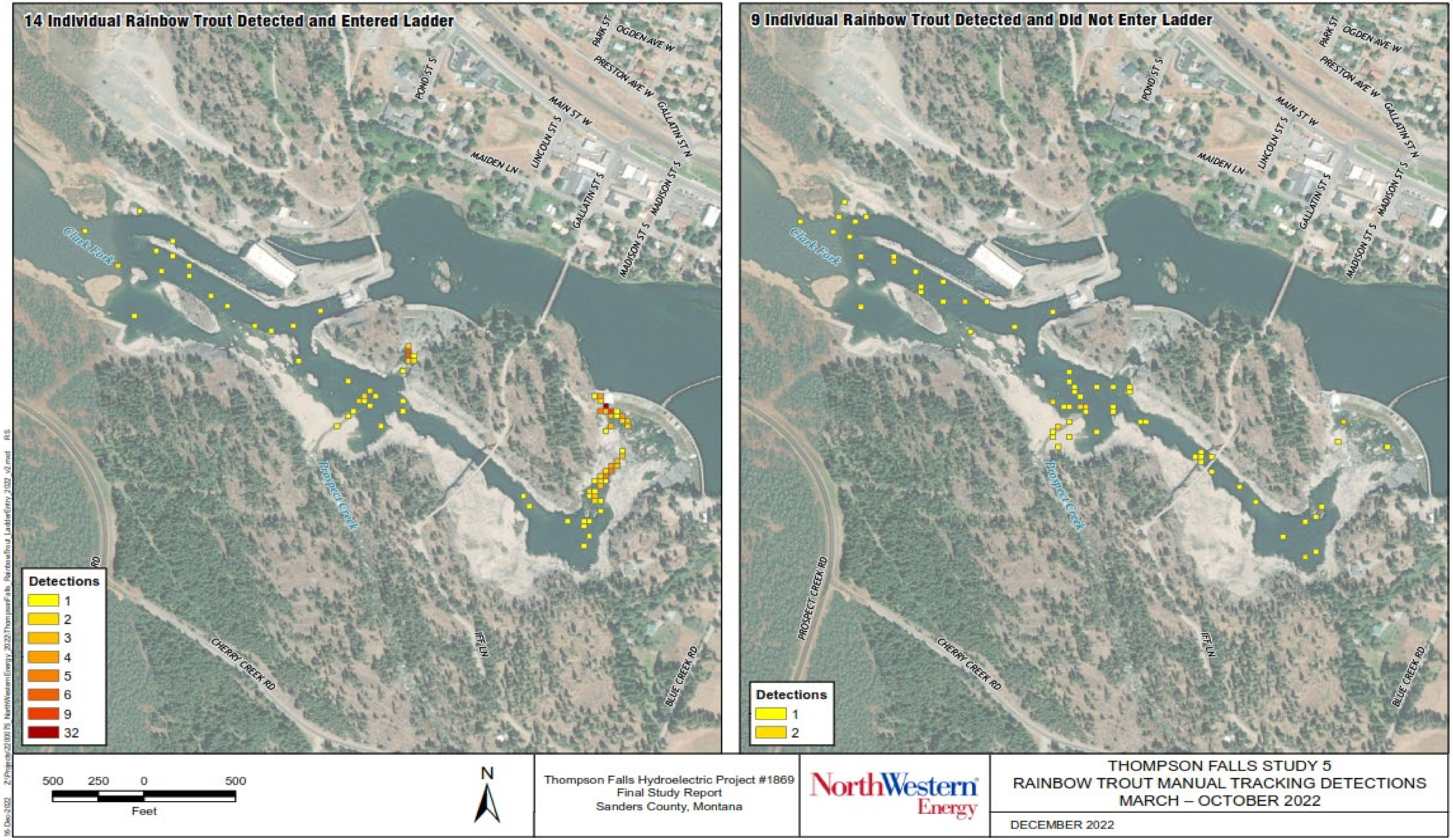
In summary, Rainbow Trout were observed utilizing many locations in the ZOP. Detection data collected by fixed receivers and manual tracking indicate Rainbow Trout moved immediately upstream into the ZOP after release at Flatiron FAS and continued to the near field *via* the falls, concentrating within the MDR zone near the fish passage facility entrance during March and April. There were few detections of Rainbow Trout in the MDL zone. Rainbow Trout presence in the ZOP during the 2022 study appeared to be limited primarily to the spring months. Neither the manual tracking nor the fixed receivers detected significant Rainbow Trout presence in the ZOP during peak spring flows or summer and fall.

Figure 3-4 Monthly Manual Tracking of 23 Individual Rainbow Trout, March – June 2022. No Rainbow Trout were Recorded July – October. Number of Individual Fish Detected in the ZOP Each Month Provided.



Note: ZOP = Zone of Passage

Figure 3-5. Manual Tracking of 14 Individual Rainbow Trout that Entered the Fish Passage Facility (left) and 9 Individual Rainbow Trout that Did Not Enter the Fish Passage Facility (right), March – October 2022.



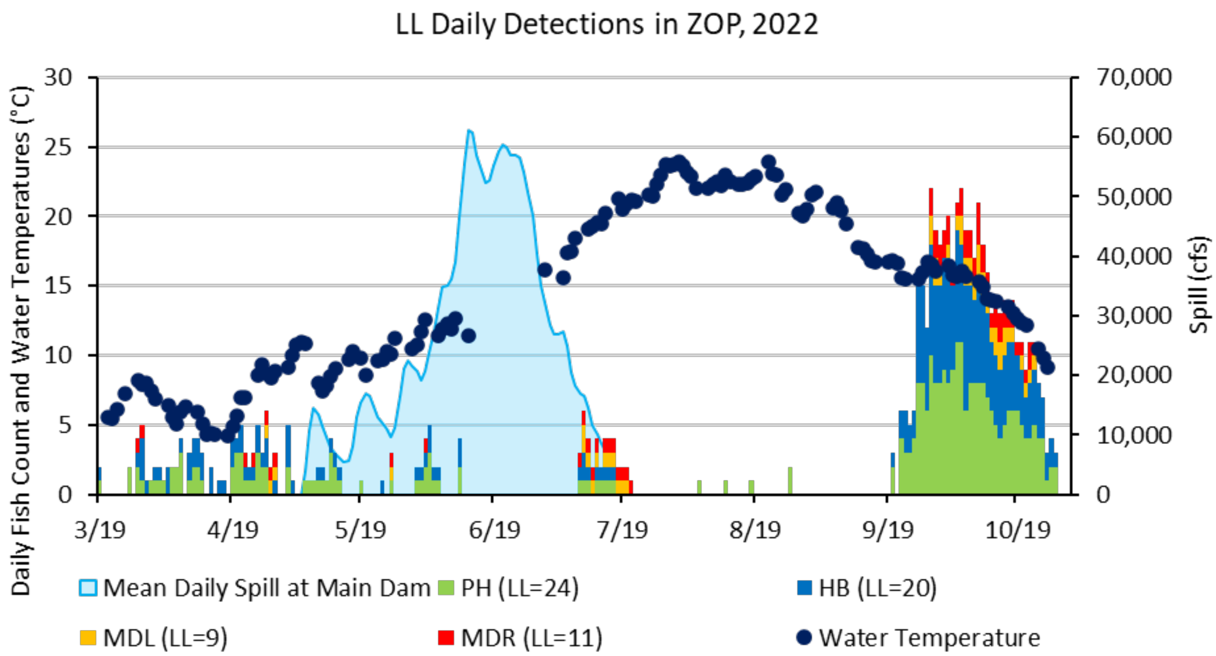
Note:

ZOP = Zone of Passage

3.5.2 *Brown Trout*

In 2022, the fixed receivers detected Brown Trout entering the ZOP shortly after release at Flatiron FAS. This was true for both fish tagged and released in the spring and fall. There were some Brown Trout that ventured to the near field in the spring, but the earliest fish passage entrance was July 20. The daily detection of Brown Trout at each fixed receiver along with mean daily spill at the Main Dam and daily water temperature are presented in **Figure 3-6**. During the 2022 season, seven Brown Trout entered the fish passage facility, one in July, and six in the fall.

Figure 3-6. Daily Detections of Brown Trout by the Fixed Receivers, Mean Daily Spill at the Main Dam, and Daily Water Temperature Measurements, during 2022 Study Season.



Manual tracking detected 15 of the 25 tagged Brown Trout during study. Manual tracking confirmed that the peak presence of Brown Trout in the ZOP and near field occurred during the fall months, September and October (**Table 3-6**). In contrast to Rainbow Trout, no Brown Trout were detected in the ZOP in March *via* manual tracking and monthly detections were limited to one or two individuals in the ZOP April through July. No Brown Trout were detected in the ZOP in August. The locations for the monthly detections of Brown Trout that occurred April through October are illustrated in **Figure 3-7.**

Table 3-6 Monthly Summary of the Number of Individual Brown Trout Detected *via* Manual Tracking in the ZOP and PIT tag array in the fish passage facility entrance.

Month 2022	Individual Brown Trout Detected *via* Manual Tracking		Detection *via* PIT Tag Array
	ZOP	**Near Field**	**Ladder Entrance**
MAR	-	-	-
APR	1	1	-
MAY	2	-	-
JUN	1	-	-
JUL	2	2	1
AUG	-	-	-
SEP	10	**2**	2
OCT	9	**4**	4
Total	**15**	**7**	**7**

Note: ZOP = Zone of Passage

Between March 16 and 24, eight Brown Trout were tagged and transported downstream and 50 percent (4) of these fish were manually detected in the ZOP and 75 percent (3) of those fish entered the upstream fish passage facility. Between September 20 and 29, there were 17 Brown Trout tagged and transported downstream. Sixty five percent (11) of these fish were manually detected in the ZOP and 36 percent (4) of these fish were detected entering the upstream fish passage facility.

In April there was one Brown Trout detected in the ZOP, including in the MDR zone near the fish passage entrance (**Figure 3-7**). This fish was later detected entering the upstream fish passage facility in mid-October.

In May, there were two Brown Trout detected in the far field, one of these fish later entered the upstream fish passage facility in September.

In June, one Brown Trout was detected in the ZOP. This same fish was later detected in the MDR zone and entered the fish passage facility in July.

In July, two Brown Trout were detected in the ZOP. One entered the fish passage facility in July **(Figure 3-8)**. The other Brown Trout was detected in the near field (MDL). This fish had also been detected in the near field (MDR) in April, and later entered the fish passage facility in October.

Peak activity by Brown Trout in the ZOP occurred in September and October. In September, Brown Trout were manually detected in three locations, near the original powerhouse along the wingwall (3 individuals), between Prospect Creek and Dry Channel Dam outlets, and immediately downstream the Main Dam in the MDR zone (Figure 3-8). There were a couple additional detections near the falls and MDL zone. One individual Brown Trout was detected immediately downstream of the Dry Channel Dam and remained in this reach during the fall and through the end of the 2022 monitoring period. This was the only fish in the study (of both species) detected this far upstream in the Dry Channel reach.

In October, Brown Trout detections included two primary groupings, one group with detections in proximity of the fish passage entrance within the MDR zone and a second group with detections between the mouth of Prospect Creek and Dry Channel Dam (**Figure 3-8**). There were a few additional fish detections dispersed downstream in the Powerhouse detection zone.

No Brown Trout were detected upstream in Prospect Creek *via* the remote PIT Tag array during the study season.

Manual tracking detected seven individual Brown Trout in the ZOP that were recorded entering the fish passage facility entrance and another eight individual Brown Trout that did not enter the fish passage facility (**Figure 3-9**). The manual tracking illustrates Brown Trout explored and were recorded at similar locations within the ZOP regardless of whether the fish entered the fish passage facility. In general, Brown Trout detected near the MDR zone (but not recorded at the fish passage facility entrance) were concentrated near the fish passage facility entrance in October, and to some extent in September (Figure 3-9).

In summary, there was no consistent holding area observed for Brown Trout in the ZOP during the spring and summer months. Peak activities and movement in the ZOP occurred in the fall. Brown Trout appeared to utilize many locations in the ZOP with some grouping of detections occurring near the mouth of Prospect Creek and in proximity of the fish passage facility entrance.

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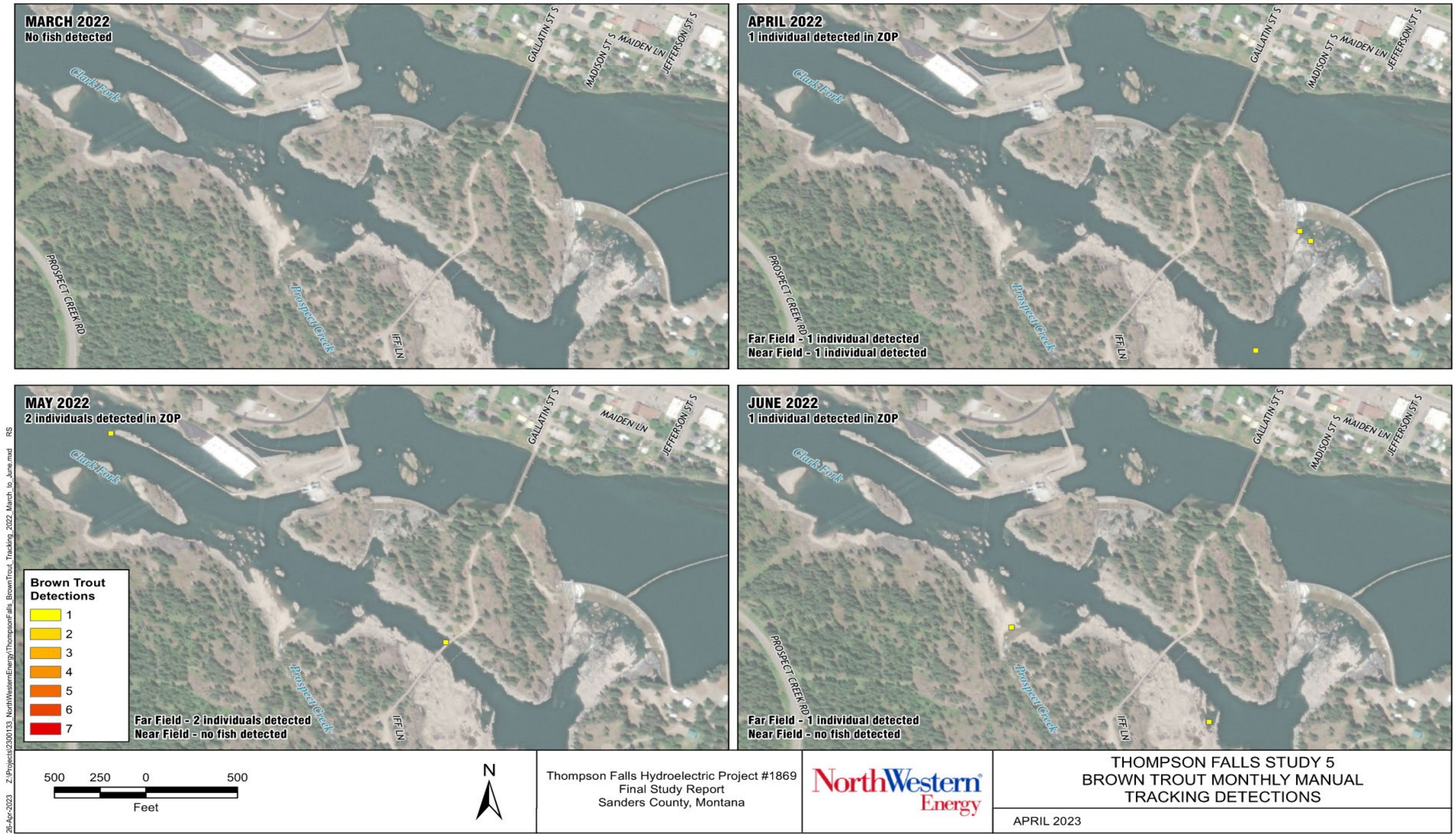
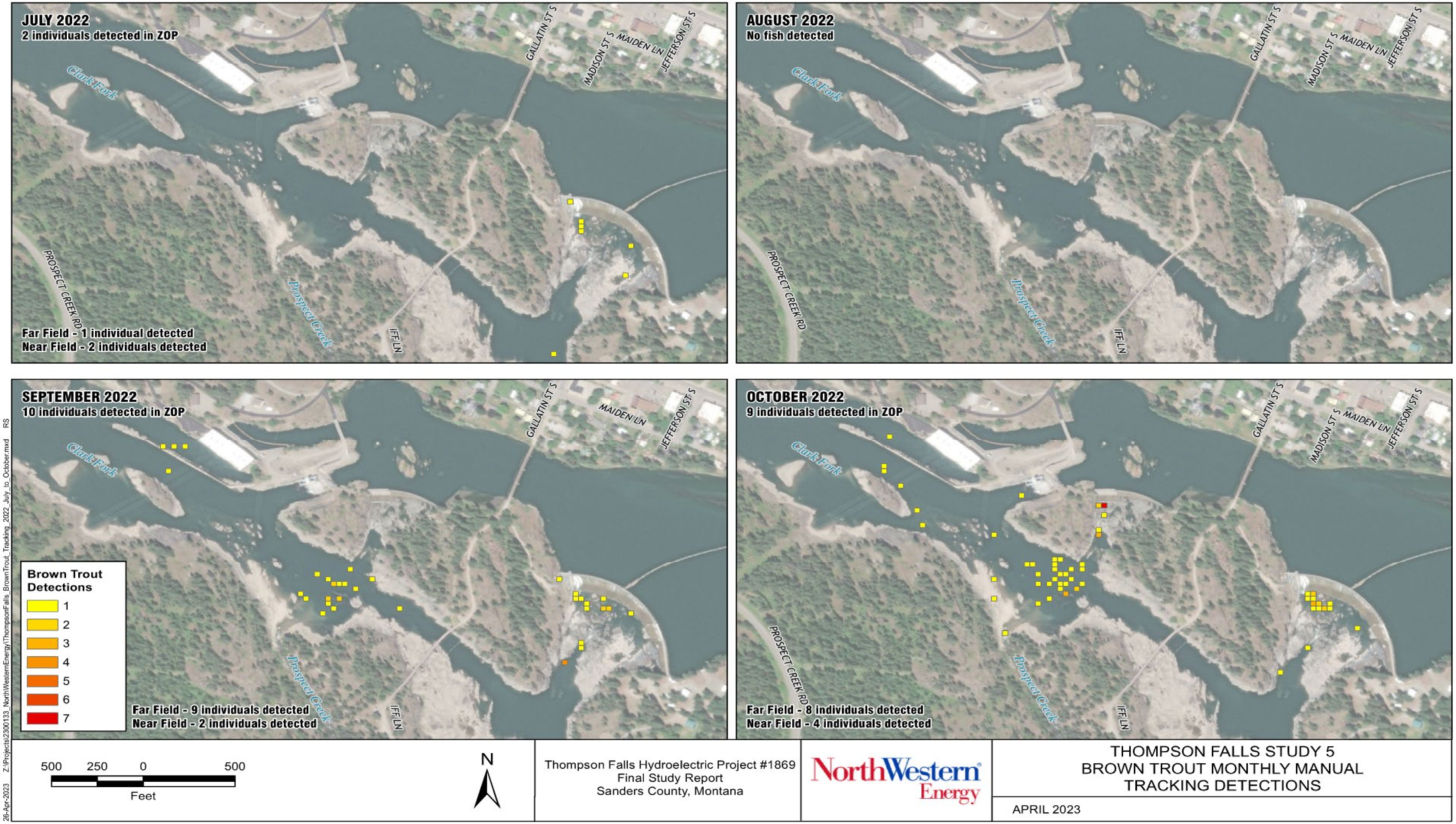
Figure 3-7. Monthly manual tracking Brown Trout, March – June 2022. Number of individual fish detected in the ZOP each month provided.



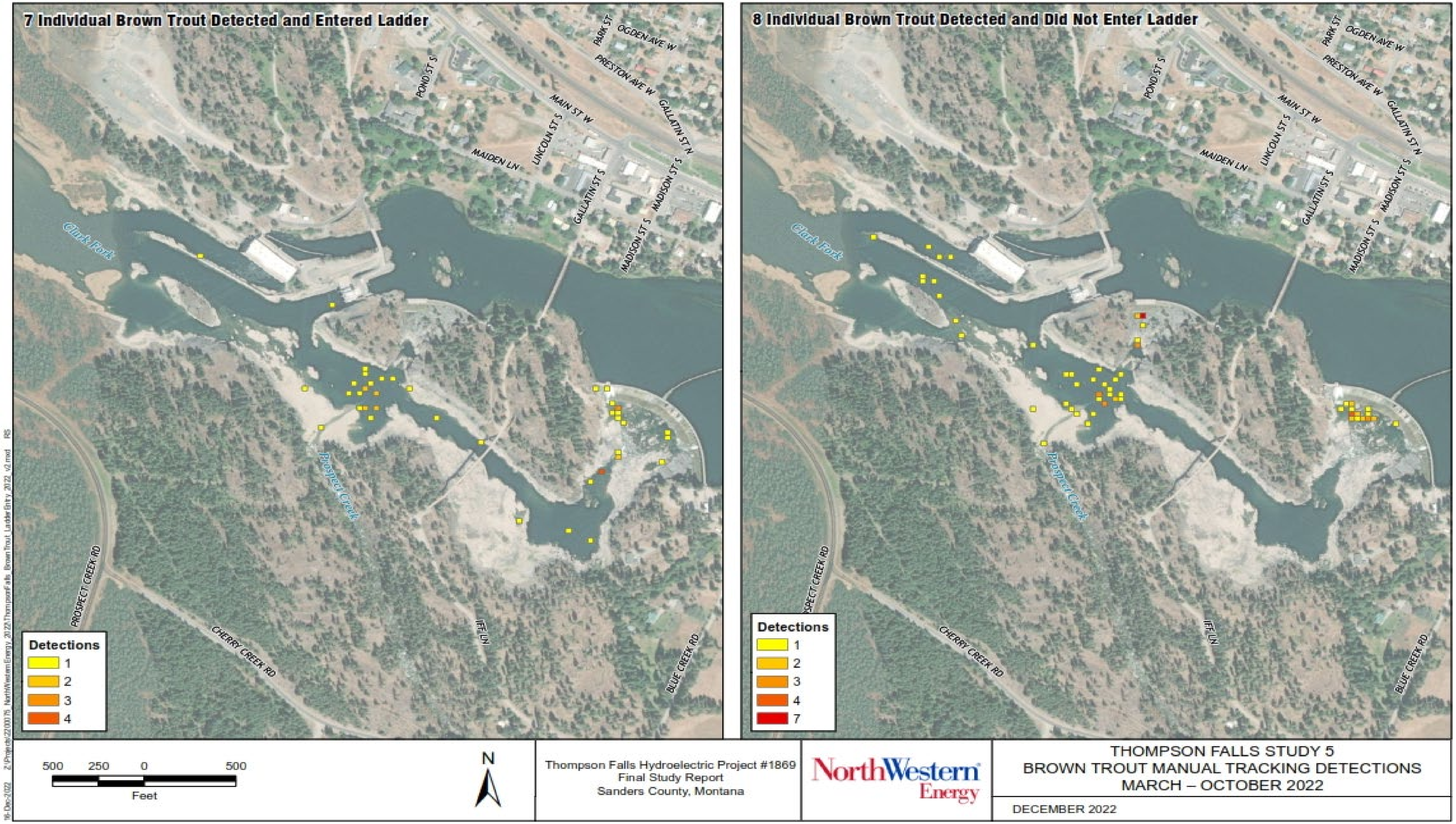
Note: ZOP = Zone of Passage

Figure 3-8. Monthly manual tracking Brown Trout, June – October 2022. Number of individual fish detected in the ZOP each month provided.



Note: ZOP = Zone of Passage

Figure 3-9. Manual tracking of 7 individual Brown Trout that entered the fish passage facility (left) and 8 individual Brown Trout that did not enter the fish passage facility (right), March – October 2022.



Note:

ZOP = Zone of Passage

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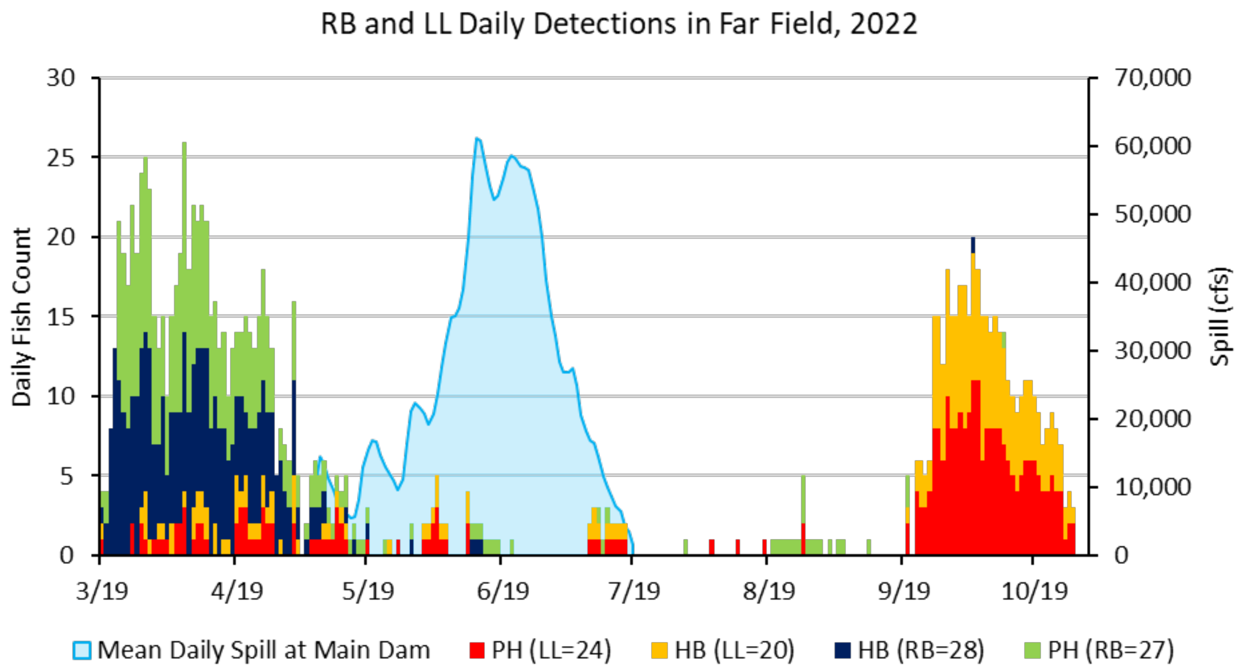
3.5.3 *Movement Patterns in the Far Field*

Daily detections of Rainbow and Brown trout in the far field (*via* Powerhouse and High Bridge fixed station receivers), May 6 through July 19, are illustrated in **Figure 3-10**. Spill occurs at the Main Dam when streamflow is 23,000 cfs or greater.

Figure 3-10. Summary of Daily Detections from the Powerhouse and High Bridge Fixed Receiver Stations of Rainbow and Brown Trout in the Far Field and Mean Daily Spill at the Main Dam, 2022.

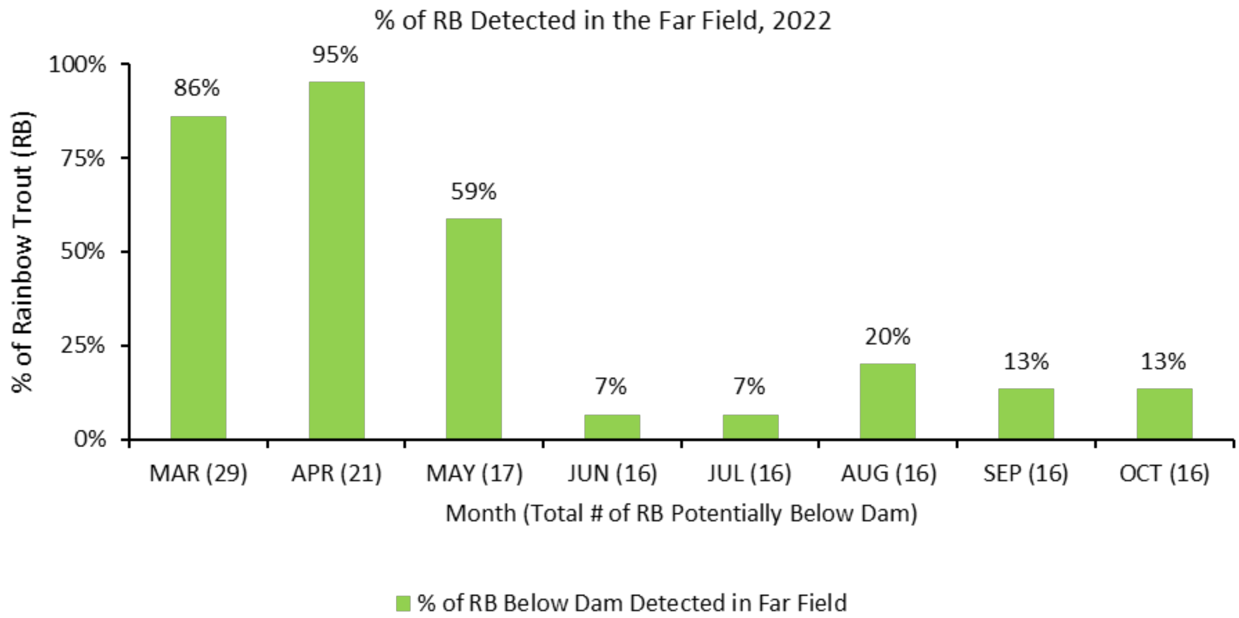


Notes: cfs = cubic feet per second; HB = High Bridge; LL = Brown Trout; PH = Powerhouse; RB = Rainbow Trout.

3.5.3.1 Rainbow Trout in the Far Field

Rainbow Trout detections in the far field were largely limited to the initial months following release at Flatiron FAS, March through early May (**Figures 3-10, 3-11**). The number of Rainbow Trout in the far field declined in May and the following months. This was likely due to tagged fish entering the fish passage facility and thus leaving the study, and also tagged fish leaving the ZOP during high flow. Rainbow Trout were present at low numbers, 1 to 3 individuals, in the far field (primarily the Powerhouse area) between June and October. Between June and October, approximately 7 to 20 percent of the 16 Rainbow Trout present below the dam were detected in the far field with the lowest detections in June and July (Figure 3-10).

Figure 3-11. The Percentage of Rainbow Trout Detected in the Far Field by Month, 2022.

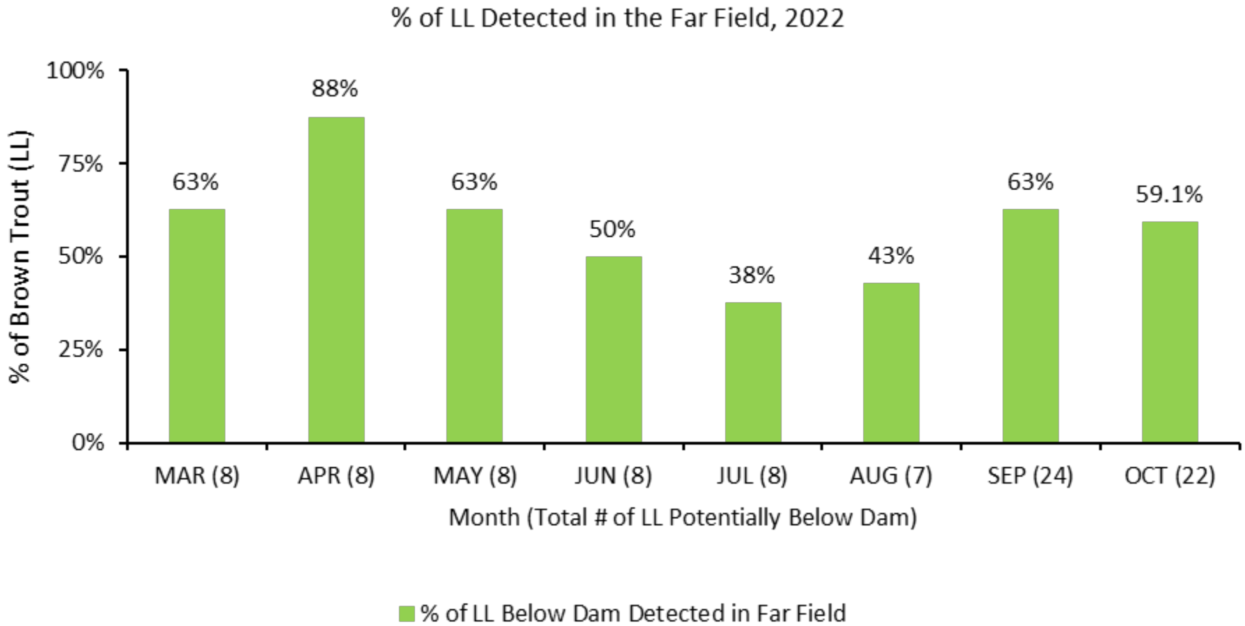


3.5.3.2 Brown Trout in the Far Field

Brown Trout detections in the far field were greatest in the spring and fall immediately following the respective fish collection, tagging, and transport activities. In April, 88 percent of the Brown Trout tagged in the spring were detected in the far field (Powerhouse/High Bridge), but that number declined to 38 percent in July (**Figure 3-12**). After the introduction of 17 new Brown Trout to the study in September, over half of these fish were detected in the far field in September and October (15 and 13, respectively).

Brown Trout detections in the far field during spill declined (*refer to* Figure 3-10), but there was a greater proportion of the tagged Brown Trout that remained in the ZOP (based on fixed station receiver data) during this period than Rainbow Trout (*refer to* Figures 3-11 and 3-12).

Figure 3-12. The Percentage of Brown Trout Detected in the Far Field by Month, 2022.

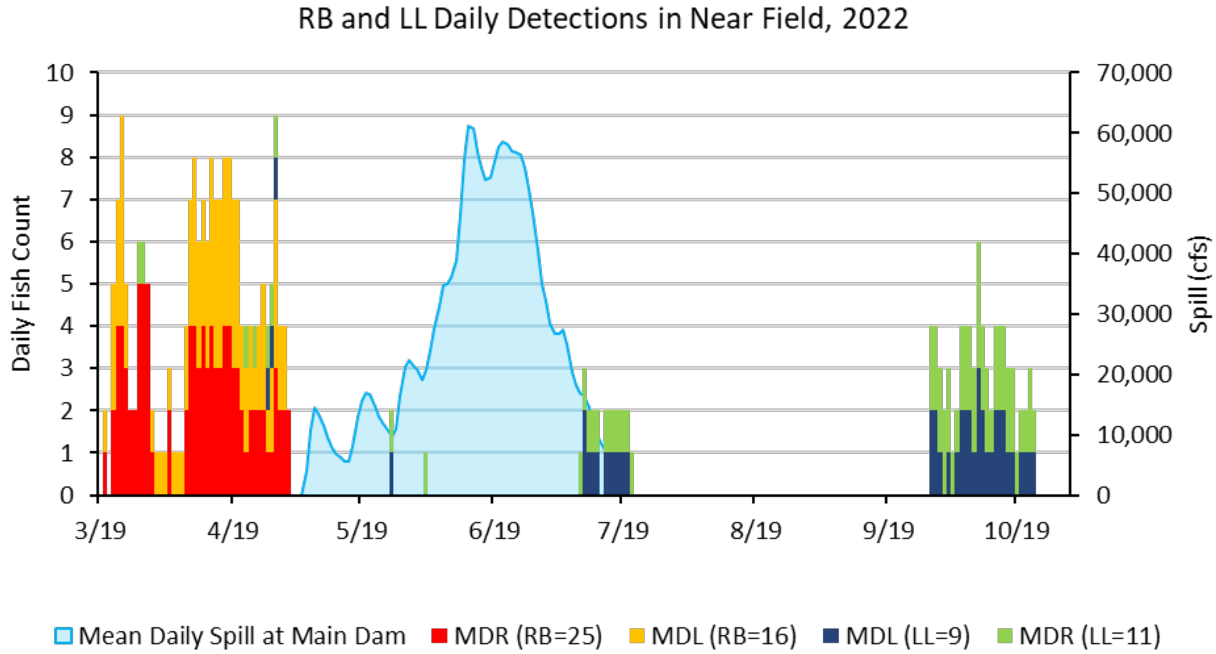


3.5.4 *Movement Patterns in the Near Field*

Daily detections of Rainbow and Brown trout in the near field (*via* MDR and MDL fixed station receivers) corresponding to the mean daily spill at the Main Dam, May 6 through July 19, are illustrated in **Figure 3-13**. The majority of near field activity and detections occurred pre-spill by Rainbow Trout and then towards the end of spill in July and the fall by Brown Trout.

In 2022, the majority (86%) of near field fish detections were by the MDR receiver; 91 percent of Rainbow Trout and 79 percent of Brown Trout near field detections. This trend was also observed for near field detections recorded in 2021.

Figure 3-13. Summary of Daily Detections from the MDR and MDL Fixed Receiver Stations of Rainbow and Brown Trout in the Far Field and Mean Daily Spill at the Main Dam, 2022.

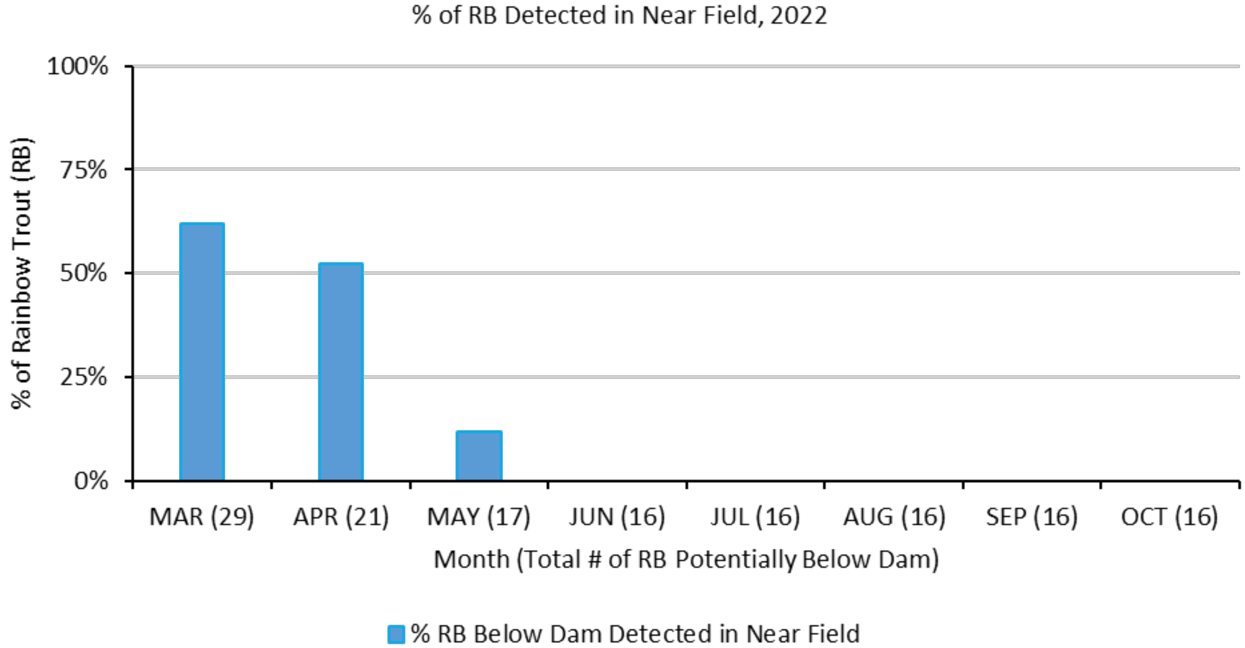


Notes: cfs = cubic feet per second; LL = Brown Trout; MDL = Main Dam Left; MDR = Main Dam Right; RB = Rainbow Trout.

3.5.4.1 Rainbow Trout in the Near Field

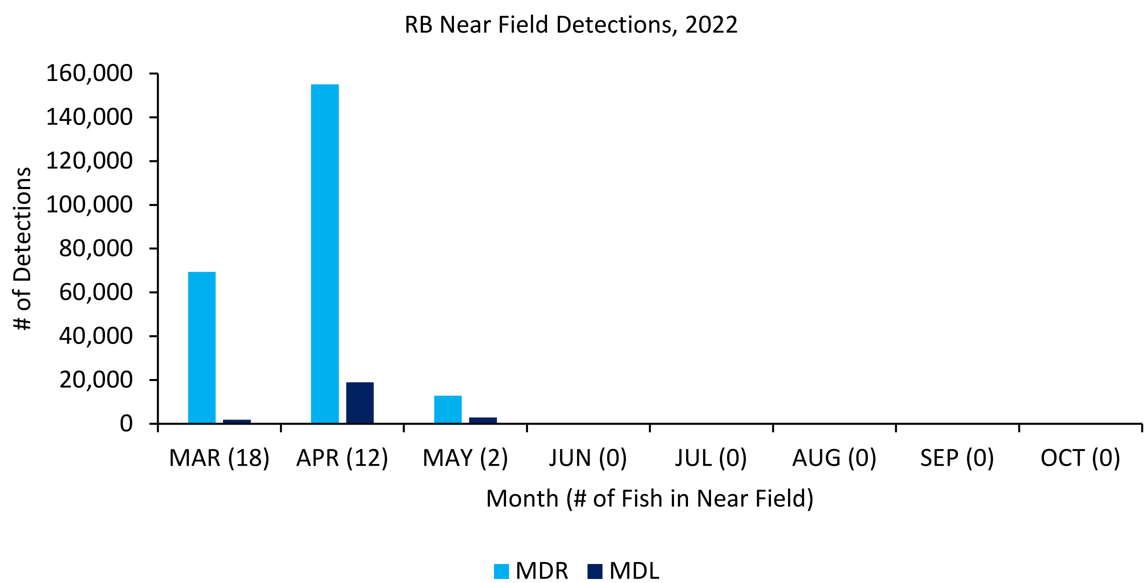
Rainbow Trout were only present in the near field in the spring months, March, April, and May, prior to spill (**Figure 3-14**). Daily movement of Rainbow Trout into the near field show 25 individuals detected in the MDR zone and 16 individuals detected in the MDL zone, and all detections were prior to the start of spill at the Main Dam on May 6 (*refer to* Figure 3-13). This early spring movement pattern observed by Rainbow Trout in 2022 was not observed in 2021 because fish were not collected or tagged until early June, concurrent with spill at the Main Dam.

Figure 3-14. Percentage of Rainbow Trout Detected in the Near Field by Month, 2022.



The number of Rainbow Trout detected in the near field ranged from 0 to 18 fish per month, representing a total of 25 individuals. Rainbow Trout spent more time within the MDR zone than the MDL zone, as evidenced by a greater number of detections and numbers of fish (**Figure 3-15**). Rainbow Trout moved quickly after release upstream to the near field and concentrated within the MDR zone near the fish passage facility with minimal detections in the MDL zone (Figure 3-15).

Figure 3-15. The Number of MDR and MDL Receiver Detections of Rainbow Trout by Month, 2022.



Notes: MDL = Main Dam Left; MDR = Main Dam Right; RB = Rainbow Trout

3.5.4.2 Brown Trout in the Near Field

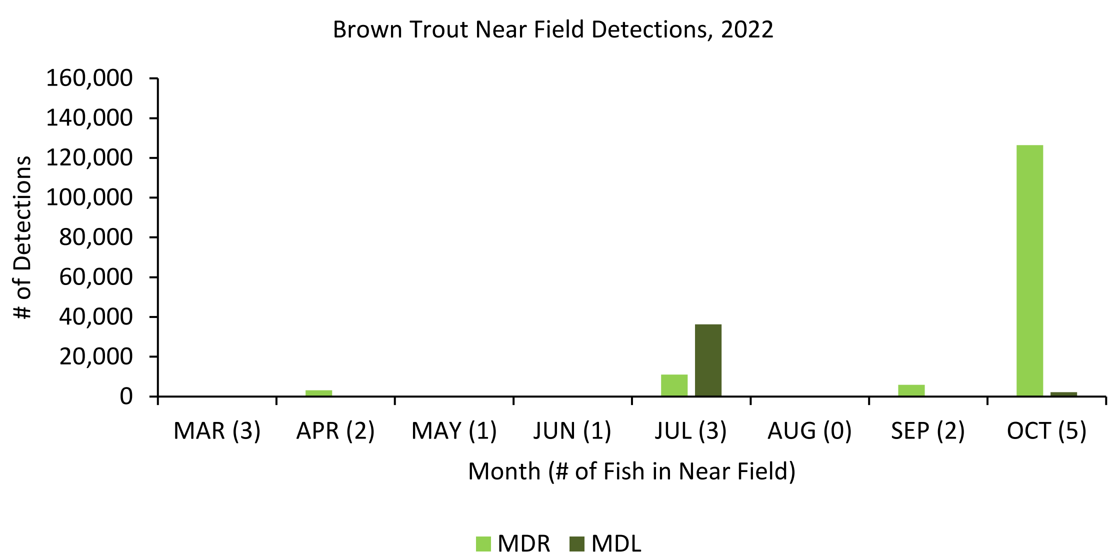
During the 2022 season, there were 11 individual Brown Trout detected in the MDR zone and nine individuals in the MDL zone (*refer to* Figure 3-13). Unlike Rainbow Trout, Brown Trout were detected in the near field every month except August during the 2022 season (**Figures 3-16, 3-17**). The detections of Brown Trout in the near field were limited to a small number (1-3 individuals per month) of the spring-tagged fish between March and July, as well as a small number of the fall-tagged fish in September and October (2 and 5 individuals, respectively) (Figure 3-17).

Spring presence of Brown Trout was primarily detected by the MDR receiver (Figure 3-16). Four individual Brown Trout were detected in the near field for 12 days during Main Dam spill (*refer to* **Figure 3-13**). One of these Brown Trout entered the fish passage facility the day after spill ceased at the Main Dam, July 20.

During the month of July, there were three individuals detected in the near field and the majority of detections were recorded by the MDL receiver (Figure 3-16). This was the only month and instance when MDL detections outnumbered MDR detections. However, when looking at the daily fish count at each station during July, more individual fish were detected at MDR than at MDL (*refer to* Figure 3-13).

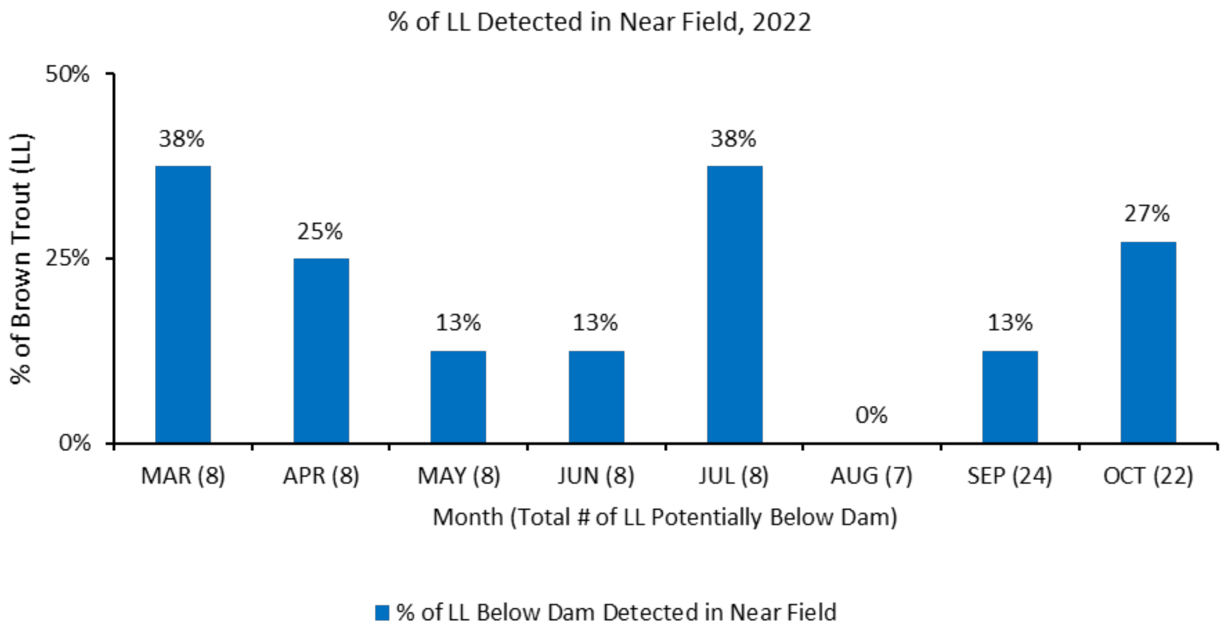
During the month of September, 17 Brown Trout were collected and added to the study. A notable increase in near field detections occurred in October with the detections at MDR substantially greater than MDL in total count for the month (Figure 3-16) and daily presence (*refer to* Figure 3--13). There were two Brown Trout that entered the near field and the fish passage facility in September and October that were not detected by the fixed receivers, presumably because the batteries in the radio tags had expired.

Figure 3-16. The Number of MDR and MDL Receiver Detections of Brown Trout by Month, 2022.



Notes: MDL = Main Dam Left; MDR = Main Dam Right.

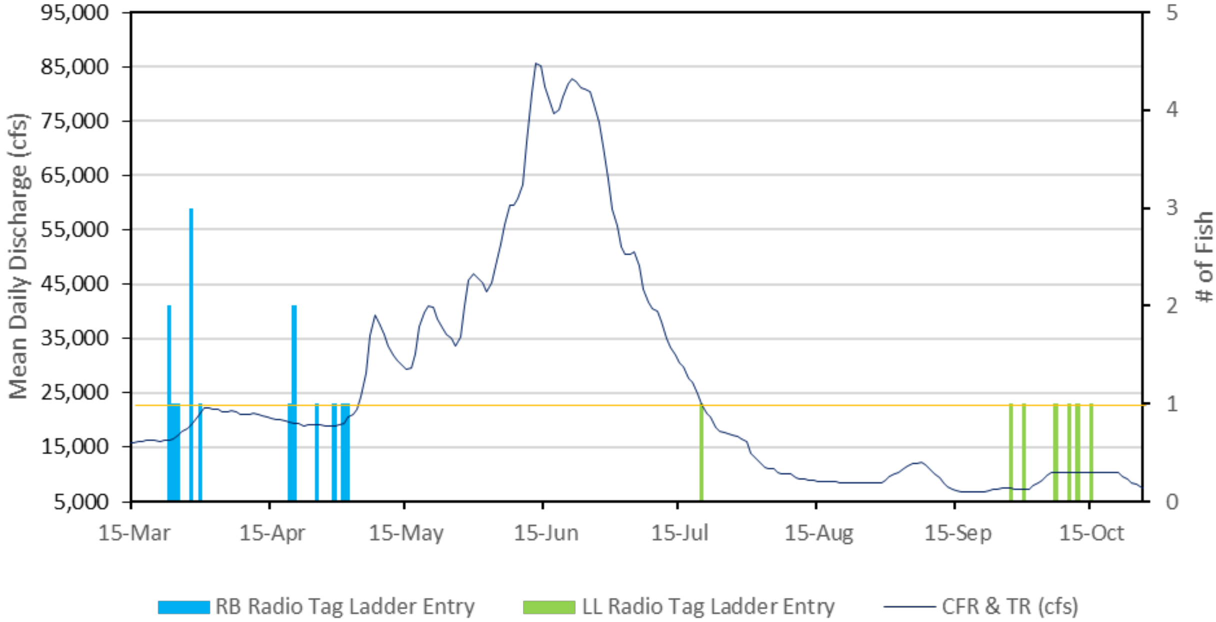
Figure 3-17. Percentage of Brown Trout Detected in the Near Field by Month, 2022.



3.5.5 *Fish Passage Facility Entrances*

Radio-tagged Rainbow Trout entered the fish passage facility in the spring, prior to high flow (**Figure 3-18**). Radio-tagged Brown Trout entered the fish passage facility primarily during the fall months, September and October, with the exception of one Brown Trout entering the fish passage facility in July. Neither species were detected in the fish passage facility entrance during peak flows.

Figure 3-18. Summary of Individual Radio Tagged Rainbow Trout and Brown Trout Entering the Fish Passage Facility and Mean Daily Streamflow, 2022.

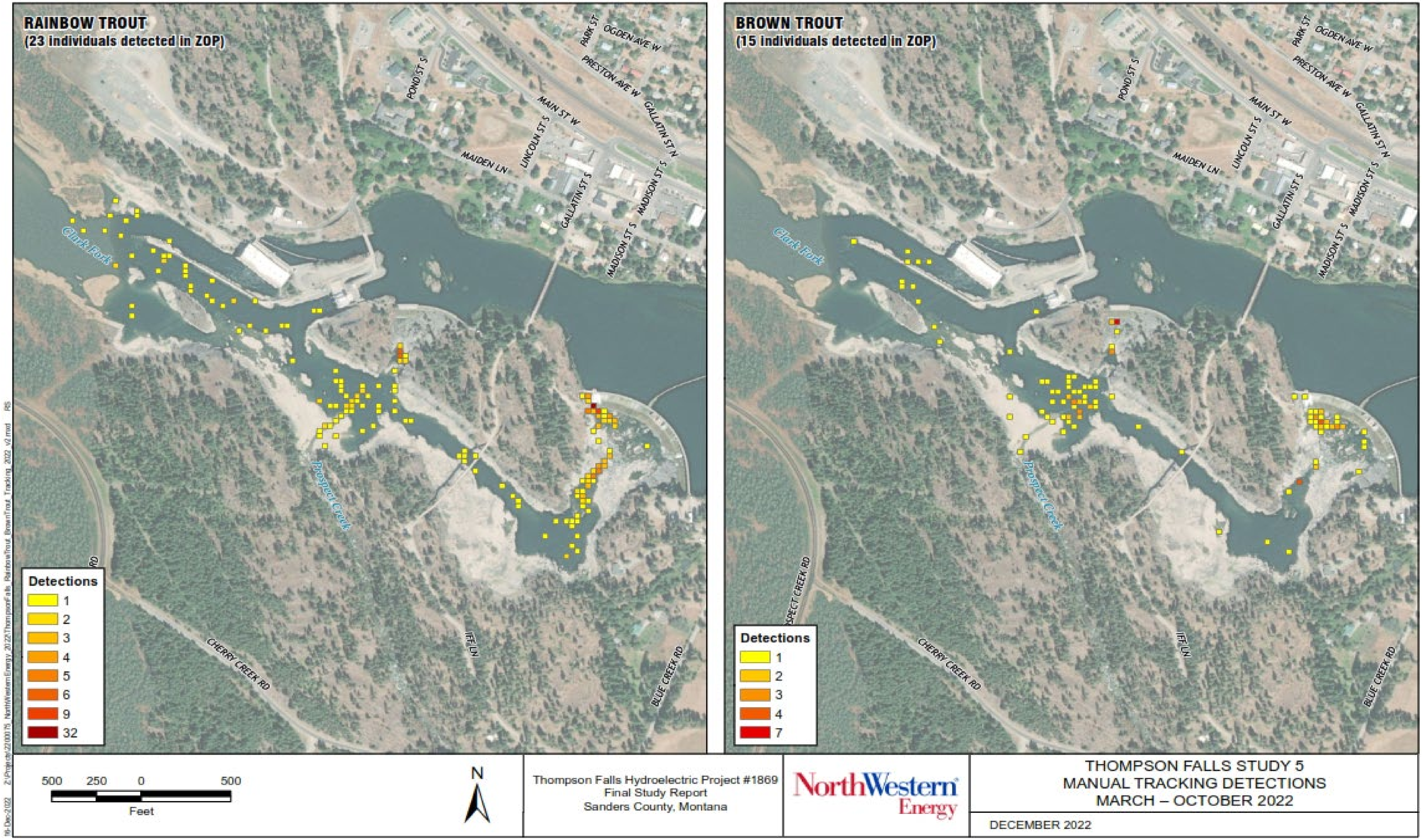


Notes: CFR = Clark Fork River; cfs = cubic feet per second; RB = Rainbow Trout; LL = Brown Trout; TR = Thompson River. Spill Occurs When Flows Exceed 23,000 cfs (yellow line).

3.5.6 *Summary of Locations Where Fish Hold within the ZOP*

The manual tracking data indicated most fish move up the main section of the channel and were not concentrated along the tailrace areas near the Original Powerhouse and New Powerhouse (**Figure 3-19**). Some fish were detected in these locations, but they were spread out and not in one specific location, additionally they were typically only detected for a short period of time before moving further upstream. The two areas where Brown and Rainbow trout congregated the most were near the mouth of Prospect Creek and along the right side of the Main Dam, near the upstream fish passage facility.

Figure 3-19. Manual Tracking of 23 Individual Radio-Tagged Rainbow Trout and 15 Individual Radio-Tagged Brown Trout, 2022 Season.



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3.6 Water Temperature Profiles

NorthWestern completed water quality monitoring activity over 3 years, 2019 to 2021 (NorthWestern 2022d), including temperature monitoring of the Clark Fork River both upstream and downstream of the study area. The data show water temperatures in the summer are warm throughout the Clark Fork River system and there is no significant difference in temperature upstream and downstream of Thompson Falls Dam (**Table 3-7**) (NorthWestern 2022d). The Thompson River provides a cool water inflow to Thompson Falls Reservoir.

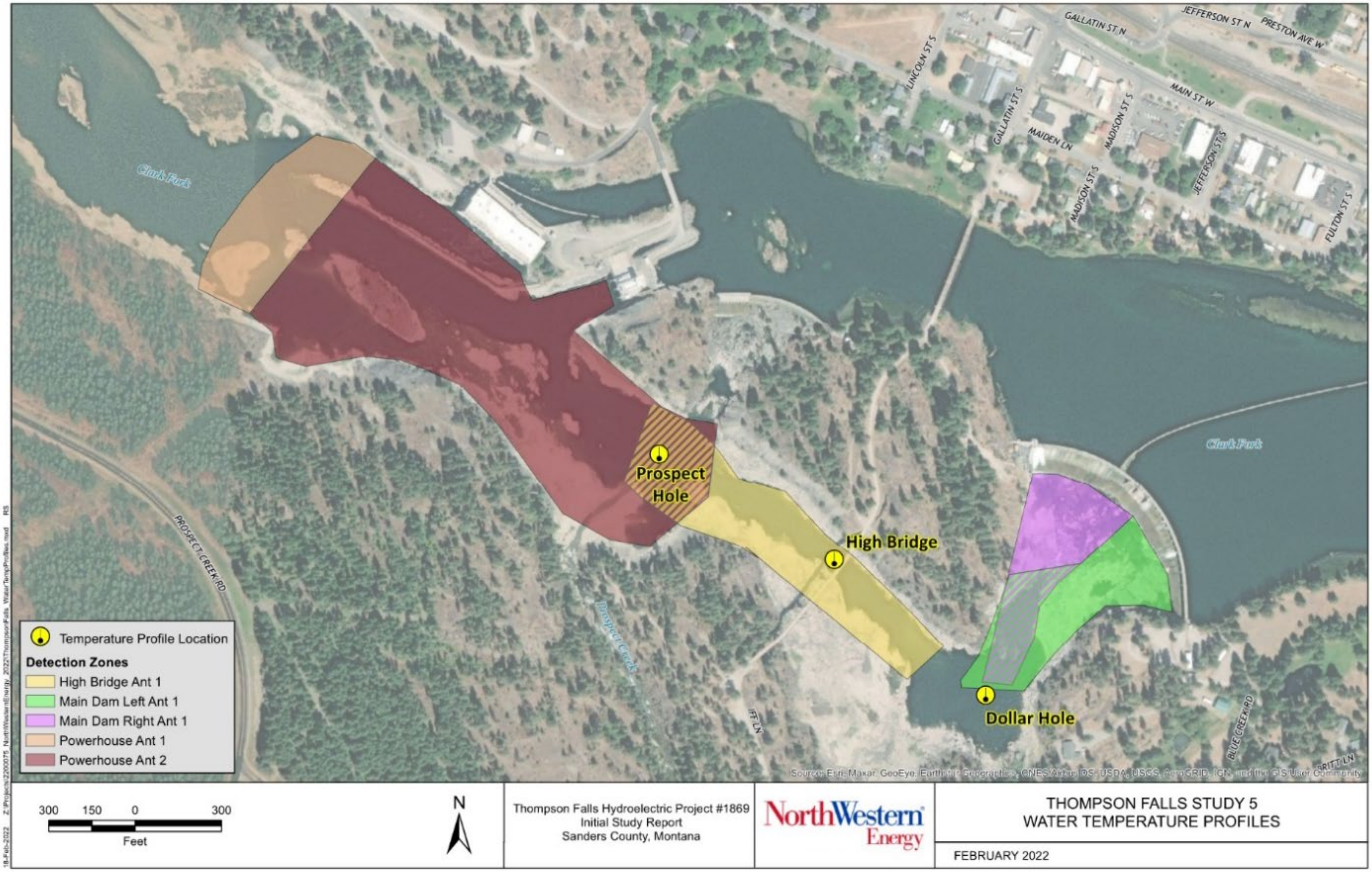
Table 3-7 Summary of 2019 Water Temperature Data.

Site Name	Site Description	Date of Sample	Variable	Temperature (°C)
CF1	Clark Fork River upstream of Thompson Falls Reservoir	8/8/19	Instantaneous Maximum Temperature	23.8
		8/3/19-8/9/19	7-Day Maximum	23.3
CF2	Clark Fork River upstream of Dam in Thompson Falls Reservoir	8/9/19	Instantaneous Maximum Temperature	23.2
		8/3/19-8/9/19	7-Day Maximum	23.0
CF4	Clark Fork River at Birdland Bay Bridge	8/7/19	Instantaneous Maximum Temperature	23.0
		8/3/19-8/9/19	7-Day Maximum	22.9
TR1	Thompson River at Mouth	8/3/19	Instantaneous Maximum Temperature	18.8
		8/1/19-8/7/19	7-Day Maximum	18.3

Notes: °C = degrees Celsius**.**
Source: NorthWestern 2022d.

Data collected in 2021 and 2022 in conjunction of this telemetry study allowed NorthWestern to examine a smaller scale of thermal profiles in the study area. NorthWestern collected temperature profile data in 2021 and 2022 at three locations: Prospect Hole, High Bridge, and Dollar Hole (**Figure 3-20**). In 2021 profiles were taken in August and September. In 2022 profiles were taken in July and August (**Figures 3-21, 3-22, 3-23**). In both years, all three sites showed distinct thermal stratification during the summer. A summary of the 2021 results is provided in the Fish Behavior Study ISR (NorthWestern 2022b).

Figure 3-20. Temperature Profile Locations and Fixed Station Detection Zones.



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On July 28, 2022, all three sites were thermally stratified (**Figure 3-21**). Surface temperatures were around 23°C at all sites and declined to around 18°C at depths ranging from 5 to 17 feet from the surface. Similar to data collected in 2021, water temperatures remained cooler closer to the surface at the Prospect Hole site than the other sites.

By August 9, 2022, thermal stratification remained distinct at Prospect Hole, but less so at the High Bridge. Temperature stratification was not apparent at the Dollar Hole (**Figure 3--22**). Prospect Hole provided the coolest water temperatures (more favorable to salmonids) in early August, with temperatures remaining below 20°C at the surface and depth. The High Bridge and Dollar Hole sites were less favorable for salmonids in early August. Temperatures exceeded 20°C at all depths at the Dollar Hole, and above 30 feet at the High Bridge.

By the end of August, all three sites had again established a distinct thermal stratification with surface temperatures between 19°C and just over 20°C (*refer to* **Figure 3-23**). Water temperature at the Prospect Hole and High Bridge sites was approximately 15°C at 10 feet below the surface. Water temperature at the Dollar Hole remained approximately 18°C at a depth of 18 feet or more.

Figure 3-21. Temperature Profile at Prospect Hole, High Bridge, and Dollar Hole on July 28, 2022.

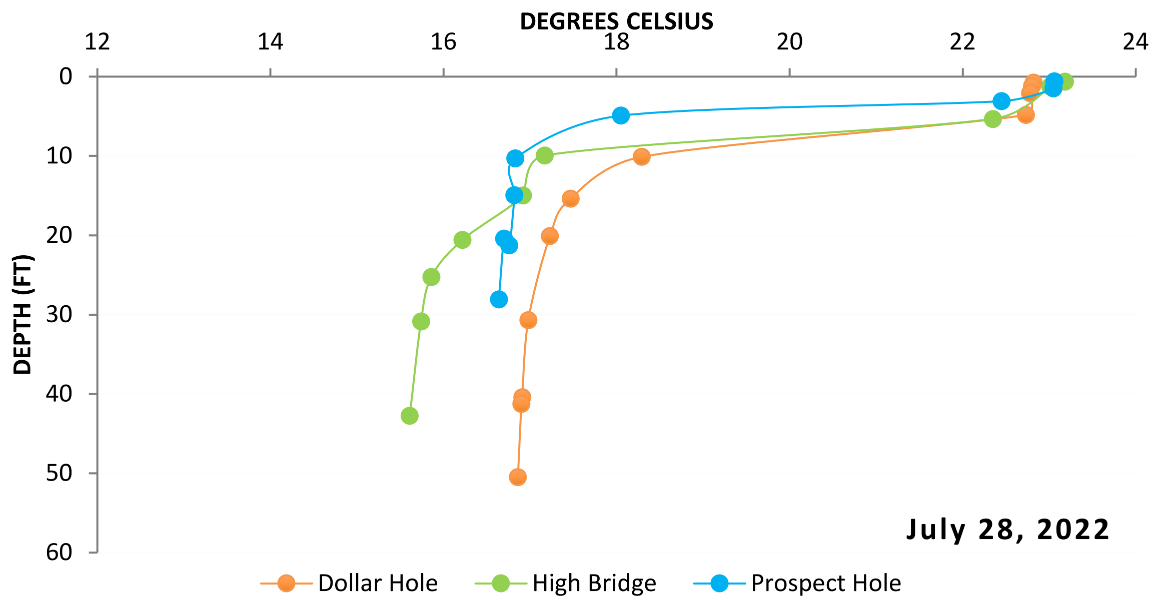


Figure 3-22. Temperature Profile at Prospect Hole, High Bridge, and Dollar Hole on August 9, 2022.

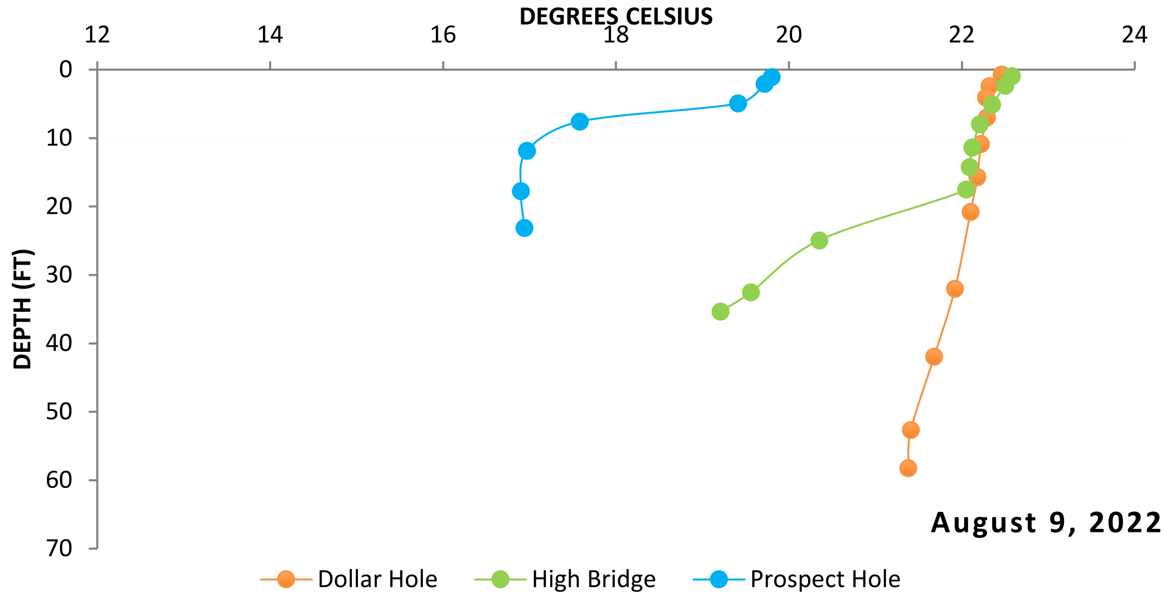
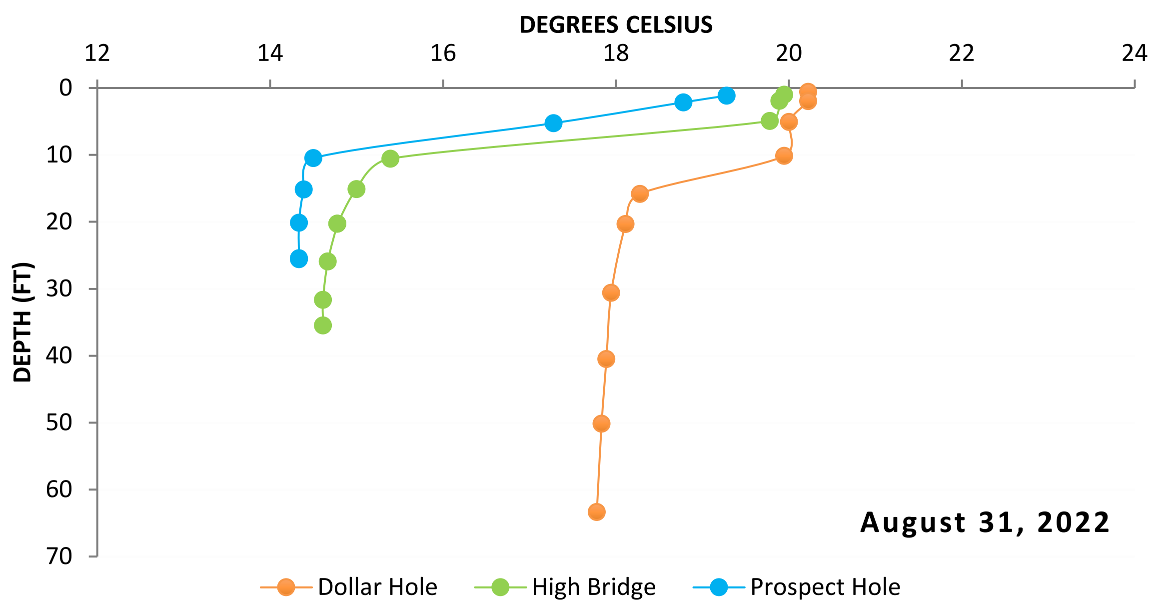


Figure 3-23. Temperature Profile at Prospect Hole, High Bridge, and Dollar Hole on August 31, 2022.



3.7 Fish Depth

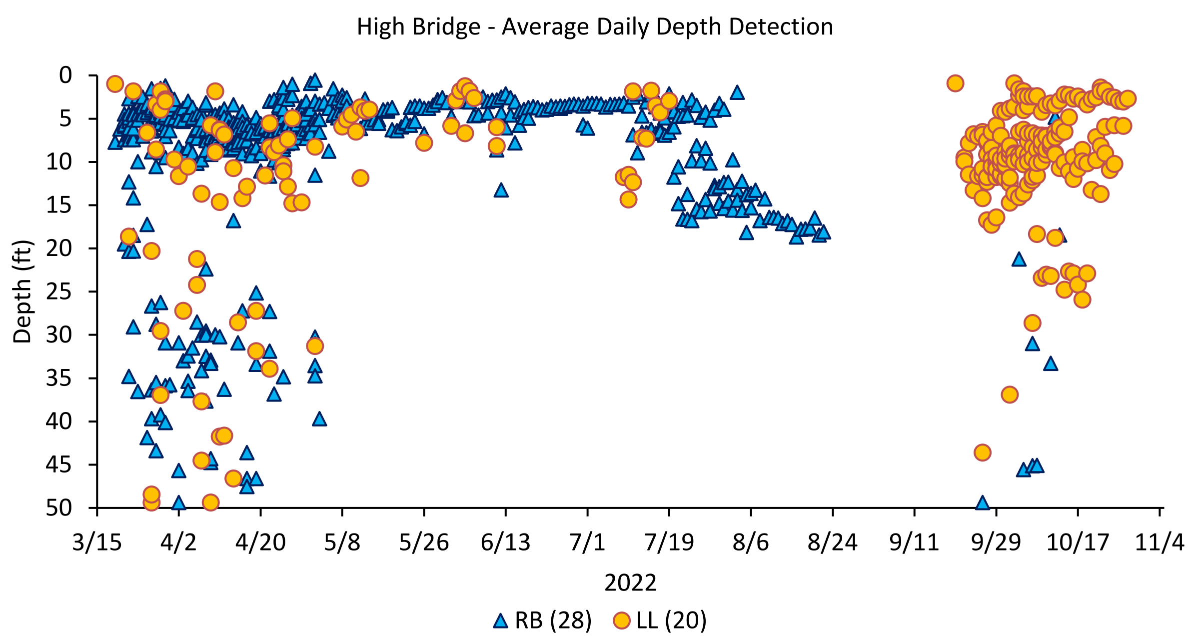
The radio tags used in this study included pressure sensors which provided data to evaluate depth use by Rainbow and Brown trout in the ZOP. Average daily pressure values were converted from a pound-force per square inch (PSI) to feet (PSI = 2.307 feet). It should be noted that water depths in the study area change seasonally based on the total flow in the Clark Fork River and the pool elevation of Noxon Reservoir. In 2022 water levels during the end of July, and all of August, were near baseflow levels and had little water mixing within the sections where fish depths are analyzed in this section.

The average daily pressure data was collected by the High Bridge fixed receiver station. The High Bridge receiver was used because it overlaps with the areas where temperature profile information was collected and covers a large portion of the study area. The sensor data reflect information collected from 28 individual Rainbow Trout and 20 individual Brown Trout. This evaluation looks at fish use of the water column as temperatures increase in the system, often exceeding optimal threshold for salmonids (>21°C) for extended periods of time during the summer months, thus records of all fish detected in the High Bridge zone (HB zone) were included.

Brown Trout data represent 20 individual fish and all daily detections within the HB zone. Unlike Rainbow Trout, there were no Brown Trout that returned to the ZOP after entry into the fish passage facility and release upstream during the study season.

Results from 2022 show a similar trend as in 2021. During the summer months when the thermocline has established (July – August), trout are more often found in deeper waters to access cooler water temperatures (**Figure 3-24**). During the spring and fall periods trout are found primarily at shallower depths, but also venture into depths greater than those found in the summer months.

Figure 3-24. Daily Average Depth (ft from surface) of Rainbow Trout and Brown Trout Detected by the High Bridge Station, 2022.



Notes: ft = feet; LL = Brown Trout; RB = Rainbow Trout.

The average daily depth for Rainbow Trout detected within the HB zone, show many detections between March and early May (prior to spill) primarily between 2 and 10 feet below the surface with some fish moving at various depths (up to 50 feet). This period coincides with when Rainbow Trout were detected moving into the near field and entering the fish passage facility. The majority of fish remained with 2 to 8 feet of the surface until around July 10 when Rainbow Trout dispersed to different depths (max depth ~19 feet). Detections during peak summer temperatures were about 17 feet below the surface within the HB zone. Detections stopped abruptly August 21 and Rainbow Trout were not detected again until the end of September and early October when there were a few fish at various depths (*refer to* **Figure 3-24**). Surface water temperatures exceeded 20°C by July 15, were near 24°C at this time in August and did not decline below 20°C until early September (NorthWestern 2023a). During the fall, two of the four Rainbow Trout observed in the HB zone had entered the fish passage facility in March and one fish had entered Prospect Creek in the spring and was leaving Prospect and moving downstream out of the ZOP.

Brown Trout showed a similar behavior as Rainbow Trout with regards to location in the water column during the spring (*refer to* Figure 3-24). Brown Trout were limited in detections during the summer and increased in detections during the fall, due to additional fall tagging efforts. In the fall, Brown Trout were observed mostly at depths ranging from 1 to 17 feet with the deepest recorded at 43 feet (*refer to* Figure 3-24).

3.8 Fish Swimming Abilities and CFD Modeling

To assess upstream fish passage conditions, in the area downstream of the Main Dam, NorthWestern conducted two-dimensional (2D) and three-dimensional (3D) CFD modeling (NorthWestern 2023b). The goal of the Hydraulic Conditions Study was to assess the velocity field downstream of the fish passage facility to understand if the flow field created by discharge from the fish passage facility provides a sufficient behavioral cue (attraction flow) to Bull Trout and other species, and whether velocities are low enough as to not fatigue fish attempting to approach the fish passage facility entrance. The first phase was performed using 2D simulations of four flow scenarios to provide an overview of the river channel hydraulics. The 2D simulations were then used to focus and refine modeling to a greater 3D resolution for two of the flow scenarios.

The CFD model results were compared to fish swimming ability to assess fish passage conditions at the modeled flows. Swimming abilities were reviewed for Rainbow Trout, Brown Trout, Bull Trout, Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*), Mountain Whitefish (*Prosopium williamsoni*), Northern Pikeminnow (*Ptychocheilus oregonensis*), and Largescale Sucker (*Catostomus macrocheilus*) based on available literature (NorthWestern 2022b). Results are summarized in **Table 3-8.**

Table 3-8. Summary of Upper Limit of Adult Fish Swimming Abilities, Prolonged and Burst Speed.

Common Name	Prolonged Speed (fps)	Burst Speed (fps)
Brown Trout	7.7	13.2
Bull Trout	2.8	7.5
Largescale Sucker	1.9	6.0
Mountain Whitefish	5.0	10.0
Northern Pikeminnow	3.8	4.4
Rainbow Trout	4.0	13.5
Westslope Cutthroat Trout	6.4	13.5

Note: fps = feet per second.

Based on the results of the first phase 2D modeling (NorthWestern 2022c), three areas of interest, the High Bridge, falls, and fish passage facility entrance, were evaluated further with 3D modeling at 2,000 and 37,000 cfs. The High Bridge and falls areas were selected because the 2D modeling indicated possible velocity barriers at those locations. The fish passage facility entrance is a key location for fish to find and enter the fish passage facility.

3.8.1 *Model Scenario: 200 cfs*

When the Clark Fork River flow is 23,000 cfs or less, all flow is routed through the powerhouses, except for approximately 200 cfs passed through the fish passage facility and over the Main Dam as attraction flow. A discharge rate of approximately 200 cfs generally represents the minimum discharge rate of the Main Dam and fish passage facility. The 200 cfs model run was completed at a 2D scale and does not contain more detailed cross-sectional velocities through the water column.

Modeling indicates that, at 200 cfs, velocities downstream of the Main Dam generally are less than 2 fps. Within the falls, flow velocities increase to a maximum of approximately 17 fps. As flows exit the falls and enter the main river channel, the velocities are quickly dissipated to 3 fps or less. The flow path streamlines[13] are shown in **Figure 3-25**. As indicated in **Figure 3-26**, all flow is concentrated towards and over the falls area, and then downstream and to the right before passing below the High Bridge. The high velocity jet (HVJ) is not submerged and the discharges from the upstream fish passage entrance produce a significant portion of the flow in this area. Therefore, at this flow rate, most of the flow path streamlines are concentrated near the entrance of the fish passage facility, indicating improved fish attraction to the fish passage facility entrance (NorthWestern 2022c).

[13] Streamlines are imaginary lines that represent the direction of the flowing fluid at a certain point in time. These show the direction in which a massless fluid element will travel at any point in time.

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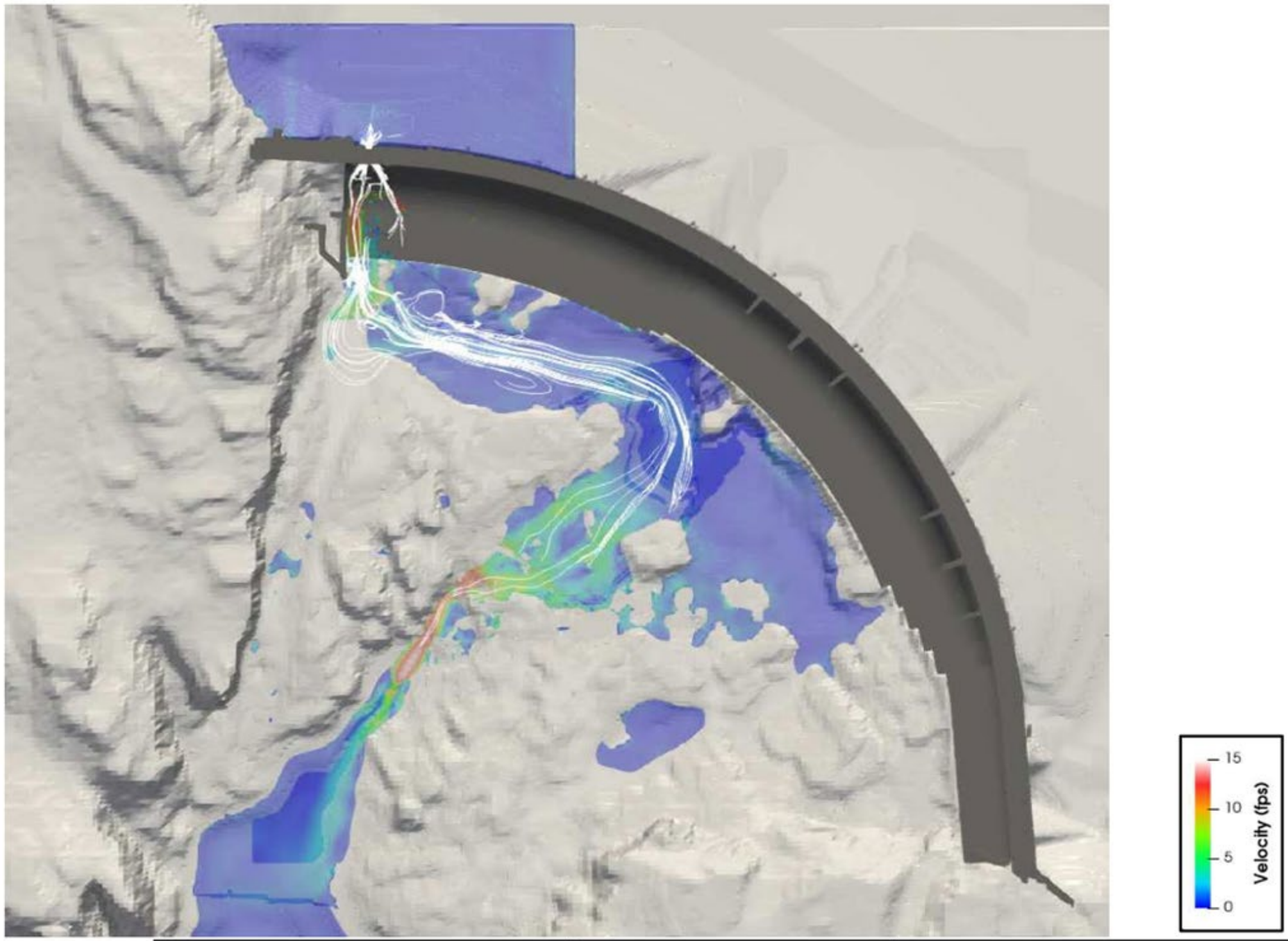
Figure 3-25. Run 4: 200 cfs Flow Path Streamlines.



Notes
1. Legend shown without transparency.

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RUN 4: 200 CFS
FLOW PATH STREAMLINES

February 2022

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3.8.2 *Model Scenario: 2,000 cfs*

The 2,000 cfs flow scenario represents a total river flow of 25,000 cfs resulting in approximately 2,000 cfs spill over the Main Dam (*refer to* **Figure 3-22**). The 2,000 cfs scenario was modeled with both the 2D and 3D modeling. The 3D results compute velocities from the High Bridge upstream to the Main Dam to range from approximately 2 to 23 fps. **Figure 3-26** illustrates the overall velocity map for the study area. On this figure, areas mapped in green have an average water velocity less than 7 fps and are assumed to be passable by all species of upstream migrating adult fish. Areas mapped in yellow have an average velocity between 7.1 and 14 fps and are assumed to be passable by salmonids swimming at burst speed. Areas mapped in red have an average velocity in excess of 14 fps, which exceeds the burst speed of all local fish species.

The highest velocities are immediately downstream of the open radial gate and are quickly dissipated from the energy of the turbulent flow in the pool downstream of the Main Dam structure. Flows through the falls also have high velocity, in excess of fish burst speed.

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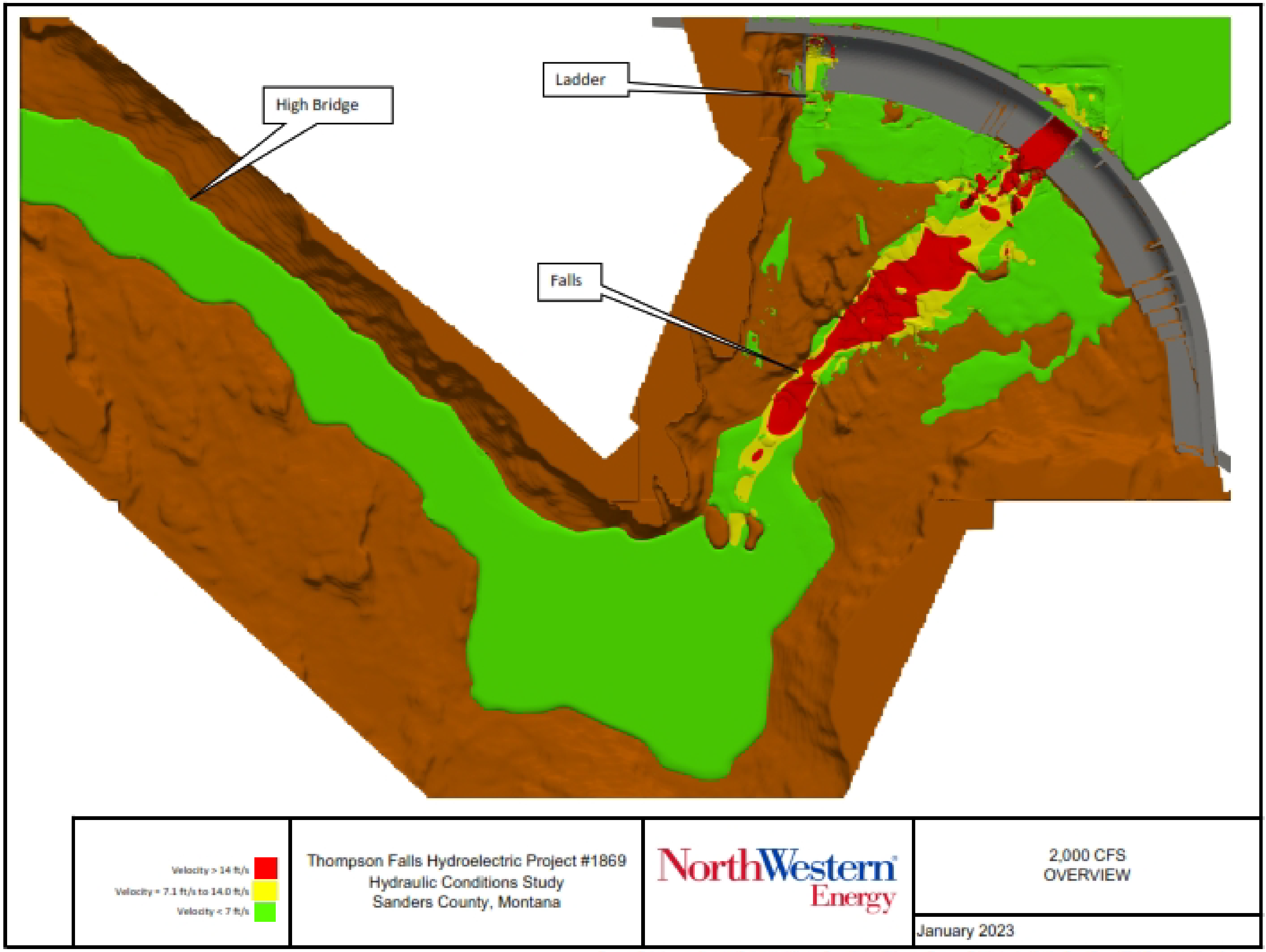
Figure 3-26. CFD Modeled Water Velocity at 2,000 cfs Spill.



Notes: CDF = computational fluid dynamics; cfs = cubic feet per second.

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The CFD modeling evaluated velocity at cross-sections at the High Bridge, falls, and fish passage facility entrance as shown on **Figures 3-27, 3-28, 3-29**, respectively. The percentage of available wetted area for fish to move upstream through the High Bridge, falls, and fish passage facility entrance cross-sections, based on the three velocity groupings corresponding with fish swimming abilities, is presented in **Table 3-9**.

Table 3-9. Percent of Wetted Area Available for Fish to Access Based on Swimming Abilities: 2,000 cfs Model Scenario.

Basic Model Map	Velocity Gradient (fps)	2,000 cfs Model – % Area Available for Fish Passage		
		High Bridge	Falls	Fish Passage Facility Entrance
Most Species – mix of Prolonged and Burst speeds	0-7.0	100	8	79
Many Species – Burst Speeds	7.1-14.0	0	16	21
Exceeds Burst Speeds	>14.0	0	76	0

Notes: % = percentage; cfs = cubic feet per second; fps = feet per second.

The velocities for the 2,000 cfs spill scenario at the Main Dam along the cross section at the High Bridge were 7.0 fps or less providing access for the majority of fish species (*refer to* **Table 3-9**). As fish move upstream to the falls area, approximately 23 percent of the area provided velocities accessible for fish to swim upstream. Approximately three-quarters of the falls presented flows exceeding 14 fps (*refer to* Table 3-9), which exceeds all burst speeds of fish listed in **Table 3-8**. For fish able to migrate upstream through the falls and continue upstream towards the fish passage facility entrance, flows in the fish passage facility area provided more suitable velocities (<7 fps) to accommodate a wider range of swimming abilities (**Figure 3-27**, *refer to* Table 3-8).

At the fish passage facility entrance there is a high velocity jet (HVJ) that provides attraction flow during no spill and lower spill flows (**Figure 3-30**). Many fish passage structures use high velocity attraction flow at or near their entrances. This practice is based on behaviors observed in salmonids. Migratory salmon and steelhead tend to assume upstream migration paths by "cueing-in" on higher velocity currents. The HJV is designed to guide fish into the fish passage facility using their natural behaviors in finding upstream migration paths (USDA 2007).

The model at 2,000 cfs indicates the attractant flow contribution does not prevent access to the facility (HVJ is not submerged) and velocities around the entrance area are within swimming abilities of fish (**Figure 3-31**, *refer to* Table 3-8).

The flow path modeled for 2,000 cfs spill in the Hydraulics Condition Study ISR (NorthWestern, 2022c), shows the majority of water flow and velocity move through the center of the falls (Figure 3-31). Water velocities to the right and left of the radial gates are minimal (**Figure 3-32**). In the near field, upstream of the falls, contributing flows at 2,000 cfs spill include the radial gate, half panel removed on right side of the Main Dam, and HVJ at the fish passage facility entrance (Figure 3-31). The primary source of spill is released at the radial gates. When the radial gates open to release spill, the flow path is directly down through the falls and then turns right and continues on a direct path down the center of the channel past the High Bridge. There is a slow eddy on river right at the bend in the channel between the falls and High Bridge.

The flow path shown near the fish passage facility originates from attractant flow contributions and not the radial gates (**Figure 3-32**). At the fish passage facility entrance, the HVJ contributes a maximum of 80 cfs and the removal of a half-panel contributes approximately 100 to 125 cfs along the right side of the Main Dam providing an attractant flow to the area that is more defined than in the immediate area (Figure 3-32). The path of flow from the fish passage facility area flows to the falls and joins the primary flow path downstream (**Figure 3-33**). The flow paths do not provide any visible obstacles or distractions that might create confusion or prevent fish from accessing the near field, MDR zone, and fish passage facility entrance area.

Figure 3-27. Model Scenario, 2,000 cfs. Cross-section at High Bridge.

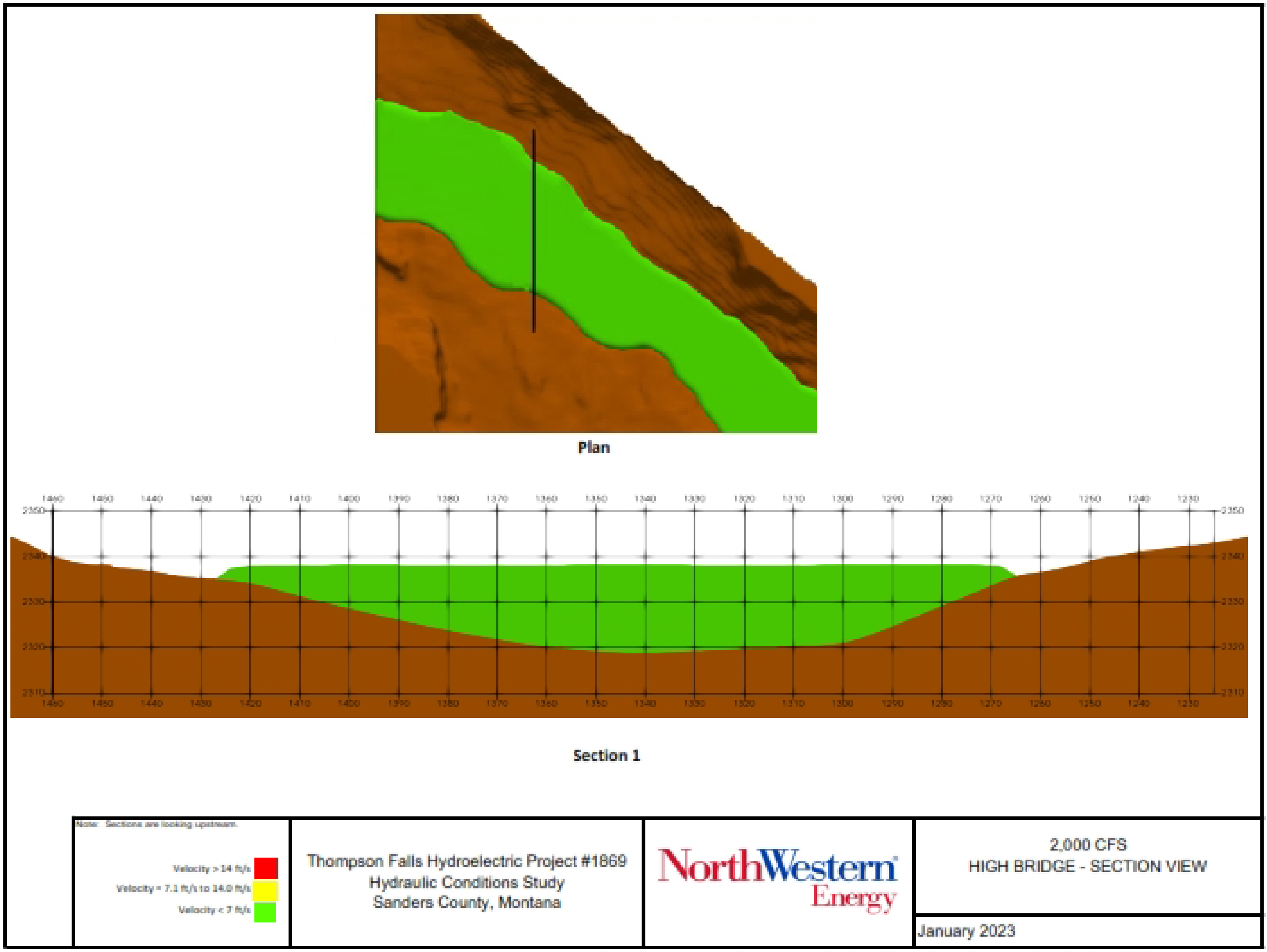


Figure 3-28. Model Scenario, 2,000 cfs. Cross-section at the Falls.

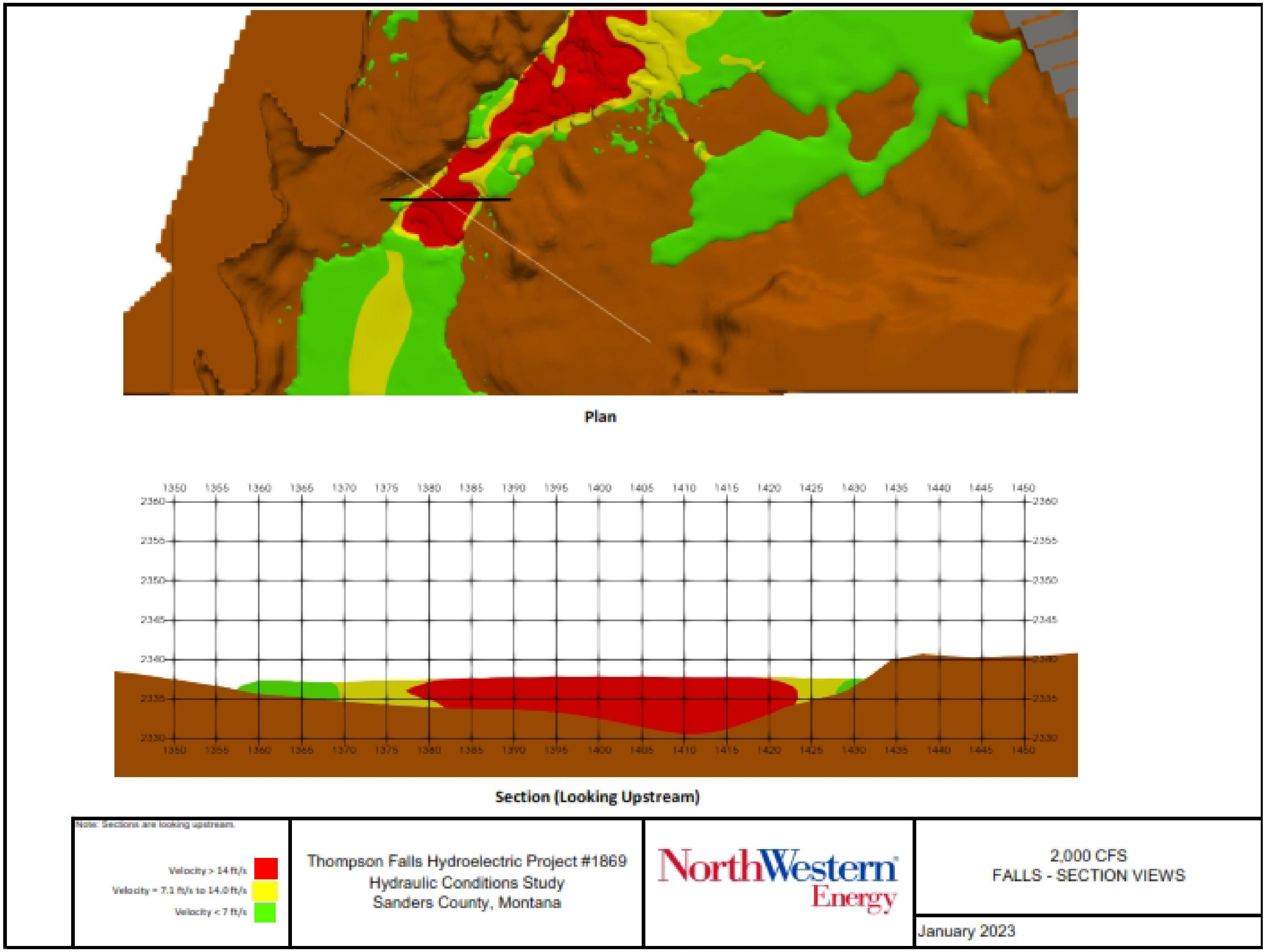


Figure 3-29. Model Scenario, 2,000 cfs. Cross-section at the Fish Passage Facility Entrance.

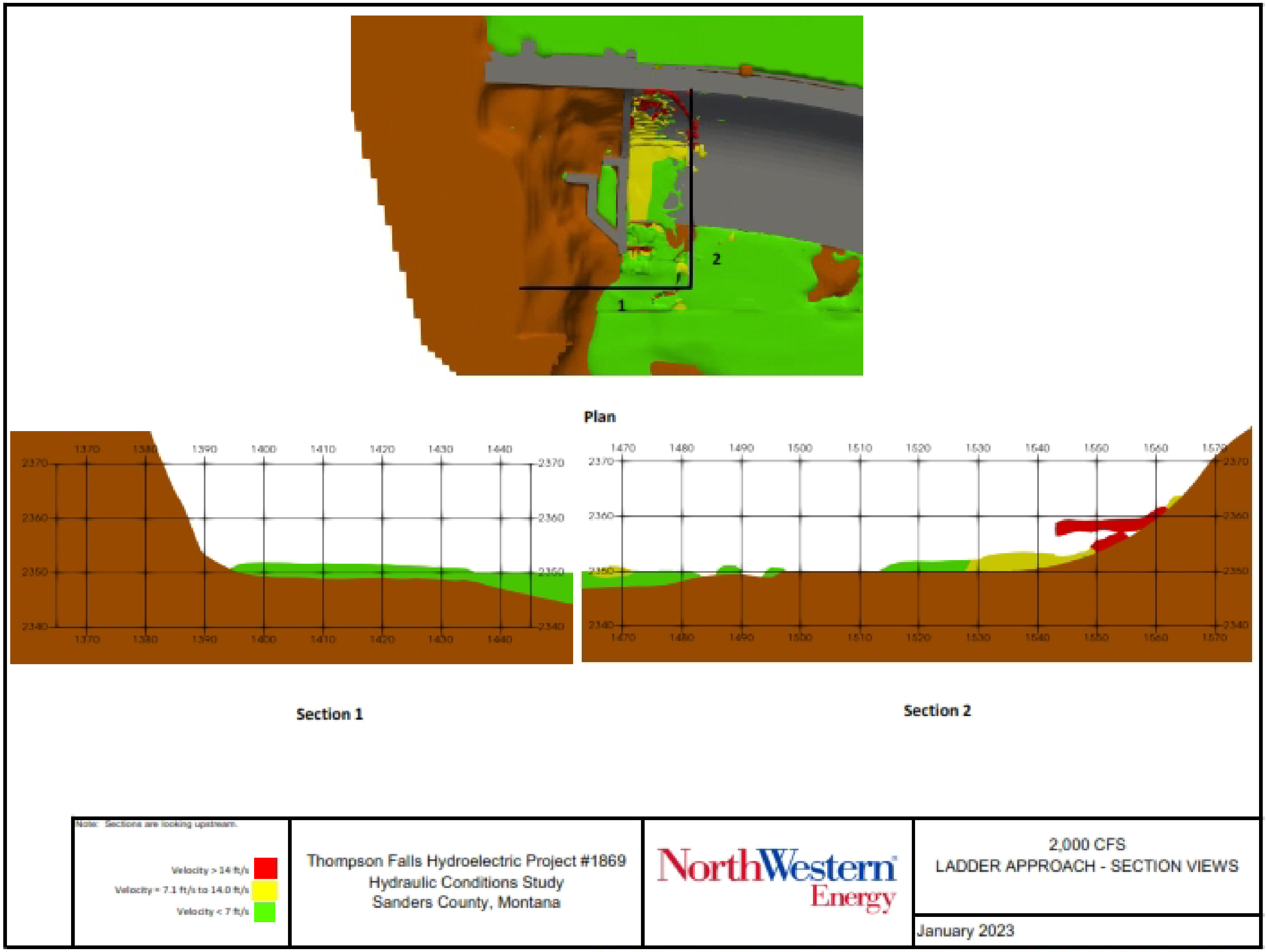


Figure 3-30. Velocities at Fish Passage Facility Entrance Area: 2000 cfs.

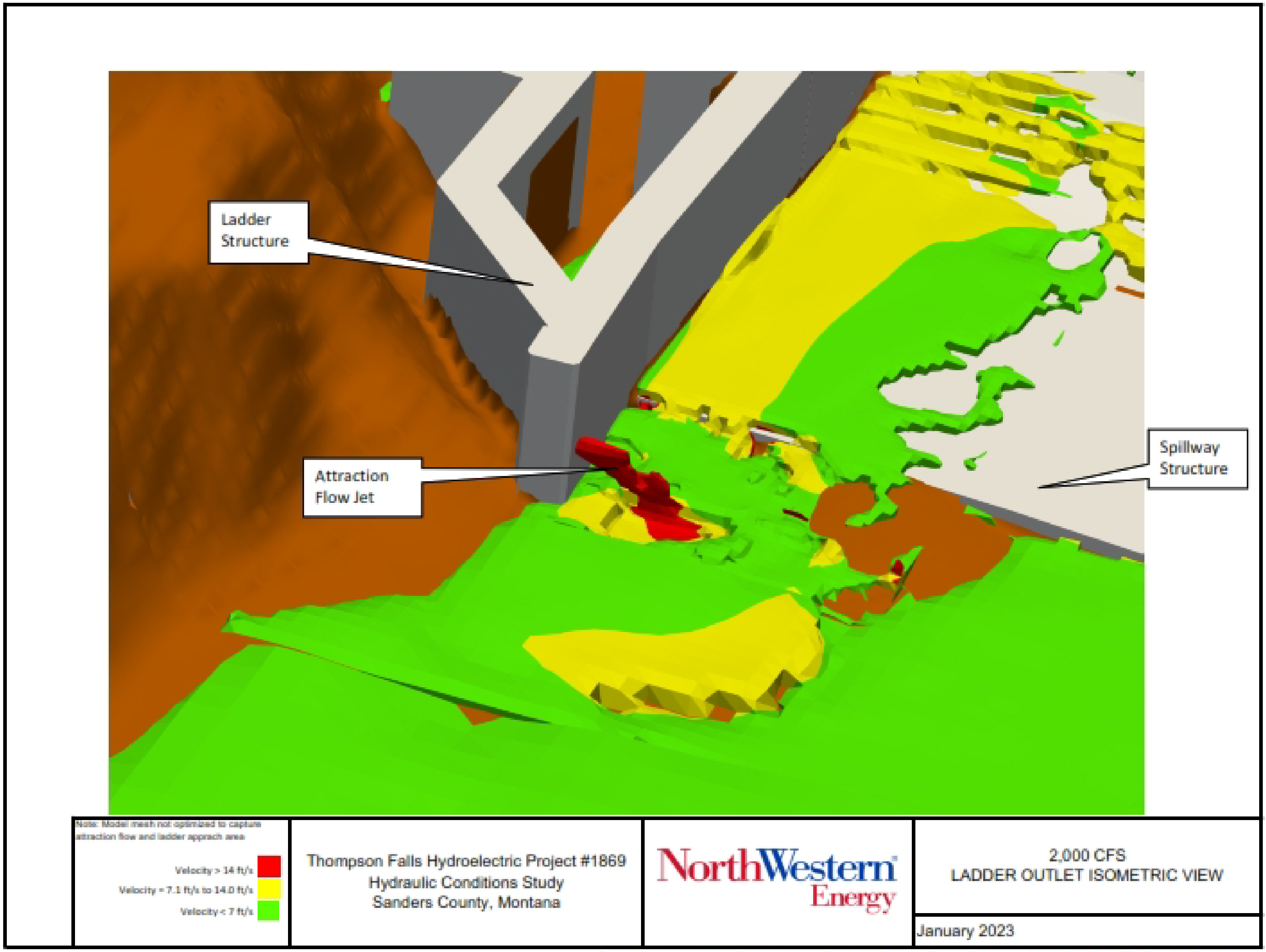
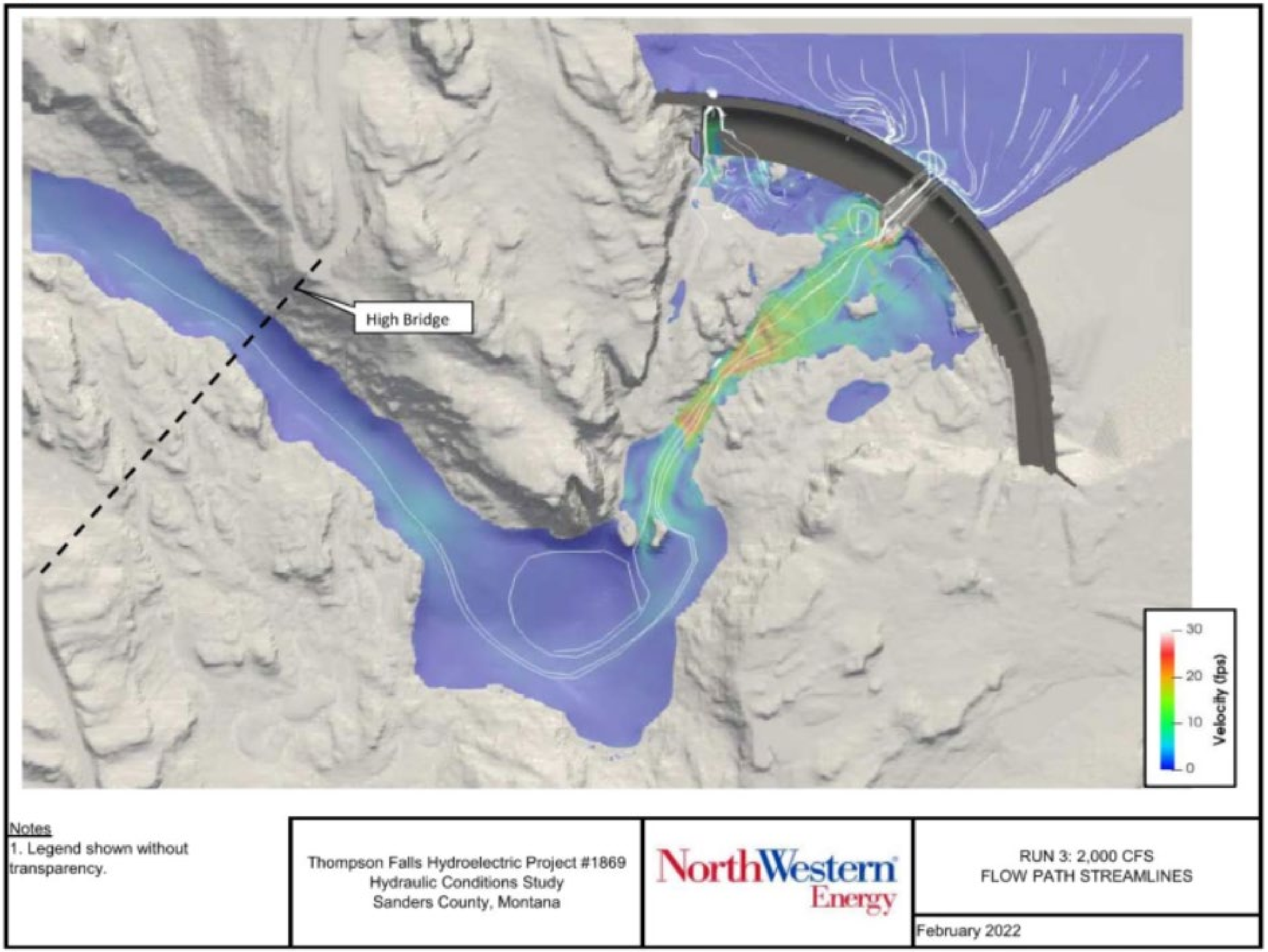
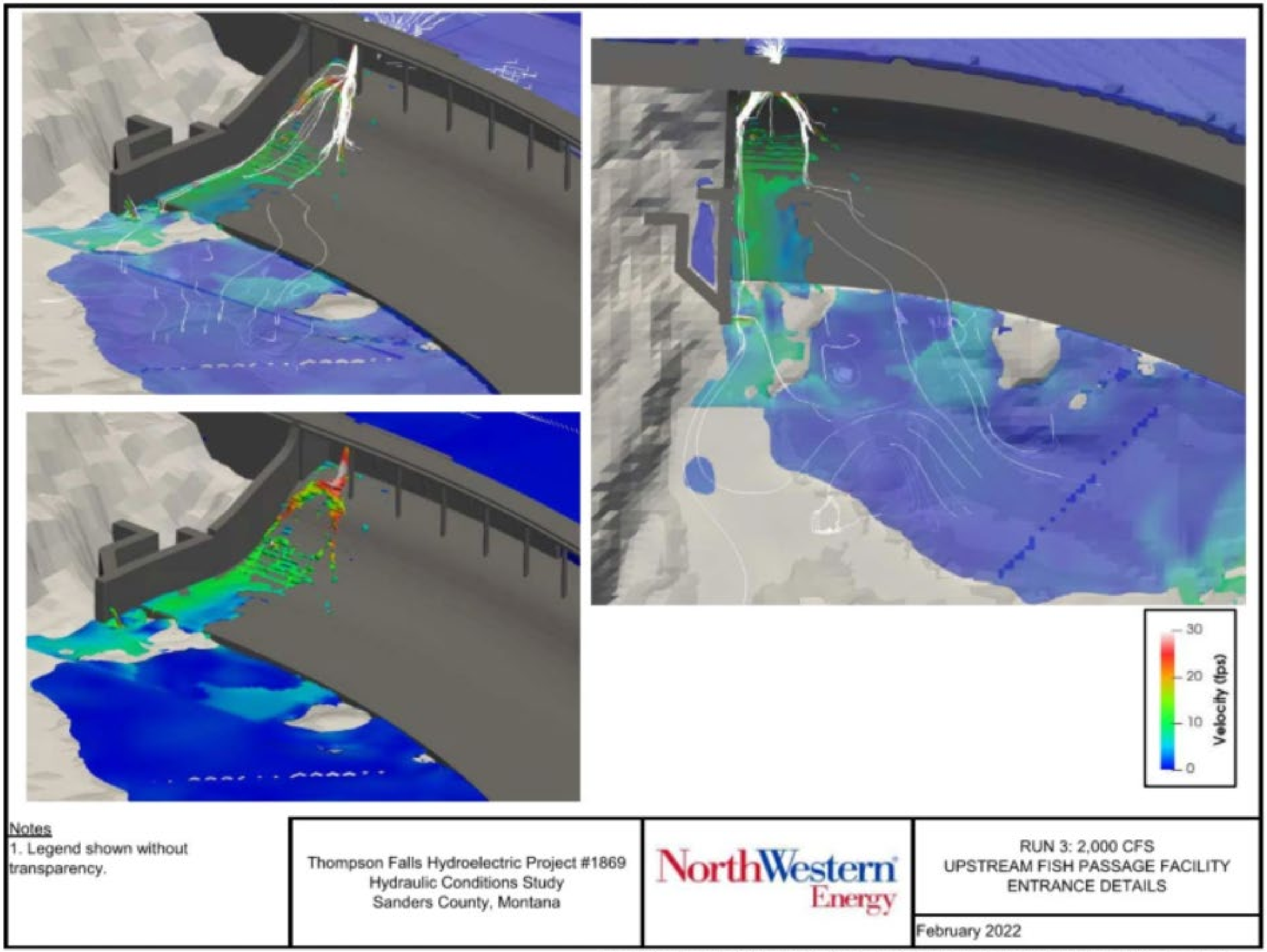


Figure 3-31 Flow Path Streamlines, 2,000 cfs at the Main Dam.



Source: NorthWestern 2022c

Figure 3-32. Flow Path Details at the Fish Passage Facility Entrance under Model Run for 2,000 cfs at the Main Dam (river flow approximately 25,000 cfs).



In summary, at 2,000 cfs spill, the velocities from the upstream fish passage facility downstream to the High Bridge range from about 3 to 23 fps, with the higher velocities in the main channel path and lower velocities along the edges of the channel banks. The falls presents the greatest velocity obstacle, requiring a greater energy expense for fish moving upstream. The HVJ is not submerged and the discharges from the upstream fish passage entrance produce a significant portion of the flow in this area. Therefore, at these lower flow rates, most of the flow path streamlines are concentrated near the entrance of the fish passage facility resulting in fish attraction to the fish passage facility entrance.

3.8.3 *Model Scenario: 25,000 cfs*

The 25,000 cfs model represents the total river flow of 48,000 and 25,000 cfs spill over the Main Dam. This scenario represents the upstream fish passage maximum design capacity. The 2D results indicate velocities that range from 2 to 27 fps from the High Bridge upstream to the Main Dam. The highest velocities are through the falls with the maximum being 27 fps. The area below the Main Dam and also near the High Bridge show high velocities of 20 and 19 fps respectively. Velocities at the 2D modeled scenario of 24,000 cfs appear to be similar to the more detailed 3D model results of 37,000 cfs.

Flow path streamlines modeled for 25,000 cfs spill in the Hydraulics Condition Study ISR (NorthWestern 2022c), show a similar pathway as the 37,000 cfs spill, with the majority of spill at the dam moving downstream through the falls (**Figure 3-33**). The flow is focused out of the radial gates and river channel due to the larger volume of water being released but remains most intense and concentrated through the radial gates and carrying down through the falls. It appears there are little and limited flow path streamlines from the upstream fish passage facility which are quickly mixed with turbulence and flow from the radial gates. Velocities are relatively low (<5 fps) at the upstream fish passage facility due to the submergence of the upstream fish passage facility. The HVJ has limited influence on the resulting downstream velocity field.

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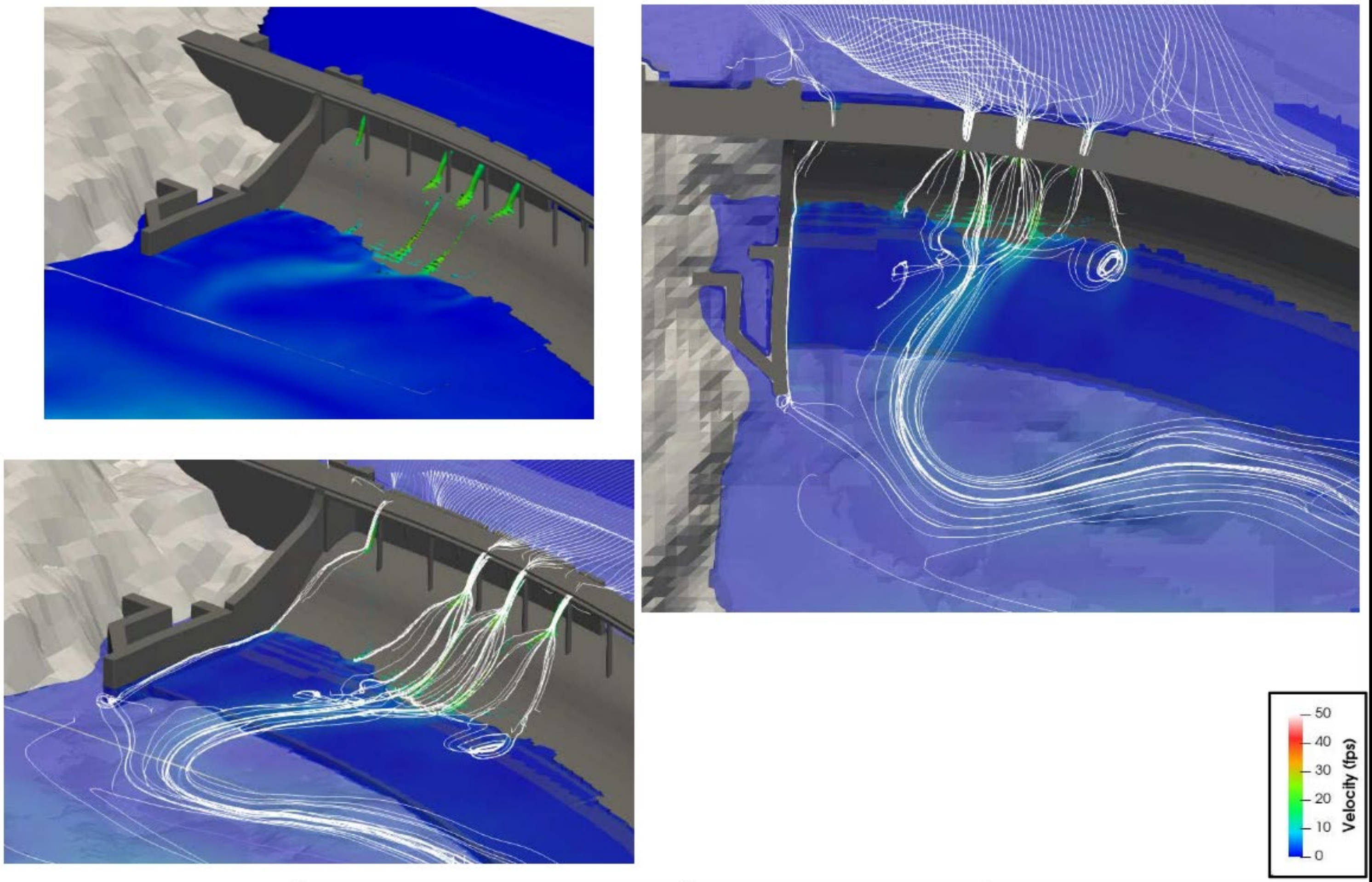
Figure 3-33. Run 2: 25,000 cfs Upstream Fish Passage Facility Entrance Details.



Notes
1. Legend shown without transparency.

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Hydraulic Conditions Study
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RUN 2: 25,000 CFS
UPSTREAM FISH PASSAGE FACILITY
ENTRANCE DETAILS

February 2022

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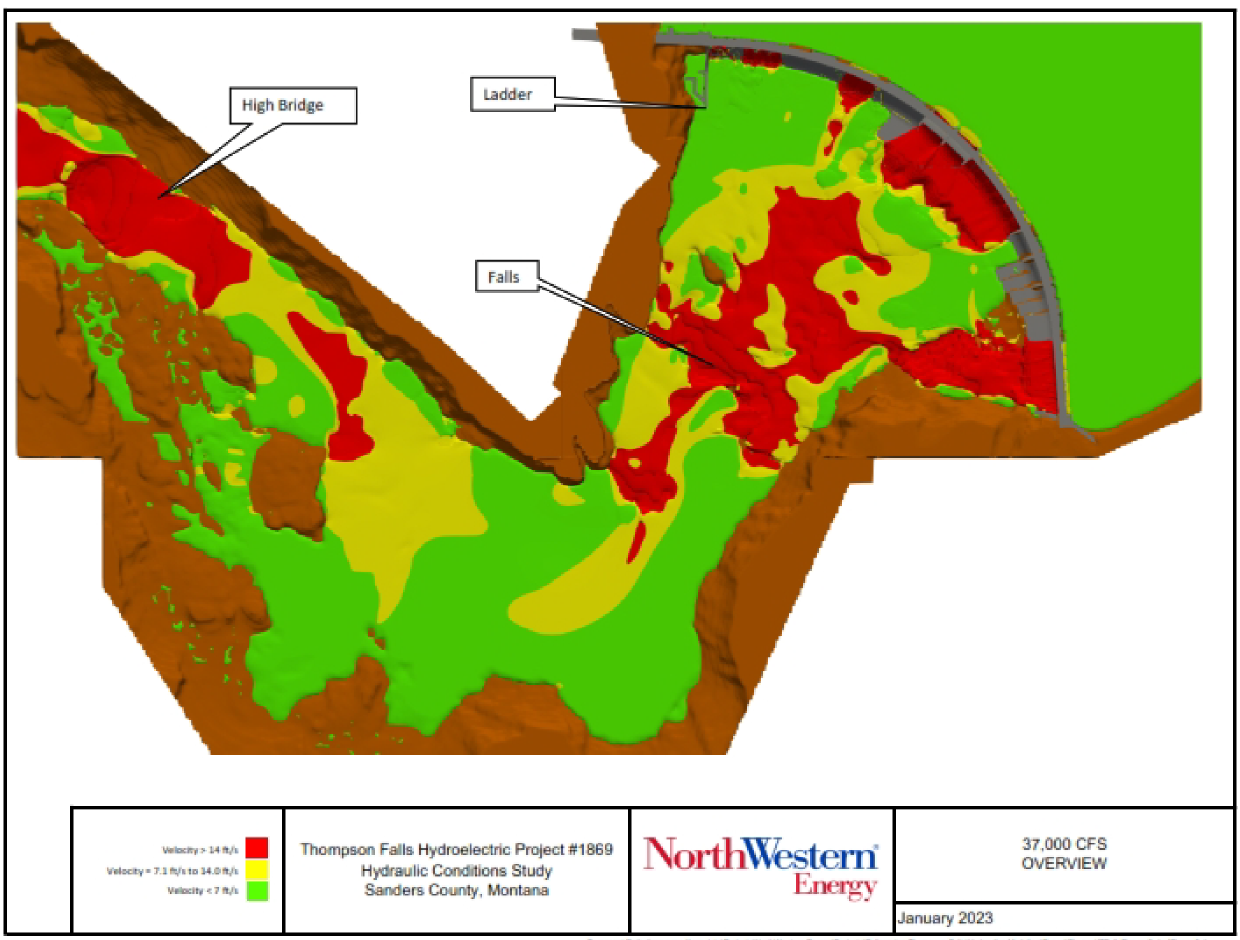
3.8.4 *Model Scenario: 37,000 cfs*

The 37,000 cfs model represents the total river flow of 60,000 and 37,000 cfs spill over the Main Dam. This scenario exceeds the design capacity, 25,000 cfs spill (48,000 cfs river flow), for the upstream fish passage facility. However, it represents the spill conditions for the maximum flow rate the fish passage facility is operated (J. Hanson, personal communication, January 2023).

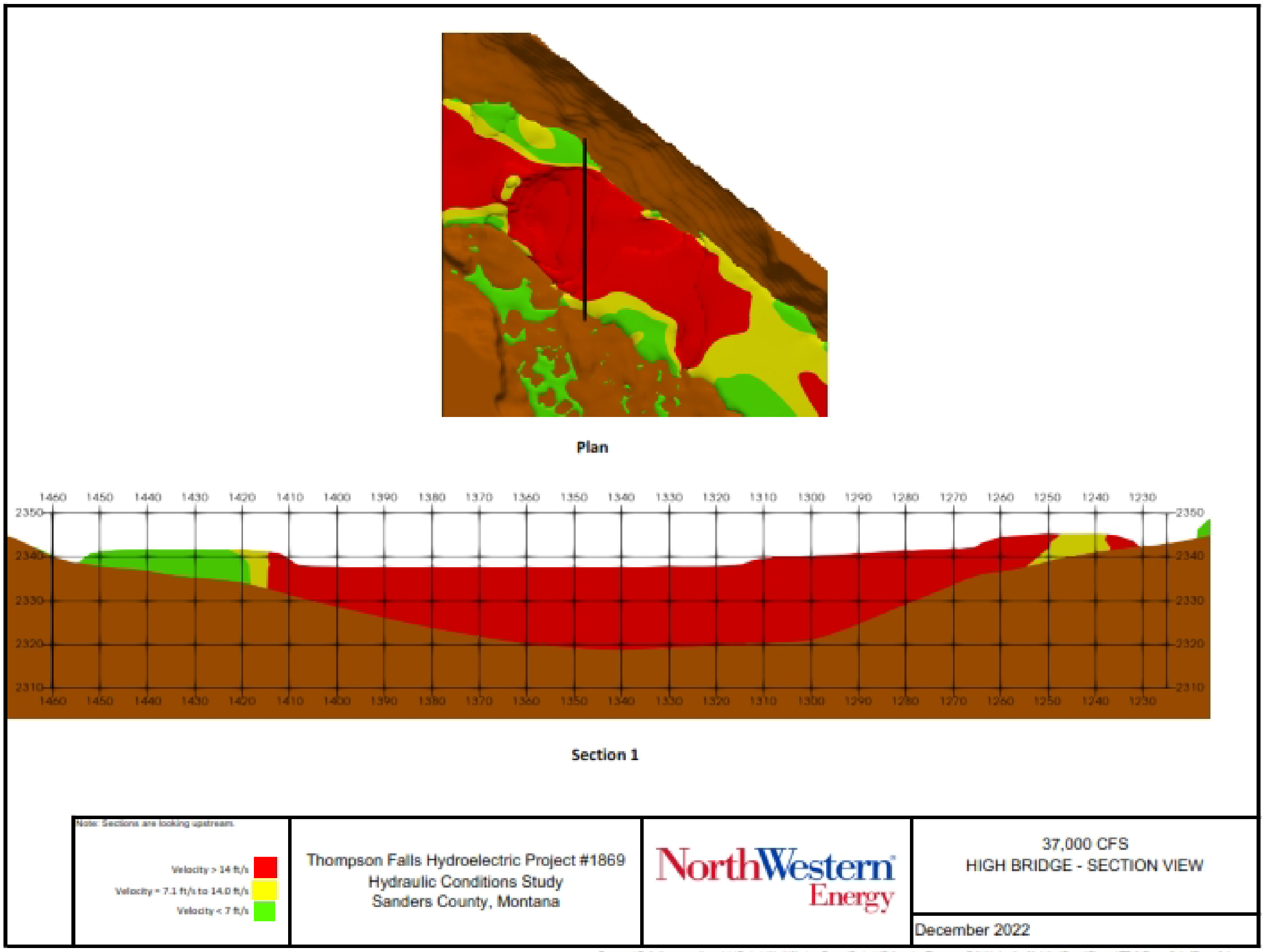
Figure 3-34 illustrates the velocities in the study area at 37,000 cfs spill, respectively. On this figure, areas mapped in green have an average water velocity less than 7 fps and are assumed to be passable by all species of upstream migrating adult fish. Areas mapped in yellow have an average velocity between 7.1 and 14 fps and are assumed to be passable by salmonids swimming at burst speed. Areas mapped in red have an average velocity in excess of 14 fps, which exceeds the burst speed of all local fish species. At 37,000 cfs spill, the volume of spill at the Main Dam creates a turbulent environment with high velocity conditions in the ZOP. The high velocities modeled below the High Bridge (extant of the model) and upstream through the falls present velocity obstacles for upstream migration.

Figure 3-34. CFD Modeled Velocity at 37,000 cfs Spill.



Cross sections of the High Bridge, falls, and fish passage facility entrance were modeled at 37,000 cfs. At that flow rate, the majority of the river at the High Bridge cross-section has a velocity greater than 14 fps, except for the locations along the margins of the river (**Figure 3-35**).

Figure 3-35. Model Scenario, 37,000 cfs. Cross-section at High Bridge.



The falls section is displayed in two figures with the plan view in **Figure 3-36** and profile of the cross-sections in **Figure 3-37**. The majority of the falls cross-sections show velocities exceeding 14 fps except for the areas along the margins of the riverbanks and isolated areas near the bottom of the channel cross section.

Figure 3-36. Model Scenario, 37,000 cfs. Cross-section at the Falls.

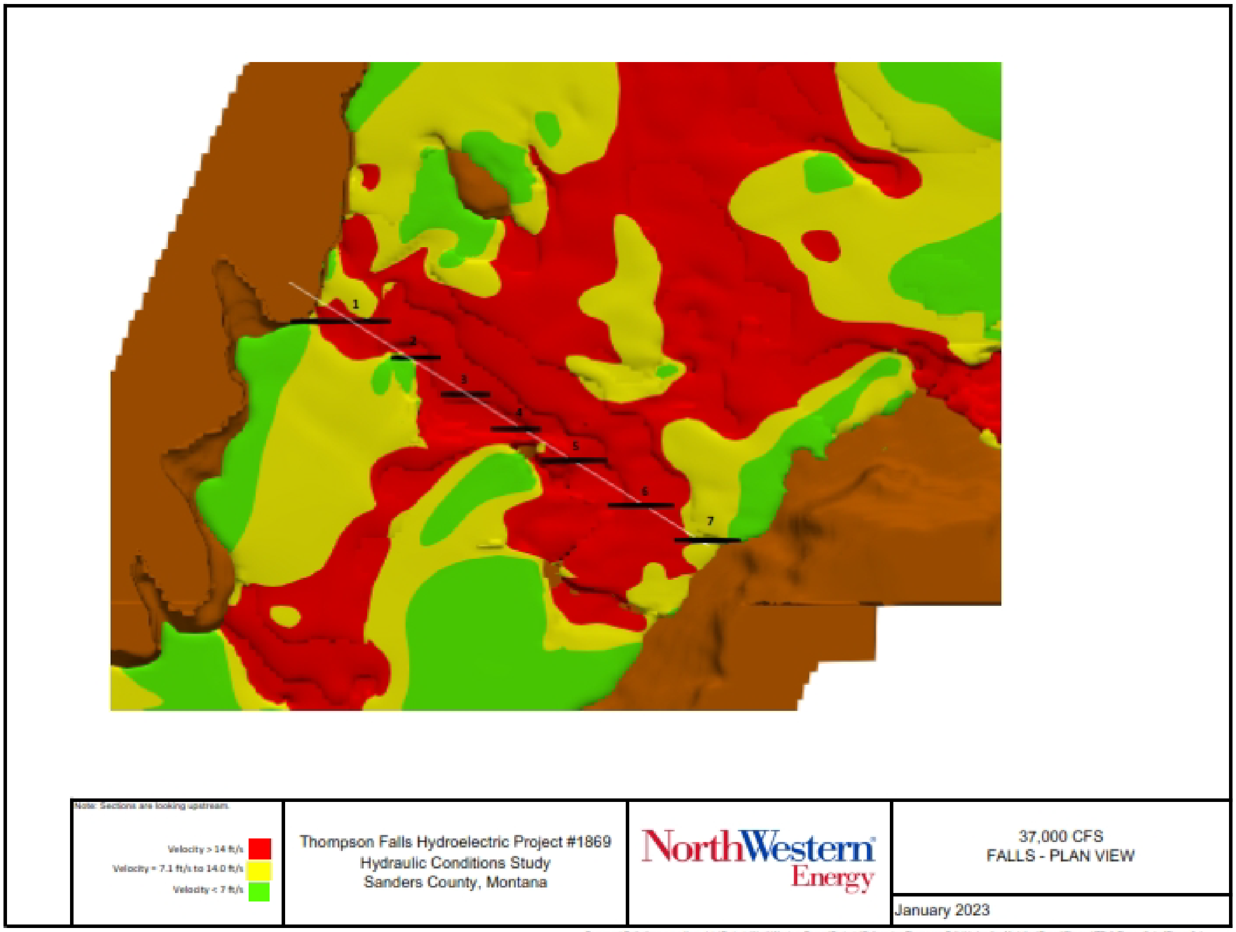
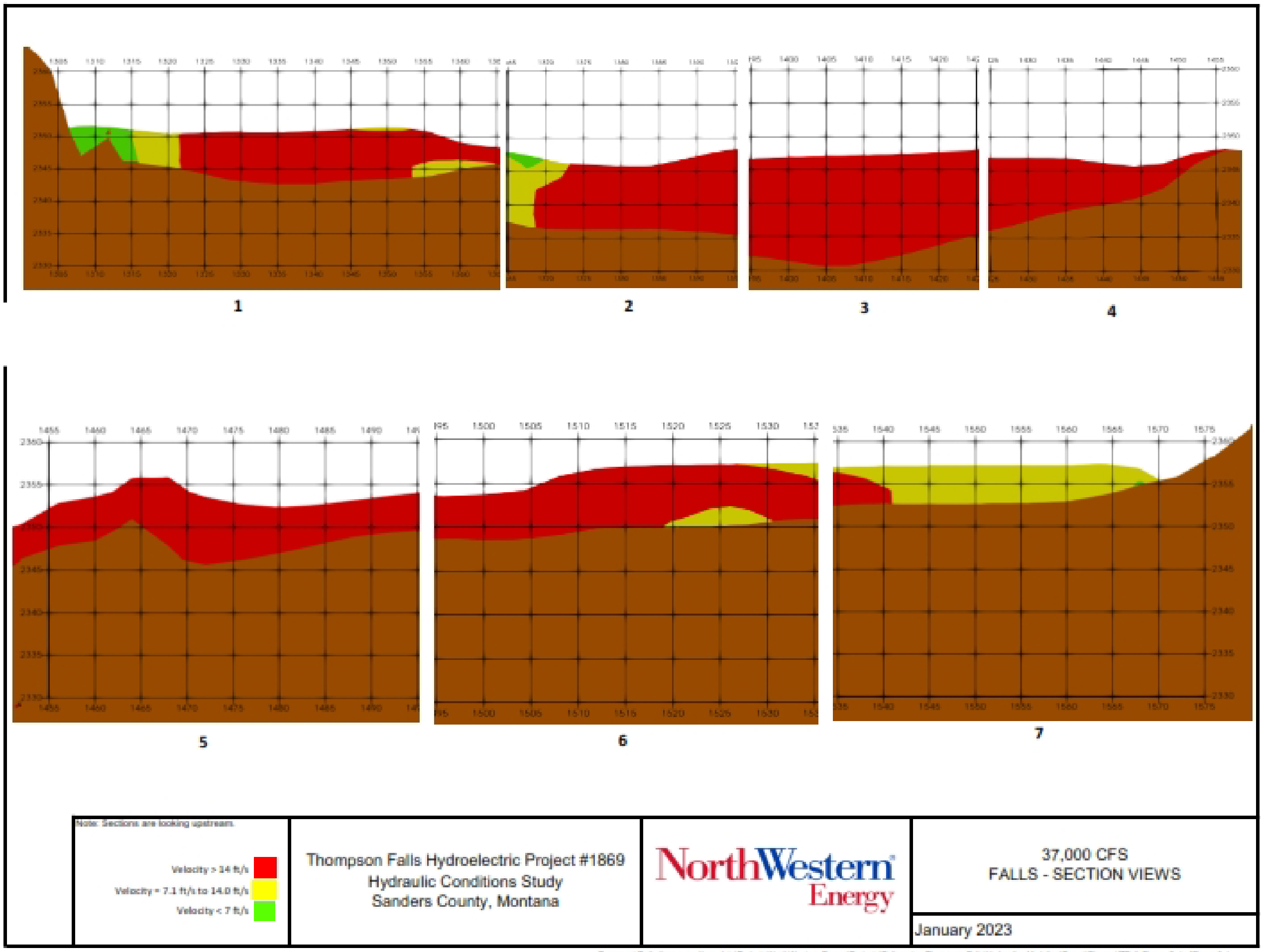
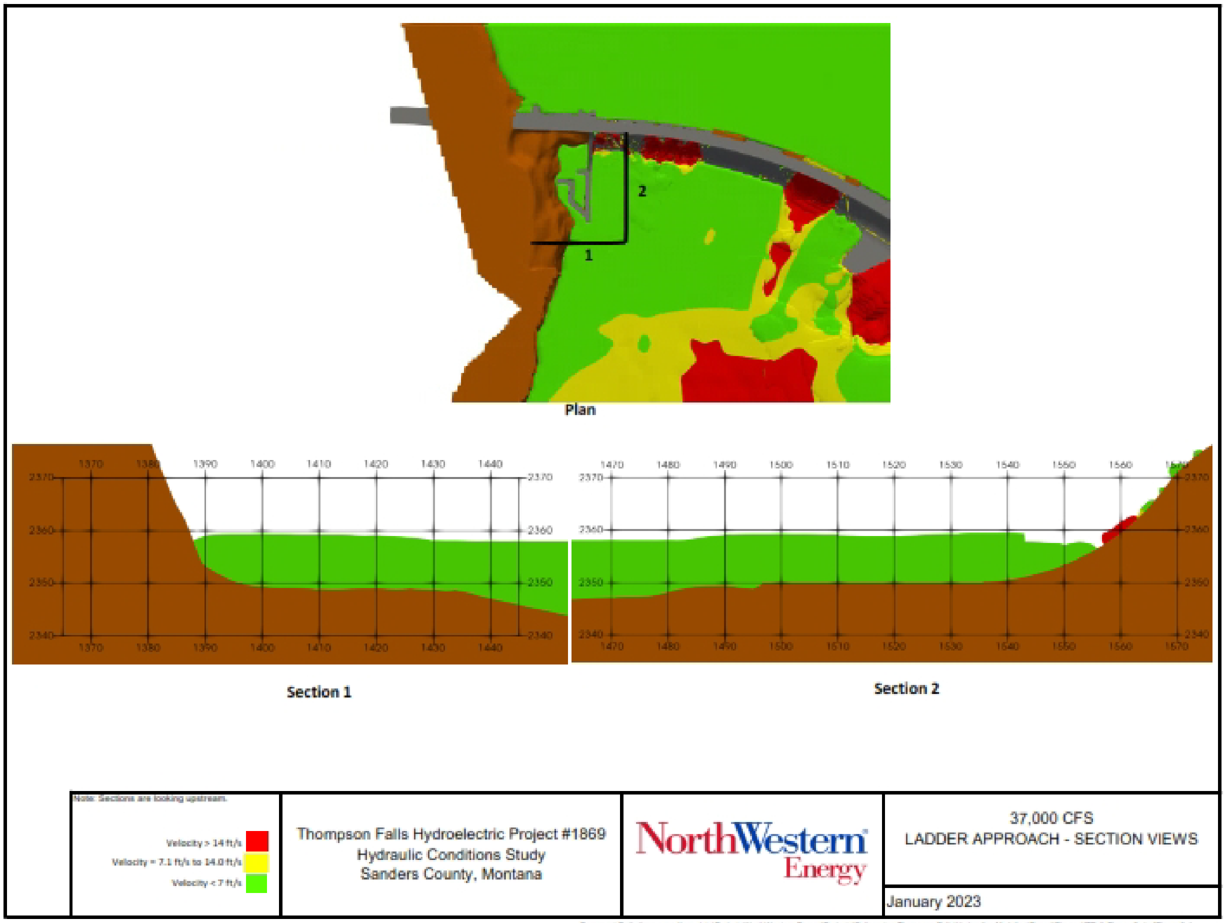


Figure 3-37. Model scenario, 37,000 cfs. Cross-section at the Falls.



If fish make the journey upstream to the Main Dam, the velocities on the river right near the upstream fish passage facility are below 7 fps, likely accessible for fish (**Figure 3-38**). However, the fish passage facility entrances are submerged, including the HVJ. At peak spring flows, it appears attractant flow is negligible at the fish ladder entrance.

Figure 3-38. Model Scenario, 37,000 cfs. Cross-section at the Fish Passage Facility Entrance.



The percentage of available wetted area for fish to move through based on the three velocity groupings corresponding with fish swimming abilities is presented in **Table 3-10.** The model indicates hydraulic conditions for fish to move upstream at the High Bridge and falls was limited to about 11 and 16 percent, respectively, when flows at the Main Dam were 37,000 cfs. The majority (89%) of velocities throughout the water column at the High Bridge exceeded swimming abilities of fish (Table 3-10). As fish move upstream, velocities at the falls presented a similar situation with about 84 percent of the area not likely to be accessible to fish. However, velocities and conditions at the fish passage facility entrance were 7.0 fps or less and provided 100 percent accessibility. The model shows higher velocities in the main channel path and lower velocities along the edges of the channel banks.

Table 3-10 Percent of Wetted Area Available for Fish: 37,000 cfs Model Scenario.

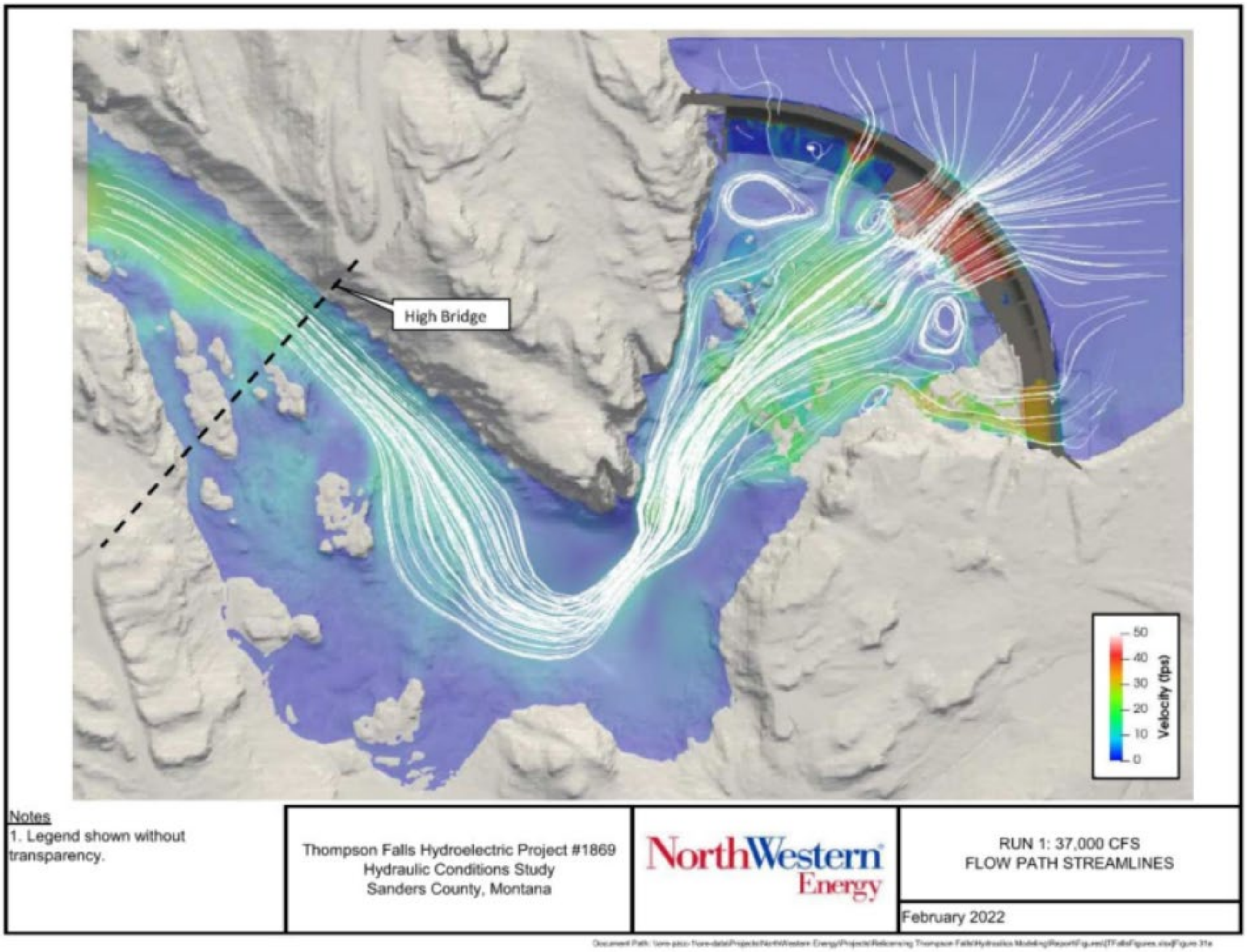
Basic Model Map	Velocity Gradient (fps)	37,000 cfs Model – % Area Available for Fish Passage		
		High Bridge	Falls	Fish Passage Facility Entrance
Most Species -mix of Prolonged and Burst Speeds	0-7.0	7	2	100
Many Species - Burst Speeds	7.1-14.0	4	14	0
Exceeds Burst Speeds	>14.0	89	84	0

Notes: % = percentage; cfs = cubic feet per second; fps = feet per second.

The margins and fringes of the channel at the High Bridge and falls provide conditions more favorable to fish swimming abilities during the high flow scenario. The area near the upstream fish passage entrance provides a calmer environment with slower velocities (≤7.0 fps) that provide accessibility to fish based on their swimming abilities.

The flow path modeled for 37,000 cfs spill in the Hydraulics Condition Study ISR (NorthWestern, 2022c), show a similar pathway as the 25,000 cfs spill, albeit at a greater volume, with the majority of spill at the dam moving downstream through the falls (**Figure 3-39**). The flow is spread out along the radial gates and river channel due to the larger volume of water but remains most intense and concentrated through the falls. Spill from the Main Dam travels downstream through the falls area and makes a 90-degree right turn and continues on a direct path downstream. Velocity appears to increase immediately downstream of the High Bridge as the channel depth lessons and constricts slightly. Although the flow path at the High Bridge coincides with higher velocity in the area, there are some bedrock features in the channel that break up flow and create slower velocity pockets outside the primary flow path that may benefit fish movement upstream (Figure 3-39).

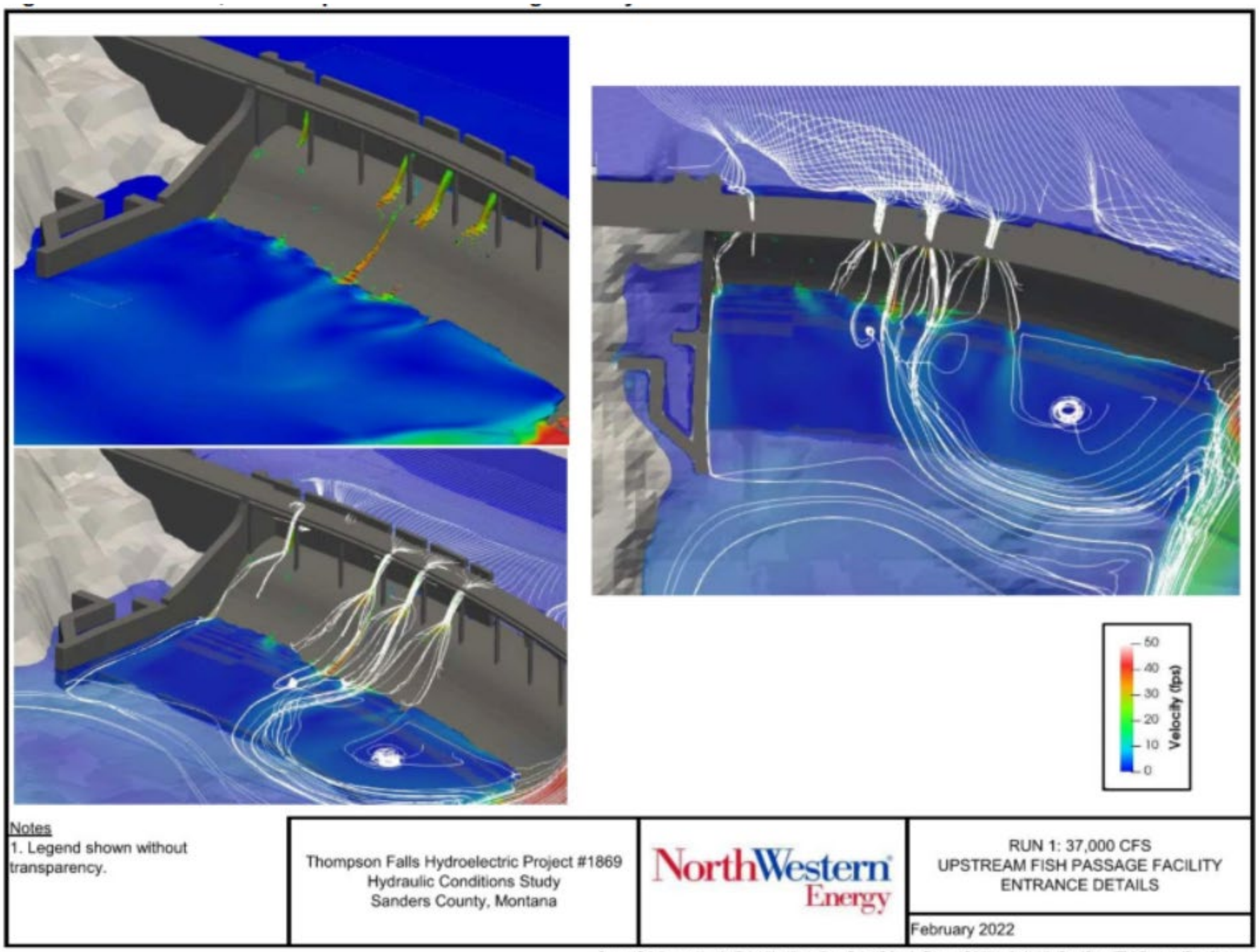
Figure 3-39. Flow Path Streamlines, 37,000 cfs.



At the Main Dam, the flow path shows the development of two primary eddies, one on river right and one on river left (*refer to* **Figure 3-39**). When taking a closer look at river right, there is an eddy that develops on the spill apron (**Figure 3-40**). All eddies provide slower velocities compared to the primary flow path.

The flow path of the attraction flow at the fish passage facility is visible but appears to merge with the larger eddy and/or main flow downstream through the falls and is not detectible when looking for changes in velocity in the area (Figure 3-40). It is not unexpected that the attractant flow has little influence at 37,000 cfs spill considering the fish passage facility's upper design flow is 25,000 cfs spill.

Figure 3-40. Flow Path Details at the Fish Passage Facility Entrance: 37,000 cfs.



3.8.5 *Fish Behavior at Modeled Scenarios*

Manual and fixed station detection data was reviewed during times when flow was 2,000 cfs (±10%) and 37,000 cfs (±10%) in 2021 and 2022. A plus/minus 10 percent range of the modeled flow was used when looking in the fish detection database, because flows change rapidly in the ZOP.

During 2021, spill at the Main Dam was 1,800 to 2,200 cfs on May 2 and 33,300 to 40,700 cfs on June 5 and 6. In 2021, fish collection did not begin until June, thus there were no tagged fish in the study area during either flow scenario.

During 2022, spill at the Main Dam was 1,800 to 2,200 cfs on May 6 and July 19 and 33,300 to 40,700 cfs on June 7 through 10, and June 29 through July 2. Fish were detected in the ZOP when spill was 1,800 to 2,200 cfs, but none at 33,300 to 40,700 cfs.

On the ascending limb of the hydrograph, May 6, the manual fish tracking detected two Rainbow Trout in the far field, downstream of the modeled reach. Fixed station receivers detected three Rainbow Trout in the far field and one Brown Trout in the far field, all downstream of the modeled reach. There were no fish detected in the near field on May 6. On the descending limb of the hydrograph, July 19, the manual fish tracking detected one Brown Trout in the near field. The same Brown Trout was also detected by the fixed station receiver in the near field. The Brown Trout was in the MDR zone near the entrance of the fish passage facility and entered the fish passage facility the following day, July 20.

3.8.6 *Summary*

As shown in **Table 3-11**, two locations (High Bridge and falls) present maximum velocities of 20 fps or greater (NorthWestern 2022c) at some flows, exceeding swimming abilities of all species. Based on the 3D modeling, the falls appears to be the most challenging area for upstream fish passage during all flows. When spill is 37,000 cfs at the Main Dam, both the High Bridge and the falls have a maximum velocity of 20 fps (Table 3-10). However, in the two high flow scenarios, the velocities near the fish passage facility entrance remain 7.0 fps or less and appear to be accessible to all fish species (Table 3-11). Although maximum velocity at the fish passage facility entrance exceeds 7.0 fps at low flows, these maximum velocities are limited in area, and represent attraction flow for fish.

Table 3-11. Summary of 2D Model Estimated Maximum Velocity Near the High Bridge, Falls, and the Fish Passage Facility Entrance.

Model flow (cfs)	Max Velocity Near High Bridge (fps)	Max Velocity Through Falls (fps)	Max Velocity at Fish Passage Facility Entrance (fps)
37,000*	20	20	5
25,000	19	27	5
2,000*	2	23	12
200	<1	17	8

Notes: * = 3D flow simulations; cfs = cubic feet per second; fps = feet per second.
Source: NorthWestern 2022c.

Table 3-12 summarizes fish passage conditions in the critical locations in the study area at 2,000 and 37,000 cfs. The percentage of accessible area varies significantly at the High Bridge area between high and low flows. The falls has limited passage areas at all flows. At both modeled flows, the fish passage facility entrance remains entirely below 14.1 fps.

Table 3-12. Percentage of Cross-Section with Velocity Less Than 14.1 FPS.

3-D Model	% Wetted Area Passable for Fish[14]		
Flow Below Main Dam (cfs)	High Bridge	Falls	Fish Passage Facility Entrance
2,000	100	23	100
37,000	11	16	100

Notes: % = percentage; cfs = cubic feet per second.

Flows immediately downstream of the Main Dam are very complex, dynamic, and highly turbulent. The depth of the channel near the High Bridge, the Dollar Hole, the falls, and immediately below the Main Dam contribute to the flow dynamics in the reach (**Table 3-13**).

Table 3-13. Summary of CFD model computed depths at the High Bridge, at the bend in the river, falls, and upstream of the falls along the Main Dam spillway.

CFD Model	Depth (feet)			
Spill (cfs)	High Bridge	Bend in River	Falls	Main Dam
37,000	50	50	25	5-8
25,000	50	50	21	5-8
2,000	36	50	7	2-6
200	36	50	3	1-5

Note: cfs = cubic feet per second.
Source: NorthWestern 2022c.

[14] Defined as velocity less than 14.1 fps.

4. Discussion

4.1 Effectiveness of Study Methodology

As described in **Section 1 – Introduction**, NorthWestern, in collaboration with the TAC, established a Scientific Review Panel in 2020 to evaluate the Project's fish passage facility. The Scientific Review Panel was convened in compliance with TC 1-h of the 2008 Biological Opinion (FWS 2008) and the FERC License amendment approving construction of the fish passage facility (FERC 2009). The Scientific Review Panel identified a large volume of qualitative data gathered from the fish passage facility but noted a data gap when quantitatively evaluating the proportion of "motivated" fish entering the ZOP and finding the fish passage facility entrance. This Fish Behavior Study, and the Hydraulic Condition Study, were initiated by NorthWestern in response to recommendations from the Scientific Review Panel. Specifically, the Scientific Review Panel (2020) suggested NorthWestern,

> …initiate two parallel studies to assist in the determination of the fish passage facility's attraction and entrance efficiency:
>
> - two-dimensional CFD study that incorporates measured or approximated bathymetry to resolve, at a minimum, a depth-averaged velocity field and water depths in the near field downstream of the dam/project.
> - telemetry (radio-tag) study using sufficient sample sizes of surrogates to posit movement paths/rates and behavior in response to hydraulic conditions in the near field; the telemetry should be augmented by a literature review of the relative swimming capacities and behaviors of Rainbow, Westslope Cutthroat, Brown and Bull Trout.

The Scientific Review Panel (2020) recommended a minimum of 50 fish be used in the telemetry study, and potentially more if capture locations, species, fish lengths, time of year, etc. differ.

To date, NorthWestern has radio tagged and released 70 Rainbow and Brown trout. An additional 30 Rainbow Trout have been tagged this spring. Therefore, by the time the study is complete, the sample size will meet the recommendations of the Scientific Panel (2020).

Over the 2 years of study, all but one of the 70 fish collected, tagged, and transported downstream for release at Flatiron FAS were later detected in the far field. This includes fish collected and tagged in March, June, and September; fish of both species; and fish collected by electrofishing and at the fish passage facility. These data indicate that handling or tagging mortality was low or none during the study. The data also support the assumption that tagged fish were motivated, at some level, to move upstream. The study methodology was effective in generating information on fish movement in the study area.

The Hydraulic Conditions Study (NorthWestern 2023c) included both 2D and 3D modeling and extended further downstream than suggested by the Scientific Panel (2020) and approved by FERC in its Study Plan Determination, thus providing more extensive and detailed information on fish passage conditions in the study area.

4.2 Fish Passage Conditions at Varying Flows

The telemetry data, and the CFD modeling data, provide insight into fish passage conditions at flows at or exceeding the high design flow for the fish passage facility. The data indicate that, during spill at the Main Dam, the detection of fish in the ZOP was limited to a few individuals. Rainbow Trout were very active in the ZOP from March through May, prior to the start of high flow. Fixed station receivers, both in the far and near field areas had over 2 million detections (post-processing) as Rainbow Trout moved upstream into the ZOP and between sites. Of the 29-tagged Rainbow Trout in 2022, 86 percent of the Rainbow Trout moved upstream into the near field in the spring and about half entered the upstream fish passage facility. However, no Rainbow Trout were detected in the near field after May. Rainbow Trout were essentially absent from the ZOP once spill started at the Main Dam, and for the remainder of the season. Brown Trout present in the ZOP during the spring, appeared to leave the ZOP during spill, and then returned in the fall.

These general trends were observed in a telemetry study conducted in the study area from 2004 to 2006 (Gillin and Haddix 2005, Haddix and Gillin 2006, GEI Consultants, Inc. 2007). The study included radio tagged Rainbow, Brown, Westslope Cutthroat, and Bull trout. The study found that the greatest amount of fish movement in the study area was recorded prior to the peak of spring runoff (Gillin and Haddix 2005, Haddix and Gillin 2006, GEI Consultants, Inc. 2007).

The 2004-2006 study found that Rainbow Trout were the first to enter the study area, followed by Westslope Cutthroat and Brown trout, and then Bull Trout. In 2006, the peak detection of Rainbow Trout occurred between March 26 and April 23. Bull Trout were not detected in the study area in March. They made forays to the Main Dam in April and May. By June, they were primarily detected by the antenna pointing upstream of the mouth of Prospect Creek. Similarly, Westslope Cutthroat Trout were rare in the study area in March and made forays to the Main Dam in April and May. However, Westslope Cutthroat were rarely detected in the study area after May. Brown Trout were detected in the study area from late March through June. There appeared to be two peaks of Brown Trout activity, one in early April and again in mid-May (GEI Consultants, Inc. 2007).

The 2007 telemetry report noted that fish presence in the study area during peak flow season was detected by the fixed receiver with antennas pointed to areas in the far field, such as the mouth of Prospect Creek. The report noted that, “There are relatively quiescent areas in this portion of the river that would be suitable holding habitat for trout during runoff. It is likely that many fish left the main channel area during spill to avoid turbulent and high velocity conditions” (GEI Consultants, Inc. 2007). The results from the previous telemetry study are additional confirmation of the results from the current study.

As records and data collected from fish ascending the fish passage facility, manual fish tracking, and 3D model results support, velocities in much of the river often exceed swimming ability for most fish during spring flows and likely limit access upstream for fish in the ZOP and to the near field. The CFD model confirms that there is limited available area with suitable velocities at higher spill quantities for fish to navigate through the High Bridge and falls locations.

While the past and more recent telemetry data indicate that many fish leave the study area during high flow, a few fish remain and manage to find the fish passage facility. Fish are known to ascend the fish passage facility when spill is exceeding design capacity (>25,000 cfs spill). Records at the fish passage facility indicate 61 fish recorded at the fish passage facility at flows exceeding the design capacity from 2011 through 2022 (NorthWestern, unpublished data). The fish include 32 salmonids (21 Rainbow Trout, 5 Bull Trout, 3 Brown Trout, 3 Westslope Cutthroat Trout) and 29 non-salmonids (25 Largescale Sucker, 4 Northern Pikeminnow).

In general, non-salmonids recorded at the fish passage facility are primarily native Largescale Sucker, Northern Pikeminnow, and non-native Smallmouth Bass. Salmonids are primarily Rainbow and Brown trout. Over the last 10 years, about half of non-salmonids ascend the fish passage facility during low to moderate spill conditions (when spill is <15,000 cfs), and the majority of salmonids ascend after spill. Peak counts for Largescale Sucker and Northern Pikeminnow at the fish passage facility are in the spring when water temperatures are around 10 to 11°C, which also coincides with the ascending limb of the hydrograph and the start of spill at the Main Dam. Smallmouth Bass counts peak in the latter part of July and August usually after spill has occurred.

Peak Rainbow Trout counts at the fish passage facility occurs prior to, and after spill. Peak Rainbow Trout counts at the ladder occur in, descending order July, April, September, August, and then March. Peak Brown Trout counts occur at the fish passage facility post spill in July and fall months. In contrast to Rainbow and Brown trout, 78 percent of Bull Trout ascending the fish passage facility were documented between the onset of spill to approximately 33,000 cfs spill.

4.3 Velocity Barriers in the ZOP

During spill at the Main Dam, the telemetry and CFD modeling results indicate velocity obstacles may exist in the ZOP, specifically at the falls where the channel is constricted by boulders and rock. The CFD model indicates the falls would be a particularly challenging area for slower swimming non-salmonids to navigate. Another area with high velocities, at and above 25,000 cfs, is immediately downstream of the High Bridge where the channel constricts again. Both constricted areas (at the falls and High Bridge) are natural features of the Clark Fork River. During spill, the area accessible for various fish species to move upstream declines and is limited to the margins of the wetted channel and near the bottom of the channel depending on the roughness and available topography.

The CFD modeling indicates velocities near the fish passage entrance are within fish swimming abilities at all flow scenarios. There are no apparent velocity barriers near the fish passage facility entrance that would discourage fish from finding or entering the fish passage facility.

When looking at flow path streamlines it appears that at modeled flows of 200 cfs there remains a distinguishable level of attraction flow near the fish passage facility entrance that flows downstream and through the falls. As flows increase to 2,000 cfs the flow path streamlines remain distinguishable near the fish passage facility entrance although as it reaches the falls area it begins mixing with the flow paths from spill at the radial gates. As total spill increases and reaches 25,000 and 37,000 cfs, flow path streamlines from the fish passage facility entrance area are not as distinct and appear to be overwhelmed from flows at the radial gates and flow over the Main Dam. These data may indicate that attraction flow may be insufficient at some flows to provide the velocity clues that upstream migrating fish require to readily find the fish passage facility entrance.

4.4 Fish Passage Efficiency

The results of the study indicate fish are motivated to move upstream and readily, unimpeded, and quickly access the ZOP following release. Of the 70 tagged fish, 69 (98%) were later detected in the far field.

However, not all fish detected in the far field proceeded to the near field. Of the 69 fish that were detected in the far field, 43 (62%) made a foray to the near field, including 72 percent of the Rainbow Trout and 51 percent of the Brown Trout. The proportion of fish making the foray to the near field was much higher in 2022 (72%) than in 2021 (31%). The time of fish collection may have been a factor in the proportion of fish that moved upstream into the near field. In 2022, Brown Trout collected in March and transported downstream had a higher percentage of fish (88%) entering the near field than Brown Trout collected and transported downstream in the fall (35%). Only one June-tagged Rainbow Trout was detected in the near field, but 25 (86%) of the March-tagged Rainbow Trout were detected in the near field.

Of the 43 trout that were detected in the near field in both years of study, 24 (56%) were detected in the fish passage facility entrance, including 54 percent of the Rainbow Trout and 59 percent of the Brown Trout. Hypothetically, if all fish that entered the near field in 2022 (25 Rainbow and 13 Brown trout) continued to the fish passage facility entrance, attraction efficiency[15] would have increased from 48 to 86 percent for Rainbow Trout and from 29 to 54 percent for Brown Trout.

In total, over the two years of study, 24 (35%) of the 70 radio tagged fish were detected at the fish passage facility entrance. Detections at the fish passage facility entrance were much higher in 2022 than in 2021, with 19 percent detected in 2021 and 39 percent detected in 2022.

[15] Number of fish in entrance/# of fish in far field

4.5 Location of Fish Passage Facility

The efficacy of fish passage was noted during the development of study plans as a potential concern due to the location of the passage facility. The data collected during this study supports that the fish passage facility was correctly sited for the following reasons:

- Telemetry shows that fish enter the near field and preferentially select the right bank. Ninety-one percent of the near field detections were attributed to the MDR area near the upstream fish passage facility.
- The left side of the near field (MDL) is generally more turbulent and violent at various spill regimes at the Main Dam. CFD modeling also shows the higher velocities along the left bank during spill that are less accessible/suitable for several species based on their swimming abilities.
- The results indicate that a fish passage facility located at the powerhouses or Dry Channel Dam would be less effective than the current passage facility location. In 2022, only three Brown Trout were detected near the original powerhouse and two Trout (1 Rainbow and 1 Brown Trout) downstream of the Dry Channel Dam.
- During the manual tracking the above five fish were detected for only a short duration (<1 week) before making forays further upstream near the mouth of Prospect Creek, to the Main Dam or to the fish passage facility entrance.

4.6 Water Temperature Effects on Fish Migration

River temperature may be a contributing factor limiting salmonid movement during July and August when Clark Fork River temperatures tend to peak. Summer water temperatures in the Lower Clark Fork River, both coming into from upstream, and downstream of the Project, typically exceed optimal thermal conditions for trout (NorthWestern 2022d). During the hot summer season, few salmonids are generally recorded at the fish passage facility (NorthWestern 2016, 2017, 2018, 2019a, 2019b, 2020, 2021, 2022a). Radio-tagged fish were not present in the near field, and relatively few were detected in the far field, during the period of high water temperatures.

Temperature profiles indicate Prospect Creek provides a cooler water source and creates an area more tolerable for salmonids in the summer. Thermal stratification observed at the three sites near the High Bridge indicate thermal conditions are likely more preferrable for salmonids at the Prospect Hole compared to the High Bridge and Dollar Holes. This may explain observations of fish staying near the confluence of Prospect Creek during the summer and greater number of detections (*via* manual tracking) clustered in this region compared to other areas in the ZOP.

5. 2023 Study Season

The fish collection methods implemented in 2021 and 2022 will continue in 2023 with emphasis on Rainbow Trout. NorthWestern collected 30 Rainbow Trout during the spring 2023. These fish have been radio tagged and their movements will be monitored until the end of July 2023. Methods of fish collection and data analysis implemented in 2021 and 2022 will continue for the 2023 season.

Manual tracking will continue to occur throughout the third study season, ending July 31 with frequency dependent on fish presence (as determined from data from the fixed receivers) in the ZOP. Manual tracking will focus on spring movement prior to and during peak flows as well as determining if fish tagged in 2023 show similar movement patterns as in 2022.

Because the Draft License Application will be submitted in early August, the results from 2023 fish movements (fixed and manual data) within the ZOP and travel time between the far and near fields will be summarized in the Final License Application, as described in the Modified Study Plan.

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Appendix A 2021 and 2022 Fish Collection Details

Table A-1. Trout Collection Sampling Dates, Method, Location, Water Temperature, Effort, and Catch Per Unit Effort in 2021.

2021 Season	Date	Method	Location	Water Temp °C	Effort (Hours)	RB	RB CPUE	LL	LL CPUE
Spring	2-Jun	Electrofishing	MCFR	13.7	1.9	1	0.5		
	3-Jun	Electrofishing	MCFR	14.4	2.0	2	1.0		
	7-Jun	Electrofishing	MCFR	13.1	2.5				
	8-Jun	Electrofishing	MCFR	12.7	1.1	2	1.8		
	8-Jun	Angling	TR	12.7	8.0				
	9-Jun	Electrofishing	MCFR	12.7	3.5	1	0.3		
	11-Jun	Electrofishing	MCFR	12.1	1.5				
	14-Jun	Electrofishing	MCFR	14.5	1.0	1	1.0	4	3.9
	16-Jun	Electrofishing	MCFR	15.9	1.6			2	1.3
Spring Summary	**8 days**	**Electrofishing**	**MCFR**		**15.2**	**7**	**0.5**	**6**	**0.4**
	1 day	**Angling**	**TR**		**8.0**	**0**	**0**	**0**	**0**
Fall	29-Sep	Ladder	Ladder	14.8				1	
	1-Oct	Ladder	Ladder	13.7				2	

Notes: °C = degrees Celsius; CPUE = Catch Per Unit Effort; Ladder = Upstream Fish Passage Facility Workstation; LL = Brown Trout; MCFR = Main Clark Fork River; NA = not applicable; RB = Rainbow Trout; TR = Thompson River.

Table A-2. Trout Collection Sampling Dates, Method, Location, Water Temperature, Effort, and Catch Per Unit Effort in 2022

2022 Season	Date	Method	Location	Water Temp °C	Effort (Hours)	RB	RB CPUE	LL	LL CPUE
Spring	16-Mar	Electrofishing	MCFR	4.5	0.4	1	2.5	1	2.5
	24-Mar			7.1	0.4	1	2.5	6	14.7
	17-Mar	Ladder		4.8		3		1	
	18-Mar			5.7		2			
	21-Mar			5.6		13			
	23-Mar			6.1		1			
	28-Mar			8.2		6			
	29-Mar			7.9		2			
Spring Summary	**2 days**	**Electrofishing**	**MCFR**		**0.8**	**2**	**2.5**	**7**	**8.8**
	6 days	**Ladder**	**Ladder**			**27**		**1**	
Fall	20-Sep	Ladder		16.8				1	
	21-Sep			16.6				3	
	22-Sep			15.6				1	
	23-Sep			15.5				2	
	26-Sep			15.5				4	
	21-Sep	Electrofishing	MCFR	16.6	1.5			2	1.3
	26-Sep			15.5	2.1			-	-
	29-Sep			16.5	1.5			4	2.7
Fall Summary	**3 days**	**Electrofishing**	**MCFR**		**5.1**			**6**	**1.2**
	5 days	**Ladder**	**Ladder**					**11**	

Notes: °C = degrees Celsius; CPUE = Catch Per Unit Effort; Ladder = Upstream Fish Passage Facility Workstation; LL = Brown Trout; MCFR = Main Clark Fork River; NA = not applicable; RB = Rainbow Trout.

Table A-3. Trout Tagged and Transported in 2021.

Date Tagged & Transported	Species	Length (mm)	Weight (g)	Radio Tag #	PIT TAG ID[16]
6/2/2021	RB	383	682	58	3212832
6/3/2021	RB	398	862	49	3212788
6/3/2021	RB	457	1052	51	3212871
6/8/2021	RB	534	1304	52	3211820
6/8/2021	RB	502	1328	56	3211805
6/9/2021	RB	409	616	54	3212869
6/14/2021	RB	433	705	55	3212787
Total RB	**7**				
6/14/2021	LL	436	896	39	3212850
6/14/2021	LL	444	959	48	3212806
6/14/2021	LL	506	1501	59	3212840
6/14/2021	LL	392	623	60	3212798
6/16/2021	LL	379	574	46	3212853
6/16/2021	LL	472	917	47	3212794
9/29/2021	LL	483	996	28	3212709
10/1/2021	LL	334	326	26	3212719
10/1/2021	LL	406	616	27	0300297
Total LL	**9**				

Notes: g = gram; ID = identification; LL = Brown Trout; mm = millimeters; RB = Rainbow Trout.

[16] 98900103 are the first digits of each PIT tag

Table A-4. Trout Tagged and Transported in 2022.

Date Tagged & Transported	Species	Length (mm)	Weight (g)	Radio Tag #	PIT TAG ID[17]
3/16/2022	RB	518	1758	35	3212802
3/17/2022	RB	522	1344	43	3212696
3/17/2022	RB	549	1440	44	3212732
3/17/2022	RB	511	1086	61	3212755
3/18/2022	RB	516	1528	38	3212764
3/18/2022	RB	447	818	64	3212765
3/21/2022	RB	536	1816	31	300845
3/21/2022	RB	500	1242	32	3212747
3/21/2022	RB	452	994	33	3212707
3/21/2022	RB	388	672	36	3212761
3/21/2022	RB	603	1486	41	3211792
3/21/2022	RB	410	676	45	3211966
3/21/2022	RB	495	1076	50	3211807
3/21/2022	RB	550	1728	53	3211933
3/21/2022	RB	510	1400	57	3211861
3/21/2022	RB	597	788	62	3211790
3/21/2022	RB	513	1290	63	3211858
3/21/2022	RB	533	1582	79	3212917
3/21/2022	RB	414	650	80	3212713
3/23/2022	RB	450	1066	77	3211851
3/24/2022	RB	412	688	67	3212781
3/28/2022	RB	529	1318	34	300523
3/28/2022	RB	521	1362	42	3211827
3/28/2022	RB	463	1114	65	3211788
3/28/2022	RB	551	1542	74	3211907
3/28/2022	RB	494	1118	75	3211816
3/28/2022	RB	470	1094	78	3211847
3/29/2022	RB	493	1212	40	3212744
3/29/2022	RB	506	1312	73	3211781
RB TOTAL	**29**				
3/16/2022	LL	476	1048	37	3212776
3/21/2022	LL	409	586	72	3211808
3/24/2022	LL	392	530	66	3212792
3/24/2022	LL	400	588	68	3212849
3/24/2022	LL	414	644	69	3212795

[17] 98900103 are the first digits of each PIT tag

Date Tagged & Transported	Species	Length (mm)	Weight (g)	Radio Tag #	PIT TAG ID[17]
3/24/2022	LL	430	736	70	3212809
3/24/2022	LL	407	664	71	3212857
3/24/2022	LL	479	876	76	3212844
Spring LL Total	**8**				
9/20/2022	LL	602	1714	20	3212726
9/21/2022	LL	340	344	18	3212630
9/21/2022	LL	370	400	24	3212672
9/21/2022	LL	446	824	19	3212576
9/21/2022	LL	377	526	21	3212648
9/21/2022	LL	402	572	23	3212624
9/22/2022	LL	467	738	22	3212955
9/23/2022	LL	482	1058	11	3212635
9/23/2022	LL	442	830	12	3212628
9/26/2022	LL	518	1178	13	3212695
9/26/2022	LL	382	502	14	3212662
9/26/2022	LL	496	1076	15	3212610
9/26/2022	LL	444	824	30	3212608
9/29/2022	LL	502	1254	16	3212580
9/29/2022	LL	397	536	17	3212583
9/29/2022	LL	323	336	25	3212582
9/29/2022	LL	347	374	29	3212627
Fall LL Total	**17**				
LL Total	**25**				

Notes: g = gram; ID = identification; LL = Brown Trout; mm = millimeters; RB = Rainbow Trout.

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Appendix B Travel Time for 2021 and 2022 Radio Tagged Trout

Table B-1. Travel Time for 9 Brown Trout and 7 Rainbow Trout Radio Tagged Trout in 2021.

Tag #	Spp.	Date Transport to Flatiron (2021)	Date First Detected (2021)			Travel Time (Days)				Comments
			Far Field	*Near Field*	*Fish Passage Facility Entrance*	*From Flatiron to Far Field*	*From Far to Near Field*	*From Near to Fish Passage Facility Entrance*	*Far Field to Fish passage facility Entrance*	
26	LL	10/1	10/17	-	-	18	-	-	-	
27[18]	LL	10/1 10/25	10/2 10/26	10/19 10/27	10/22	1 1	17 1	3	20	10/22 ascended ladder 10/25 transported to Flatiron 10/27 Main Dam
28	LL	9/29	10/1	-	-	2	-	-	-	10/25-11/4 detected by Prospect Ck array
39	LL	6/14	6/21	9/30	-	7	101	-	-	9/30 manual tracked fish just below falls
46	LL	6/16	6/29	-	-	13	-	-	-	
47[7]	LL	6/16 10/25	6/19 10/26	10/14 10/31	10/15	3 1	114 5	1	115	10/24 ascended fish passage facility; 10/25 transported to Flatiron 10/29 Fish passage facility Closed 11/1 Main Dam
48	LL	6/14	6/19	-	-	5	-	-	-	
59	LL	6/14	6/20	-	-	6	-	-	-	
60[7]	LL	6/14	6/23 6/30	6/25 9/26	6/29	9	2 88	4	6	6/29 water temp 21.3°C

[18] Brown Trout #27 and #47 were transported back downstream on October 25. Brown Trout #60 entered the near field two separate forays.

Tag #	Spp.	Date Transport to Flatiron (2021)	Date First Detected (2021)			Travel Time (Days)				Comments
			Far Field	***Near Field***	***Fish Passage Facility Entrance***	***From Flatiron to Far Field***	***From Far to Near Field***	***From Near to Fish Passage Facility Entrance***	***Far Field to Fish passage facility Entrance***	
49	RB	6/3	7/5	-	-	32	-	-	-	
51	RB	6/3	6/29	-	-	26	-	-	-	
52	RB	6/8	7/6	8/12	-	28	37	-	-	8/12 water temp 21.4°C
54	RB	6/9	6/29	-	-	20	-	-	-	
55	RB	6/14	6/30	-	-	16	-	-	-	
56	RB	6/8	6/24	-	-	16	-	-	-	
58	RB	6/2	6/2	-	-	<1	-	-	-	9/13 angler mortality at mouth of Prospect Ck

Notes: °C = degrees Celsius; LL = Brown Trout; RB = Rainbow Trout.

Table B-2. Travel time for 29 Rainbow Trout Radio Tagged in 2022. In chronological order of transported and released at Flatiron FAS.

Tag #	Spp.	Date Transport to Flatiron (2022)	Date First Detected (2022)			Travel Time (Days)				Comments
			Far Field	Near Field	Fish Passage Facility Entrance	From Flatiron to Far Field	From Far to Near Field	From Near to Fish Passage Facility Entrance	Far Field to Fish passage facility Entrance	
35	RB	16-Mar	23-Mar	28-Mar	-	6.7	5.3	-	-	Detected near Blueside
61	RB	17-Mar	19-Mar	20-Mar	-	1.9	1.2	-	-	Detected in Graves Creek and Prospect Creek
43	RB	17-Mar	23-Mar	29-Mar	-	5.4	6.5	-	-	Detected in Prospect Creek
44	RB	17-Mar	20-Mar	-	-	3.0	-	-	-	
38	RB	18-Mar	20-Mar	22-Mar	23-Mar	2.1	2.0	1.0	3.0	Detected in Thompson River
64	RB	18-Mar	21-Mar	29-Mar	-	3.1	8.3	-	-	
31	RB	21-Mar	21-Mar	23-Mar	23-Mar	0.3	1.8	0.2	1.9	Detected in Thompson River
36	RB	21-Mar	21-Mar	23-Mar	24-Mar	0.4	1.9	0.9	2.9	Detected in Thompson River
41	RB	21-Mar	21-Mar	28-Mar	28-Mar	0.2	7.0	0.03	7.1	
45	RB	21-Mar	21-Mar	28-Mar	28-Mar	0.4	6.7	0.2	6.9	Detected in Thompson River
53	RB	21-Mar	23-Mar	24-Mar	30-Mar	1.8	1.3	5.9	7.2	
32	RB	21-Mar	28-Mar	8-Apr	20-Apr	7.4	10.9	12.2	23.1	Detected in Thompson River
33	RB	21-Mar	22-Mar	29-Mar	-	1.0	7.1	-	-	
62	RB	21-Mar	22-Mar	24-Mar	25-Mar	1.0	2.0	1.0	3.1	Detected in Thompson River
57	RB	21-Mar	24-Mar	26-Apr	2-May	3.1	32.7	6.3	39.0	

Tag #	Spp.	Date Transport to Flatiron (2022)	Date First Detected (2022)			Travel Time (Days)				Comments
			Far Field	Near Field	Fish Passage Facility Entrance	From Flatiron to Far Field	From Far to Near Field	From Near to Fish Passage Facility Entrance	Far Field to Fish passage facility Entrance	
80	RB	21-Mar	22-Mar	-	-	0.6	-	-	-	Detected in Prospect Creek
79	RB	21-Mar	22-Mar	27-Mar	28-Mar	1.3	4.9	1.0	5.9	
63	RB	21-Mar	21-Mar	22-Mar	20-Apr	0.0	0.4	29.9	30.3	Detected in Thompson River
50	RB	21-Mar	22-Mar	22-Mar	29-Apr	0.4	0.6	37.7	38.3	Detected in Thompson River
77	RB	23-Mar	26-Mar	23-Apr	-	2.9	28.6	-	-	
67	RB	24-Mar	27-Mar	30-Mar	-	3.1	2.4	-	-	
75	RB	28-Mar	8-Apr	8-Apr	25-Apr	11.4	0.1	16.4	16.5	
34	RB	28-Mar	5-Apr	14-Apr	-	8.1	9.4	-	-	
74	RB	28-Mar	28-Mar	29-Mar	-	0.2	0.9	-	-	Detected near Vermilion River
65	RB	28-Mar	29-Mar	-	-	0.7		-	-	Detected in Graves Creek
42	RB	28-Mar	29-Mar	-	-	0.9		-	-	Detected near Marten Creek
78	RB	28-Mar	2-Apr	14-Apr	-	5.2	12.3	-	-	Detected in Prospect Creek
73	RB	29-Mar	31-Mar	29-Apr	1-May	2.2	28.7	2.5	31.2	Detected in Thompson River
40	RB	29-Mar	29-Mar	30-Mar	-	0.2	0.4	-	-	Detected in Prospect Creek

Note: RB = Rainbow Trout.

Table B-3. Travel time for 25 Brown Trout Radio Tagged in 2022. In chronological order of transported and released at Flatiron FAS.

Tag #	Spp.	Date Transported to Flatiron (2022)	Date First Detected (2022)			Travel Time (Days)				Comments
			Far Field	Near Field	Fish Passage Facility Entrance	From Flatiron to Far Field	From Far to Near Field	From Near to Fish Passage Facility Entrance	Far Field to Fish passage facility Entrance	
37	LL	16-Mar	19-Mar	29-Mar	20-Jul	3.0	10.1	112.6	122.7	Detected in Thompson River
72	LL	21-Mar	6-Apr			16.1		-	-	
70	LL	24-Mar	28-Mar	24-Apr	12-Oct	4.2	26.4	171.6	198.0	Detected in Graves Creek
68	LL	24-Mar	26-Mar	28-Mar		1.6	2.2			
66	LL	24-Mar	3-Apr	26-May	27-Sep	9.9	53.0	123.9	176.9	Detected in Graves Creek
76	LL	24-Mar	25-Mar	28-Mar	-	0.8	3.0	-	-	
69	LL	24-Mar	29-Mar	9-Jul	-	4.5	102.9	-	-	Detected near Blueside
71	LL	24-Mar	25-Mar	26-Mar		0.7	1.1	-	-	
20	LL	20-Sep	20-Sep	-	-	0.3	-	-	-	
18	LL	21-Sep	30-Sep	-	-	9.3	-	-	-	
19	LL	21-Sep	22-Sep	14-Oct	15-Oct	0.9	21.9	1.2	23.1	
21	LL	21-Sep	22-Sep	-	-	0.8				
23	LL	21-Sep	22-Sep	10-Oct	10-Oct	0.7	18.1	0.3	18.5	
24	LL	21-Sep	23-Sep	29-Sep	30-Sep	2.0	5.9	0.9	6.9	
22	LL	22-Sep	22-Sep	-	-	0.5	-	-	-	
11	LL	23-Sep	24-Sep	6-Oct	7-Oct	0.9	12.1	0.9	13.0	Detected in Thompson River
12	LL	23-Sep	27-Sep	-	-	4.5	-	-	-	
13	LL	26-Sep	26-Sep	29-Sep	-	0.5	2.4	-	-	
14	LL	26-Sep	26-Sep	-	-	0.2	-	-	-	
15	LL	26-Sep	29-Sep	-	-	3.1	-	-	-	
30	LL	26-Sep	26-Sep	22-Oct	-	0.2	25.8	-	-	

Tag #	Spp.	Date Transported to Flatiron (2022)	Date First Detected (2022)			Travel Time (Days)				Comments
			Far Field	Near Field	Fish Passage Facility Entrance	From Flatiron to Far Field	From Far to Near Field	From Near to Fish Passage Facility Entrance	Far Field to Fish passage facility Entrance	
16	LL	29-Sep	2-Oct	-	-	3.0	-	-	-	
17	LL	29-Sep	29-Sep	-	-	0.0	-	-	-	
25	LL	29-Sep	-	-	-	-	-	-	-	
29	LL	29-Sep	1-Oct	-	-	1.6	-	-	-	

Note: LL = Brown Trout.