Thompson Falls Hydroelectric Project
FERC Project No. 1869

Fisheries and Aquatic Resources
Protection, Mitigation and Enhancement Plan

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List of Abbreviations and Acronyms

%	percent
°C	degrees Celsius
CFD	computational fluid dynamics
cfs	cubic feet per second
CSKT	Confederated Salish and Kootenai Tribes
FERC	Federal Energy Regulatory Commission
fish passage facility	Thompson Falls Upstream Fish Passage Facility
FLA	Final License Application
FWP	Montana Fish, Wildlife and Parks
FWS	U.S. Fish and Wildlife Service
kW	kilowatts
Licensee	NorthWestern Energy
ladder	Thompson Falls Upstream Fish Passage Facility
NMFS	National Marine Fisheries Service
NorthWestern	NorthWestern Energy
PIT	passive integrated transponder
Plan	Protection, Mitigation, and Enhancement Plan
PM&E	Protection, mitigation, and enhancement
Project	Thompson Falls Hydroelectric Project
RM	river miles
SKQ	Seli'š Ksanka Qlispe'
Thompson Falls Project	Thompson Falls Hydroelectric Project
U.S.	United States

1. Introduction

The Thompson Falls Hydroelectric Project No. 1869 (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.), including the Thompson Falls Project, are regulated by the Federal Energy Regulatory Commission (FERC) under the authority of the Federal Power Act. The Project's FERC License was issued on December 28, 1979, amended and extended on April 30, 1990, and 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. Concurrently, NorthWestern filed a Pre-Application Document. Northwestern submitted a Final License Application (FLA) to FERC on December 29, 2023.

This Fisheries and Aquatic Resources Protection, Mitigation and Enhancement (PM&E) Plan (Plan) establishes the goals, program objectives, tasks, and schedule for implementing the fish and aquatic PM&E measures during the license term.

2. Environmental Setting

The Thompson Falls Project, situated on the Clark Fork River in Sanders County, Montana, has an authorized installed capacity of 92,370 kilowatts (kW). Initial development began in June 1912 under the Thompson Falls Power Company, with the first generating unit operational on July 1, 1915, and the sixth unit operational in May 1917. A seventh unit was added in a new powerhouse completed in 1995. NorthWestern acquired the project in 2014 and has been operating it as part of its integrated electric system ever since.

The original development of the Project completed in 1917 includes:

- A Main Channel Dam, a concrete gravity structure 1,016 feet long and 54 feet high with an overflow section 913 feet long having 8-foot-high fixed wheel panels atop 8 foot-high flashboards with four radial gates
- A smaller dam of the same type, known as the Dry Channel Dam, 449 feet long and 45 feet high with an overflow section 289 feet long having 8-foot-high fixed wheel panels atop 4-foot flashboards, located west of the Main Channel Dam in a dry channel of the river
- A rock cut canal 450 feet long and 80 feet wide
- 6 main penstocks 14 feet in diameter
- The original steel frame and masonry powerhouse containing six generation units, three rated at 7,000 kW, 1 rated at 6,000 kW and 2 rated at 6,375 kW
- Two generator step-up transformers
- Two 6.6-kilovolt (kV) generator leads
- A 1,092-acre reservoir controlled by the Main Channel and Dry Channel Dams

The newer development, completed in 1995, includes:

- A 78-foot wide, 300-foot-long intake channel
- A 78-foot wide, 200-foot-long powerhouse containing one 52,613 kW generating unit
- A 100-foot-wide, 1,000-foot-long tailrace channel
- A 1,000-foot-long access road with a 360-foot-long bridge over the reservoir and a 135-foot-long bridge over the intake canal
- A short 115 kV generator lead line running from the generator, through a generator step-up transformer, connecting to the transmission grid on the third floor of the Units' 1-6 powerhouse

In 2009 & 2010 an upstream fish passage facility was constructed in the river-right non-overflow section of the Main Channel Dam. The 48-step pool reinforced concrete fish passage facility began operation in 2011 and includes a fish sampling facility consisting of a holding pool and trapping mechanism(s), fish crowder, fish lock, sampling facilities' shelter, a sampling and handling table, and sampling facility water supply pipelines.

The Project is more fully described in Exhibit A of the FLA, and the FERC Project boundary, which establishes the geographic extent of the Project, appears in Exhibit G of the FLA. An overview map of the main features of the Project appears in Figure 2-1.

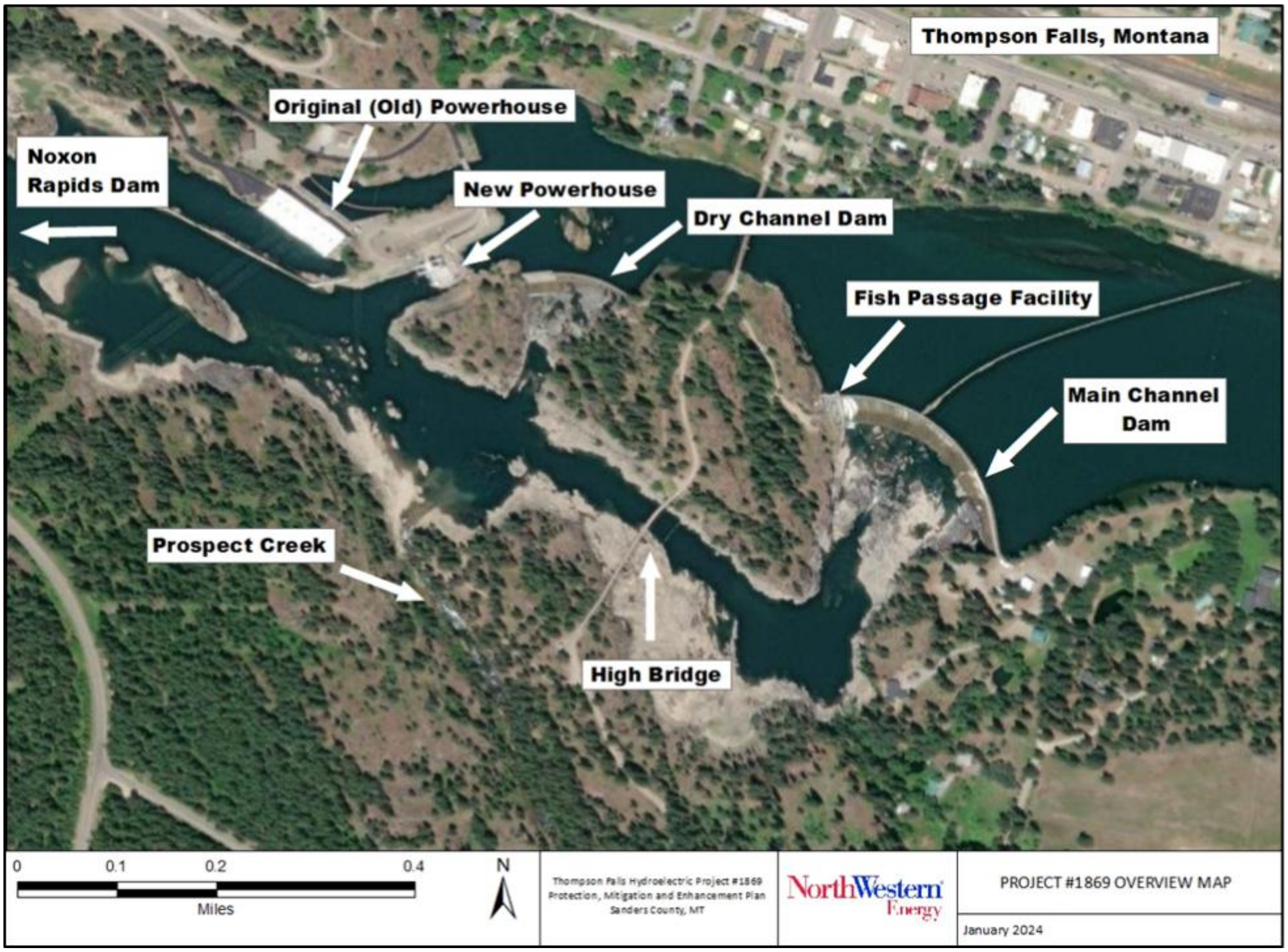

Figure 2-1: Overview of the main features of the Project.

2.1 General Description of the Clark Fork River Basin

The Project is located at approximately River Mile 65 on the Clark Fork River. The Clark Fork River is the largest river in the state of Montana based on its flow volume. The Clark Fork River is approximately 320 miles long, with headwaters in southwest Montana, and the terminus at Lake Pend Oreille, Idaho. Outflows from Lake Pend Oreille create the Pend Oreille River, which ultimately reaches its confluence with the Columbia River.

The drainage area upstream of the Project is 20,904 square miles and includes upstream flow from the Thompson, Flathead, Blackfoot, and Bitterroot rivers, among many other tributaries. The Project is in the lower Clark Fork River subbasin, which contains 180 miles of perennial stream. In general, the ascending limb of the hydrograph in the lower Clark Fork River begins between mid- and late March, peaks between late May and mid-June, and descends to base flow levels around mid-August.

There are five major facilities in the Clark Fork River basin (Figure 2-2). The furthest upstream is Hungry Horse Dam on the South Fork of the Flathead River, managed by the U.S. Bureau of Reclamation. The South Fork of the Flathead River is a tributary to the Flathead River which in turn is a tributary to the Clark Fork River. Downstream of Hungry Horse Dam on the Flathead River is the Seli'š Ksanka Qlispe' (SKQ) Hydroelectric Project (FERC Project No. 5) owned by the Confederated Salish and Kootenai Tribes (CSKT) and operated by its federally chartered corporation, Energy Keepers, Inc. The SKQ Project is located approximately 100 miles upstream of the Project. Other smaller water control facilities are present in the Clark Fork River basin upstream of the Project (Figure 2-2).

Downstream of the Project on the Clark Fork River is Avista Utilities' (Avista) Clark Fork River Project (FERC Project No. 2058) consisting of Noxon Rapids Dam, located approximately 33 miles downstream of the Project in Montana, and Cabinet Gorge Dam, approximately 19 miles downstream of Noxon Rapids Dam in Idaho and approximately 52 miles downstream of the Project (Figure 2-3). Cabinet Gorge Dam has an upstream fish capture facility. Noxon Rapids Dam does not provide upstream fish passage.

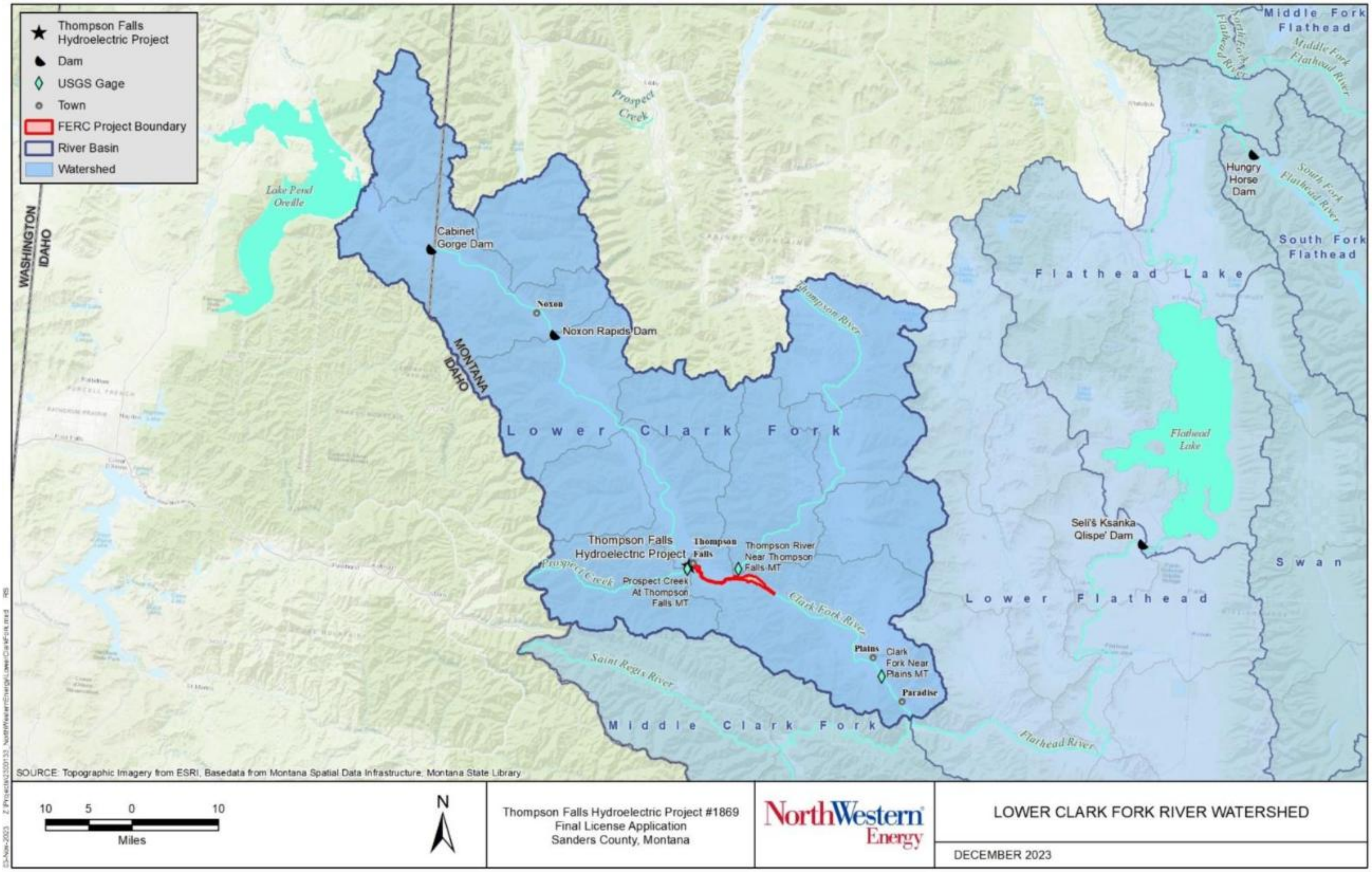

Figure 2-2: Project location and surrounding watersheds.

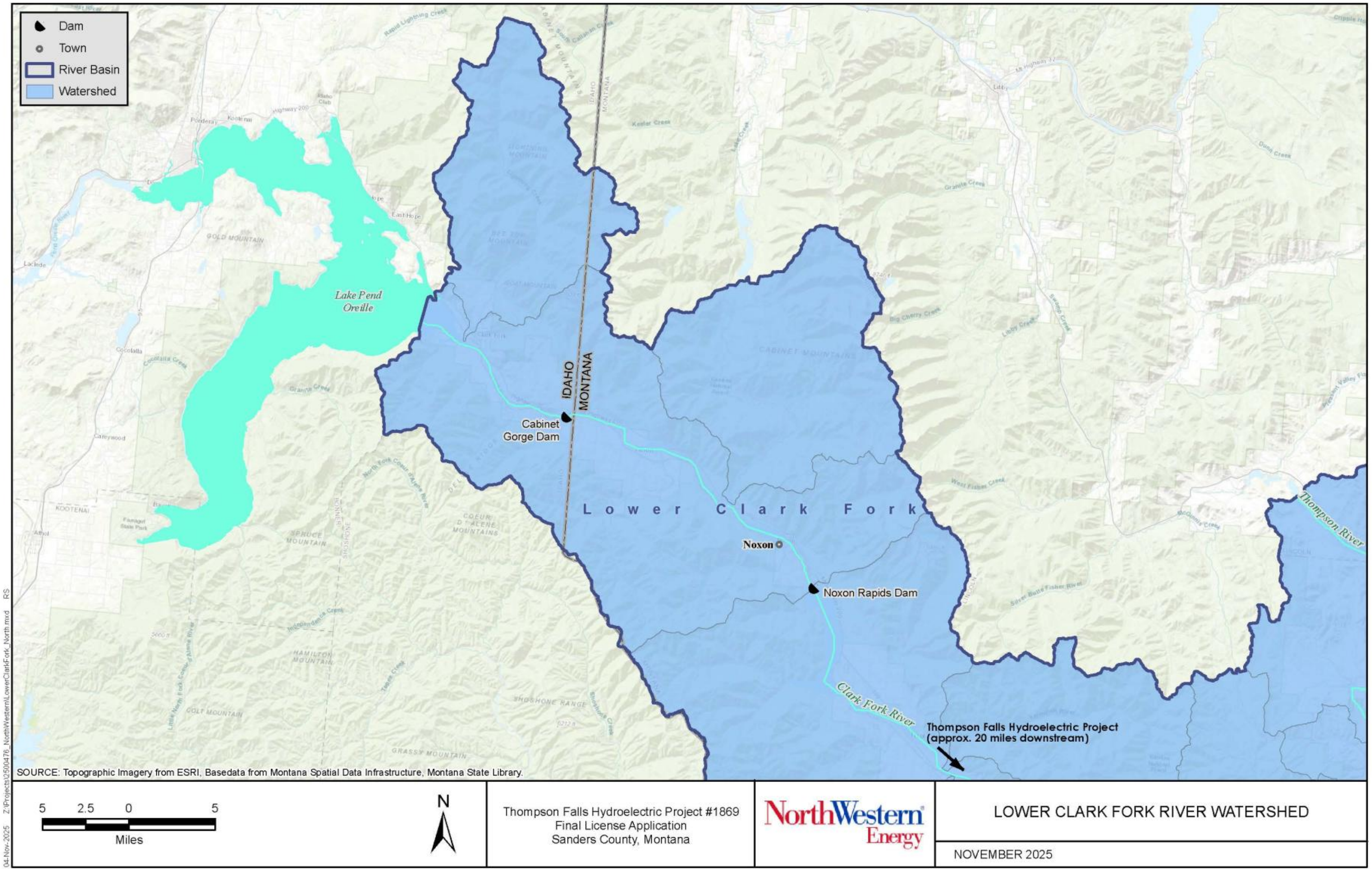

Figure 2-3: Project location relative to Noxon Rapids and Cabinet Gorge Dams and Lake Pend Oreille.

2.2 Aquatic Habitat in the Project Area

2.2.1 Thompson Falls Reservoir

The Project boundary encompasses about 10 miles of river and reservoir. The maximum depth of the reservoir is approximately 90 feet. The reservoir ranges from 400 to 1,800 feet wide. The downstream six miles of the reservoir provide lacustrine habitat, and the upstream four miles provide lotic habitat.

The downstream section of the reservoir has substantially lower water velocity, mean widths near 1,673 feet and abundant aquatic vegetation. The upstream section of the reservoir has noticeable flowing water, average widths around 459 feet and minimal aquatic vegetation.

Water temperature data collected in Thompson Falls Reservoir indicate that the reservoir does not stratify in the summer months and is generally thermally homogeneous. The Project does not modify water temperatures, as incoming water temperatures to the reservoir have been shown to be the same as those leaving the Project below the dam and powerhouse. The cool water influence of the Thompson River extends downstream in Thompson Falls Reservoir a short distance, approximately 328 feet downstream of the Thompson River confluence and 50 feet from the river-right bank. Additional water temperature data indicate there may also be some cool water potentially from groundwater inflow, near Cherry Creek, approximately 2 miles downstream from the Thompson River. However, these small areas of cool water do not extend throughout the reservoir and appear to be highly localized. No large cool water zones have been documented in the Thompson Falls Reservoir.

Tributaries that feed into the Thompson Falls Reservoir include Cherry Creek and the Thompson River (**Figure 2-4**). Cherry Creek enters on the south side of the reservoir approximately 4 miles upstream of the Main Channel Dam and is known to provide habitat for salmonids. Cherry Creek is a relatively small tributary and averages 16 feet across at its mouth and quickly narrows to 11 feet across within about 200 feet upstream of its confluence with the Clark Fork River.

The Thompson River flows into Thompson Reservoir approximately 6 miles upstream of the Thompson Falls dams. Approximately 0.2 miles of the Thompson River falls within the FERC Project boundary, at its confluence with the Clark Fork River. The Thompson River is a considerably larger tributary than Cherry Creek and has more variable habitat at the confluence with the Thompson Falls Reservoir.

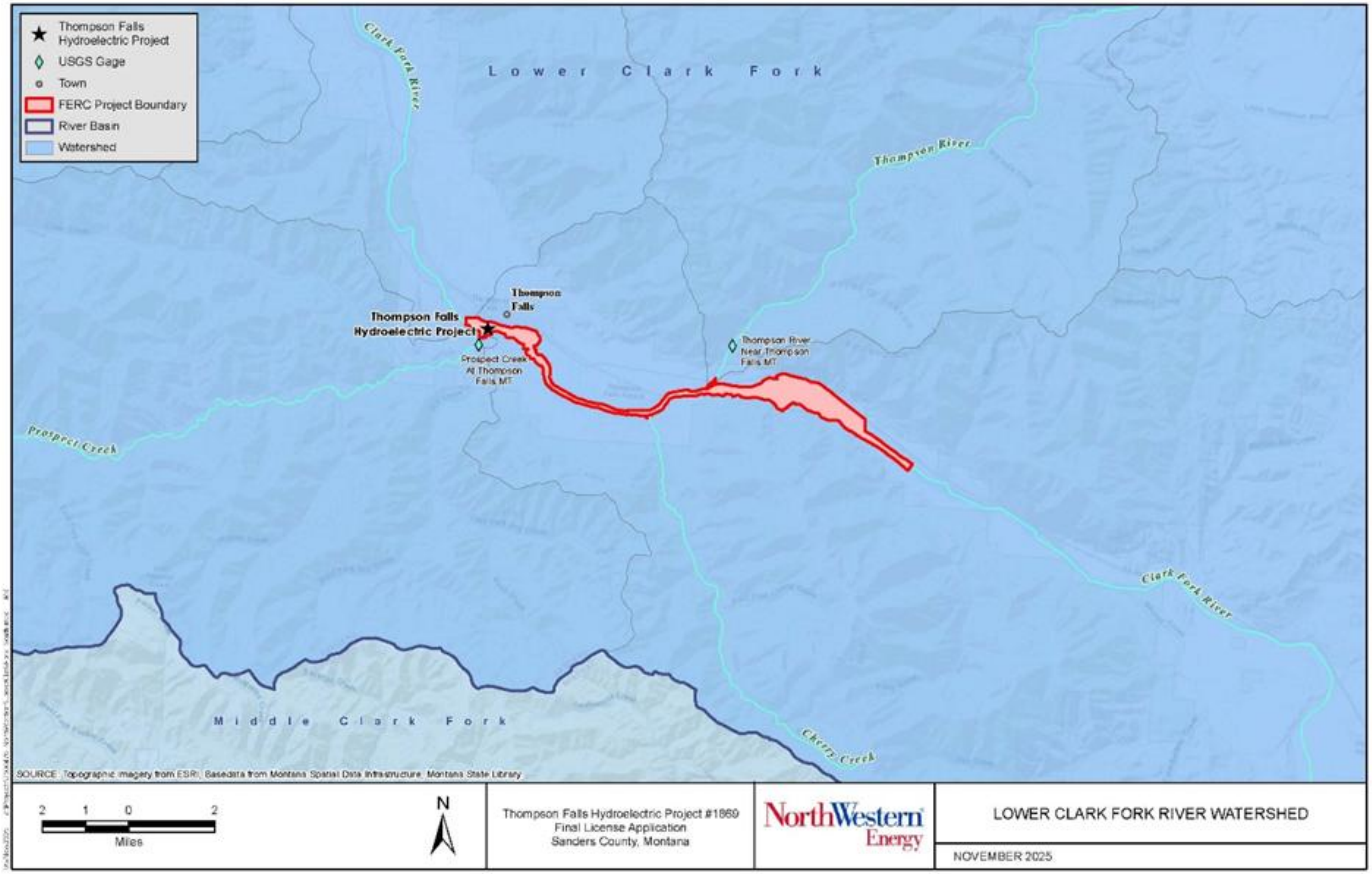

Figure 2-4: Tributaries that flow into the Thompson Falls Project Boundary.

2.2.2 Clark Fork River Downstream of the Project

Downstream of the Project is Noxon Rapids Reservoir, part of Avista's Clark Fork Project (FERC Project No. 2058). Noxon Rapids Dam, approximately 33 miles downstream of the Thompson Falls Project, impounds Noxon Rapids Reservoir which is the largest reservoir in the Lower Clark Fork River basin, impounding an area of approximately 8,000 acres at full pool.

The habitat in the reach of the Clark Fork River downstream of the Project is classified as riverine, but habitat conditions are influenced both by the Project operations and operations of Noxon Rapids Dam. Tailrace elevations immediately downstream of the Project are related to the total volume of water passing through the Project and the elevation of Noxon Rapids Reservoir. In general, the tailrace elevation rises with increased flow through the Project while reduced flows result in lower tailrace elevations in addition to the effects on the tailrace from the Noxon Reservoir elevation.

Prospect Creek flows into the Clark Fork River about 2,600 feet downstream of the Main Channel Dam in the bypass reach, directly across from the Dry Channel Dam, and upstream of both powerhouses. Prospect Creek provides a cold-water refuge for salmonids during the warm summer months. This summer cold-water refuge area consistently attracts salmonids to the confluence when summer mainstem water temperatures are high.

2.3 Fish Species and Distribution

2.3.1 Fish Populations in the Project Vicinity

Native species present in the Project vicinity include salmonids (Westslope Cutthroat Trout, Bull Trout, and Mountain Whitefish) and non-salmonids (Longnose and Largescale sucker, Northern Pikeminnow, Peamouth, Longnose Dace, Redside Shiner, and Sculpin *spp*.).

Some of the more common nonnative species present in the Project vicinity include game fish such as Largemouth Bass, Smallmouth Bass, Northern Pike, Yellow Perch, Rainbow Trout, and Brown Trout. Based on gillnet and electrofishing sampling within Thompson Falls Reservoir, non-salmonids such as bass, Northern Pike, and Yellow Perch are more common in the lower portions of the reservoir; and Largescale Suckers, Northern Pikeminnow, and Rainbow Trout are more abundant in the upper portions of the reservoir where riverine-like habitats exist.

Upstream in the Clark Fork River above the Project, Largescale Sucker, Smallmouth Bass, Northern Pikeminnow, and Mountain Whitefish remain the most common species. Other species recorded less frequently include Bull Trout, Brown Trout, Longnose Sucker, Northern Pike, Pumpkinseed, Rainbow Trout, Westslope Cutthroat Trout, and Yellow Perch (NorthWestern 2025).

NorthWestern has historically conducted routine fisheries surveys. These surveys include fall gillnetting in Thompson Falls Reservoir since 2004, and, starting in 2009, spring electrofishing in Thompson Falls Reservoir and fall electrofishing in two reaches of the Clark Fork River. The objective of these fisheries surveys is to collect information on species composition and relative abundance. Annual reports of results have been submitted to FERC, and more information on species composition and abundance can be found in FERC's eLibrary[1] and on NorthWestern's website[2]. Montana Fish, Wildlife, and Parks (FWP) also maintains a publicly available database of information collected by the state and outside sources regarding survey information and species composition.[3]

2.3.2 Threatened Fish Species in the Project Vicinity - Bull Trout

Bull Trout are listed as threatened under the Endangered Species Act and are the only federally-listed aquatic species occurring in the Project area. Designated critical habitat for the Bull Trout is located within the Project boundary. Two tributaries near the Project, Prospect Creek (located immediately downstream of the Main Channel Dam), and the Thompson River (located about 6 miles upstream of the Main Channel Dam) are also designated as critical habitat for the Bull Trout. West Fork Thompson River and Fishtrap Creek, tributaries to the Thompson River, are designated Bull Trout critical habitat, as well as the mainstem Thompson River and the Clark Fork River. Table 2-1 summarizes the designated Bull Trout critical habitat within the Lower and Middle Clark Fork River.

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[1] https://elibrary.ferc.gov/eLibrary

[2] https://www.northwesternenergy.com/clean-energy/hydropower/thompson-falls-hydro-project/annual-reports-ferc-orders

[3] https://myfwp.mt.gov/fishMT/reports/surveyreport

Table 2-1: Bull Trout spawning and rearing designated critical habitat tributaries to the Lower and Middle Clark Fork rivers and Lower Flathead River.

Upstream or Downstream of Project	River Reach Description	Bull Trout Designated Spawning and Rearing Critical Habitat Tributaries to the Clark Fork River/Flathead River (smaller tributaries)
Downstream	Noxon Rapids Dam upstream to Thompson Falls Dam (River mile 169.7-208)	Swamp Creek, Vermilion River, Graves Creek, Prospect Creek
Upstream	Lower Clark Fork River – starts at Thompson Falls Dams and ends at the confluence with the lower Flathead River (River mile 208-245)	Thompson River (West Fork Thompson River, Fishtrap Creek)
Upstream	Lower Flathead River (River mile 245)	Jocko River (North Fork and South Fork), Mission Creek, Post Creek, Dry Creek
Upstream	Middle Clark Fork River – starts at the confluence with the lower Flathead River and ends at the confluence with the Blackfoot River (River mile 245-364.6)	St. Regis River (Little Joe Creek, Ward Creek, Twelvemile Creek), Cedar Creek, Trout Creek, Fish Creek (North Fork, West Fork and South Fork, Cache Creek), Petty Creek, Albert Creek, Grant Creek, Rattlesnake Creek

Source**:** FWS 2015

Prior to construction of large mainstem dams in the Clark Fork River basin, juvenile adfluvial Bull Trout out-migrated from tributary streams to feed and mature in Lake Pend Oreille, a large lake located 69 river miles (RM) downstream of Thompson Falls Dam. Additionally, some juvenile fluvial Bull Trout historically out-migrated from tributary streams to feed and mature in the lower Clark Fork River downstream of the Project. After maturing into the adult life stage, the adfluvial and fluvial Bull Trout would migrate upstream from Lake Pend Oreille and the lower Clark Fork River to their natal streams to spawn. Migration historically allowed Bull Trout in the Clark Fork River and Lake Pend Oreille to access foraging areas and exploit a wider variety of prey resources, such as Mountain or Pygmy Whitefish or Kokanee Salmon (U. S. Fish and Wildlife Service (FWS) 2008).

The historical migration pattern was disrupted by the construction of Thompson Falls Dam and two downstream dams as part of Avista's Clark Fork Project (FERC No. 2058). The Clark Fork Project consists of two developments, Noxon Rapids Dam located about 38.3 RMs downstream of the Project, and Cabinet Gorge Dam located about 58.1 RMs downstream of the Project. The Clark Fork River flows another 10 miles from the Cabinet Gorge Dam tailrace to Lake Pend Oreille.

Currently, there are no volitional upstream fish passage facilities at either of Avista's Clark Fork Project dams (Noxon Rapids and Cabinet Gorge Dams). However, to aid in restoration of the adfluvial life history for Bull Trout in the basin, Avista implements an upstream and downstream transport program at the Clark Fork Project. Specifically, Avista captures juvenile Bull Trout using weirs and electrofishing within tributaries to the Clark Fork Project reservoirs, implants them with PIT tags, and transports them to Lake Pend Oreille. Once adult Bull Trout begin upstream migrations from Lake Pend Oreille, Avista attempts to capture them at Cabinet Gorge Dam via a combination of electrofishing efforts, a permanent trapping facility constructed in 2022 at the base of the dam, and a capture facility at a nearby cold-water source. Through a rapid genetic assignment process, captured individuals are then assigned to their natal tributary and transported and released in that location by Avista. Since the transport program began in 2001, Avista has transported about 44 adult Bull Trout per year. Individual Bull Trout have been assigned and transported to tributaries to both of the Clark Fork Project reservoirs and tributaries to the Clark Fork River upstream of Thompson Falls Dam.

Bull Trout are rare in the Project area. Upstream of Thompson Falls Dam, only 11 Bull Trout were collected during NorthWestern's sampling efforts during the 14-year period from 2009 to 2022. Specifically, spring electrofishing in Thompson Falls Reservoir resulted in the capture of six Bull Trout, one in the lower section and five in the upper section. Fall electrofishing in the Clark Fork River within the upper portion of the Project Reservoir (i.e., Above Islands complex) and Clark Fork River upstream of the Project (i.e., Plains-to-Paradise reach) captured five Bull Trout. No Bull Trout have been captured during annual fall gillnet surveys in Thompson Falls Reservoir (starting in 2004). It should be noted that these fish sampling methods are not highly efficient and do not capture all individuals, but catches are representative of the relative abundance and proportion of species over time. For example, electrofishing downstream of the Project in the spring of 2011, 2012, and 2014 resulted in a total of seven individual Bull Trout out of 2,222 fish handled.

3. Project Effects

As demonstrated by studies conducted in accordance with FERC's Study Plan Determination issued in the relicensing Integrated Licensing Process for the Project, the Project's effects on fish and aquatic resources relate to the effectiveness of upstream and downstream passage, elevated Total Dissolved Gas (TDG), and maintenance drawdowns of the reservoir. The effects of the latter are addressed in the November 2025 Updated License Application Exhibit E. In addition, the effects on fish from TDG are addressed in NorthWestern's TDG Control Plan which was updated in May 2024 and submitted to FERC separately. This Plan addresses the remaining effects of the Project on fish and aquatic resources under the proposed relicensing action: the effectiveness of upstream fish passage through the Project's fishway and downstream fish passage mortality when fish pass through the Project's turbines and spillways.

3.1 Project Effects on Upstream Fish Passage

The Thompson Falls upstream fishway was constructed during 2009 and 2010 to pass adult Bull Trout and other fish species upstream of the Project. The location and design of the fishway were collaboratively developed based on site specific conditions and fisheries behavior studies (PPL Montana 2008) and agreed upon among the FERC licensee at the time and FWS, FWP, and CSKT. The fishway was designed in general accordance with the National Marine Fisheries Service (NMFS) Anadromous Salmonid Passage Facility Design Manual (NMFS 2008), which was used by FWS to guide the design of upstream passage facilities. FERC approved the final design and construction of the upstream fishway in 2009.

The fishway was constructed with a trap and sorting facility that enables NorthWestern to manually sort all fish that enter the fishway. From initial operation of the fishway in 2011 through 2024, NorthWestern collected nearly 44,000 fish in the fishway trap representing 16 species and three hybrids of different species (NorthWestern 2025).

As described in Section 2.3.2, available information indicates that Bull Trout are rare in reaches of the Clark Fork River both upstream and downstream of the Project. Thus, although the fishway was specifically designed, developed, and operated to enhance upstream passage of Bull Trout, only between zero and five Bull Trout have ascended the Thompson Falls upstream fish passage facility (ladder) annually since its operations commenced in 2011. A total of 23 (21 unique individuals) Bull Trout were collected and passed at the ladder from 2011 to 2024 (NorthWestern 2025). These numbers are consistent with other studies showing very low Bull Trout abundance in the Project area.

The majority (14) of the Bull Trout ascending the ladder were genetically assigned to the Thompson River drainage, followed by Fish Creek drainage (6) and Meadow Creek (1) as their natal stream. A Bull Trout genetically assigned to the Jocko River was detected in the lower pools of the fish passage facility but did not ascend.

Bull Trout have ascended the ladder under various river conditions with Clark Fork River flows ranging from 8,100 to 56,100 cubic feet per second (cfs), and stream temperatures ranging from 43.9°F to 72.1°F. Nevertheless, despite low abundance, the fishway provides upstream Bull Trout passage for motivated individuals making migrations as part of reproduction, foraging, and/or seeking seasonal habitats.

As part of relicensing studies, NorthWestern evaluated the effectiveness of fish passage at the Project using a combination of Computational Fluid Dynamics (CFD) Modeling, radio telemetry studies, and PIT tag studies. Rainbow and Brown Trout were used as surrogate species in the radio telemetry study due to their relative abundance. Although the upstream fishway was designed to be consistent with best practices in effect at the time (NMFS 2008), and has successfully passed a large number of fish, the fish behavior study shows that not all radio-tagged Rainbow and Brown Trout released below the dam approached or passed the fishway (NorthWestern 2023). Collectively, when the results from all three study years are pooled, a total of 100 Rainbow and Brown Trout were captured, implanted with radio tags, and released below the Project. Of the 100 tagged fish, 5 percent (%) (5/100) did not move upstream and approach the Project, 62% (62/100) approached Main Channel Dam and the upstream fishway, 37% (37/100) were detected at the fishway entrance, and 30% (30/100) ascended the fishway and exited into the reservoir.

There are several factors unrelated to the Project’s fishway or other Project operations that contribute to the fish passage effectiveness rate. Examples of non-Project factors include, but are not limited to: (1) periodic high spring flows creating challenging conditions for upstream fish movement; (2) warm summer water temperatures that impede upstream fish movement; (3) tag-related effects, such as trauma from surgery related to implanting radio tags; and (4) the wandering nature of inland trout species, which leads to complex migrations and inconsistent upstream movements.

To address radio tag related effects from the trauma of surgery in 2024 and 2025 NorthWestern implemented a study to use submersible PIT antennas to detect PIT tagged fish in the far and near field areas of the project. Initial results indicate nearly double the rate of Brown and Rainbow Trout are being detected at the fishway entrance and ascending the fishway than compared to telemetry results (see Exhibit E, section 7.1.3.3). Use of submersible PIT arrays will continue to be used for monitoring fish movement to evaluate operational and fish attractant measures in the Project’s upstream fishway.

While non-Project factors such as those identified above may reduce the passage effectiveness rate for trout, opportunities nevertheless exist to enhance fishway effectiveness by implementing and evaluating operational measures to attempt to improve attraction and passage conditions within the fishway.

NorthWestern developed a CFD model to evaluate hydraulic drop and internal flow conditions of the fish passage facility (Appendix A). The initial CFD model scenarios indicate that average velocities through pool-to-pool orifice entrances are appropriate for local fish species' burst speeds; however, there are isolated locations with relatively high velocities through orifice openings. Head differential between pools is generally consistent with design and field measurements allowing approximately 1-ft of head differential between pools. It appears that the lower pools function better in orifice mode at lower tailwaters, but as flows increase, orifice mode may not be the best configuration due to elevated water velocities.

Additional CFD modeling may be used to facilitate the identification of hydraulic conditions in and between pools that have the potential to delay or impede upstream fish movement. In addition, the CFD model will be a valuable tool to evaluate any proposed changes internal to the fish passage facility and how those changes may affect other areas within the facility.

The upstream passage element of this Plan includes an iterative process for evaluating fishway operational measures with the goal of increasing passage effectiveness over time.

3.2 Project Effects on Downstream Fish Passage

The maximum hydraulic capacity of the seven generating units at the Project is approximately 23,000 cfs. When inflow exceeds this capacity, the Project begins spilling flow through the Main Channel Dam spillway. When inflow is less than 23,000 cfs, nearly all flow is routed through the turbines.

When water is spilling over or through the dams at the Thompson Falls Project, fish can migrate downstream via the spillways, outlet works, or through the turbines. During non-spill periods, the primary downstream passage route is through the turbines. Two literature reviews of downstream fish passage survival at the Project estimated that fish survival is 94 percent through the new powerhouse (Kaplan turbine), 85 percent through the original powerhouse (Francis turbines), and 98 percent through the spillway (GEI 2007, NorthWestern 2022). Total project survival for trout larger than 100 millimeters is estimated to likely be 91 to 94 percent through all passage routes combined (GEI 2007, NorthWestern 2022).

Tagging data demonstrate successful downstream passage at the Project. From 2011 to 2018, data collected at the fish passage facility indicated that a minimum of 10 percent of the PIT-tagged fish released upstream of the dam (264 out of 2,644 tagged-fish) returned and ascended the fish passage facility a second, third, fourth, or sixth time (Table 3-1).

Table 3-1: Summary of the multiple ladder ascents by PIT-tagged fish, 2011-2019 (through July 1, 2019) (NorthWestern 2019).

Species	Total Number PIT-Tagged Fish Ascend Ladder and Released Upstream, 2011-2019	Number of Ladder Ascents				
		2x	3x	4x	5x	6x
Bull Trout	15	1	-	-	-	-
Brook Trout	4	-	-	-	-	-
Brown Trout	739	61	10	3	-	1
Rainbow Trout	1,560	157	18	6	-	-
Rainbow X Westslope Cutthrout	46	5	1	-	-	-
Mountain Whitefish	81	4	-	-	-	-
Westslope Cutthrout Trout	223	12	2	-	-	-
Largescale Sucker	125	3	-	-	-	-
Longnose Sucker	1	-	-	-	-	-
Northern Pikeminnow	159	4	1	-	-	-
TOTAL	**2,953**	**247**	**32**	**9**	**-**	**1**

Additionally, about 6.5 percent of the 1,107 Floy-tagged Smallmouth Bass ascended the fish passage facility two or more times; two fish ascended three times; one fish ascended four times; and one fish ascended five times (NorthWestern 2018). In addition, anglers have reported catching tagged fish in waters downstream of the Project that were tagged at the fish ladder and passed upstream, indicating successful downstream passage (NorthWestern 2024).

Although there are no direct estimates of the number of each species that pass downstream through the Project on an annual basis, available information shows that individuals from upstream tributaries closest to Project facilities are the most affected. For example, between 2000 and 2024, 331 adult Bull Trout were captured by Avista at the Clark Fork Project and identified through genetic testing as originating in tributaries upstream of Thompson Falls Dam. Of the 331 fish assigned to tributaries upstream of the Project, 70% (232/331) originated from the Thompson River, which flows into the Project reservoir. The other 99 adult Bull Trout were assigned to locations farther upstream within the basin as shown in Table 3-1.

Table 3-2: Abundance and origination of adult Bull Trout collected by Avista at Cabinet Gorge Dam and transported to locations upstream of the Thompson Falls Project (Source Avista PIT Tag Database, June 4, 2025)

Location	Minimum Distance from Thompson Falls Project (river miles)[a]	Abundance	% of Total
Thompson River	0	232	70%
Jocko River	52.4	38	11%
Middle Clark Fork River Tributaries	52.7	22	7%
Blackfoot River Tributaries	146.6	9	3%
Upper Clark Fork River Tributaries	146.6	30	9%

[a] Value represents the minimum distance (i.e., downstream-most point in the watershed) between the assigned tributary location and the Project boundary.

Additionally, based on genetic assignment of the 21 unique Bull Trout individuals captured at the Thompson Falls fishway since it began operating in 2011, 14 originated from the Thompson River drainage, 6 originated from Fish Creek, and 1 originated from Meadow Creek (NorthWestern 2024 and *see* Table 6-1 of FLA Exhibit E).

Collectively, these data show that Bull Trout that pass through the Thompson Falls Project are genetically assigned to many locations upstream of the project, but the majority originate from the Thompson River.

4. Goals and Objectives

The Plan establishes the goals, program objectives, tasks, and schedule for implementing the fish and aquatic PM&E measures that NorthWestern will implement under the new Project license. Information regarding the estimated costs for implementing the measures is provided in Exhibit E of the November 2025 Updated License Application.

This Plan centers on the PM&E of "target species" affected by the Project, which under this Plan are defined as, in descending order of priority: (1) federally listed Bull Trout, (2) other native fish species, and (3) wild trout (i.e., Rainbow and Brown Trout). The overarching goals of the Plan are to: (1) implement specific PM&E measures for target species; and (2) conduct a monitoring and evaluation program to ensure that the PM&E measures continue to provide benefits to these species over time.

This Plan is divided into two elements: (1) Upstream Fish Passage and (2) Downstream Fish Passage.

Upstream Fish Passage Objective

1) Implement and evaluate operational and fish attractant measures in the Project's upstream fishway to improve upstream passage effectiveness of target species at the Project over time.

Downstream Fish Passage Objectives

1) Mitigate for Project effects on Bull Trout downstream passage survival.

2) Enhance the migratory life history type for this species by implementing a juvenile adfluvial Bull Trout collection and transport program in the Thompson River drainage, which flows directly into the Project reservoir.

Additional detailed information about the tasks and implementation schedule is in Section 5.

5. Fish Passage Management Plan

5.1 Upstream Passage

5.1.1 Background

As described in section 4.1, there is an opportunity to increase passage effectiveness at the Project. But, due to the low numbers of Bull Trout in the Project tailrace, the lack of available information on how Bull Trout currently interact with the fishway, the wandering nature of Bull Trout and other inland fish species, and a lack of numeric passage criteria specific to inland salmonid species (including Bull Trout), it is inappropriate for this Plan to use numeric criteria for determining passage effectiveness of target species at the Project's fishway.

Instead, this Plan adopts an iterative fishway evaluation program to monitor, test, and modify the fishway to incrementally improve passage effectiveness over time. The evaluation program will rely on identifying and testing incremental changes to fishway operations to achieve and maintain sufficiently effective passage of target species at the Project. As shown in detail below, the process for improving passage effectiveness relies on an evaluation program using PIT arrays, and a framework for NorthWestern to consult with FWP, FWS, the U.S. Forest Service (collectively, Agencies) and the CSKT when annually selecting measures, organized within 3 distinctive tiers, for implementation and evaluation.

The Plan divides the measures into tiers based on their implementation timing. NorthWestern will implement and evaluate Tier 1 Measures during the first 10 years following license issuance. Tier 1 Measures include assessing changes to the various auxiliary water flows and/or gate configurations of the fishway. If necessary, NorthWestern will implement Tier 2 Measures from years 11 through 25 following license issuance. Tier 2 Measures include testing the effects of water quality improvement or fish attraction measures on passage effectiveness. Finally, NorthWestern will implement Tier 3 Measures from year 26 through the end of the license term if NorthWestern determines, after consultation with the Agencies and CSKT, that the Tier 1 and Tier 2 Measures do not attain sufficiently effective passage of target species at the Project. Tier 3 Measures include targeted electrofishing and angling in likely fish holding spots in the bypassed reach (e.g., Prospect Creek confluence) to capture Bull Trout and other target species and immediately transport them upstream of the dam.

5.1.2 Upstream Passage Plan and Schedule

5.1.2.1 Tier 1 Measures (Years 1 – 10)

1. Install submersible PIT arrays strategically in logistical and safe locations to obtain finer scale movements of salmonid target species.
2. PIT arrays will likely be located near the fishway entrance and at points along the Zone of Passage downstream of the dam (e.g., near the mouth of Prospect Creek and along the Main Dam spillway apron).
3. Begin sampling target species concurrent with installation of PIT arrays. Fish will be collected in the fishway and via electrofishing downstream. Sampling will include implanting PIT tags in target species and collecting genetic samples of all previously uncaptured Bull Trout to determine origination within the watershed.
4. Test the effects of various auxiliary water flows and/or gate configurations on fish attraction and movement through the fishway using the CFD model and PIT arrays within the fishway; NorthWestern will annually determine, after consultation with the Agencies and CSKT, which operational settings and flows will be implemented and evaluated using the PIT arrays. If there are any disagreements between NorthWestern and the Agencies and CSKT for the operational measures to be evaluated, NorthWestern will prepare a report for FERC approval that includes its proposal and any recommendations from the Agencies and CSKT for the measures to be evaluated. At a minimum, NorthWestern will prepare the report for review and comment by the Agencies and CSKT, allowing at least 30 days to provide comments and recommendations on the draft before filing the final report with FERC for approval. When filing the final report with FERC, NorthWestern will include its reasons, based on Project-specific information, if it does not adopt a recommendation submitted by an Agency or CSKT. Upon FERC approval of the report, NorthWestern will implement its proposed operational measures with any modifications required by FERC.
5. If at any point during the Tier 1 evaluation period, NorthWestern determines, after consultation with the Agencies and CSKT, that any tested measures are sufficiently effective at providing upstream passage of target species, then NorthWestern will prepare a report describing the proposed operational parameters and file it with FERC for approval. In addition, NorthWestern will modify the Fishway Operation and Maintenance Plan (FOMP) and submit to FERC for approval using the procedures identified in Section 6.2 of the FOMP, as necessary and appropriate to incorporate the permanent operational parameters. If at the end of the Tier 1 evaluation period NorthWestern concludes, after consultation with the Agencies and CSKT, that the fishway is not sufficiently effective at passing target species upstream, NorthWestern will begin implementing and testing Tier 2 Measures.

6. If during implementation of the Tier 1 Measures there are any disagreements between NorthWestern and the Agencies and CSKT about whether NorthWestern's permanent proposed operational measures are sufficiently effective at passing target species upstream (item 5), NorthWestern will include in the report for FERC approval its proposal and any recommendations from the Agencies and CSKT for the permanent measures. At a minimum, NorthWestern will prepare the report for review and comment by the Agencies and CSKT, allowing at least 30 days to provide comments and recommendations on the draft before filing the final report with FERC for approval. When filing the final report with FERC, NorthWestern will include its reasons, based on Project-specific information, if it does not adopt a recommendation submitted by an Agency or CSKT. Upon FERC approval of the report, NorthWestern will implement its proposed permanent operational measures with any modifications required by FERC.

5.1.2.2 Tier 2 Measures (Years 11 – 25)

1. Continue to implement items 1-3 of the Tier 1 Measures to facilitate ongoing evaluation of the fishway.
2. Test the effects of water quality improvement measures (e.g., dissolved oxygen enhancement, water temperature cooling) and/or introducing pheromones within the fishway on fish attraction and movement through the fishway using the PIT arrays and ongoing PIT-tagging. NorthWestern will annually determine, after consultation with the Agencies and CSKT, which water quality or fish attractant measures will be implemented and evaluated. If there are any disagreements between NorthWestern and the Agencies and CSKT about which water quality or fish attractant measures will be evaluated each year, NorthWestern will prepare a report for FERC approval that includes its proposal and any recommendations from the Agencies and CSKT for the measures to be evaluated. At a minimum, NorthWestern will prepare the report for review and comment by the Agencies and CSKT, allowing at least 30 days to provide comments and recommendations on the draft before filing the final report with FERC for approval. When filing the final report with FERC, NorthWestern will include its reasons, based on Project-specific information, if it does not adopt a recommendation submitted by an Agency or CSKT. Upon FERC approval of the report, NorthWestern will implement its proposed measures with any modifications required by FERC.

3. If at any point during the Tier 2 evaluation period NorthWestern determines, after consultation with the Agencies and CSKT, that any tested measures are sufficiently effective at passing target species upstream, then NorthWestern will prepare a report with any permanent proposed measures and file it with FERC for approval. In addition, NorthWestern will modify the FOMP and submit it to FERC for approval using the procedures identified in Section 6.2 of the FOMP, as necessary and appropriate to incorporate the permanent measures. If at the end of the Tier 2 evaluation period NorthWestern concludes, after consultation with the Agencies and CSKT, that the fishway is not sufficiently effective at passing target species upstream, NorthWestern will begin implementing Tier 3 Measures.
4. If during implementation of the Tier 2 Measures there are any disagreements between NorthWestern and the Agencies and CSKT about whether NorthWestern's permanent proposed measures are sufficiently effective at passing target species upstream (item 3), NorthWestern will include in the report for FERC approval its proposal and any recommendations from the Agencies and CSKT for the permanent measures. At a minimum, NorthWestern will prepare the report for review and comment by the Agencies and CSKT, allowing at least 30 days to provide comments and recommendations on the draft before filing the final report with FERC for approval. When filing the final report with FERC, NorthWestern will include its reasons, based on Project-specific information, if it does not adopt a recommendation submitted by an Agency or CSKT. Upon FERC approval of the report, NorthWestern will implement its permanent proposed measures with any modifications required by FERC.

5.1.2.3 Tier 3 Measures (Years 26+)

1. Continue to implement items 1-3 of the Tier 1 Measures to facilitate ongoing evaluation of the fishway.
2. Conduct targeted electrofishing and angling in likely fish holding spots in the bypassed reach (e.g., Prospect Creek confluence) to capture Bull Trout and other target species and immediately transport them upstream of the dam. NorthWestern will annually determine, after consultation with the Agencies and CSKT, specific methods and locations for fish collection techniques in the bypassed reach.
3. If during implementation of the Tier 3 Measures there are any disagreements between NorthWestern and the Agencies and CSKT about fish capture methods, locations, or level of effort, NorthWestern will prepare a report, after consultation with Agencies and CSKT, that includes its proposal and any recommendations from the Agencies and CSKT and submit to FERC for approval following no less than 30 day review period. When filing the report with FERC, NorthWestern will include its reasons, based on Project-specific information, if it does not adopt a recommendation submitted by an Agency or CSKT. Upon FERC approval of the report, NorthWestern will implement its proposal with any modifications required by FERC.

5.2 Downstream Passage

5.2.1 Background

Because downstream fish survival rates through the Project are high, abundance of salmonid species in the reservoir is generally low, and there is only one federally-listed threatened fish species in the Project area (Bull Trout), NorthWestern proposes to focus PM&E measures for downstream fish passage on Bull Trout in select tributaries within the Thompson River drainage, which is directly tributary to the Project reservoir. This includes implementing a tributary collection and transport program for juvenile migratory Bull Trout, consistent with other efforts in the Clark Fork River basin, to enhance migratory life history types for this species.

5.2.2 Downstream Passage Plan and Schedule

To mitigate for Project effects on Bull Trout downstream passage survival, and to aid in enhancing the migratory life history types for this species, NorthWestern will implement a juvenile Bull Trout collection and transport program in the Thompson River drainage, which flows into the Project Reservoir. The primary goals of the program are to: (1) safely transport juvenile Bull Trout collected in specific tributaries to the Thompson River to Lake Pend Oreille[4] where they can rear in the lake and return to spawn in tributary habitats as adfluvial adults; and (2) conduct an evaluation program using data collected from PIT-tag arrays installed in the Thompson River, coupled with other available information (e.g., PIT tag detections in the Project's upstream fishway and Avista's sampling data at the Clark Fork Project), to determine the efficacy of the collection and transport program at enhancing the Bull Trout population.

Bull Trout have been detected at numerous locations throughout the Thompson River drainage; however, available information shows that Bull Trout are predominately concentrated in the lower approximately 15.5 miles of the mainstem below the confluence with Fishtrap Creek, as well as in tributaries that flow into this reach (GEI and Steigers 2013). Two Thompson River tributaries in particular, (i.e., West Fork Thompson River and Fishtrap Creek) both generally have suitable water temperatures for Bull Trout year-round and are known spawning locations for this species (GEI and Steigers 2013). Further, despite generally low abundance of Bull Trout with a migratory life history compared to a resident life history, a migratory component nevertheless continues to persist in individuals originating from the West Fork Thompson River and Fishtrap Creek (Glaid 2017, Kreiner and Terrazas 2018).

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[4] A capture and transport program to Lake Pend Oreille avoids non-native predatory fish effects on juvenile Bull Trout in Thompson Falls reservoir, the two downstream Clark Fork Project reservoirs, and potential mortality from juveniles passing over the spillways and through the turbines at all three hydropower developments.

Therefore, to maximize the potential for the successful enhancement of the migratory adfluvial Bull Trout life history type, NorthWestern will focus its juvenile Bull Trout collection and transport program in the West Fork Thompson River and Fishtrap Creek. As described in detail below, during the first 10 years following license issuance, NorthWestern will develop, implement, and assess a collection and transport program using juvenile Bull Trout captured in two Thompson River tributaries (i.e., West Fork Thompson River and Fishtrap Creek). A proportion of captured Bull Trout will be PIT tagged and released downstream in Lake Pend Oreille, and a proportion will be PIT tagged and released on site to aid in evaluating the efficacy of the transport program.[5] Specifically, the program will include the following:

1. Use backpack electrofishing to capture out-migrating juvenile Bull Trout from the West Fork Thompson River and Fishtrap Creek. Based on Avista's efforts to collect juvenile Bull Trout in tributaries to the Cabinet Gorge and Noxon Rapids Reservoirs, collection efforts will occur annually in the fall. Five days of electrofishing effort will occur in each tributary from mid-October to the first part of November. Northwestern will collect genetic samples and implant PIT tags in all sampled Bull Trout to provide information on the location of origination, parentage, and to aid in evaluating the effectiveness of the downstream passage program.
2. Continue to operate and maintain PIT-tag arrays in the Thompson River drainage (i.e., within the lower 0.5-mi of mouth of the Thompson River mainstem, West Fork Thompson River, and Fishtrap Creek). These temporary PIT-tag array systems may be moved as needed within the designated reaches based on flow conditions, shifts in habitat, PIT array effectiveness analysis, or other conditions that warrant their relocation.
3. Transport a portion of collected Bull Trout downstream to Lake Pend Oreille[6] and release a portion of collected Bull Trout on site to allow for evaluation of efficacy of the transport program.

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[5] For example, program success could be determined by comparing detections of adult returns from transported fish to detections of fish released on site in the tributaries (i.e., individuals not transported).

[6] NorthWestern will coordinate with Avista and Montana Fish, Wildlife and Parks to transport fish around the Clark Fork Project and release into Lake Pend Oreille.

4. Use the PIT tag monitoring data to evaluate the success of the Bull Trout adfluvial transport program by comparing the number of adfluvial returns and the number of non-transported fish (i.e., individuals released on site). This could be accomplished using data from the tributary PIT-tag arrays, Bull Trout detected at the Thompson Falls upstream fishway, and Bull Trout detected at Avista's downstream Clark Fork Project. NorthWestern will determine on an annual basis, after consultation with the Agencies and CSKT, the specific proportion of juvenile Bull Trout to be transported versus released on site. If there are any disagreements between NorthWestern and the Agencies and CSKT about the proportion of juvenile Bull Trout to be transported versus released on site, NorthWestern will prepare a report for FERC approval that includes its proposal and any recommendations from the Agencies and CSKT for the proportion of fish to be transported. At a minimum, NorthWestern will prepare the report for review and comment by the Agencies and CSKT, allowing at least 30 days to provide comments and recommendations on the draft before filing the final report with FERC for approval. When filing the final report with FERC, NorthWestern will include its reasons, based on Project-specific information, if it does not adopt a recommendation submitted by an Agency or CSKT. Upon FERC approval of the report, and upon acquiring other federal or state permits that may be required, NorthWestern will implement the program as proposed with any modifications required by FERC.
5. The initial collection and transport program described in items 1 through 4 above will be implemented for the first 10 years following license issuance.
6. If after the initial 10-year evaluation period NorthWestern determines, after consultation with the Agencies and CSKT, that a change in the transport program is warranted based on the monitoring and evaluation program, NorthWestern will prepare a report with its proposed modifications to the program and file it with FERC for approval.
7. NorthWestern will continue to implement the transport program for the remainder of the license term, including any modifications required by FERC. If at any point during the remainder of the license term NorthWestern determines, after consultation with the Agencies and CSKT, that the transport program should be modified (e.g., change in proportion of fish transported downstream versus released on site) based on ongoing monitoring and evaluation, NorthWestern will prepare a report with its proposed modifications and file it with FERC for approval.

8. If there are any disagreements between NorthWestern and the Agencies and CSKT about whether or how to modify the transport program pursuant to items 6 and 7 above, NorthWestern will include in the report for FERC approval, its proposal and any recommendations from the Agencies and CSKT for modifying the transport program. At a minimum, NorthWestern will prepare the report for review and comment by the Agencies and CSKT, allowing at least 30 days to provide comments and recommendations on the draft before filing the final report with FERC for approval. When filing the final report with FERC, NorthWestern will include its reasons, based on Project-specific information, if it does not adopt a recommendation submitted by an Agency or CSKT. Upon FERC approval of the report, NorthWestern will modify the transport program as proposed with any changes required by FERC.

6. Conclusion

Adopting the Plan is essential to ensuring the long-term protection and enhancement of aquatic resources within the Thompson Falls Project area. This plan provides a comprehensive, adaptive framework that addresses both upstream and downstream passage challenges for target species, with particular emphasis on federally-listed Bull Trout. By implementing a tiered approach for upstream passage improvements and a scientifically grounded juvenile collection and transport program for downstream passage, the plan balances ecological needs with operational realities. Its iterative evaluation process, coupled with agency and tribal collaboration, ensures that measures remain effective and responsive to new information over the license term. These actions not only mitigate project-related impacts but also contribute to regional recovery efforts for migratory life history types, supporting broader conservation goals in the Clark Fork River basin. For these reasons, adoption of this plan represents a proactive, responsible, and sustainable path forward for fisheries protection and enhancement at the Thompson Falls Hydroelectric Project.

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Appendix A – Computational Fluid Dynamics Model Thompson Falls Fish Ladder

Technical Memorandum

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To: Andy Welch, NorthWestern Energy

From: Evan Pearce (GEI Consultants, Inc) and Ally Bosworth (GEI Consultants, Inc)

cc: Jon Hanson, NorthWestern Energy

Date: November 21, 2025

Re: Thompson Falls Hydroelectric Project (P-1869)
Fishway Computational Fluid Dynamics (CFD) Hydraulic Analysis

Project No.: 2500476

1. Introduction

The Thompson Falls Hydroelectric Project (Thompson Falls Project or Project) is located on the Clark Fork River in Sanders County, Montana. NorthWestern Energy (NorthWestern), the current Federal Energy Regulatory Commission (FERC) licensee, is engaged in an evaluation of the Thompson Falls Project upstream fish passage facility (fishway or ladder). The evaluation is to determine if improvements can be made to the fishway's operation or configuration to improve fish passage at the Project.

NorthWestern engaged GEI Consultants, Inc. to prepare a Computational Fluid Dynamics (CFD) model of the fishway. The purpose of the CFD evaluation is to identify if there are adverse hydraulics, flow distributions, or ineffective configurations of the plates separating the pools, that could affect fish passage. In conjunction with the CFD evaluation, an ongoing biological study being conducted by NorthWestern will use the CFD results to inform betterments with the goal to increase fish migration up the ladder. Future design and/or operational recommendations are anticipated as part of these efforts.

2. Fishway Configuration Overview

On February 12, 2009, FERC issued an Order Approving Construction and Operation of Fish Passage Facilities for the Project (FERC 2009). This Order included the reasonable and prudent measures, Terms and Conditions (including the construction of a full-height fishway at the right abutment of the Main Channel Dam), and conservation recommendations from the U.S. Fish and Wildlife Service's 2008 Biological Opinion (FWS 2008).

The fishway was constructed on the right side (facing downstream) of the Main Channel Dam, adjacent to the non-overflow gravity dam section. The Main Channel Dam is the furthest upstream impoundment structure of the Project, which also includes two powerhouses, and the Dry Channel Dam. Figure 2-1 shows the general configuration of the Project.

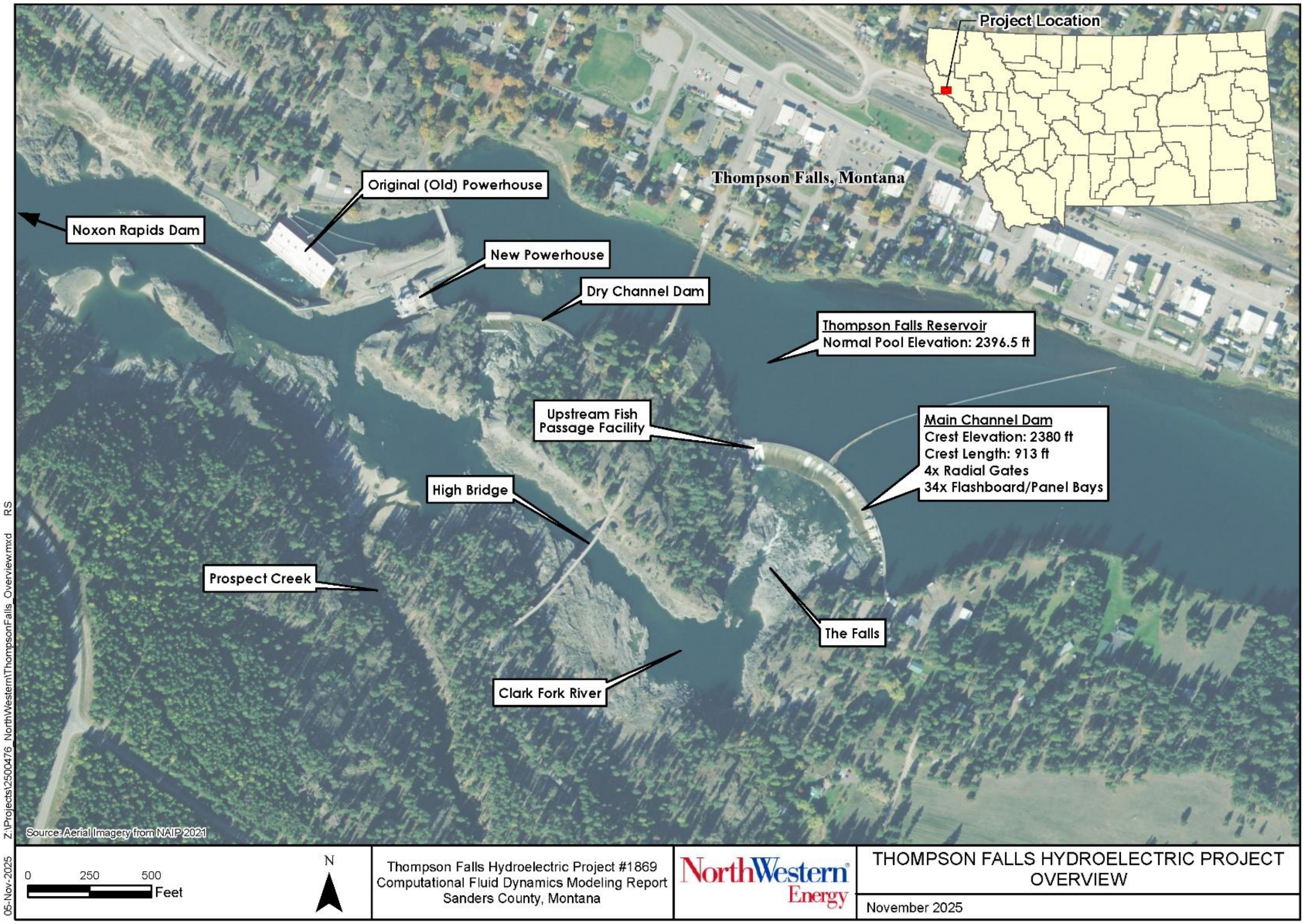

Figure 2-1 Project Site Overview

The reinforced concrete fishway was designed in general accordance with the National Oceanic and Atmospheric Administration Fisheries Criteria (NMFS 2011), used by the U.S. Fish and Wildlife Service in the design of Bull Trout (*Salvelinus confluentus*) upstream passage facilities. Because the ladder was a pioneering structure in Bull Trout passage, it was designed with flexibility to allow operations of the ladder in one of two modes, identified as “orifice” and “weir” modes.

The ladder was constructed with a sloping concrete floor, with 48 individual pools created by internal weir plates constructed across the concrete “U” section. Hydraulically, the ladder was designed to induce a 1-foot drop in the hydraulic grade line for each of the 48 pools to allow passage of a diverse population of fish over the Thompson Falls Main Channel Dam. Each pool is separated by an aluminum weir plate with a sliding weir gate leaf. The sliding weir gate leaf can be adjusted to cover a square orifice (1 foot tall by 1 foot, 2-inches wide) at the bottom center for “orifice mode” of the plate, or a 2-foot-wide weir notch cut into the top of the plate for “weir mode”, see Figure 2-2 below. Raising the central sliding weir gate allows pool-to-pool flow through the bottom orifice (*orifice mode*). Lowering the weir gate allows pool-to-pool flow to occur through the top weir (*weir mode*). upper Pools, 46, 47, and 48 operate solely in orifice mode to reduce the effects of the forebay water level on the ladder hydraulics.

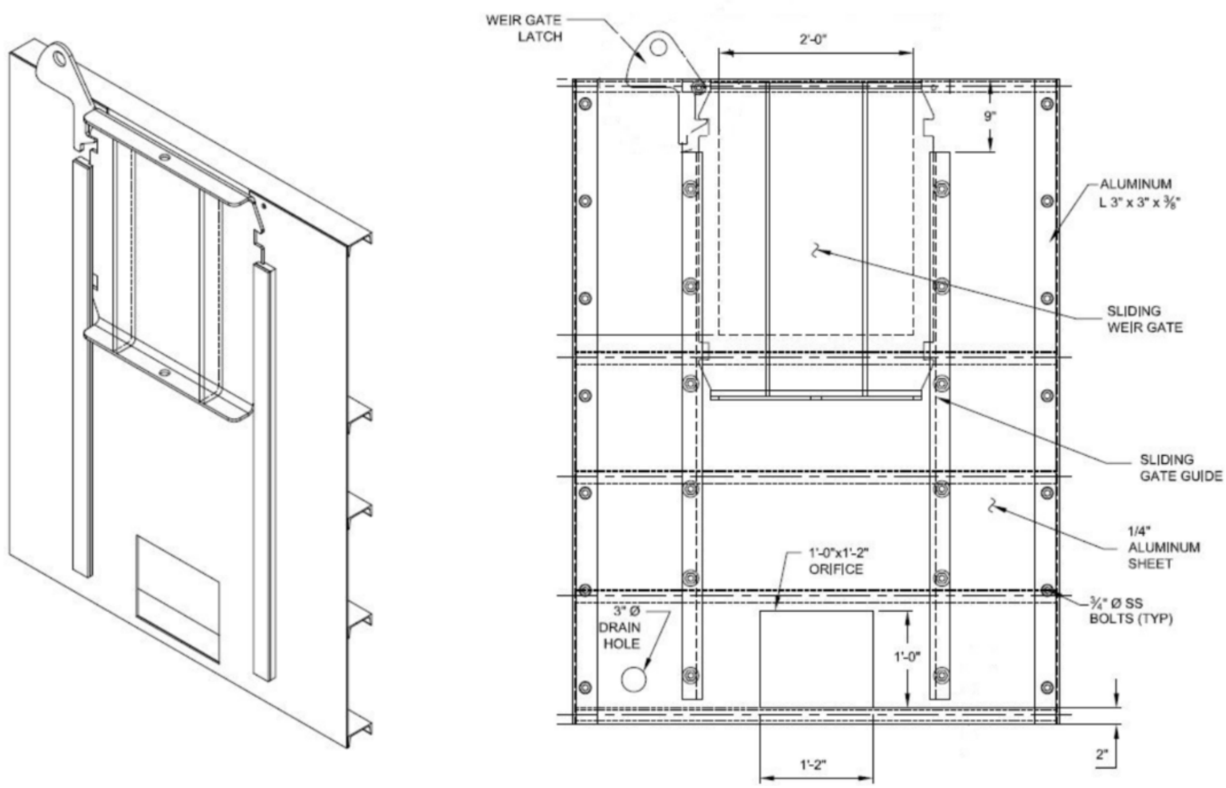

Figure 2-2. Aluminum Weir Plates - Isometric and Front Views

The fishway layout at the Thompson Falls Project is constrained due to the configuration of the existing log sluice and non-spill dam section as well as the rock abutment on the right side of the dam. In order to lay out a series of 48 pools within this geometry, a number of switchbacks and turning pools were required. By design, the fishway has four distinct areas, as follows and shown in Figure 2-3:

1. Ladder Entrance – Pool 1
2. Lower Ladder – Pools 2 thru 7
3. Middle Ladder – Pools 8-44

4. Exit Control Section – Pools 45-48

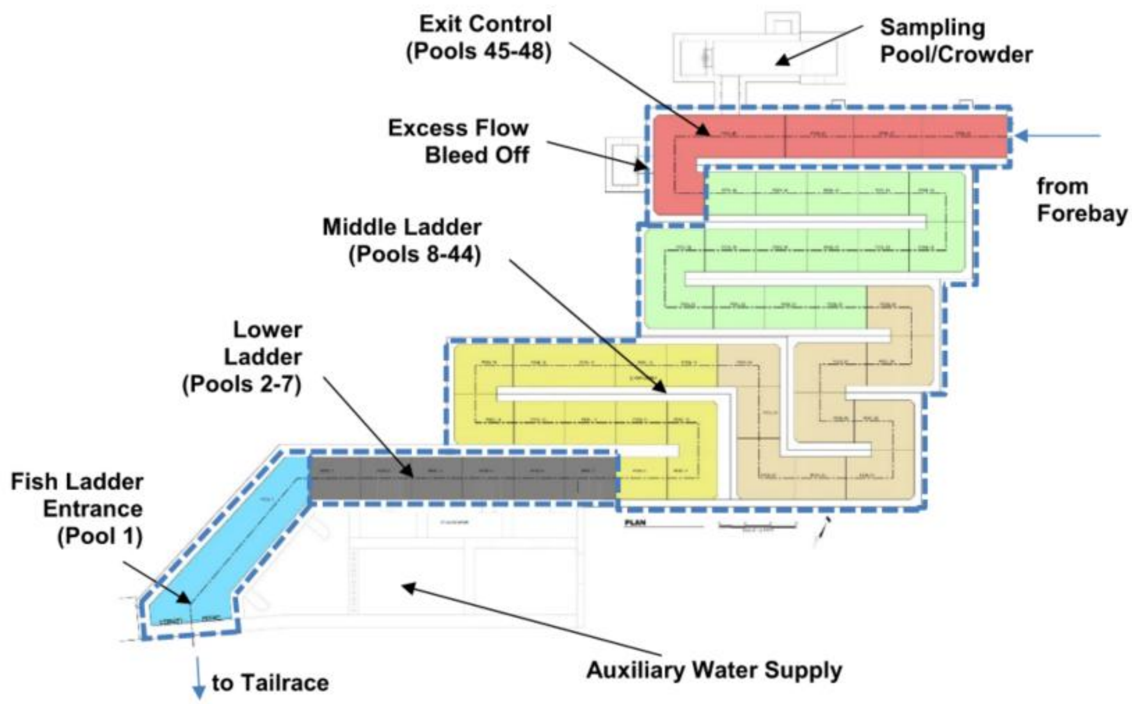

Figure 2-3. Thompson Falls Fishway Configuration

The fishway entrance into Pool 1 consists of two gated rectangular openings: one is a 24-inch-wide by 36-inch-high set at invert El. 2,346 designed to be fully submerged during low-tailwater non-spill periods; the other is a 30-inch wide by 48-inch high set at invert El. 2,349, designed to operate during spill when the tailwater elevation comes up, Figure 2-4 and Figure 2-5. An adjacent high velocity jet discharges into the tailrace and provides additional attraction flow. This entrance configuration enables fish to readily find the ladder pool-to-pool flow during both spill and non-spill periods up to the maximum design tailwater El. 2,359.

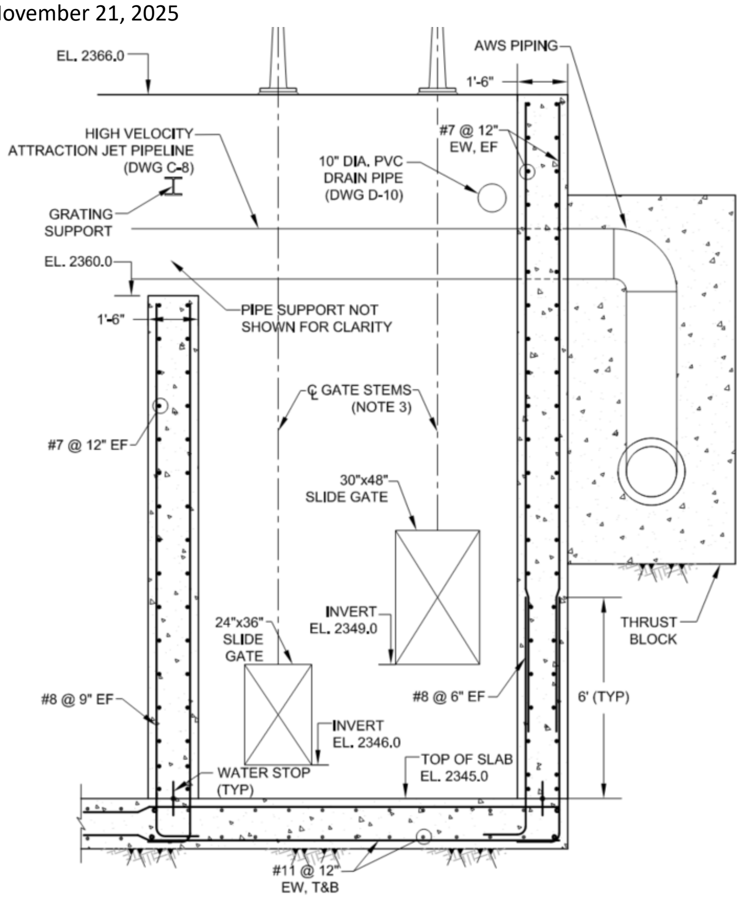

Figure 2-4. Ladder Entrance Configuration

Figure 2-5. Ladder Entrance – View from downstream, showing High Velocity Jet in use

3. Operation Assumptions

The aluminum weir plates, whether in orifice or weir mode, are sized to convey 6 cfs down the fishway while maintaining a 1-foot (ft) head differential between pools. Flow is introduced into the Exit Control Section of the fishway from the forebay. The forebay elevation ranges from El. 2,395.5 to 2,397.0 and as the elevation increases during a flood event, the flow can increase up to 7 cfs in the Exit Control Section. Excessive flow is bled off at Pool 45 to maintain the desired 6 cfs in the lower pools. For the purposes of this CFD modeling analysis, 6 cfs inflow into the Exit Control Section was maintained for all simulations. Historically, the fishway has been operated in weir mode in Pools 2 through 7 (lower pools) and orifice mode in the remaining pools.

The fishway is designed to operate and collect fish within a tailwater range between El. 2,348 to 2,359. The upper limit is associated with a spill discharge of approximately 25,000 cfs at the Main Channel Dam (MDS), which equates to a project discharge of 48,000 cfs at full powerhouse capacity. Since operations began the fishway has been operated beyond the designed upper limit of spill of 25,000 cfs to approximately 37,000 cfs spill. During non-spill conditions, additional auxiliary water supply (AWS) of 20 cfs is introduced into Pool 1 through a wall diffuser to provide additional attraction flow into the tailrace. The diffuser disperses the flow to not exceed a maximum uniform velocity of 1 foot per second (fps). As the tailwater elevation increases, the AWS increases to maintain attraction flow as well as the 1-ft head differential between Pool 1 and the tailwater elevation, up to a maximum of 54 cfs. Once the Pool 1 water surface elevation exceeds El. 2,353 and the spill entrance opening is in orifice flow, 60 cfs total is needed to maintain the desired head differential.

We assumed the AWS flow is dispersed through floor diffusers in Pools 3, 5 and 7 as their respective weir plates are submerged during spill events. Table 3-1 shows our assumed ladder flows, and locations in relation to tailwater elevation boundary conditions used in the model.

Table 3-1. Assumed ladder flows and tailwater elevation in CFD modeling

TW El.	Assumed Pool 1 El	Base Flow	AWS 1	AWS 3	AWS 5	AWS 7	Total
ft	ft	cfs	cfs	cfs	cfs	cfs	cfs
2348	2349	6.0	20.0	---	---	---	**26.0**
2349	2350	6.0	26.0	---	---	---	**32.0**
2350	2351	6.0	35.5	---	---	---	**41.5**
2351	2352	6.0	45.0	---	---	---	**51.0**
2352	2353	6.0	54.0	---	---	---	**60.0**
2353	2354	6.0	54.0	---	---	---	**60.0**
2354	2355	6.0	49.0	5.0	---	---	**60.0**
2355	2356	6.0	49.0	5.0	---	---	**60.0**
2356	2357	6.0	44.0	5.0	5.0	---	**60.0**
2357	2358	6.0	44.0	5.0	5.0	---	**60.0**
2358	2359	6.0	39.0	5.0	5.0	5.0	**60.0**
2359	2360	6.0	39.0	5.0	5.0	5.0	**60.0**

As shown in Figure 3-1, the AWS flow is introduced in the model as a point source in AWS 1, AWS 3, AWS 5 or AWS 7 either through the wall or floor diffuser as indicated in Table 3-1.

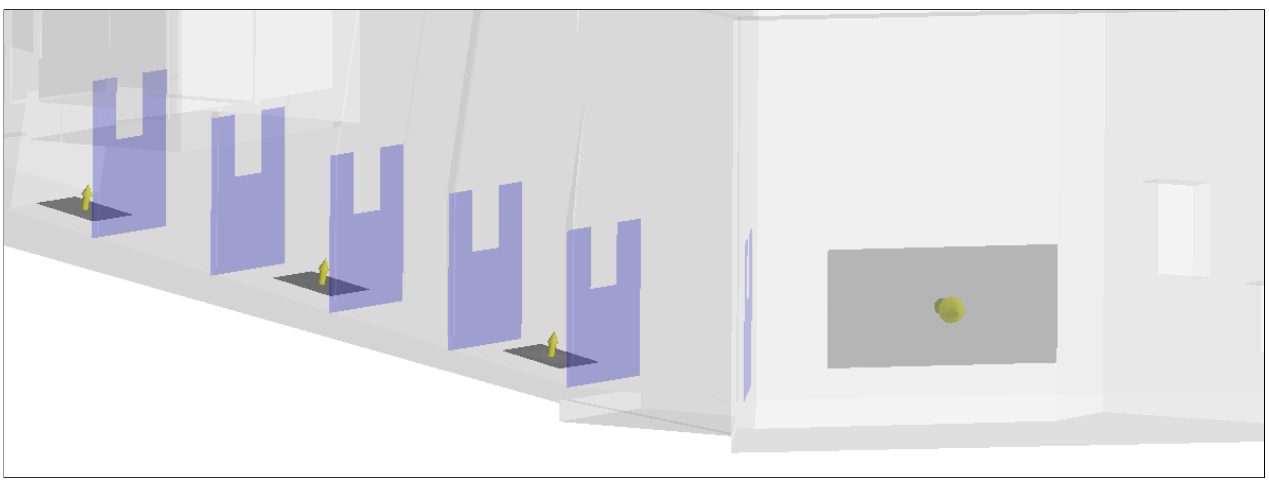

Figure 3-1 AWS Diffuser locations in CFD Model

4. Fishway Computational Fluid Dynamics Model Development

CFD simulations were performed using FLOW-3D HYDRO software (version 2023R2). The FLOW-3D model is a robust CFD program capable of modeling a wide variety of hydraulics problems. FLOW-3D solves the Reynolds-Averaged Navier-Stokes (RANS) equations using a finite volume method and the flow surface is determined using a volume of fluid (VOF) method. A single CFD model was developed for the entire Fishway structure. The model solely encompassed the ladder, but included a small portion of the tailrace. The CFD model used a mesh cell spacing of 0.5-ft for the overall model domain, but utilized a block conforming mesh resolution of 0.25-ft around the ladder geometry. The aluminum weir plates were modeled as baffles. Flow3D defines baffles as two-dimensional objects that are used to represent thin pieces of geometry. The preprocessor aligns them to the nearest cell faces and block flow of the fluid. Numerous domain removing blocks were added to the model setup to minimize the extents of the model mesh without impacting the flow results.

A vast number of modeling parameter options are available within the FLOW-3D software for users to adjust to better fit the modeling needs and scenarios. While developing the model for the fishway structure, parameters were selected to best suit the assumed constant flow through the stepped structure and varying turbulent conditions from pool to pool based on the weir plate configuration. To model the turbulent flow, the Renormalized Group (RNG) turbulence model was used. The RNG model is similar to a k-ε model with the modification that a number of numerical constants are derived explicitly. Additionally, the RNG model uses a dynamically computed mixing length. This turbulence model is generally recommended for turbulent flows because it is able to accurately model flows that have strong shear regions (Flow Science 2021). Flow is introduced upstream of Pool 45 at a static El. 2393.6 (0.6 feet above design), based on NorthWestern biologist observation of improved hydraulic conditions during operation in the orifice mode in Pools 7–45. At the downstream end of the model, a pressure boundary was used to force water to maintain a tailwater elevation in the model and also allow flow to freely exit from the model domain. To model the forces and energy losses along solid objects, the immersed boundary method (IBM) option was selected (Flow Science 2021). The IBM option simulates "ghost cells" within the solid boundary layer to resolve numerical errors that occur at the boundary layer in fractional area cells.

The ladder structure used within the CFD model was generated through a combination of geometric objects called watertight meshes (solids) developed based on the design plans of the ladder using Autodesk Civil 3D (C3D). The baffles representing the aluminum weir plates were also developed in C3D. Each plate included an orifice and weir mode configuration to facilitate adjustments to the ladder configuration within the model based on hydraulic and biological observations. The developed geometries were subsequently used to create the mesh-generated FAVOR[1] geometry in the CFD model. Figure 4-1 shows a comparison of the object geometry and the CFD model geometry.

[1] FAVOR means "Fractional Area Volume Obstacle Representation." The FAVOR method is used by FLOW-3D to represent geometry by smoothly blocking out fractional portions of the grid cells filled with the solid geometry.

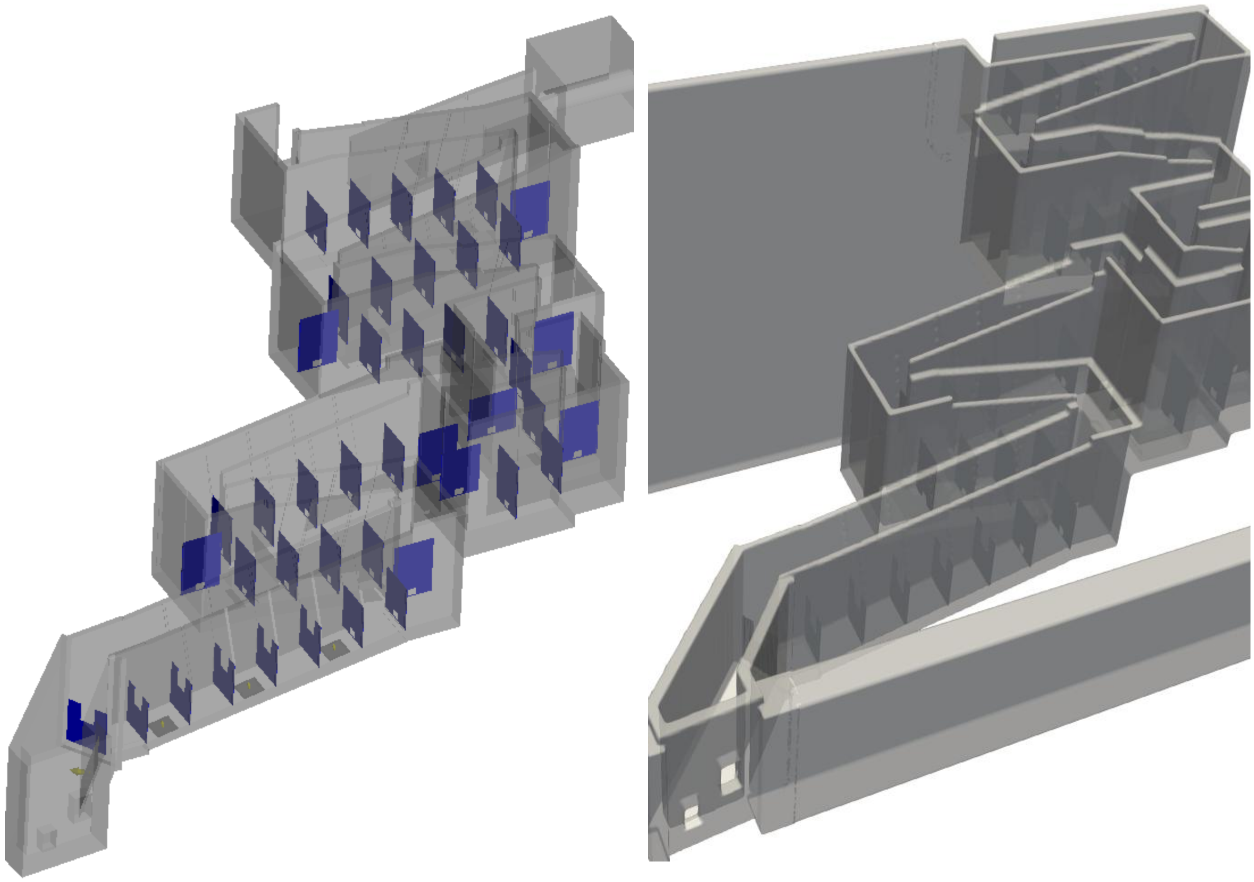

Figure 4-1 Solid vs FAVOR Geometry in FLOW-3D model

In numerical modeling, the selected timestep can have an impact on model accuracy as well as calculation runtimes. The computational timestep within the FLOW-3D model is dynamically computed during the model simulation and cannot be manually controlled by the user. In general, the timestep is adjusted by the solver to produce a stable model result and to meet convergence criteria, generally pressure residuals, at each mesh cell within the model domain. While the timestep is able to be reduced as small as 1×10^{-7} seconds, the Thompson Falls Project fishway model generally utilized a timestep of approximately 5×10^{-3} seconds, which provided a stable model result and allowed for convergence criteria to be met. During the simulation runtime, a number of solver diagnostic variables can be monitored to assess and confirm model stability. The model scenarios generally used a simulation duration of approximately 20 seconds. This simulation duration allowed for flows to reach steady-state conditions throughout the model domain. Initial condition fluid regions were used to decrease simulation times by having fluid introduced to all components of the ladder as shown in Figure 4-2.

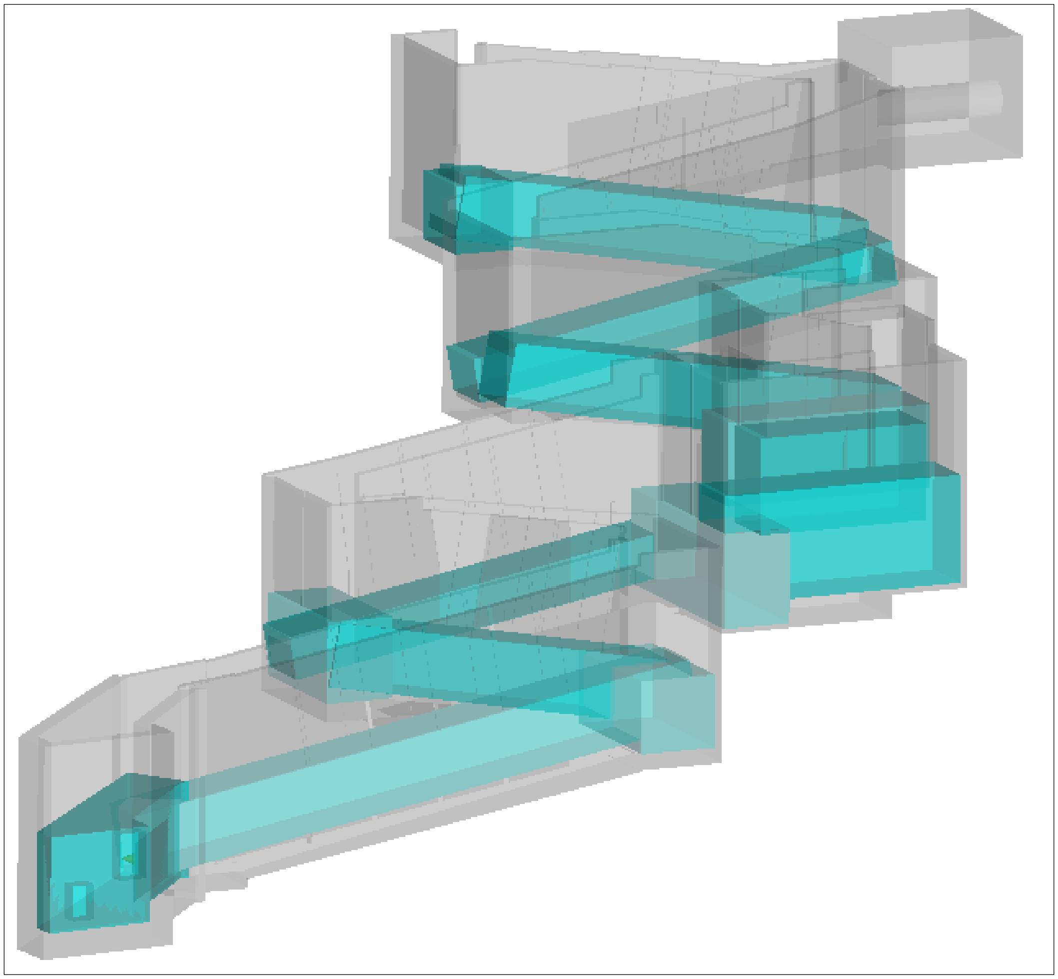

Figure 4-2. Initial Condition Fluid Regions

The FLOW-3D model allows the user to assign surface roughness values to the various geometry components within the domain. These values are designated based on absolute roughness values, also referred to as Nikuradse roughness. These values can be estimated from the more typical Manning's n-values through the Manning-Strickler equation (Ref. Chow, Ven Te, 1959). For the Thompson Falls fishway model, absolute roughness values of $0.5\text{x}10^{-3}$ was used for the concrete surfaces. This value corresponds to Manning's n-values of 0.011 which are considered to be appropriate for the concrete surfaces. It is important to note that these roughness values are primarily used within the FLOW-3D model to account for skin friction. Other losses due to momentum and impacts associated with downstream weir plates and turns in the structure are accounted for in the numerical solver directly.

Different combinations of weir plate configurations, tailwater elevations and flow distributions were modeled to produce a range of operational and hydraulic conditions experienced throughout the ladder. These scenarios are based on our understanding of the ladder operational constraints as outlined in Section 3, as well as initial changes to the historically operated configuration, agreed upon with the design team. The goal of modeling the legacy configuration is to match model observations with previously gathered fish tracking data.

The details for each scenario are provided in Table 4-1. Scenarios 1, 3, and 5 are in the "legacy configuration" with the lower pools operating in weir mode, and the rest of the ladder in orifice mode.

Scenarios 2, 4, and 6 are in all orifice mode configuration, but under different tailwater conditions. Note an AWS flow of 40 cfs was used at lower tailwater elevations to increase model stability rather than 20 cfs to 35.5 cfs as shown in Table 4-1. Since this extra flow is introduced in Pool 1, it will have limited impacts on the hydraulic results for the upstream pools. These values were selected with NorthWestern's input.

Table 4-1. CFD Model Scenarios

SCENARIO #	TAILWATER EL.	MAIN LADDER FLOW	AWS FLOW	WEIR PLATE CONFIGURATIONS - BAFFLE POSITION
1	2348	6 cfs	Pool 1: 40 cfs Pools 3/5/7: 0 cfs	1-7: Weir 8-45: Orifice
2	2348	6 cfs	Pool 1: 40 cfs Pools 3/5/7: 0 cfs	All Orifice
3	2350	6 cfs	Pool 1: 40 cfs Pools 3/5/7: 0 cfs	1-7: Weir 8-45: Orifice
4	2350	6 cfs	Pool 1: 40 cfs Pools 3/5/7: 0 cfs	All Orifice
5	2354	6 cfs	Pool 1: 49 cfs Pool 3: 5 cfs Pools 5/7: 0 cfs	1-7: Weir 8-45: Orifice
6	2354	6 cfs	Pool 1: 49 cfs Pool 3: 5 cfs Pools 5/7: 0 cfs	All Orifice

The key output goal of the CFD model is to identify problem areas in the ladder or baffle configurations leading to stalled fish passage up the ladder. Paired with monitoring data of fish migration up the ladder being collected under a separate study being conducted by NorthWestern, the CFD model will be modified to analyze potential operational configurations to improve fish passage by reducing turbulence within the ladder and ensuring velocities are appropriate for the target species. Biological monitoring includes passive integrated transponder (PIT) tag antenna arrays at various locations through the fishway, a manual fish handling station at the top of the ladder, and PIT tag arrays below the dam to determine spatial movement habits prior to entering the ladder.

5. Initial Results and Observations

General observations focus on the velocity fields and vorticity within the ladder. Velocity magnitude is a key component of fish passage where the proper range will provide attraction flow, guiding fish up the ladder. However, excessive velocity presents a physical barrier for the fish. Vorticity is the local spinning motion of a fluid, defined as the curl of its velocity field. Fish can use beneficial vortices to reduce energy expenditure and improve maneuverability, but strong or misplaced vortices can act as physical barriers, disrupt balance, and increase resistance. Streamlines have been included in some of the figures to help visualize the vorticity and velocity simultaneously. The colors in the modeling are indicative of a scale of the aspect being modeled, with the range of values indicated in the legend. In general, blue and green are indicative of values within a reasonable range for fish to successfully pass. Yellow and orange indicate values that are getting high but are still within a reasonable range, and red indicates the area is of concern for that value (velocity or vorticity).

The initial CFD model scenarios indicate isolated locations with relatively high velocities through orifice openings at entrances to U-turn pool configurations, with the maximum velocity of approximately 12 fps estimated at Pool 14 as shown in Figure 5-1. Average velocities through pool-to-pool orifice entrances are appropriate for local fish species burst speeds, with the velocities generally remaining lower than 8 fps. Head differential between pools is generally consistent with design and field measurements allowing approximately 1-ft of head differential between pools as shown in the profile views in the Figures Section and in Figure 5-2.

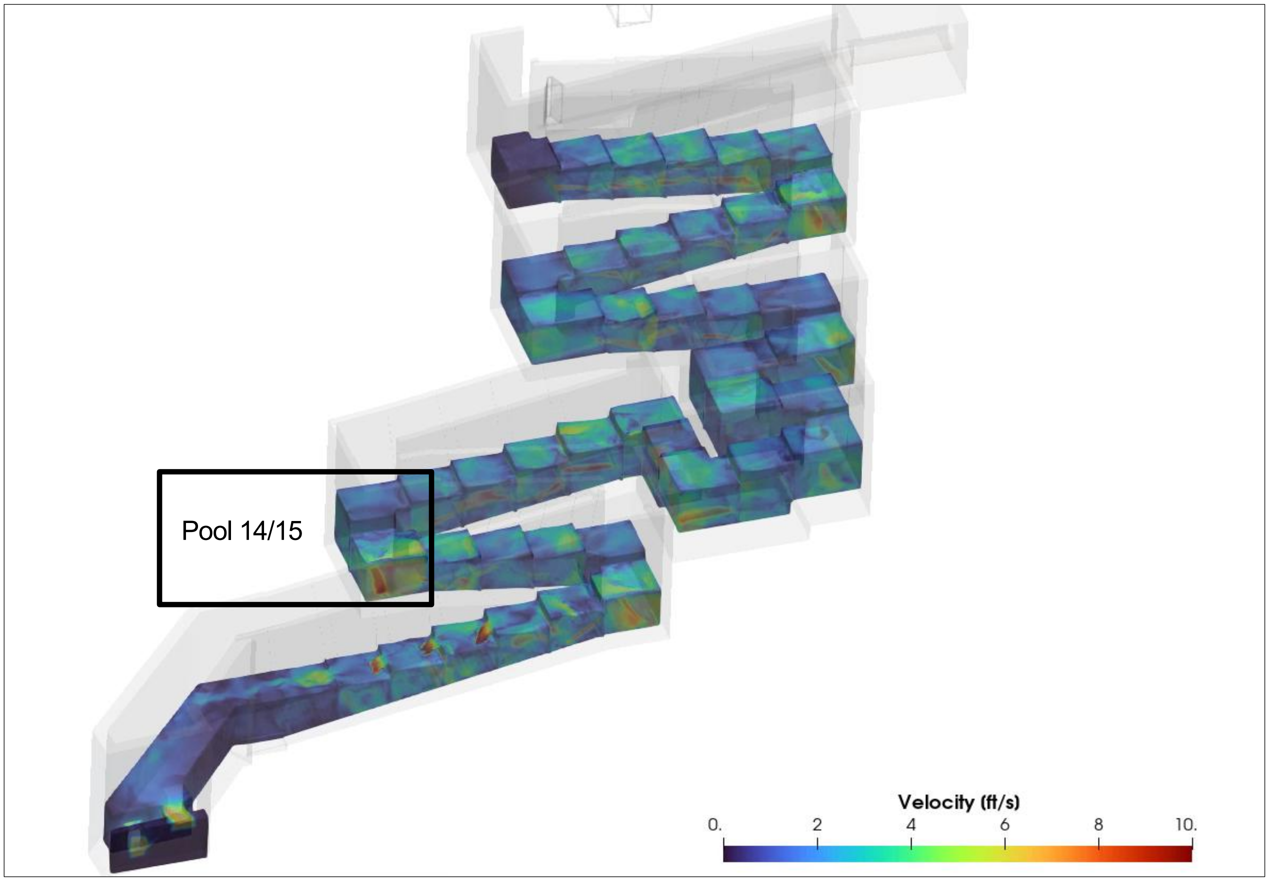

Figure 5-1. Isometric view of the entire ladder in the legacy conformation (lower pools in weir mode, the rest of the ladder in orifice mode). The turning area in pools 14/15 are highlighted to demonstrate the area of higher velocity at the in the 'U' configuration.

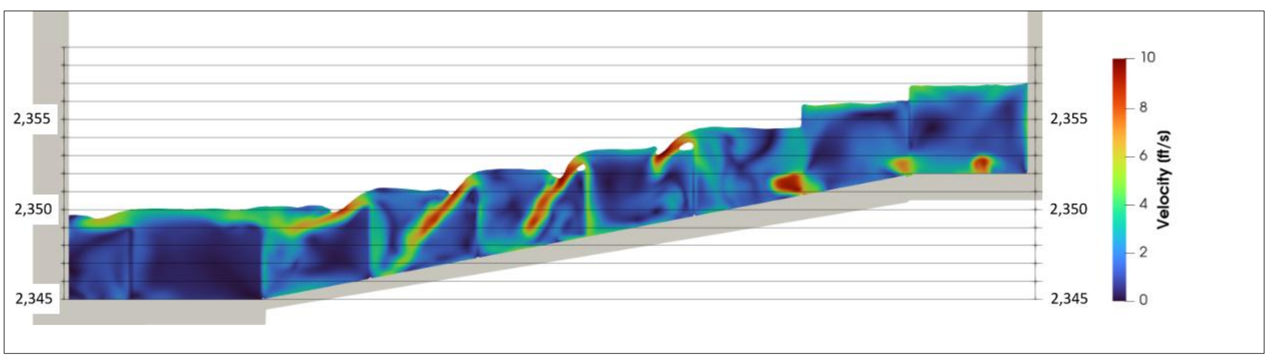

Figure 5-2. Lower pools CFD head differential, each gridline equals one foot of elevation

The analysis also considered turbulence within the ladder pools to determine if there was reasonable streaming flow to indicate to fish the path upstream. If flows become too turbulent, fish can have a difficult time determining where the next jump is, and may not be able to pass. NMFS fish passage criteria recommends that the ladder pools create streaming flow instead of plunging flow, as the plunging flows induce jumping and may cause injuries (NMFS 2011).

Scenario 1 – Low Tailwater (2348 feet elevation), Weir Mode

As discussed above, the ladder has historically been run with the lower pools (pools 2-7) almost always in weir mode due to engineer and biologist recommendations from salmonid fish passage criteria (NMFS 2008). The CFD runs of the lower ladder pools indicated chaotic vorticity patterns in the pools where the AWS diffuser systems are present and mixed with the weir spill in pools (Figure 5-3). The plunging flow combined with the AWS flow did not provide a smooth streaming flow (see Figure 5-4) that is recommended in ladder pools in NMFS 2023 passage criteria. The plunging flow over these weirs seems to go straight to the bottom of the pool and into the wall of the next weir in some of the pools.

Based on visual flow observations it was hypothesized by GEI and NorthWestern biologists that this flow pattern in the entrance of the ladder may deter fish from continuing up the ladder. Recent data confirm that Bull Trout may prefer deeper benthic passage methods (unlike other salmonid species) (USFWS 2025). This hypothesis can be further explored when additional biological monitoring and PIT tag data becomes available.

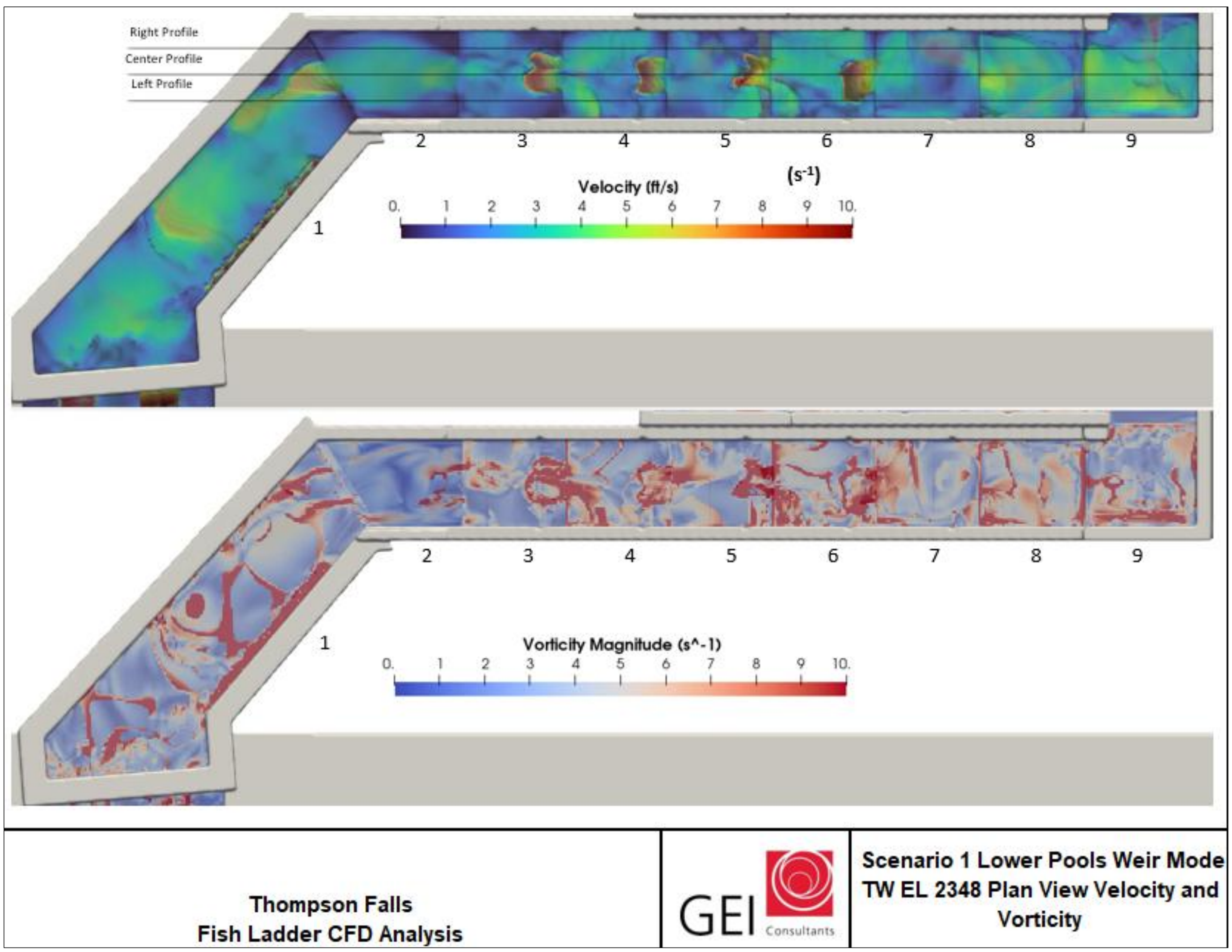

Figure 5-3. Scenario 1- Velocity and vorticity models of the lower pools in weir mode

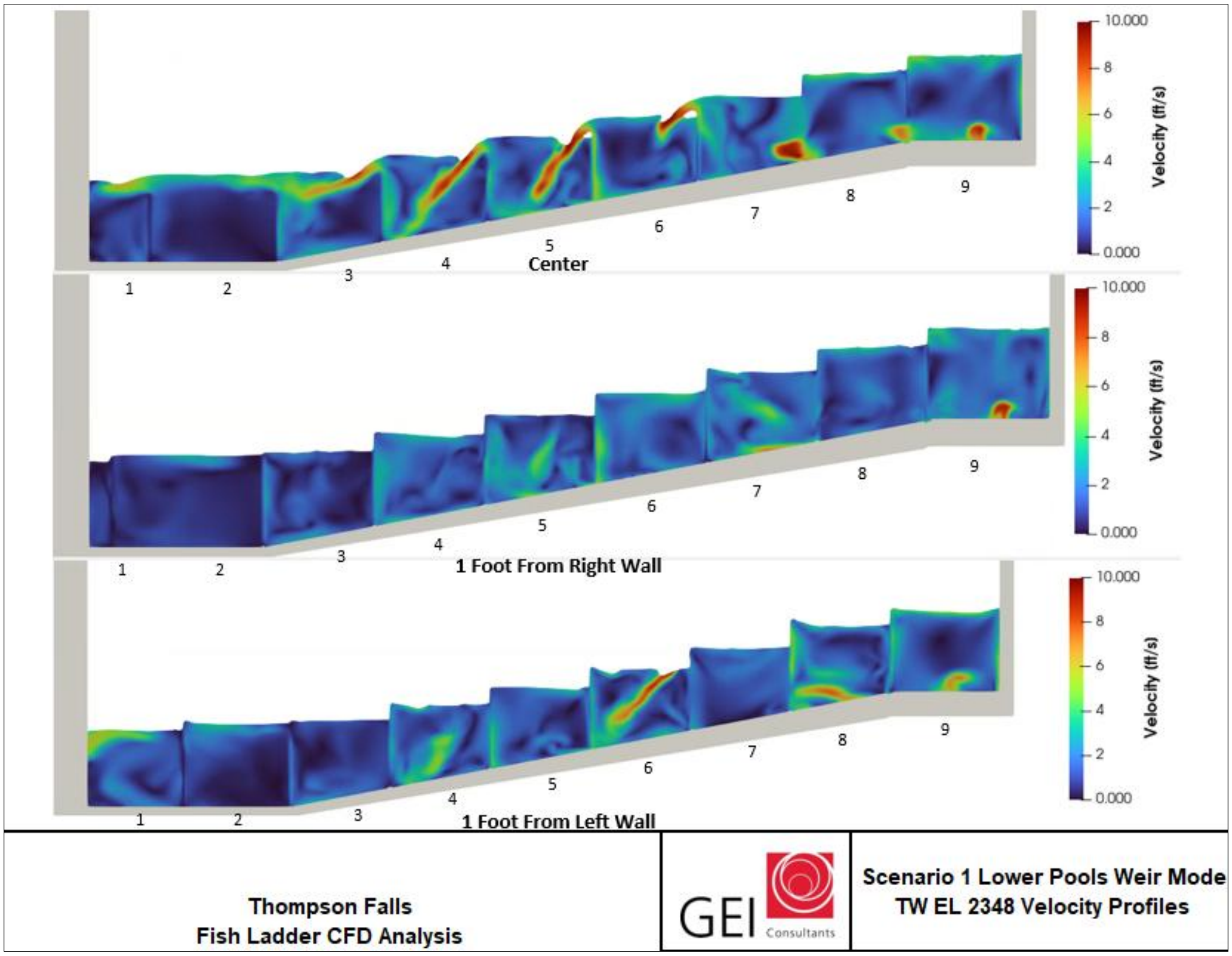

Figure 5-4. Scenario 1- Side profile of the velocities in the lower ladder pools (Center, Right, Left)

The overall velocities modeled within the ladder were within expected ranges for successful passage of the target fish species. The velocities while operating in weir mode did have a higher peak in the lower pools near the entrance, with some areas at 7-9 fps. While these velocities may be within the species swimming range, it does get into the higher levels of energy use and may exhaust the fish quickly and deter them from continuing up the ladder.

Figure 5-4 shows a clear stream of flow that continues across the tops of the ladder pools 1 through 3, but flow starts to dive lower in pool 4. The plunging flows in pools 4 -6 likely create a confusing hydraulic scenario which may discourage fish from continuing into the ladder. This scenario does not appear to create a continuous streaming flow from pool to pool that is ideal to encourage fish passage.

Scenario 2 – Low Tailwater (2348 feet elevation), Orifice Mode

The lower pools (Pools 2-7) were modeled in orifice mode with tailwater El. 2348 feet with the AWS in pool 1 set at 40 cfs. The results in this run showed a significantly less chaotic overall vorticity and velocity profile than Scenario 1 (Figure 5-5). When the lower pools are in orifice mode there is a more smooth, streaming flow through the orifices that likely present a clear attraction flow into the entrance pool for fish. This flow scenario eliminated the plunging flows in the lower ladder, and created a more ideal streaming flow scenario down to the entrance of the ladder. The velocities throughout the lower pools were fairly consistent between pools within the stream of flow, but the velocities on the edges of the pools were significantly reduced, allowing for calmer resting areas within each pool (Figure 5-6).

The main difference within the orifice mode model run was the turbulence within the lower pools, shown as vorticity in Figure 5-5. The comparison of the overall turbulent energy when switching from weir mode to orifice mode indicates a much less chaotic flow pattern within the lower pools, allowing for clearer streaming flow and likely a clearer passage indicator for fish to move upstream.

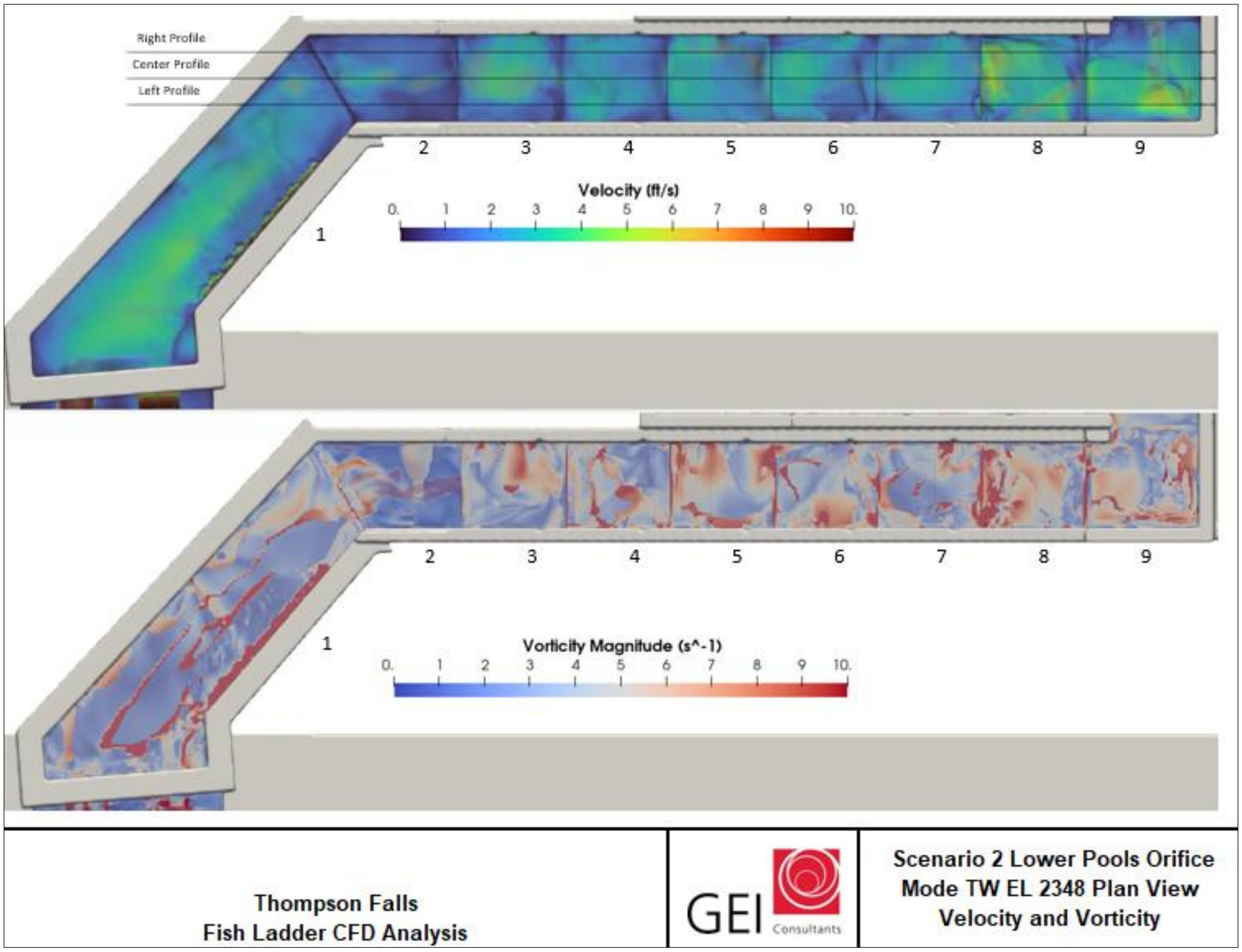

Figure 5-5. Scenario 2- Velocity and Vorticity in the Lower Pools operating in orifice mode

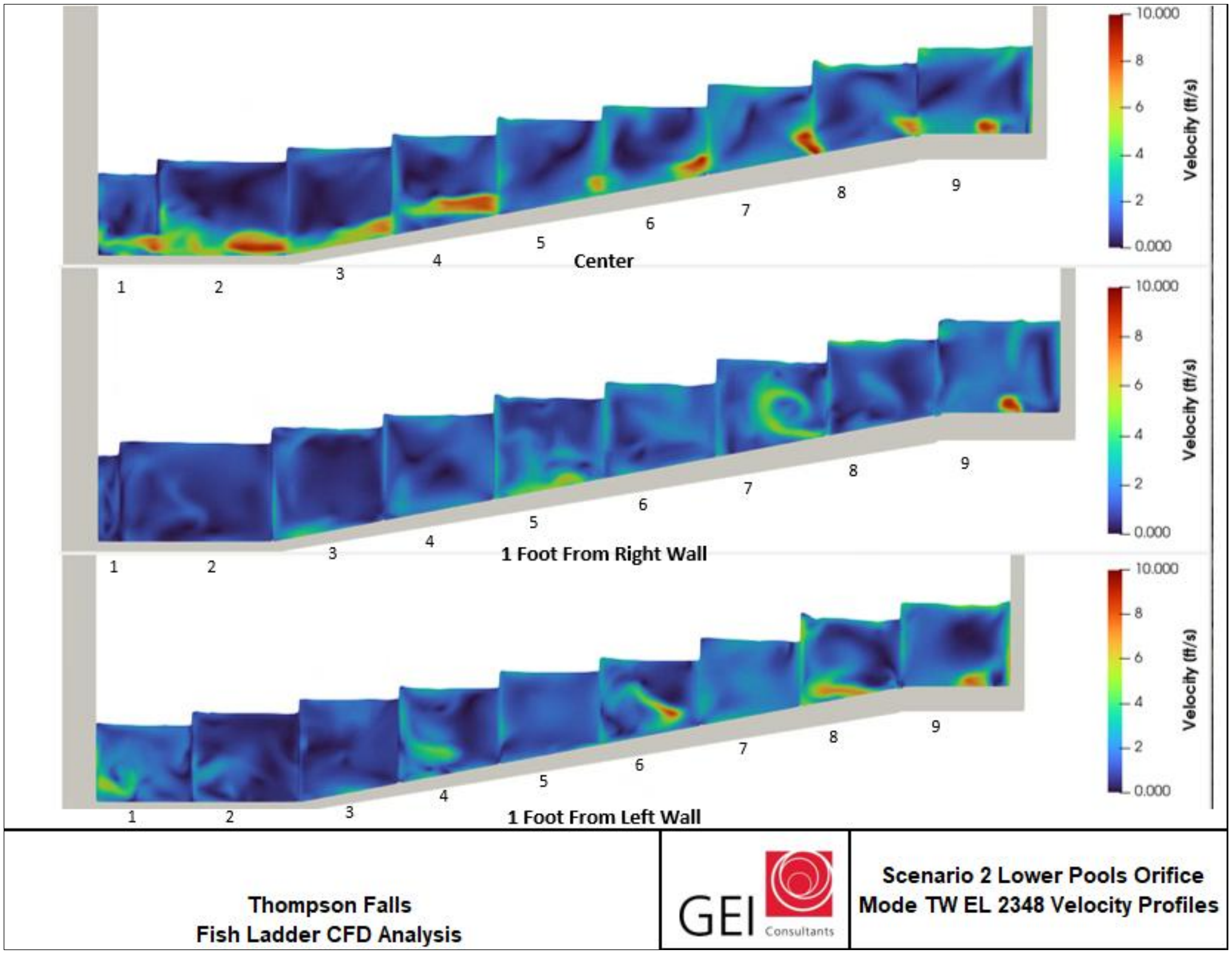

Figure 5-6. Scenario 2- Side profile of the velocities in the lower ladder pools (Center, Right, Left)

The CFD model comparisons of weir and orifice mode for low tailwater indicate an overall improvement in the streaming flow from pool to pool while in orifice mode. This likely creates an overall better passage scenario for fish moving through the ladder, as they have a more distinct attraction flow. The combination of the increase in streaming flow, and the reduction of overall turbulence within the pools indicates that fish passage may be increased by operating the lower pools in orifice mode at lower tailwaters.

Scenario 3 – Rising Tailwater (2350 feet elevation), Weir Mode

Scenario 3 has the same configuration as Scenario 1, but with a higher tailwater. All the upper pools of the ladder are set in orifice mode, with pools 1-7 in weir mode.

Overall, the velocity and vorticity look similar to that of Scenario 1, but there is a reduction in both velocity and vorticity in the entrance of the ladder with the elevated tailwater overflowing the pools (Figure 5-7).

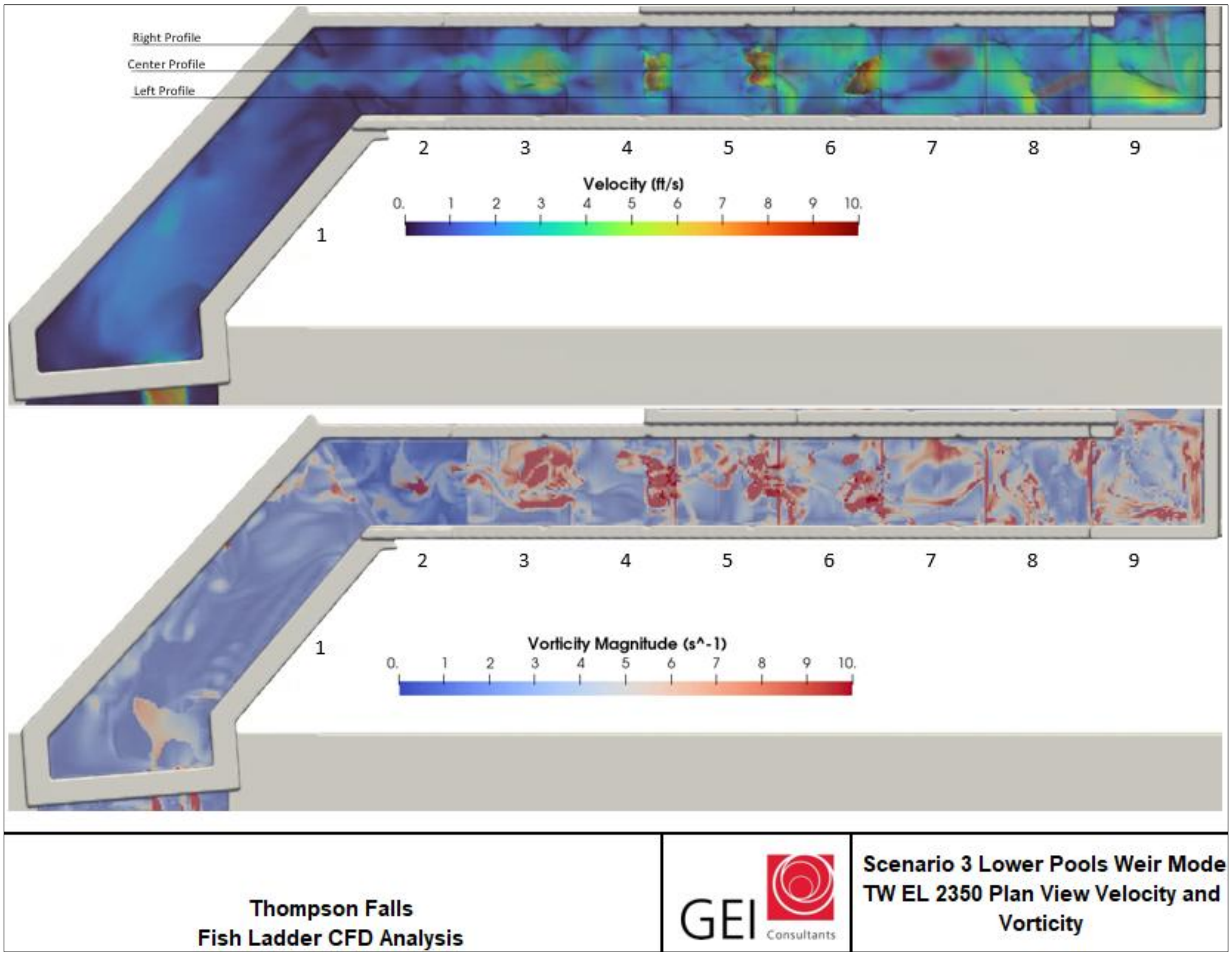

Figure 5-7. Scenario 3- Velocity and vorticity in the lower pools of the ladder in weir mode

Figure 5-8 shows significant differences from Scenario 1 in the lower pools. The streaming flow is only present from pool 3 to 4, with flow plunging to the bottom of pools 4-6. Similar to scenario 1, this will likely create a scenario where fish are attracted to the bottom, and then struggle to find the next approach point, which is common with a plunging flow scenario (NMFS 2008). The turbulence created in the entrance to the ladder likely creates a confusing approach area, causing fish to miss the cues for the next pools and fail to pass through. The hypothesis that the input from the AWS system combined with the weir spill from pool to pool may cause too much turbulence also seems accurate for the higher tailwater scenario.

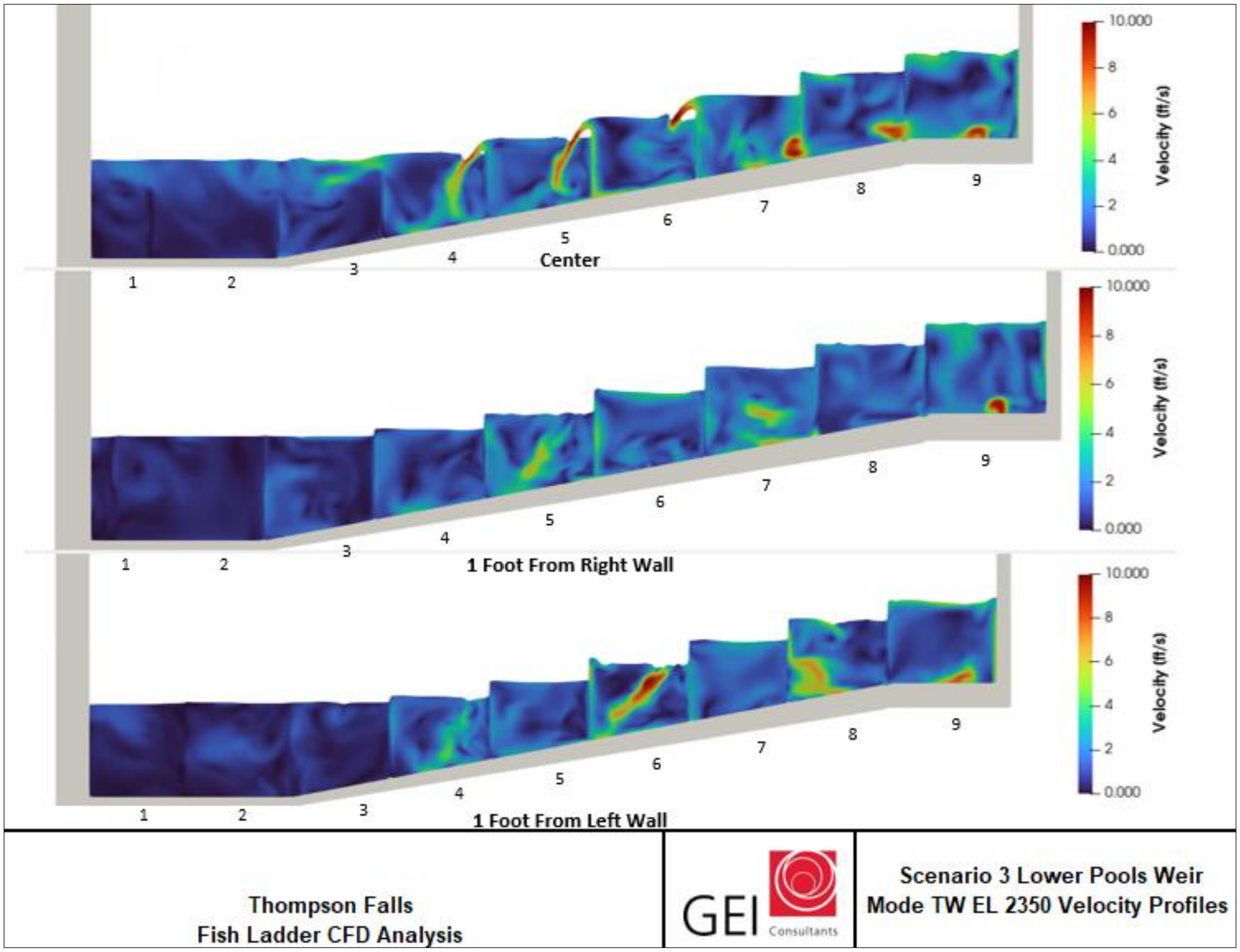

Figure 5-8. Scenario 3- Side profile of the velocities in the lower ladder pools (Center, Right, Left)

Figure 5-8 shows the elevated tailwater causes the weir spill to break up in pools 1-3, potentially losing any attraction flows that would direct fish up the ladder. The velocities in the orifices in the lower pools are also reaching higher levels indicated by the red coloration. This may indicate that fish would have a more difficult time passing through the orifices at higher flows with these elevated velocities. However, the isometric view of the velocities shown in Figure 5-9, indicates the higher velocities through the orifice do not change the dynamics in the rest of the pools which still allow plenty of space for fish to rest before continuing through to the next pool.

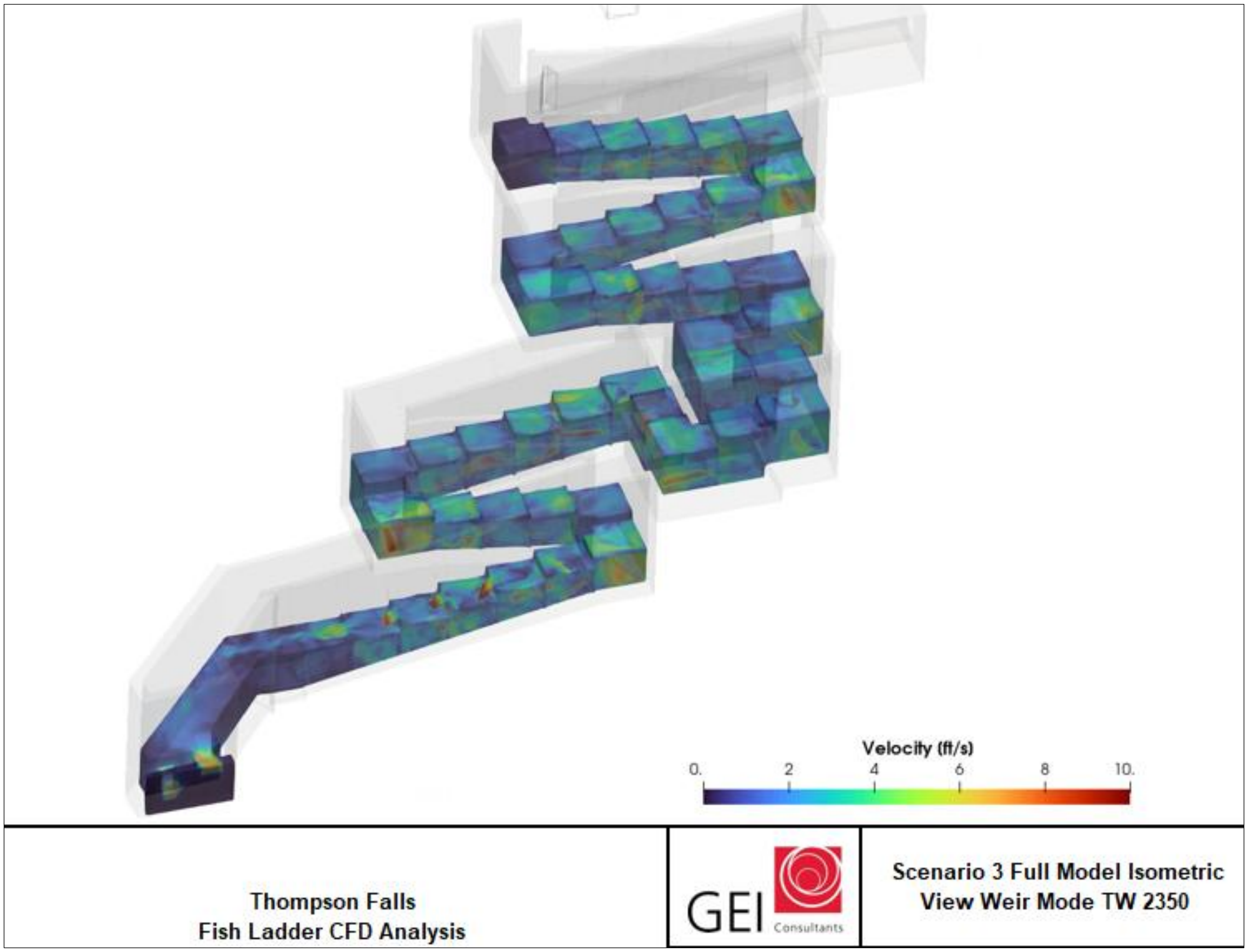

Figure 5-9. Scenario 3-Isometric view of the velocities in the full ladder

Scenario 4 – Rising Tailwater (2350 feet elevation), Orifice Mode

At a tailwater elevation of 2350 feet with the AWS in pool 1 set at 40 cfs, the results were fairly similar to those that were seen in Scenario 2 at the lower tailwater. The overall vorticity profile is less turbulent than Scenario 3 (when the ladder is in weir mode) and velocities coming through the orifices produce a streaming flow to attract fish (Figure 5-10). The velocity streams that are seen in the lower pools (Figure 5-11) are ideal for creating a smooth attractant flow for fish entering the ladder.

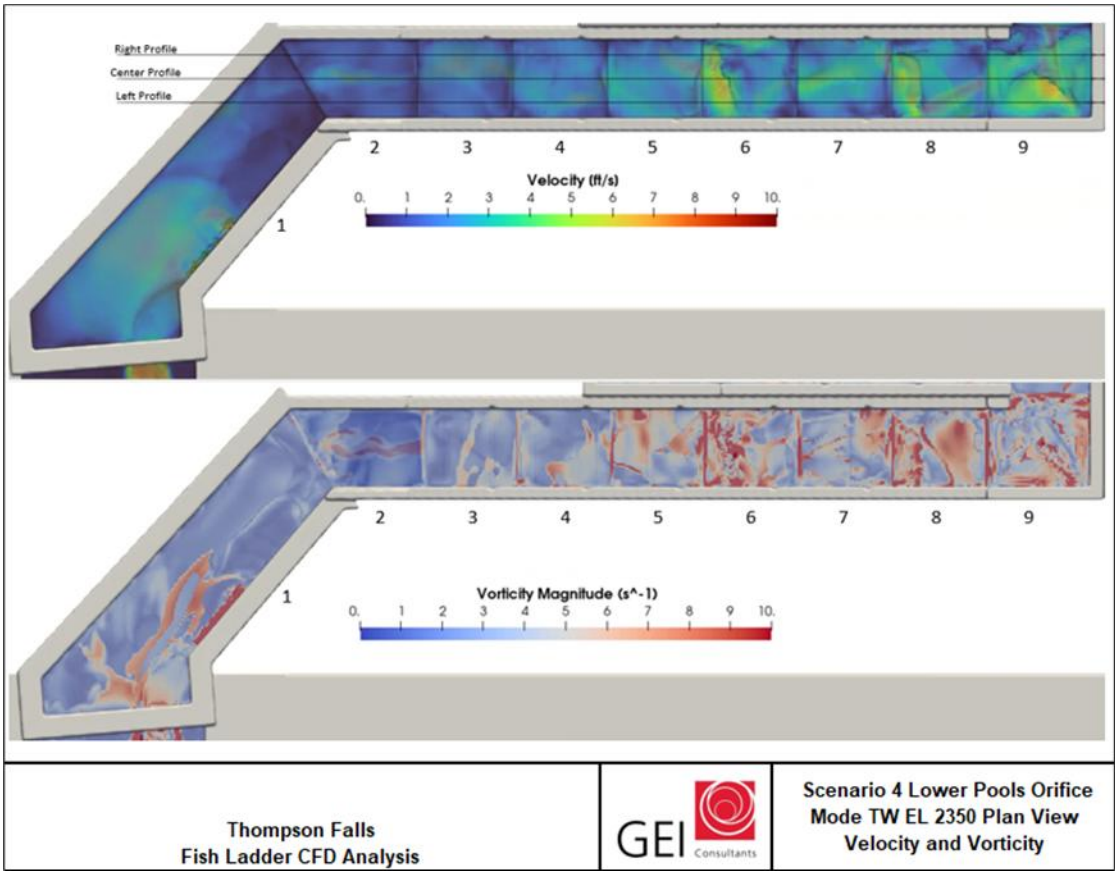

Figure 5-10. Scenario 4- Velocity and Vorticity in the Lower Pools operating in orifice mode

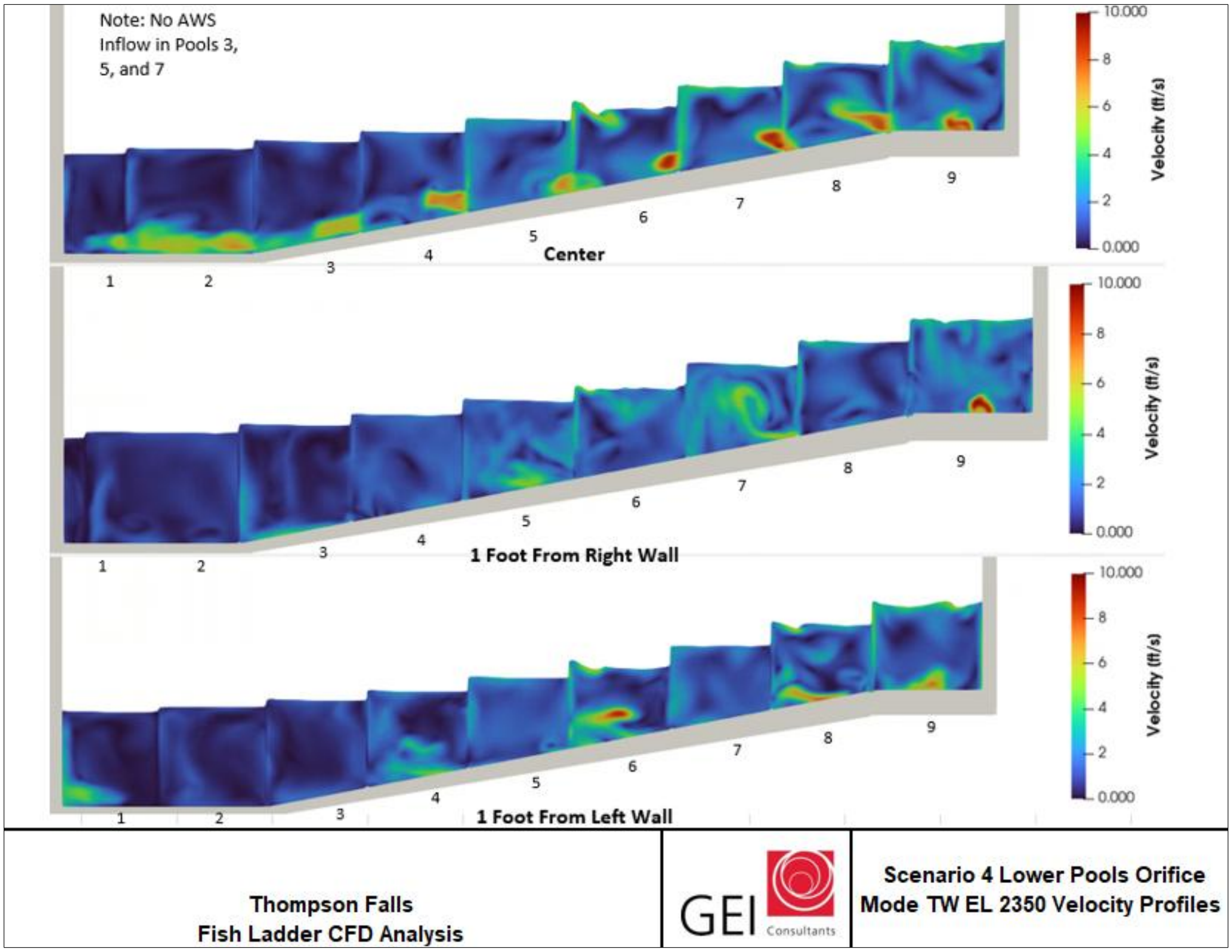

Figure 5-11. Scenario 4- Velocity profiles in lower pools (Center, Right, Left)

With this higher flow scenario, the orifices are starting to concentrate velocities. The side profiles for velocities in pools 5 through 10 indicate areas of elevated velocity, indicating fish may start having a more difficult time passing (Figure 5-11). It appears that the lower pools function better in orifice mode at lower tailwaters, but as flows increase, orifice mode may not be the best configuration. The baffle plates can be configured to accommodate a combined orifice and weir mode with potential to provide improved hydraulic conditions for fish passage at raised tailwater elevations. This baffle configuration in the lower pools will be considered in future CFD modeling simulations to inform ladder improvement recommendations.

Scenario 5 – Spill Tailwater (2354 feet elevation), Weir Mode

Scenario 5 has the same configuration as Scenarios 1 and 3, but at a tailwater of El. 2,354. The entrance to the ladder appears calm, but also appears to lack a clear attraction flow to direct fish into the ladder (Figure 5-12).

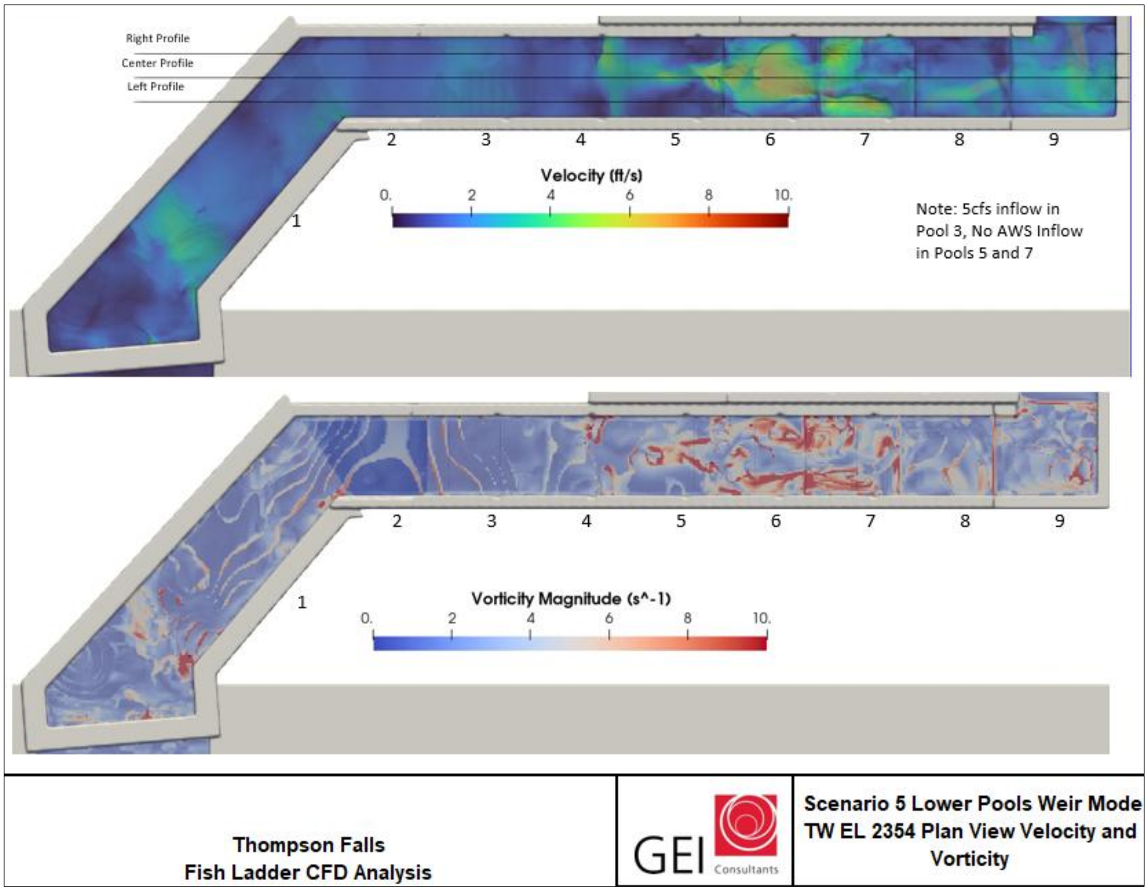

Figure 5-12. Scenario 5- Velocity and vorticity in the lower pools, pool 1 through 7 are in weir configuration, pools 8 and above are in orifice

This elevation of tailwater has pools 1 through 5 backwatered (Figure 5-13). If fish make it into the ladder entrance however, this flow scenario produced a more overall appealing approach for fish in comparison to the orifice mode scenarios at elevated tailwaters (Scenarios 4 and 6).

The streaming flow coming over the weirs in pools 5-7 appears to create a smooth attraction flow (figures 5-9 and 5-10). However, it is uncertain how fish may respond once into pool 7 and 8 where the ladder switches back into orifice mode. Pool 7 appears to have some split velocities in the right sided profile view, but the center profile view creates a fairly clear velocity attraction to indicate where fish can pass.

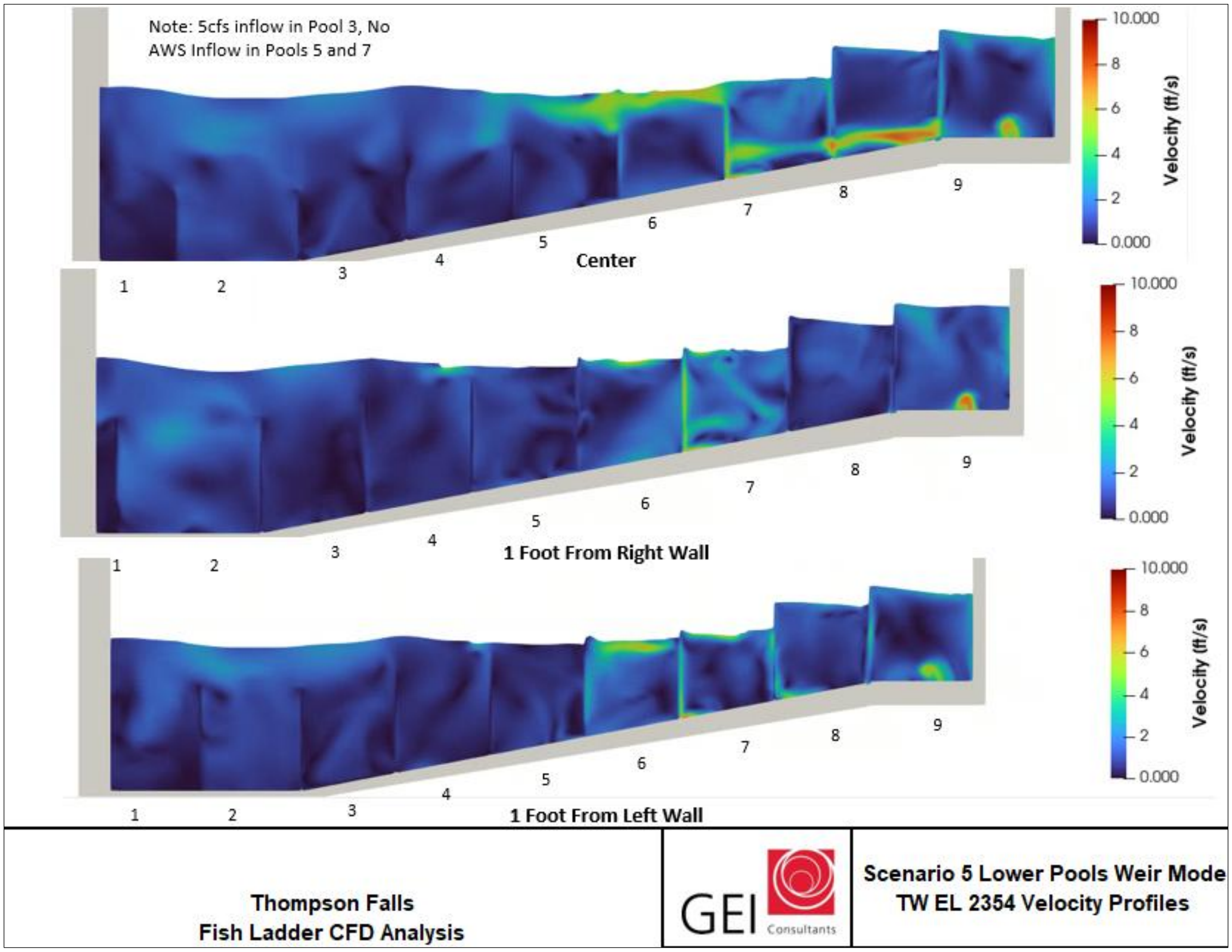

Figure 5-13**. Scenario 5- Velocity profiles in lower pools (Center, Right, Left)**

At this tailwater elevation, having the lower pools in weir mode does seem to indicate that it would be successful at passing fish once they are in the ladder.

Scenario 6 – Spill Tailwater (2354 feet elevation), Orifice Mode

Scenario 6 is at the heightened tailwater El. 2354 with the full ladder in orifice mode. In Figure 5-14 the vorticities and velocities appear to be calm, however when you look at Figure 5-15 you can see the elevated orifice velocities in the cross sections.

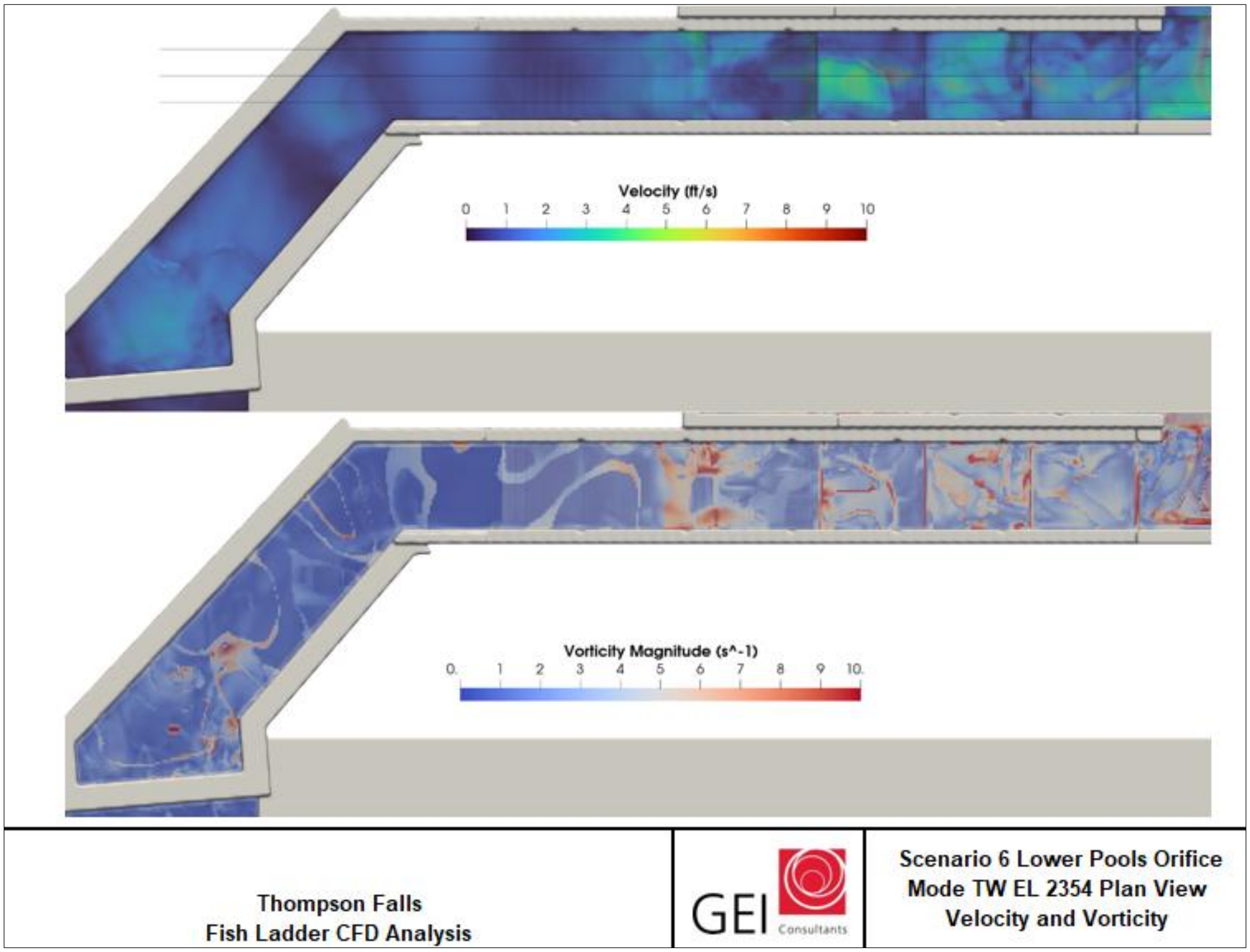

Figure 5-14. Scenario 6- Velocity and vorticity in the lower pools, all pools are in orifice configuration

While the elevated velocities in this scenario are limited to just the immediate area through the orifice of pools 6 and 7, the pools are back-watered and overtopped up to pool 6 which likely slows the velocities through the lower orifices. The velocities through pools 6 and 7 are reaching points where it may not be passable to all fish. Similar to Scenario 5, the lower pools are backwatered and it may be difficult for fish to find the entrance to the ladder at this tailwater. The mixing of the backwatered flows, the AWS, and the orifice flow dissipates most of the streaming flow that may draw fish into the ladder entrance. In this configuration the streaming flow through the orifices does extend into pool 3, which is an improvement over Scenario 5 where the streaming flow dissipates in pool 5.

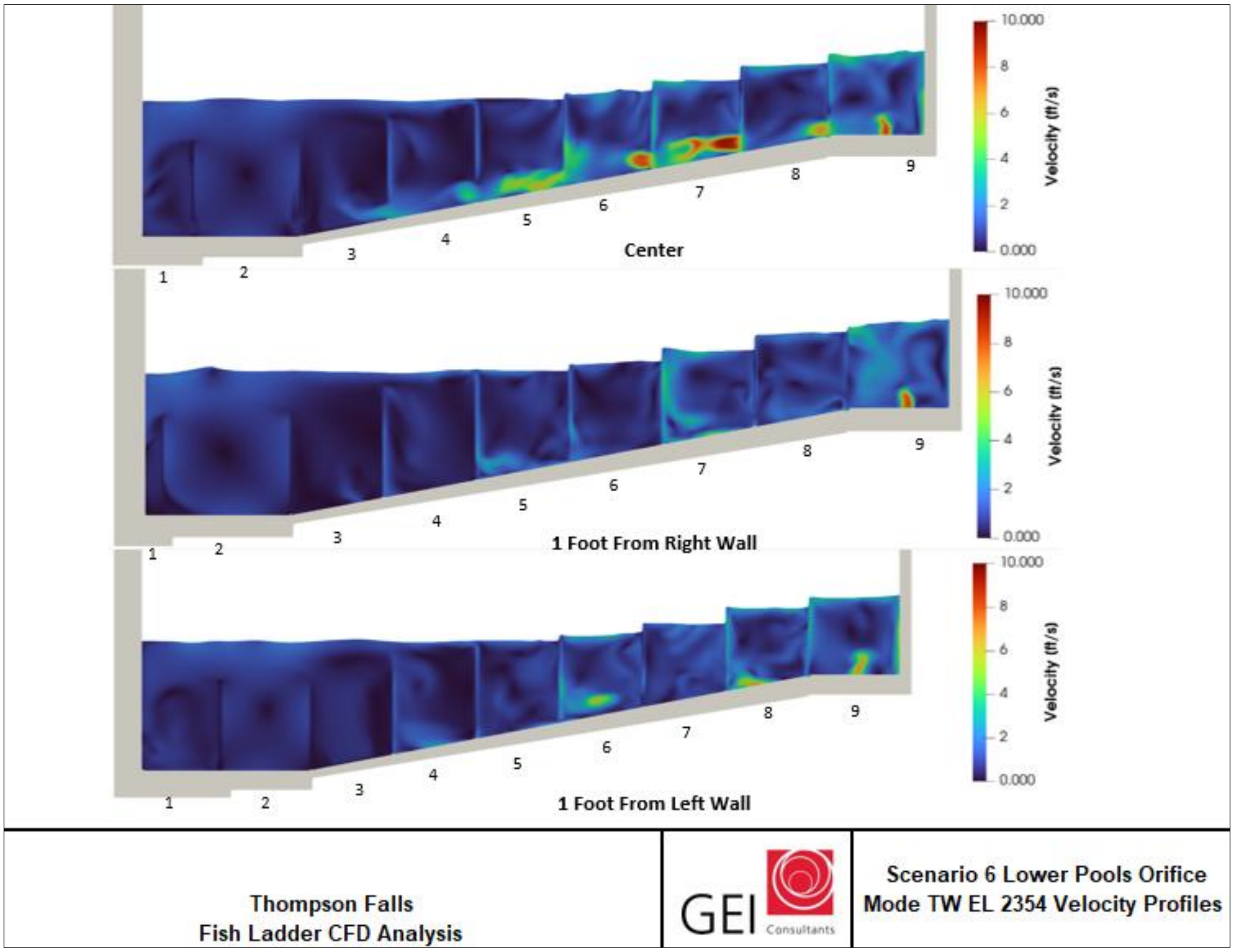

Figure 5-15. Scenario 6- Velocity profiles in lower pools (Center, Right, Left)

If fish do manage to find the entrance of the ladder in this scenario though, stretches of elevated velocities through several consecutive orifices may result in fish not being able to pass higher portions of the ladder in this configuration (Figure 5-16).

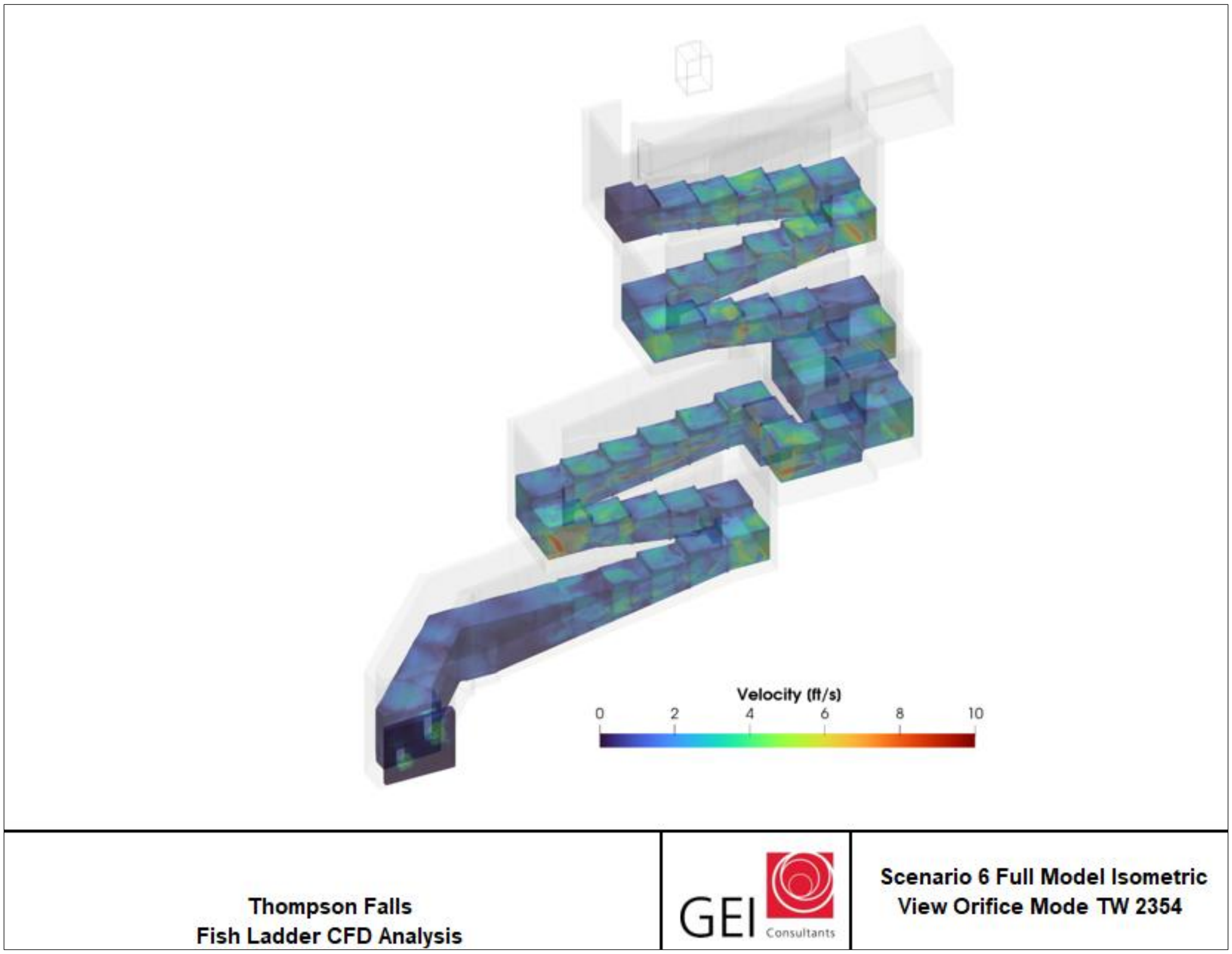

Figure 5-16. Scenario 6- Isometric view of the velocities through the full ladder

6. Further Analysis

Based on preliminary CFD modeling results, the ladder was reconfigured to operate in orifice mode for the remainder of the 2025 passage season. The NorthWestern team is continuing their on-the-ground monitoring of fish passage as well as additional physical and biological monitoring. Once all the biological data is collected and analyzed, it will be evaluated by fisheries biologists to determine if actual passage numbers aligned with the predicted potential increase in passage success from transitioning to orifice mode. Additional CFD modeling may be done to further verify velocities and turbulence in the ladder and determine if any additional changes within the ladder may further improve fish passage above the dam.

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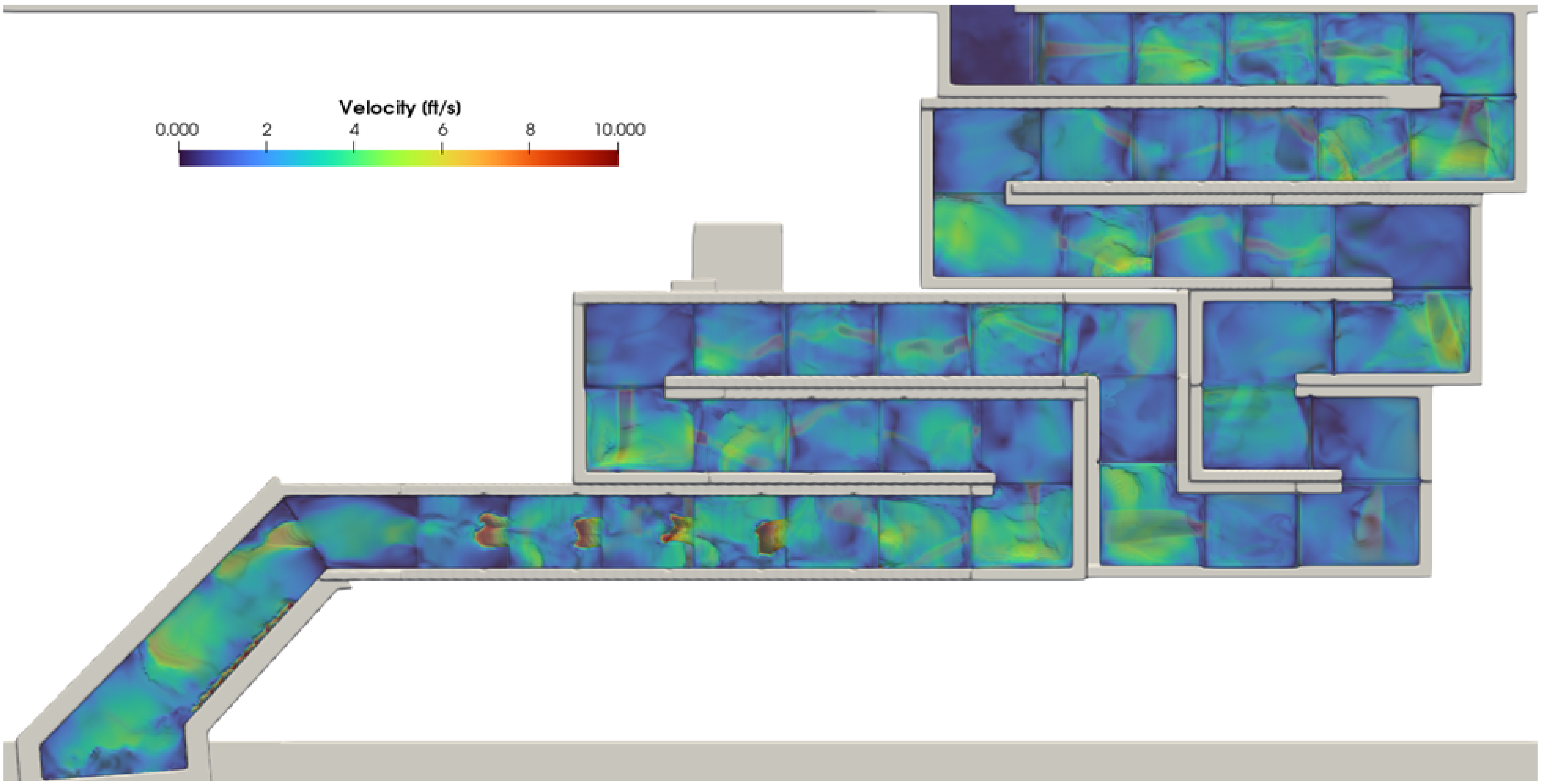
Figures



Thompson Falls
Fish Ladder CFD Analysis

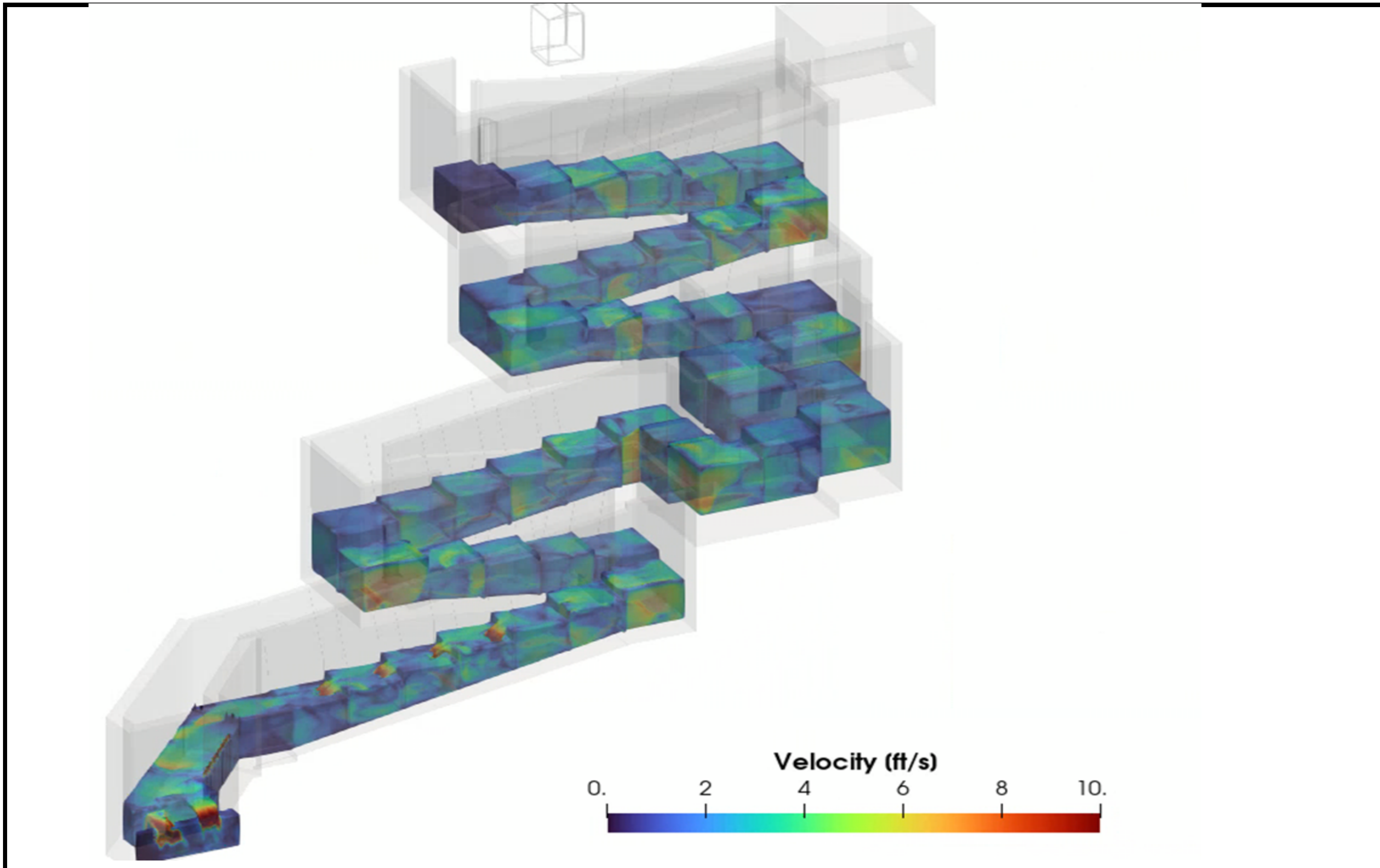
GEI Consultants

Scenario 1 Full Model Plan View
Weir Mode TW 2348 Velocity

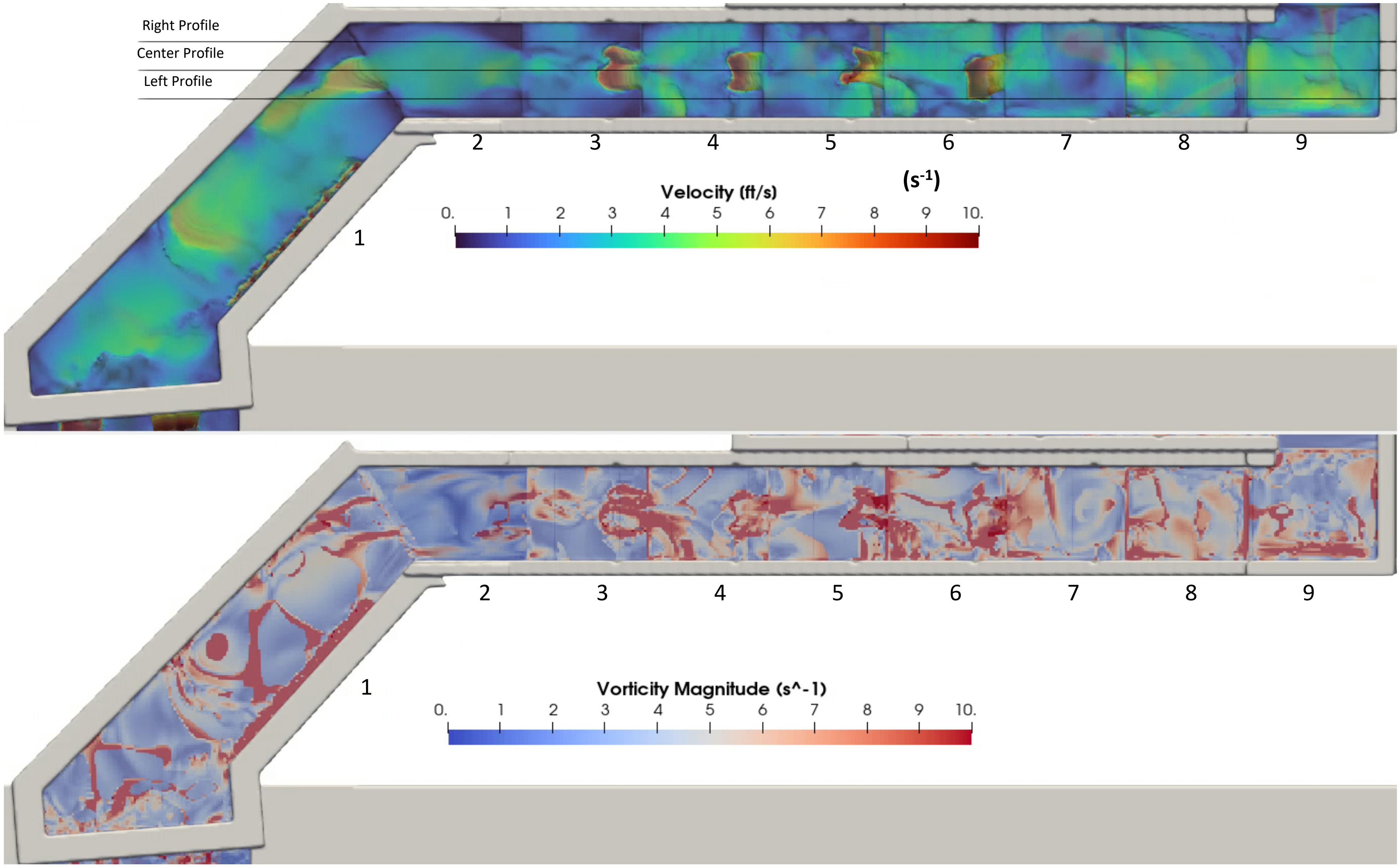
Project 2500476

November 2025

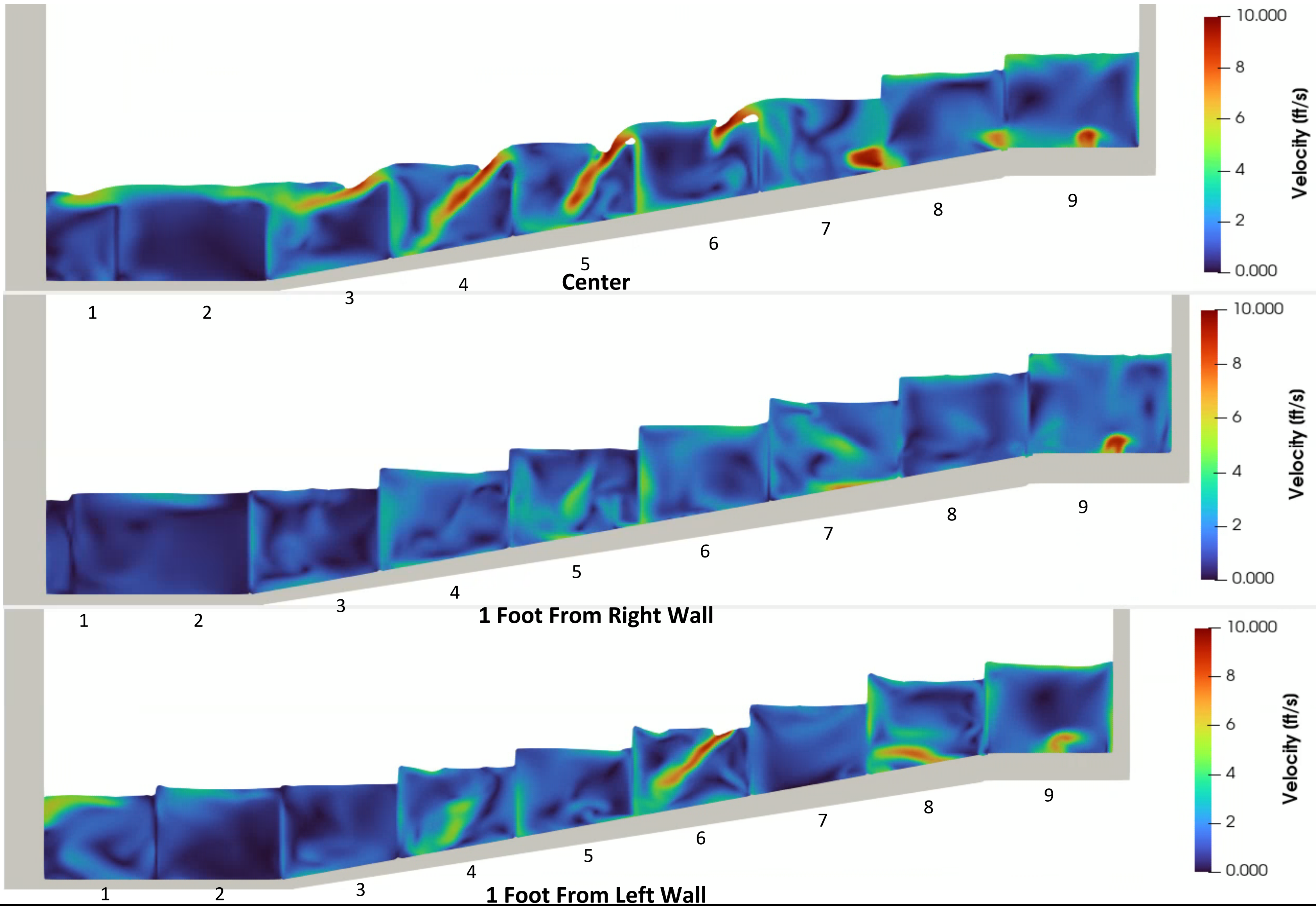
Figure 1



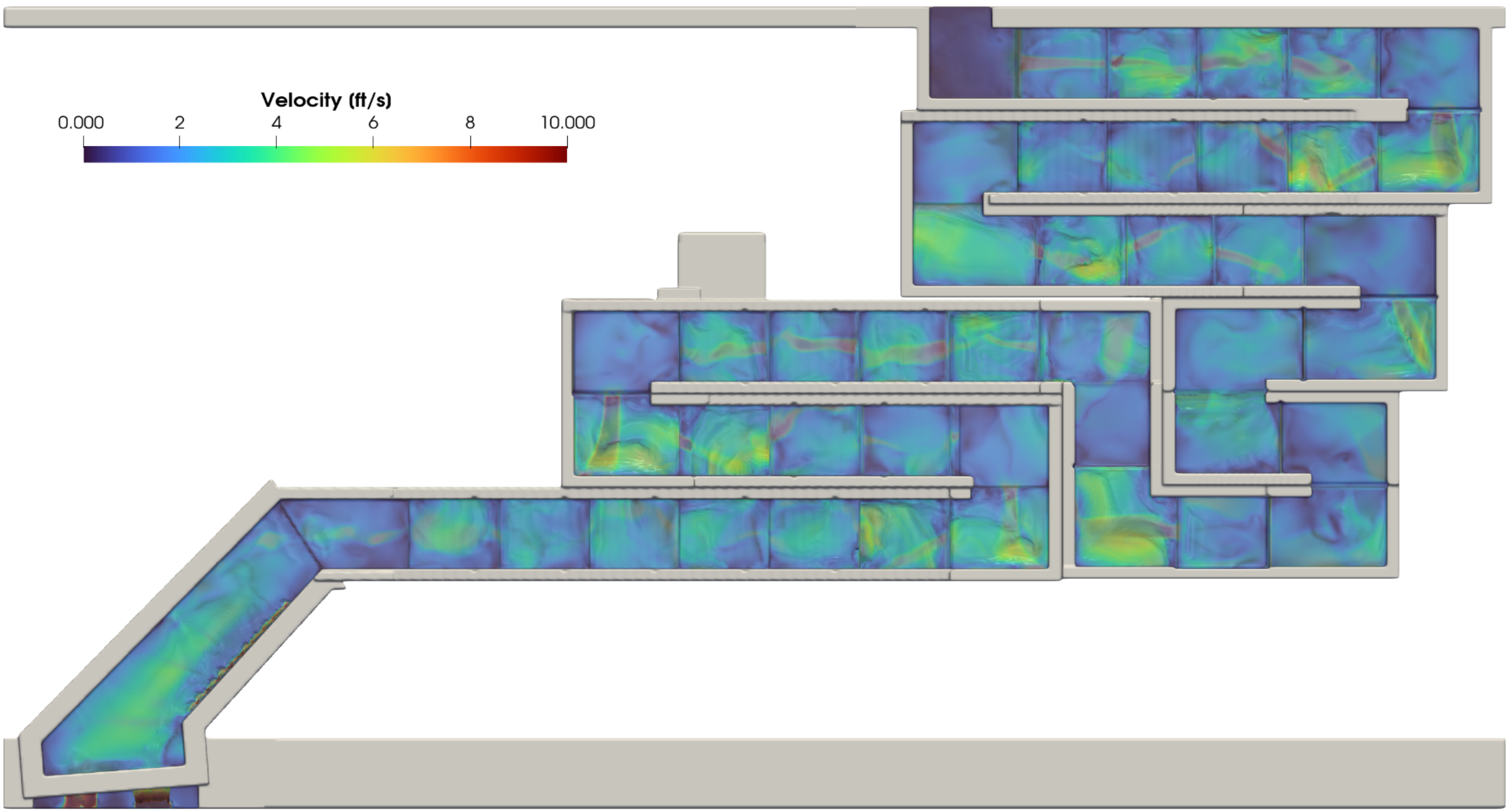
Thompson Falls **Fish Ladder CFD Analysis**	GEI Consultants	**Scenario 1 Full Model Isometric View Weir Mode TW 2348**
	Project 2500476	**November 2025** / **Figure 2**



Thompson Falls **Fish Ladder CFD Analysis**	GEI Consultants	**Scenario 1 Lower Pools Weir Mode TW EL 2348 Plan View Velocity and Vorticity**	
	Project 2500476	**November 2025**	**Figure 3**



Thompson Falls Fish Ladder CFD Analysis	GEI Consultants	**Scenario 1 Lower Pools Weir Mode TW EL 2348 Velocity Profiles**
	Project 2403711	**November 2025** · **Figure 4**

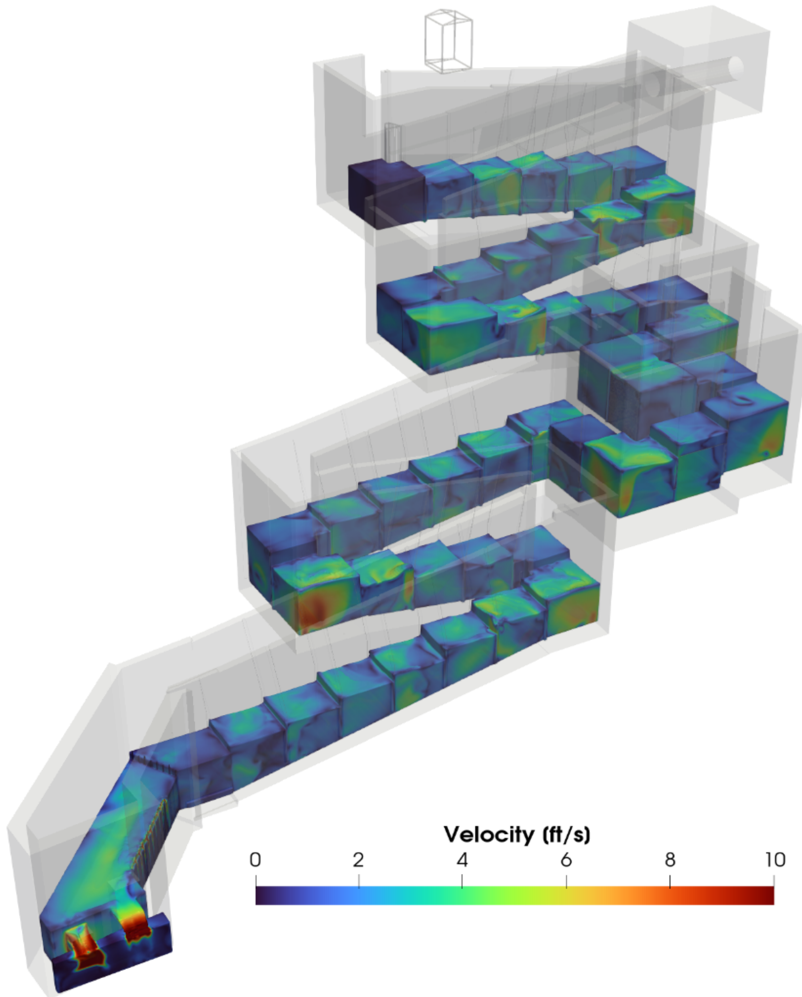


Thompson Falls
Fish Ladder CFD Analysis

GEI Consultants

Scenario 2 Full Model Plan View
Orifice Mode TW 2348 Velocity

Project 2500476	November 2025	Figure 5

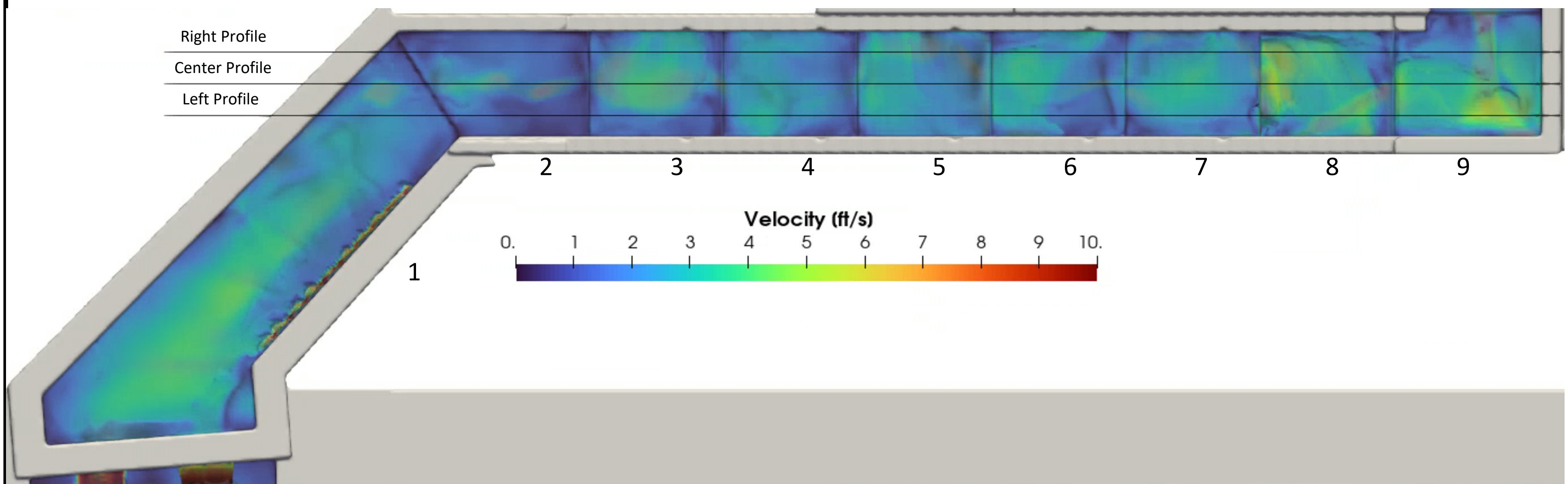


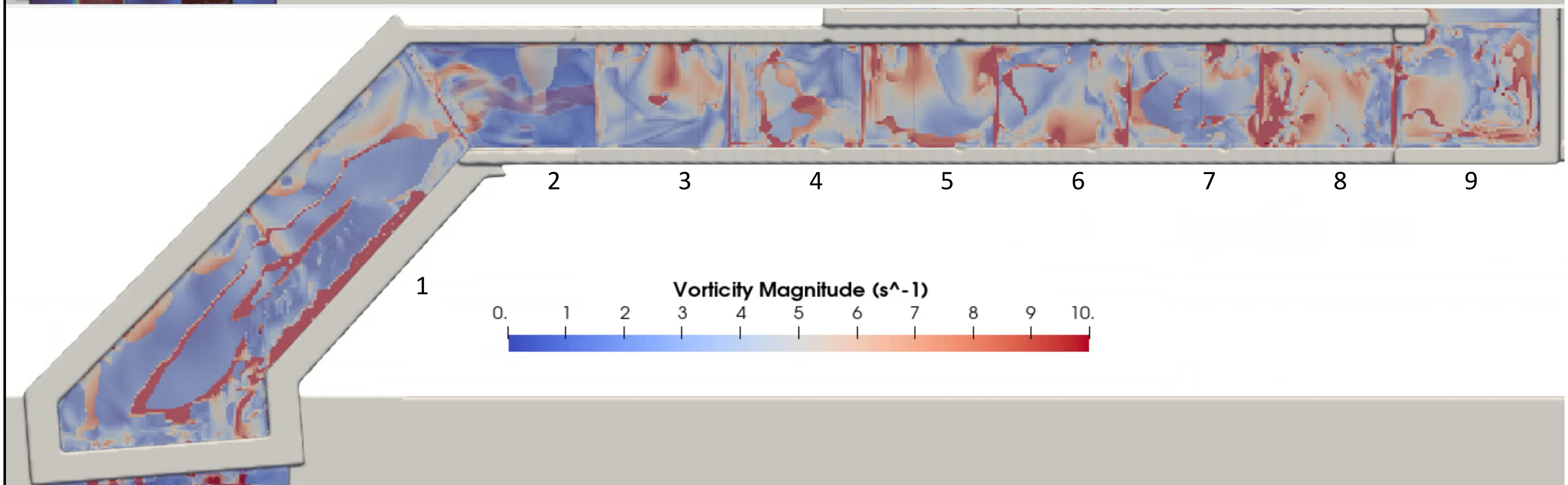
Thompson Falls
Fish Ladder CFD Analysis

GEI Consultants

Scenario 2 Full Model Isometric View Orifice Mode TW 2348

Project 2403711	**November 2025**	**Figure 6**

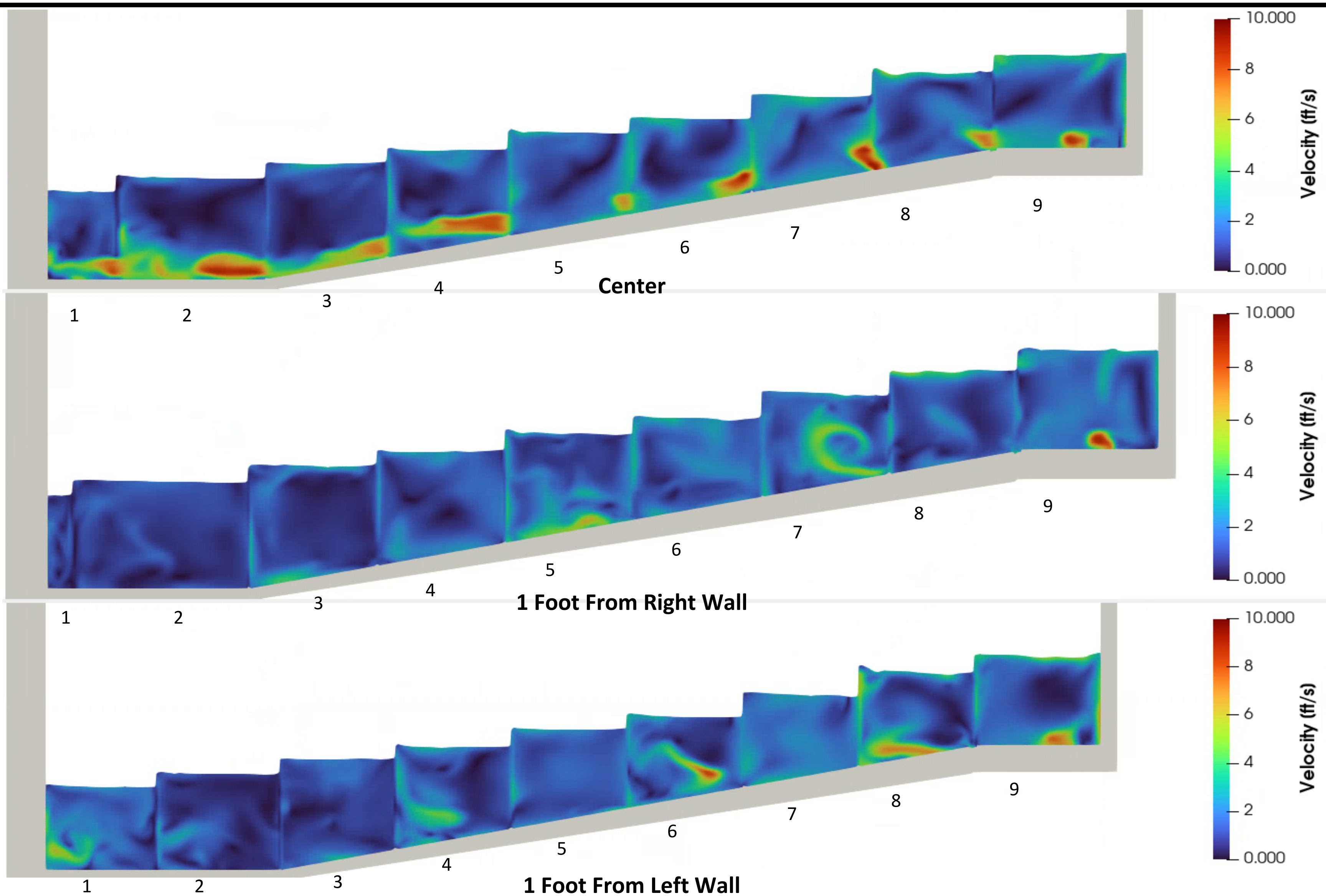




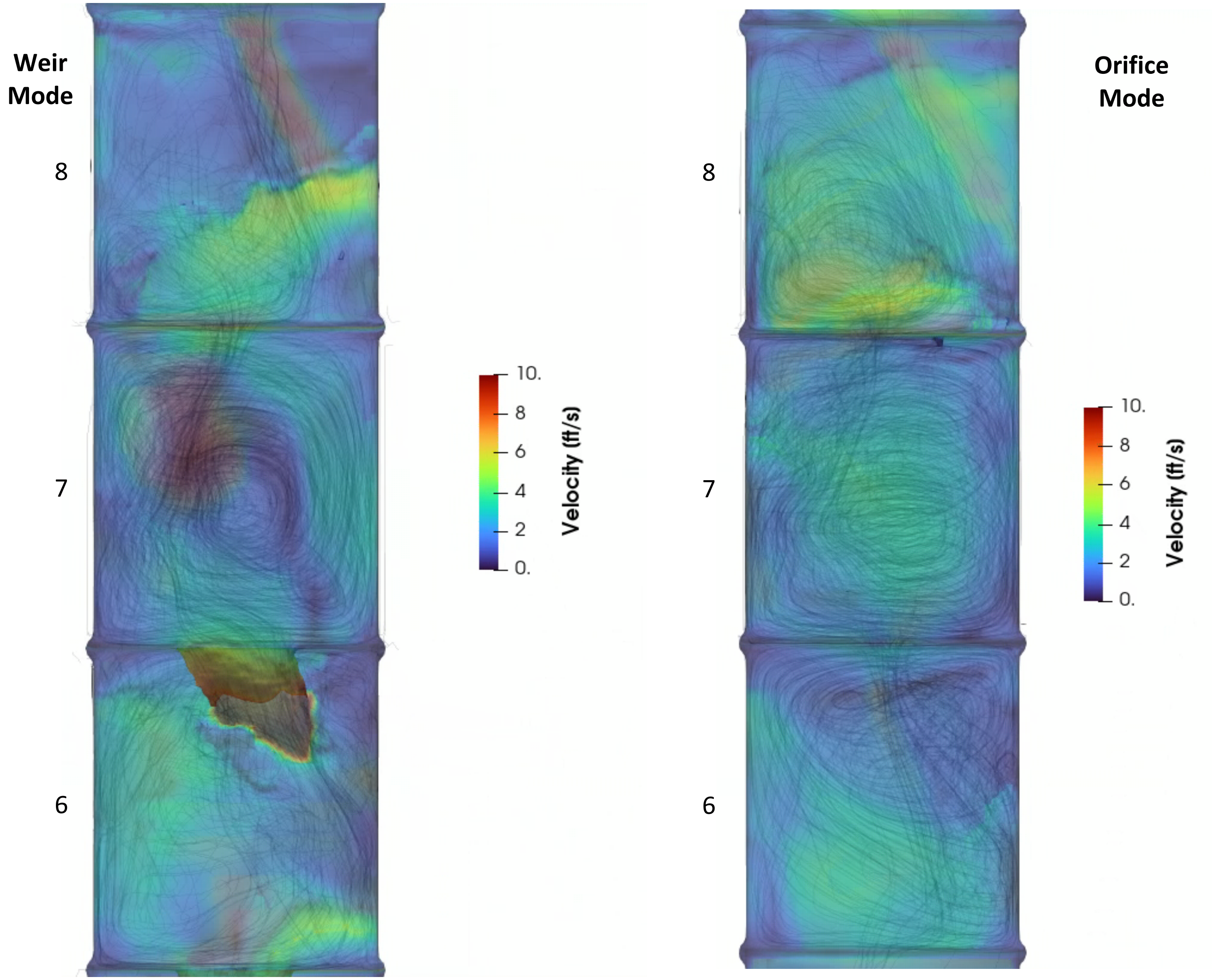
Thompson Falls
Fish Ladder CFD Analysis

Scenario 2 Lower Pools Orifice Mode TW EL 2348 Plan View Velocity and Vorticity

Project 2500476	**November 2025**	**Figure 7**



Thompson Falls **Fish Ladder CFD Analysis**	GEI Consultants	**Scenario 2 Lower Pools Orifice Mode TW EL 2348 Velocity Profiles**	
	Project 2403711	**November 2025**	**Figure 8**

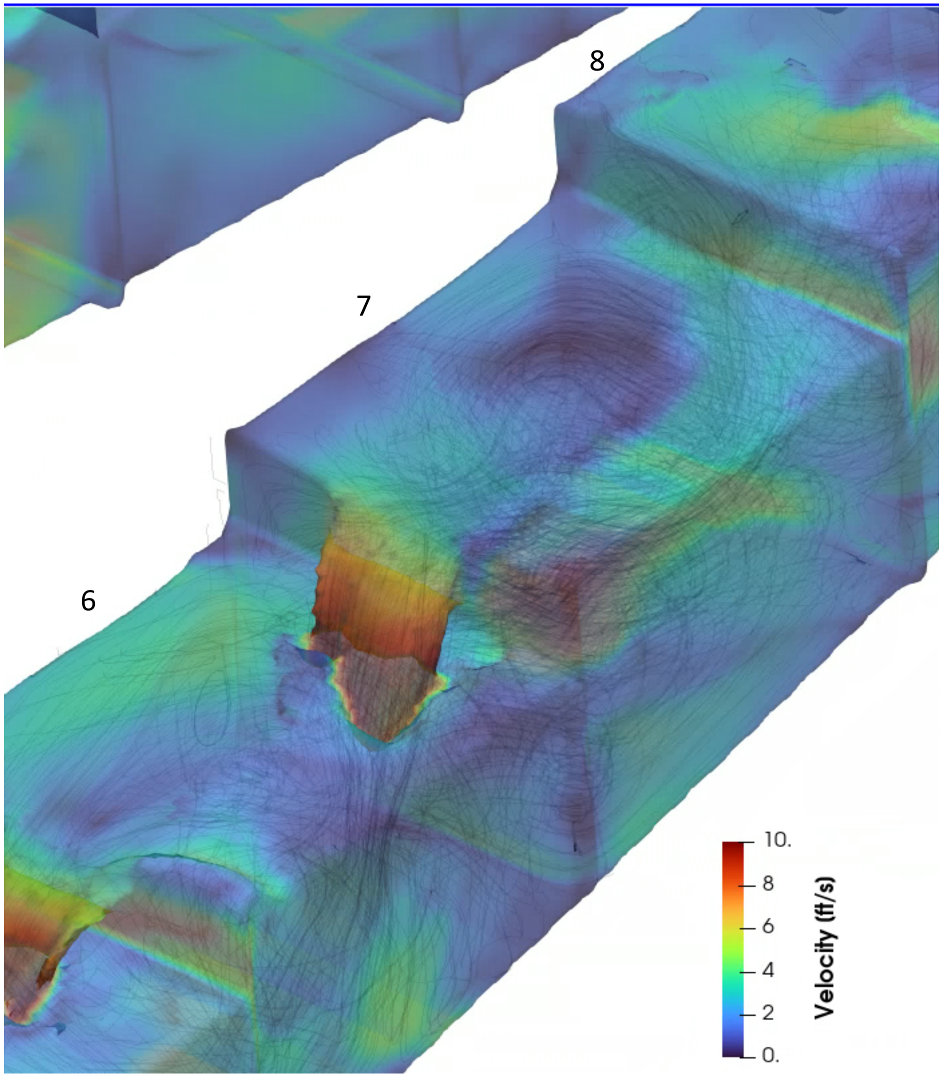


Thompson Falls
Fish Ladder CFD Analysis

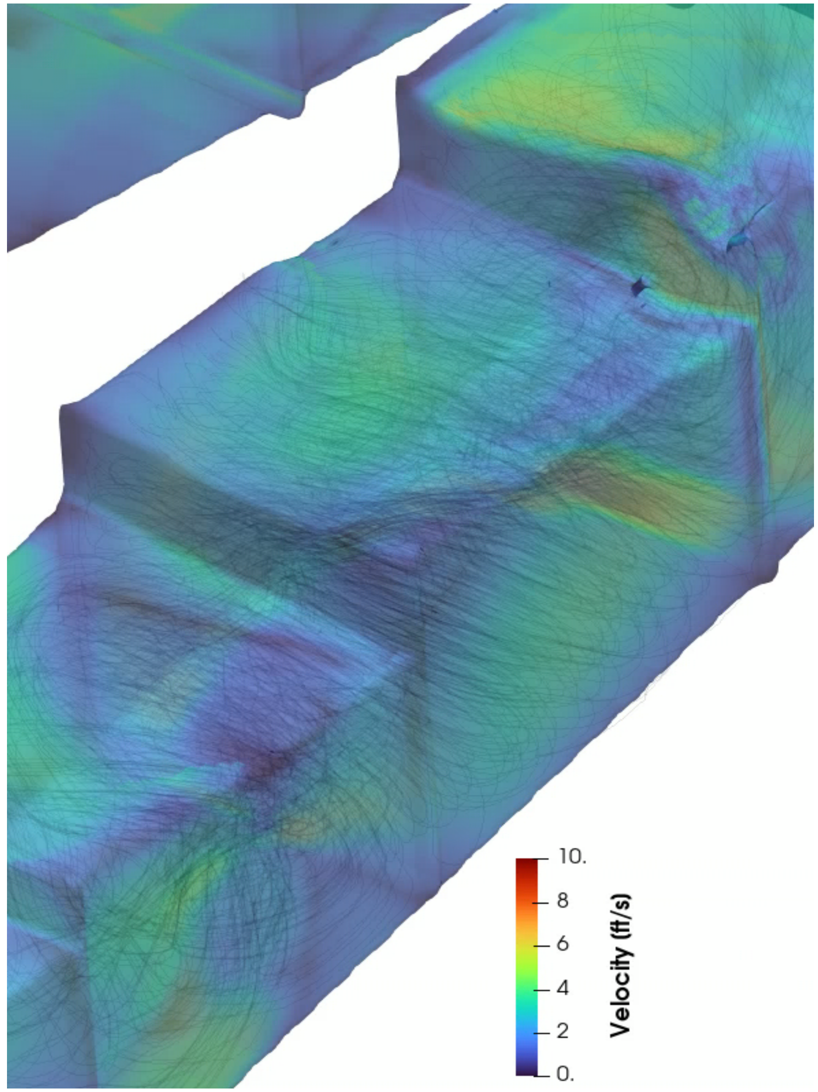
GEI Consultants

Pools 6, 7, 8 Plan View Velocity with Streamlines Weir and Orifice Comparison TW EL 2348

Project 2403711	**November 2025**	**Figure 9**

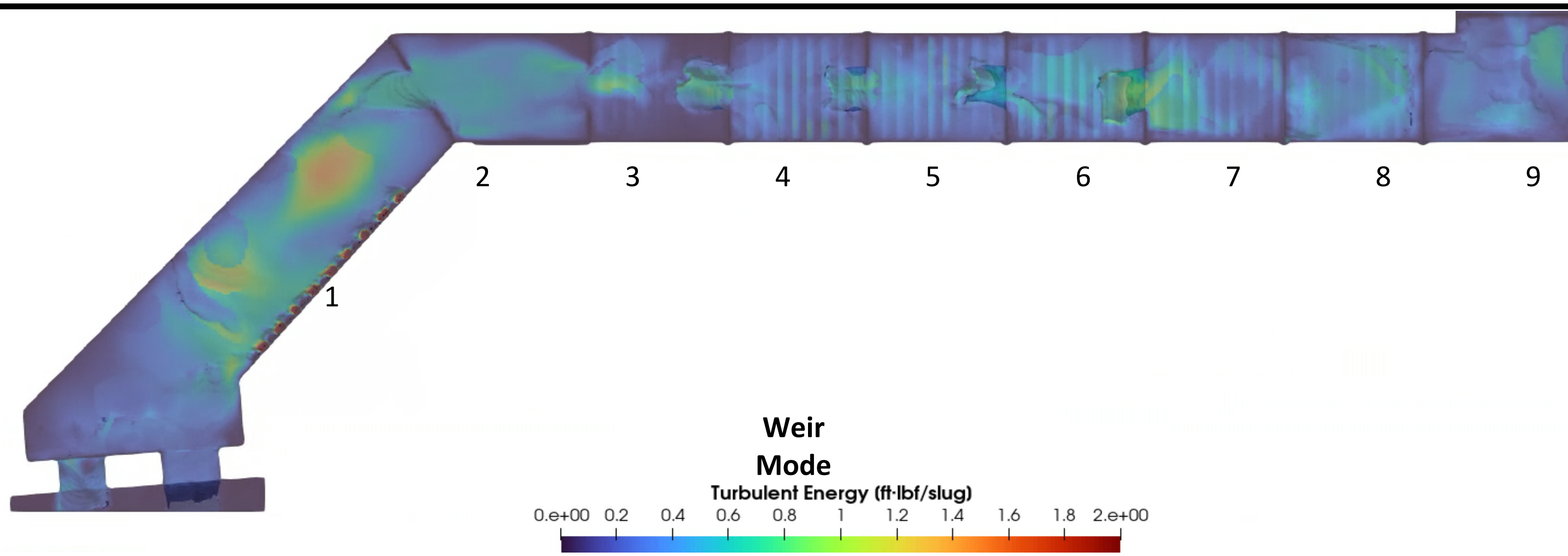


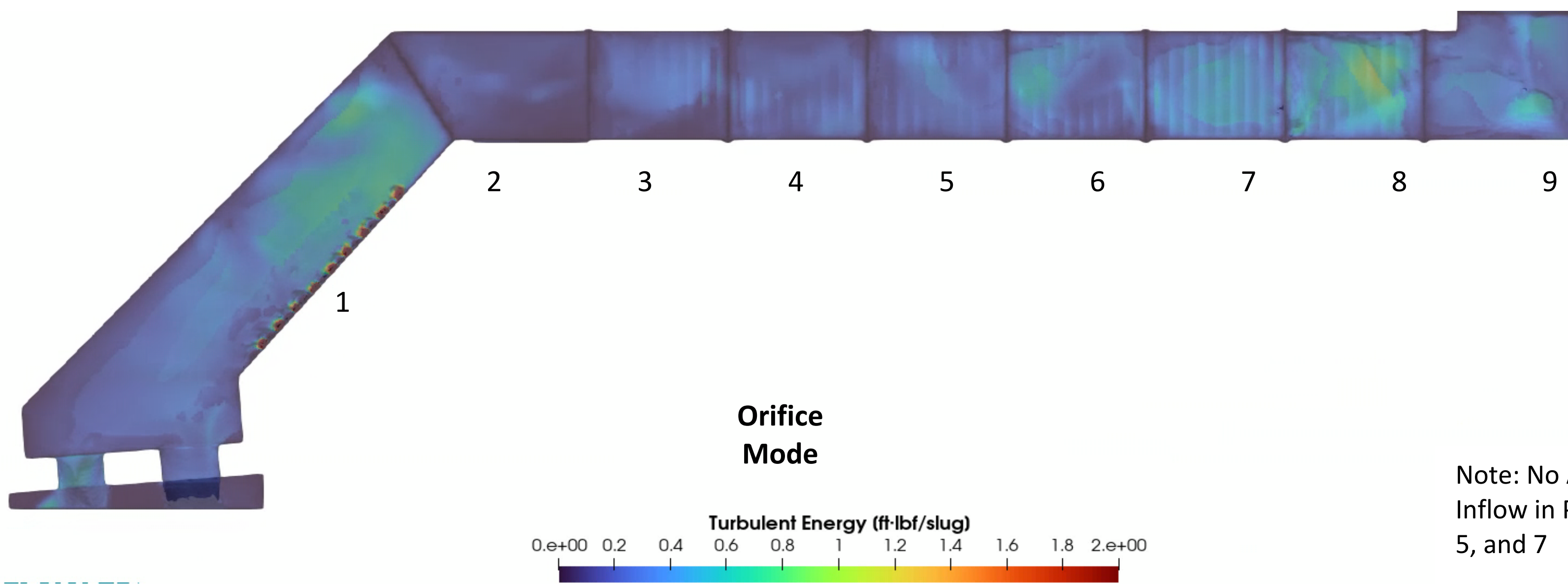
Weir Mode



Orifice Mode

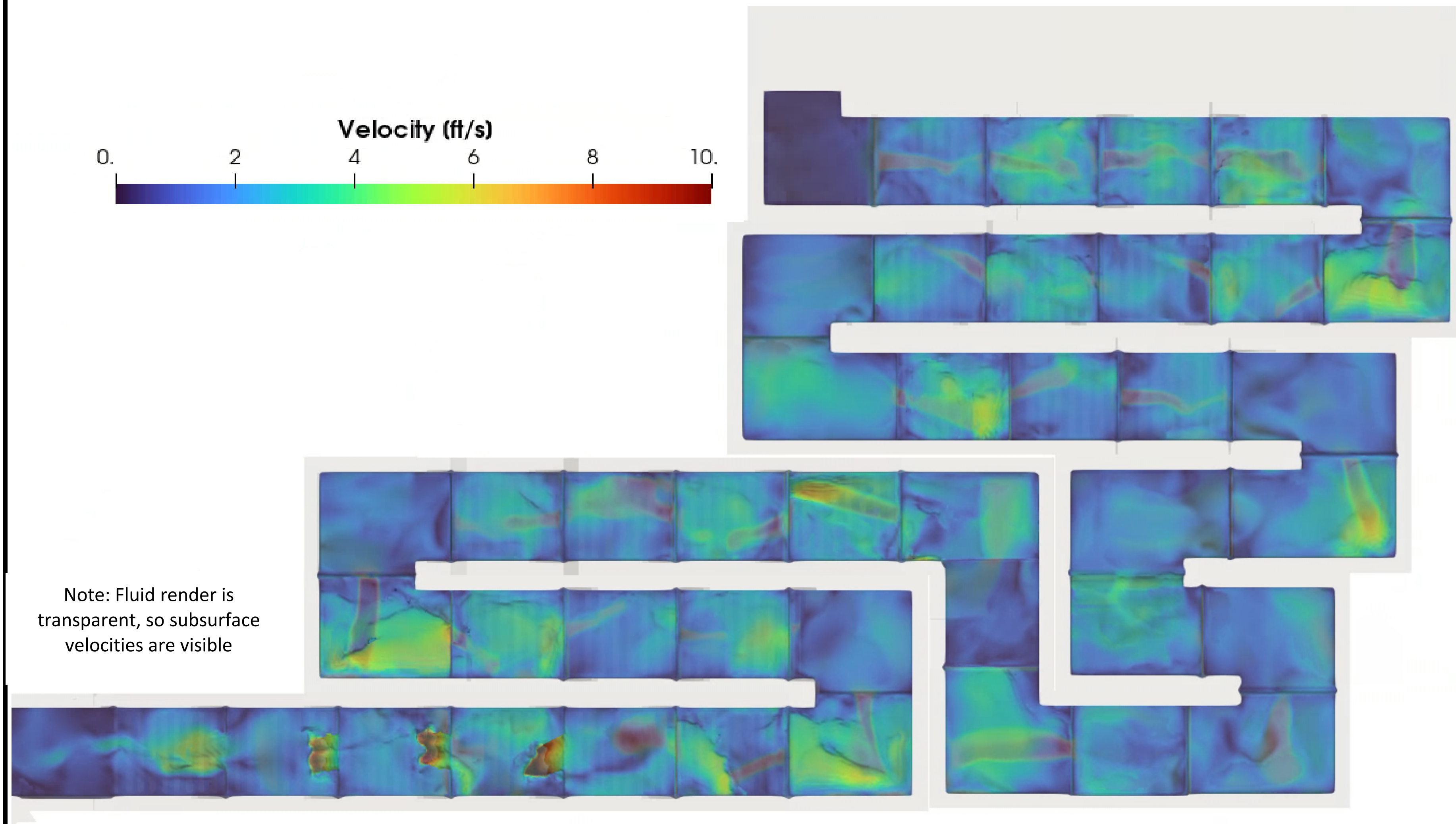
Thompson Falls Fish Ladder CFD Analysis	GEI Consultants	**Pools 6, 7, 8 Isometric View Velocity with Streamlines Weir and Orifice Comparison TW EL 2348**	
	Project 2403711	**November 2025**	**Figure 10**



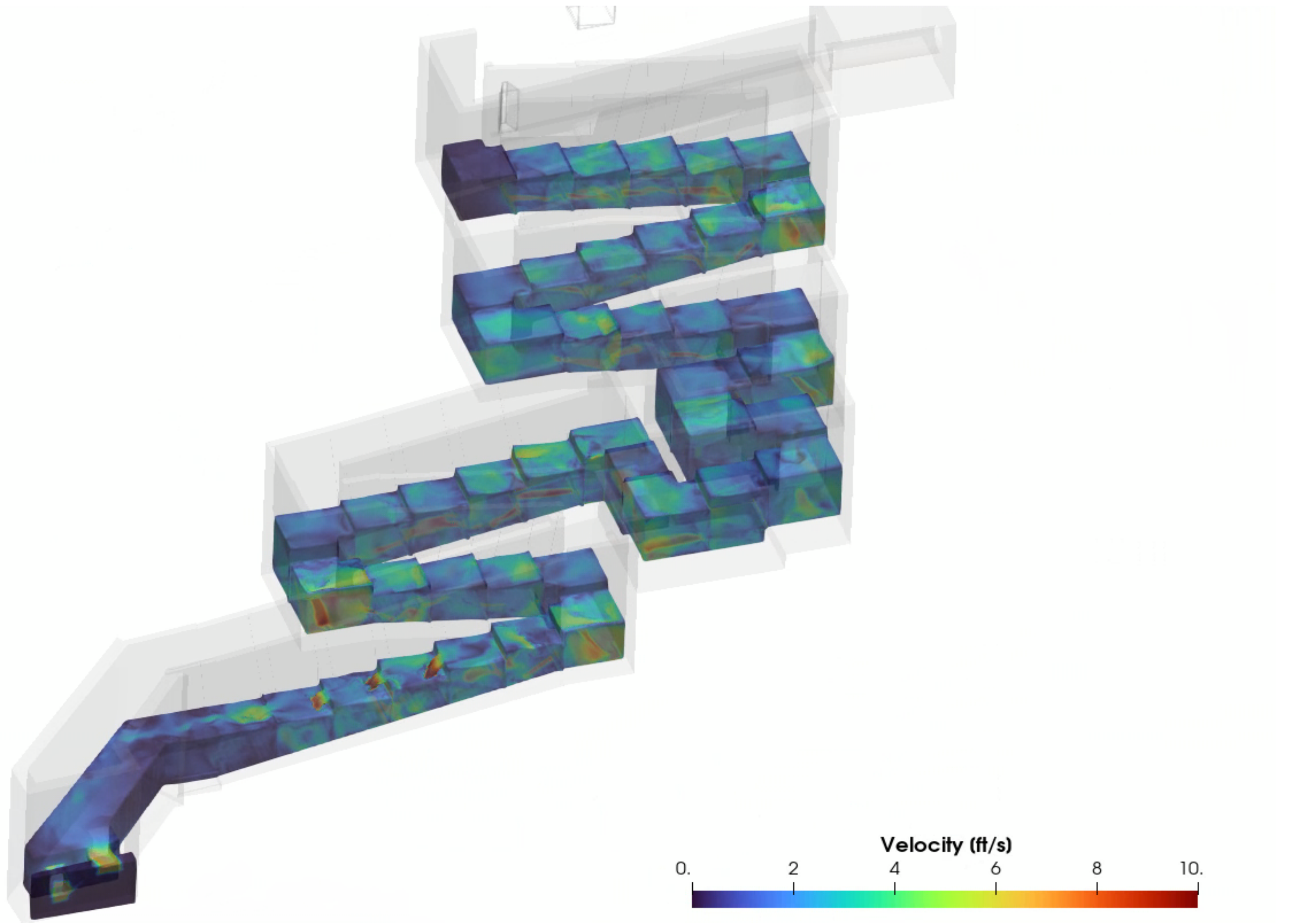


Note: No AWS Inflow in Pools 3, 5, and 7

Thompson Falls Fish Ladder CFD Analysis	GEI Consultants	**Lower Pools Turbulent Energy Plan View Weir and Orifice Comparison TW EL 2348**	
	Project 2403711	**November 2025**	**Figure 11**



Thompson Falls Fish Ladder CFD Analysis	GEI Consultants	Scenario 3 Full Model Plan View Weir Mode TW 2350 Velocity
	Project 2403711	November 2025 / Figure 12

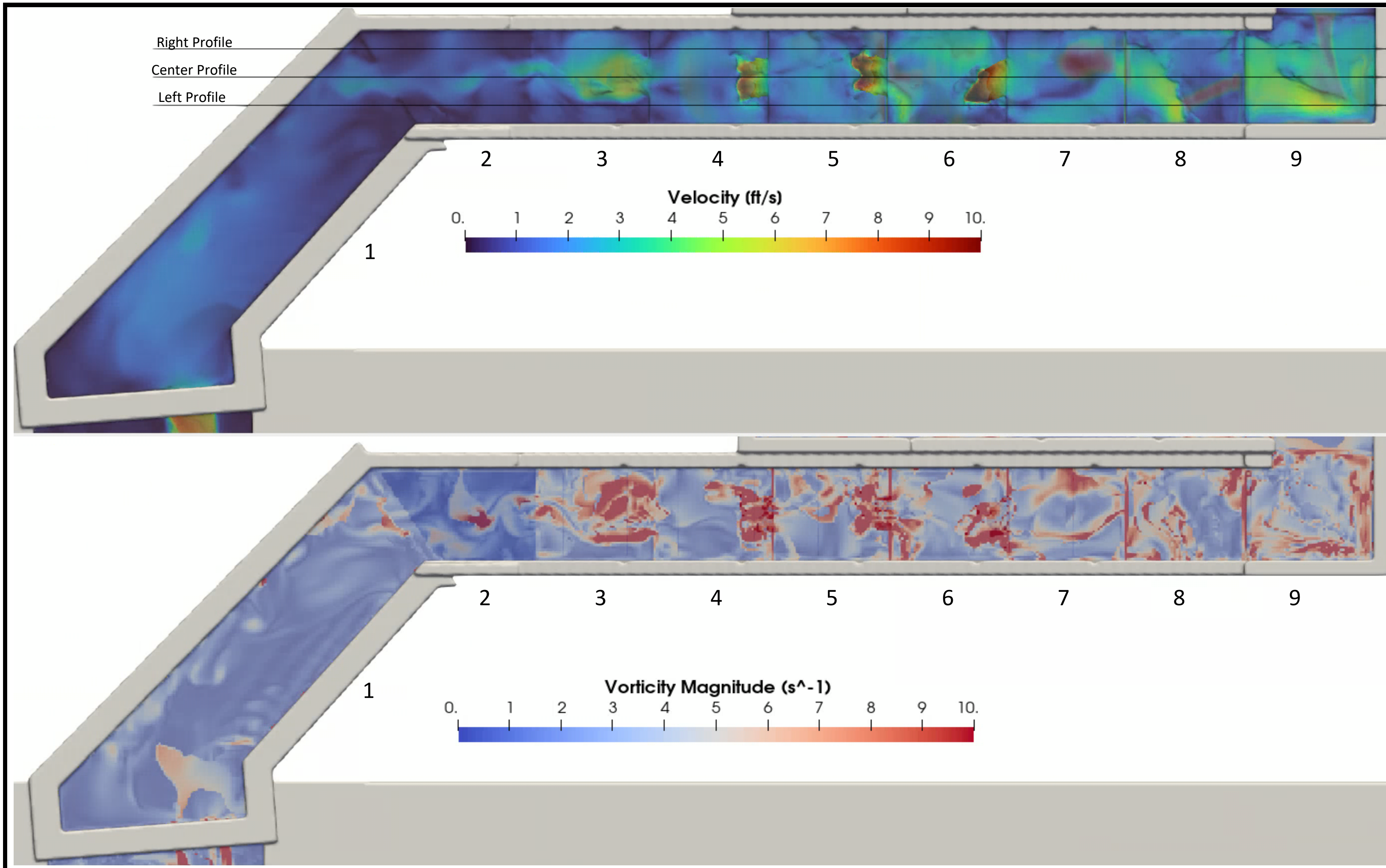


Thompson Falls
Fish Ladder CFD Analysis

GEI Consultants

Scenario 3 Full Model Isometric View Weir Mode TW 2350

Project 2403711	November 2025	Figure 13

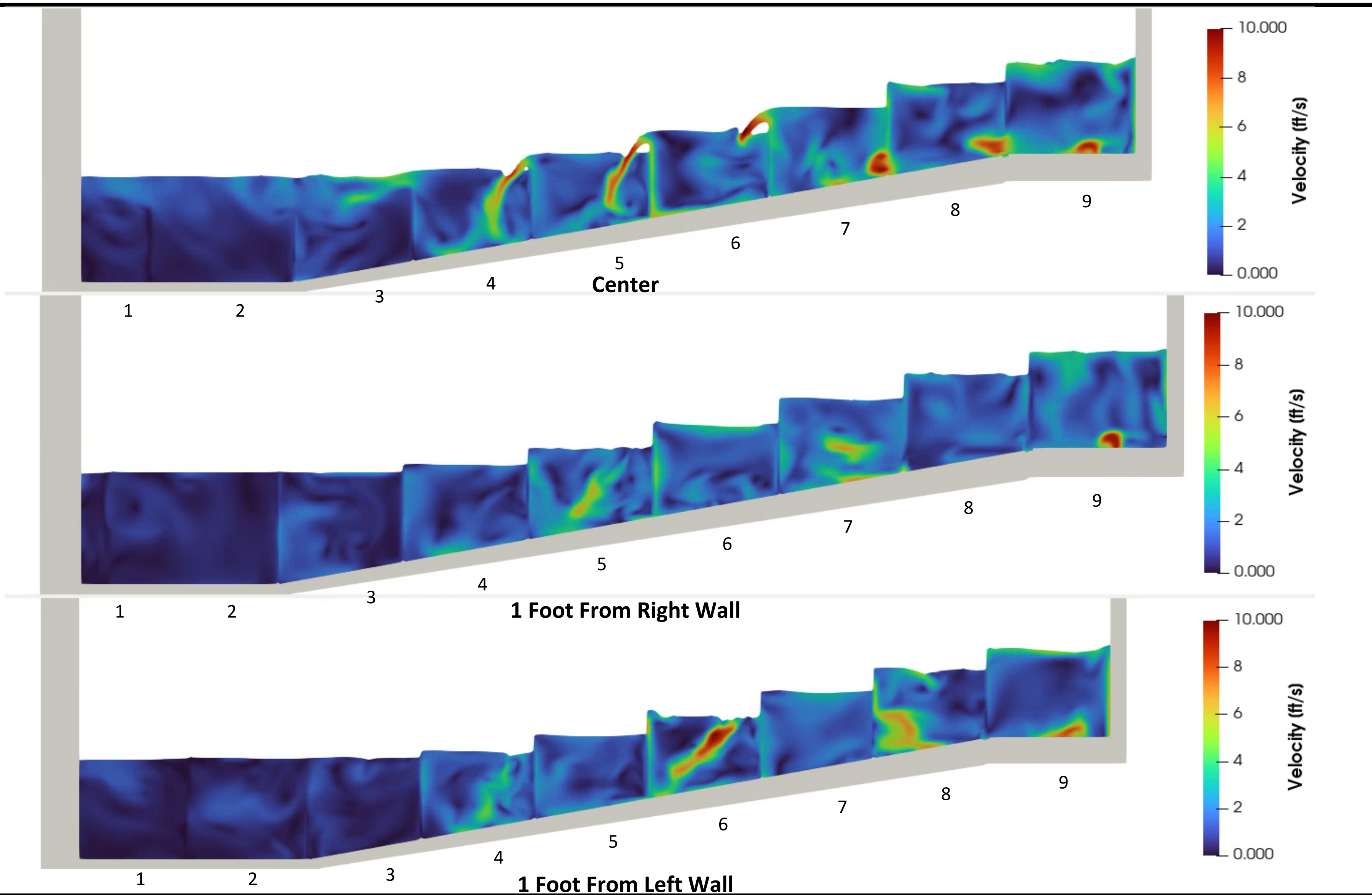


Thompson Falls
Fish Ladder CFD Analysis

GEI Consultants

Scenario 3 Lower Pools Weir Mode TW EL 2350 Plan View Velocity and Vorticity

Project 2500476 | **November 2025** | **Figure 14**

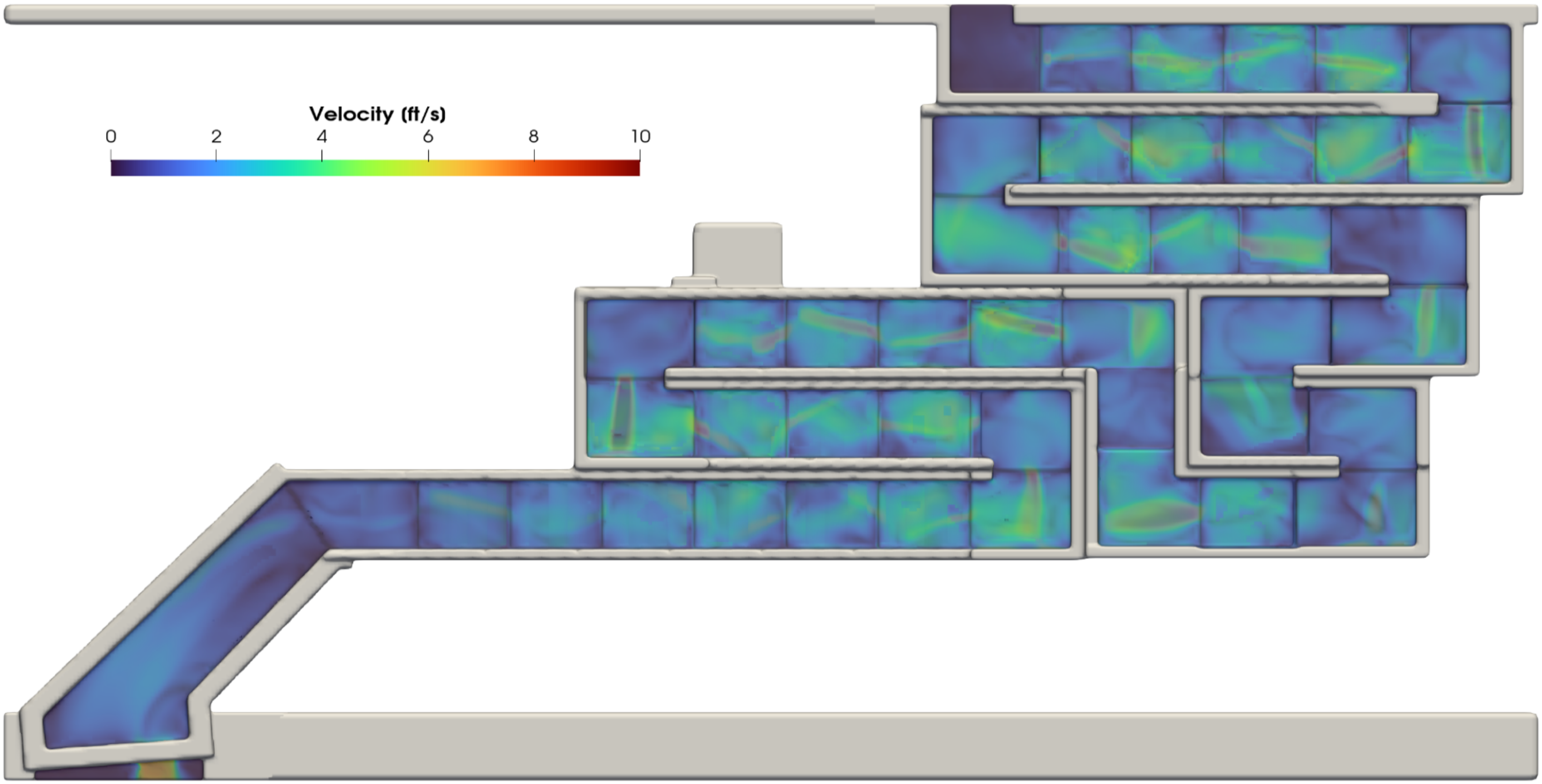


Thompson Falls
Fish Ladder CFD Analysis

GEI Consultants

Scenario 3 Lower Pools Weir Mode
TW EL 2350 Velocity Profiles

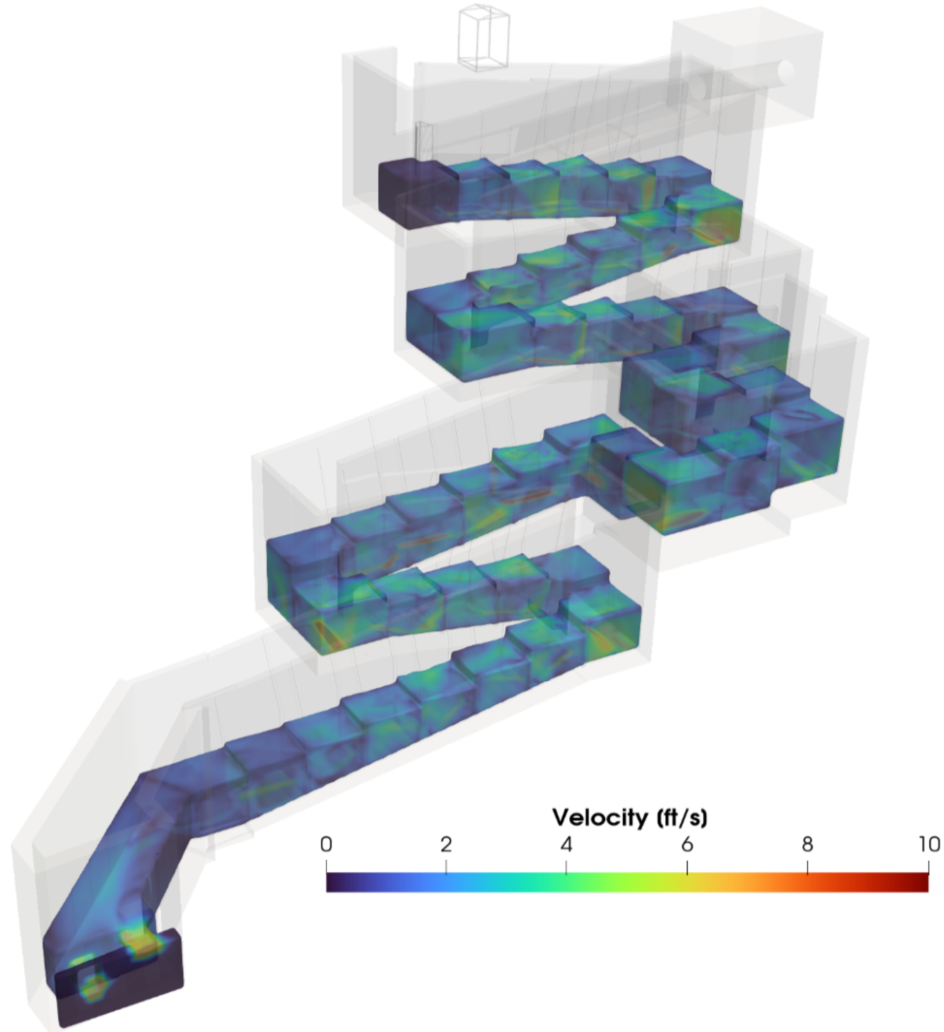
Project 2403711	November 2025	Figure 15



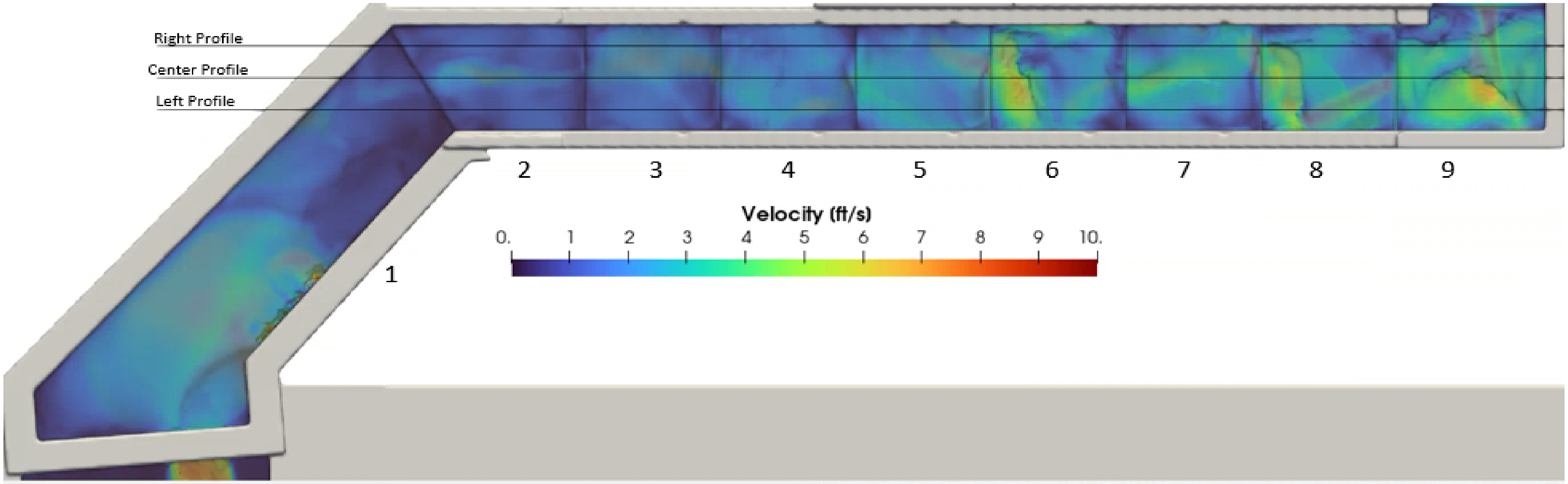
Thompson Falls
Fish Ladder CFD Analysis

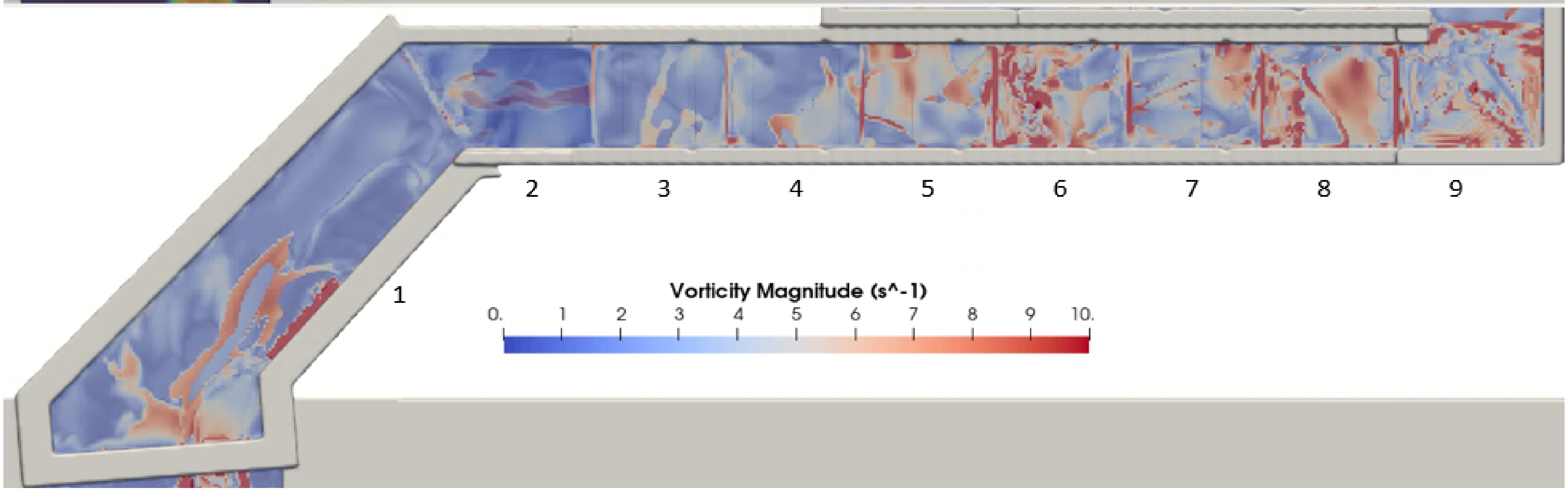
Scenario 4 Full Model Plan View
Orifice Mode TW 2350 Velocity

Project 2500476	November 2025	Figure 16

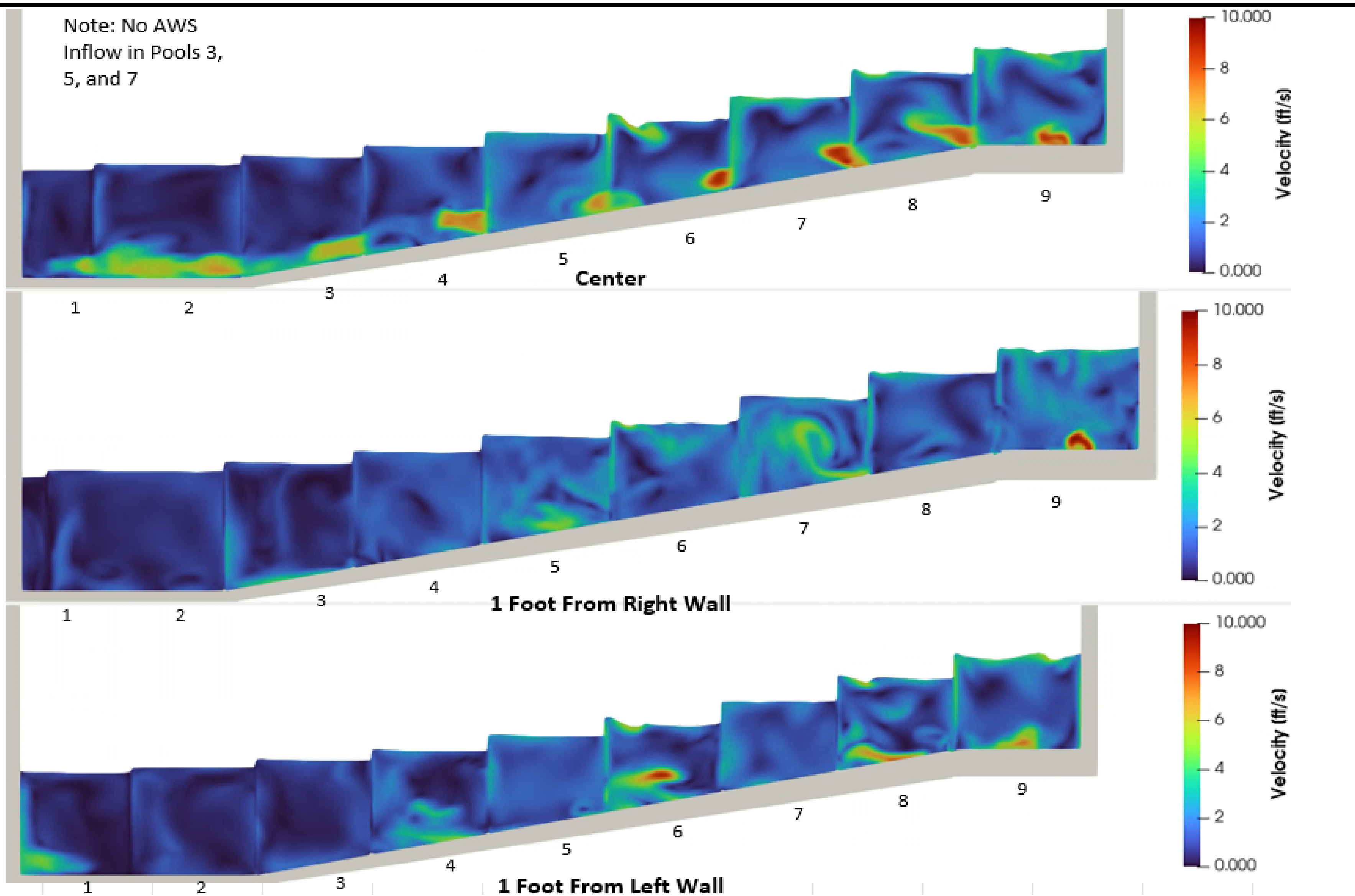


Thompson Falls **Fish Ladder CFD Analysis**	GEI Consultants	**Scenario 4 Full Model Isometric View Orifice Mode TW 2350**	
	Project 2500476	**November 2025**	**Figure 17**





Thompson Falls **Fish Ladder CFD Analysis**	GEI Consultants	**Scenario 4 Lower Pools Orifice Mode TW EL 2350 Plan View Velocity and Vorticity**
	Project 2403711	**November 2025** / **Figure 18**



Thompson Falls
Fish Ladder CFD Analysis

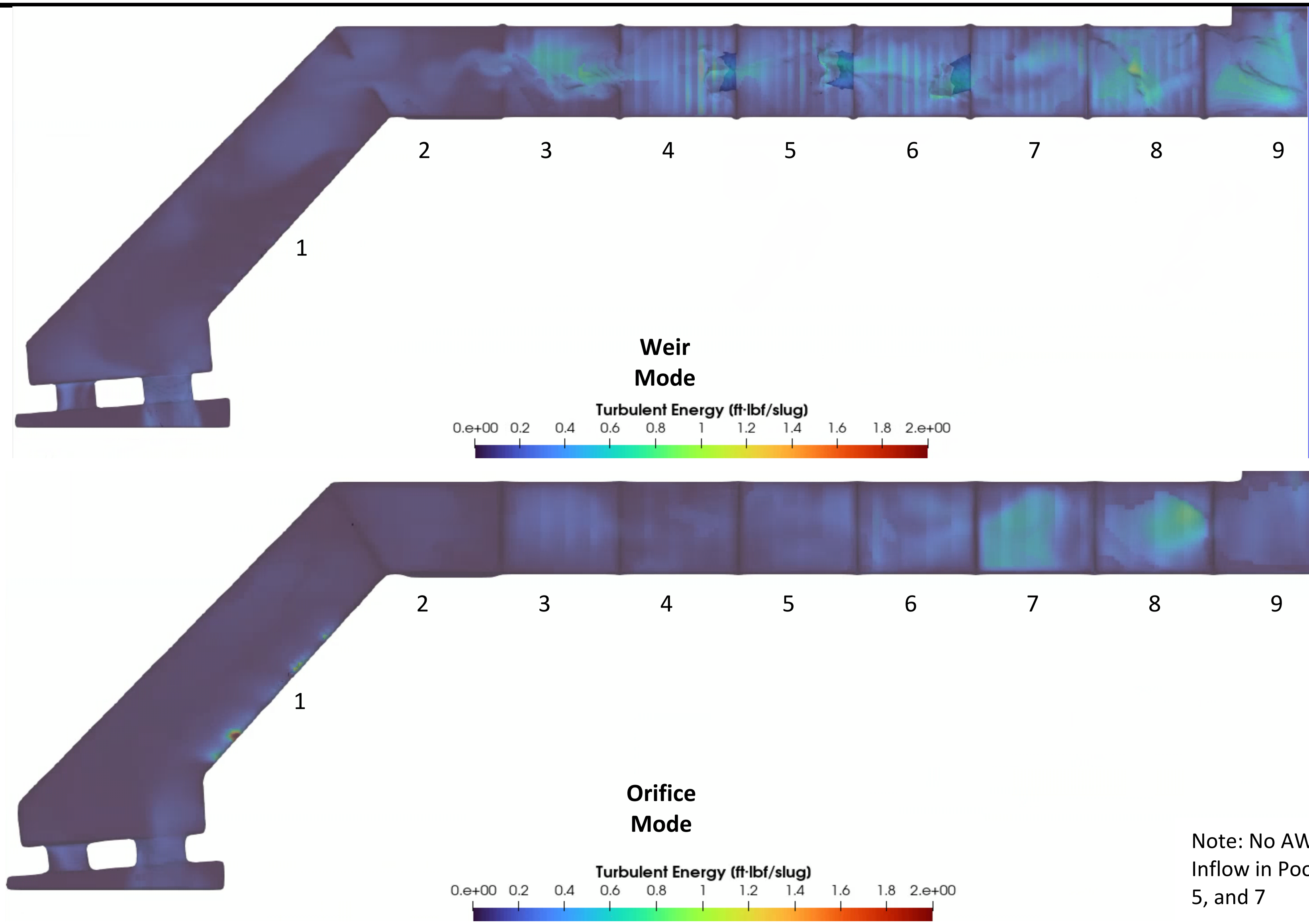
GEI Consultants

Scenario 4 Lower Pools Orifice Mode TW EL 2350 Velocity Profiles

Project 2403711

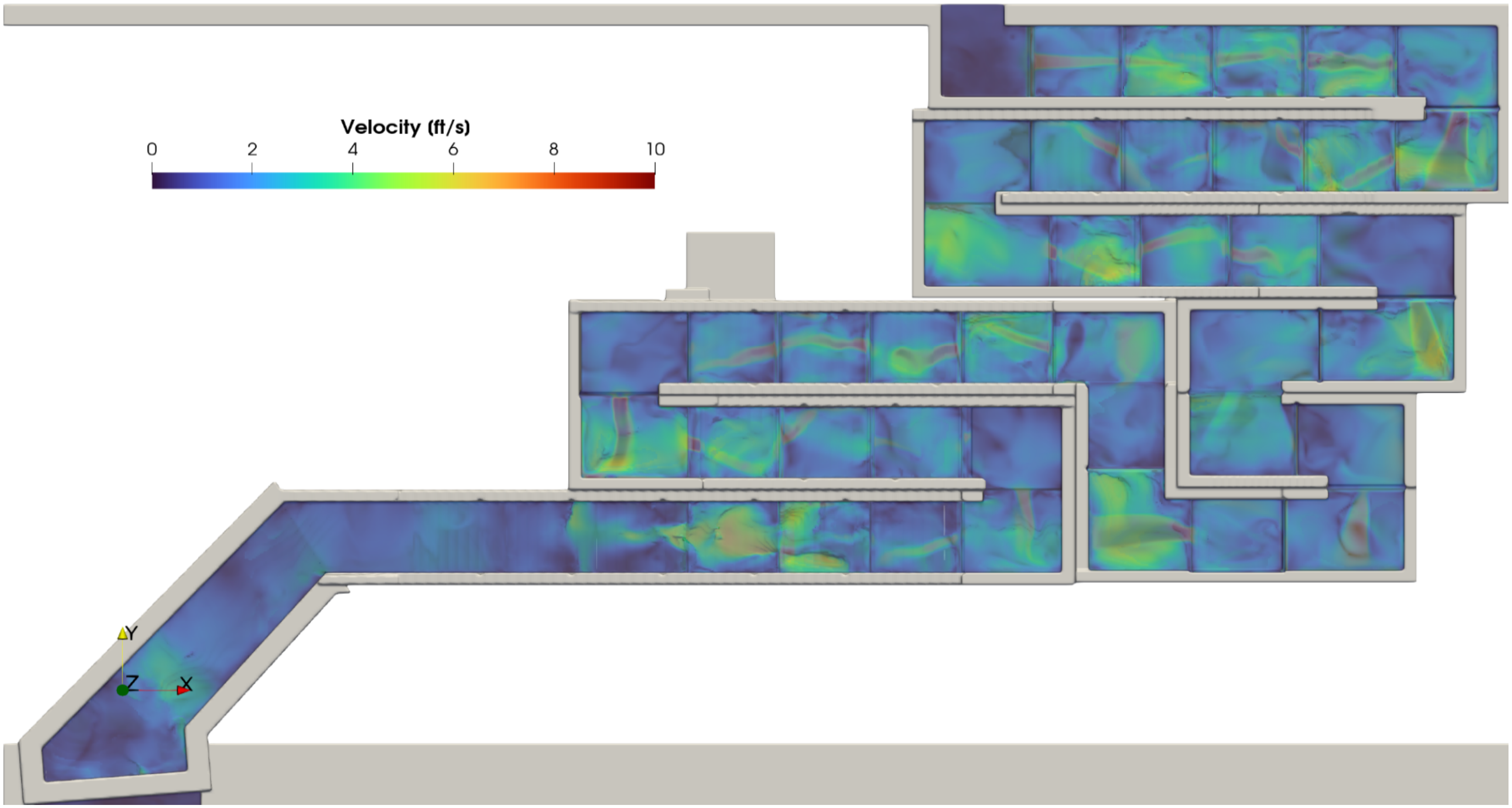
November 2025

Figure 19



Note: No AWS Inflow in Pools 3, 5, and 7

Thompson Falls Fish Ladder CFD Analysis	GEI Consultants	**Lower Pools Turbulent Energy Plan View Weir and Orifice Comparison TW EL 2350**	
	Project 2403711	**November 2025**	**Figure 20**



Thompson Falls
Fish Ladder CFD Analysis

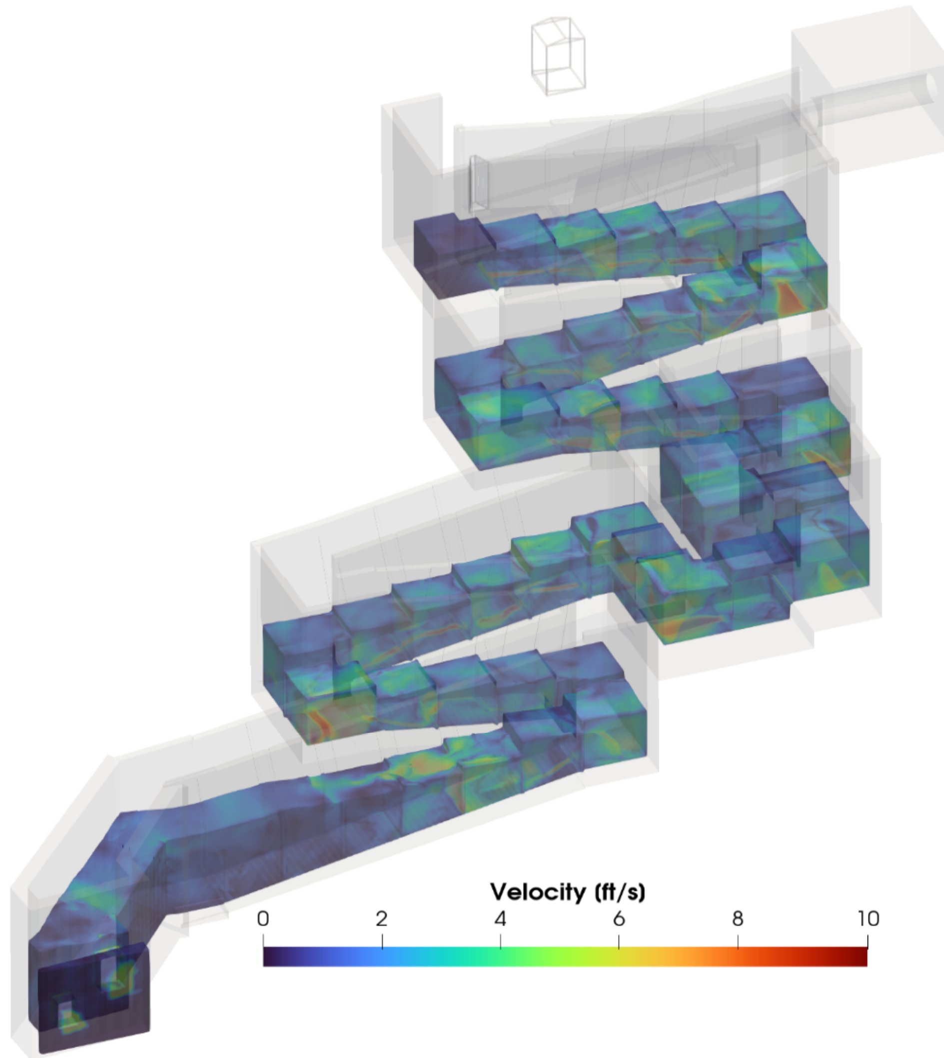
GEI Consultants

Scenario 5 Full Model Plan View
Weir Mode TW 2354 Velocity

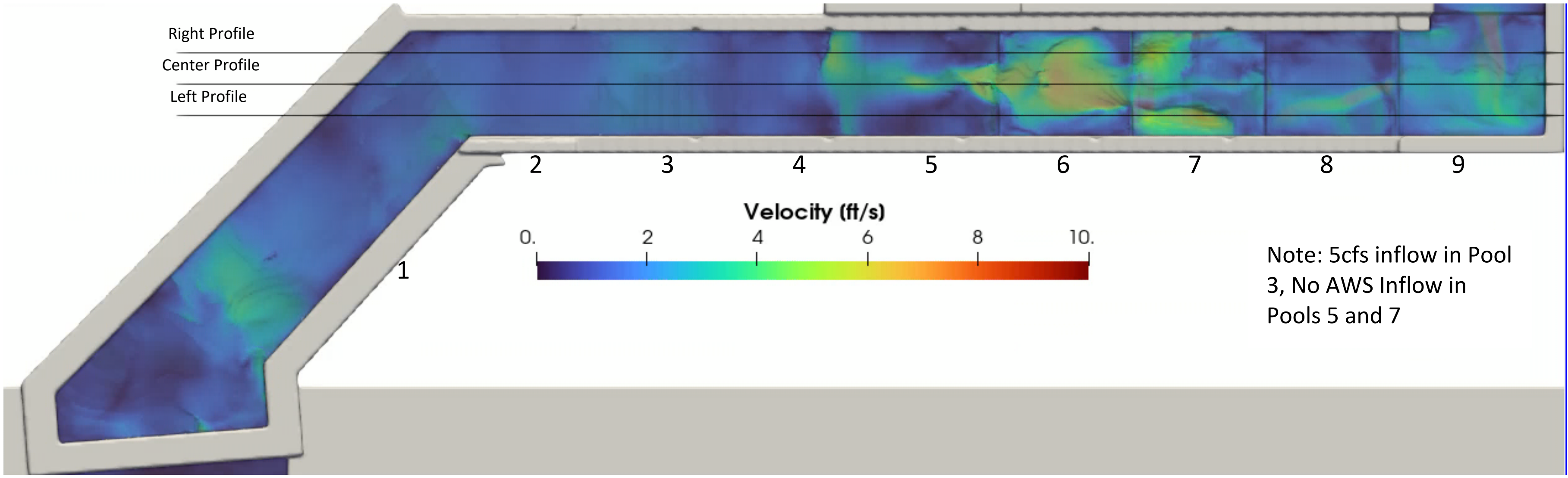
Project 2500476

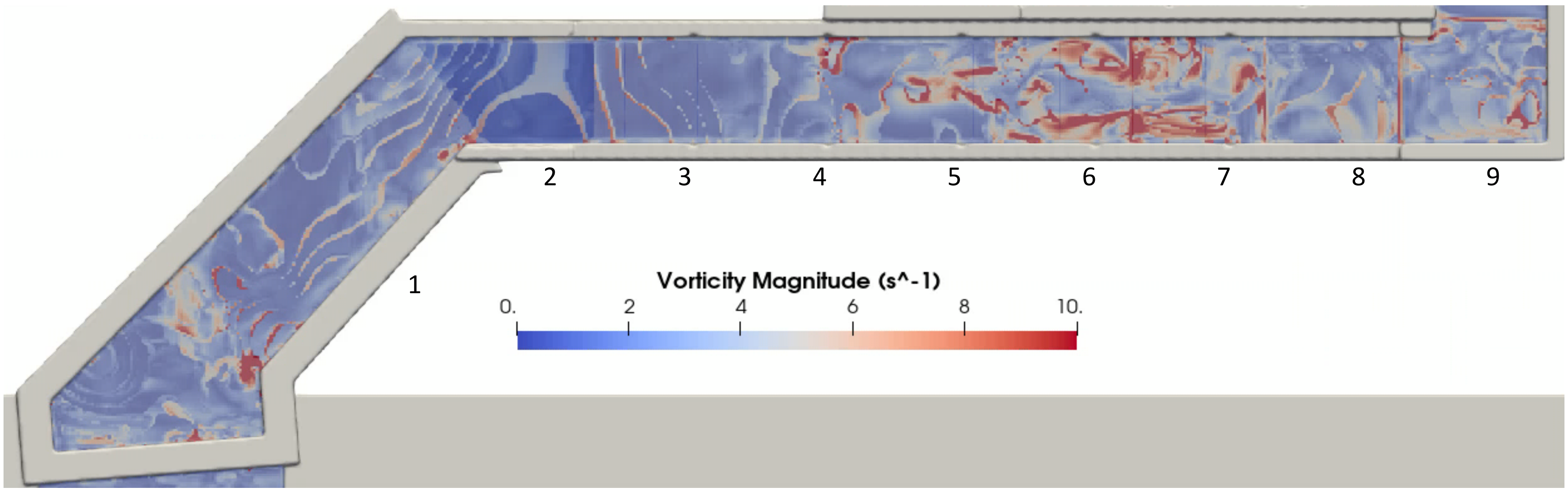
November 2025

Figure 21



Thompson Falls **Fish Ladder CFD Analysis**	GEI Consultants	**Scenario 5 Full Model Isometric View Weir Mode TW 2354**
	Project 2500476	**November 2025** / **Figure 22**



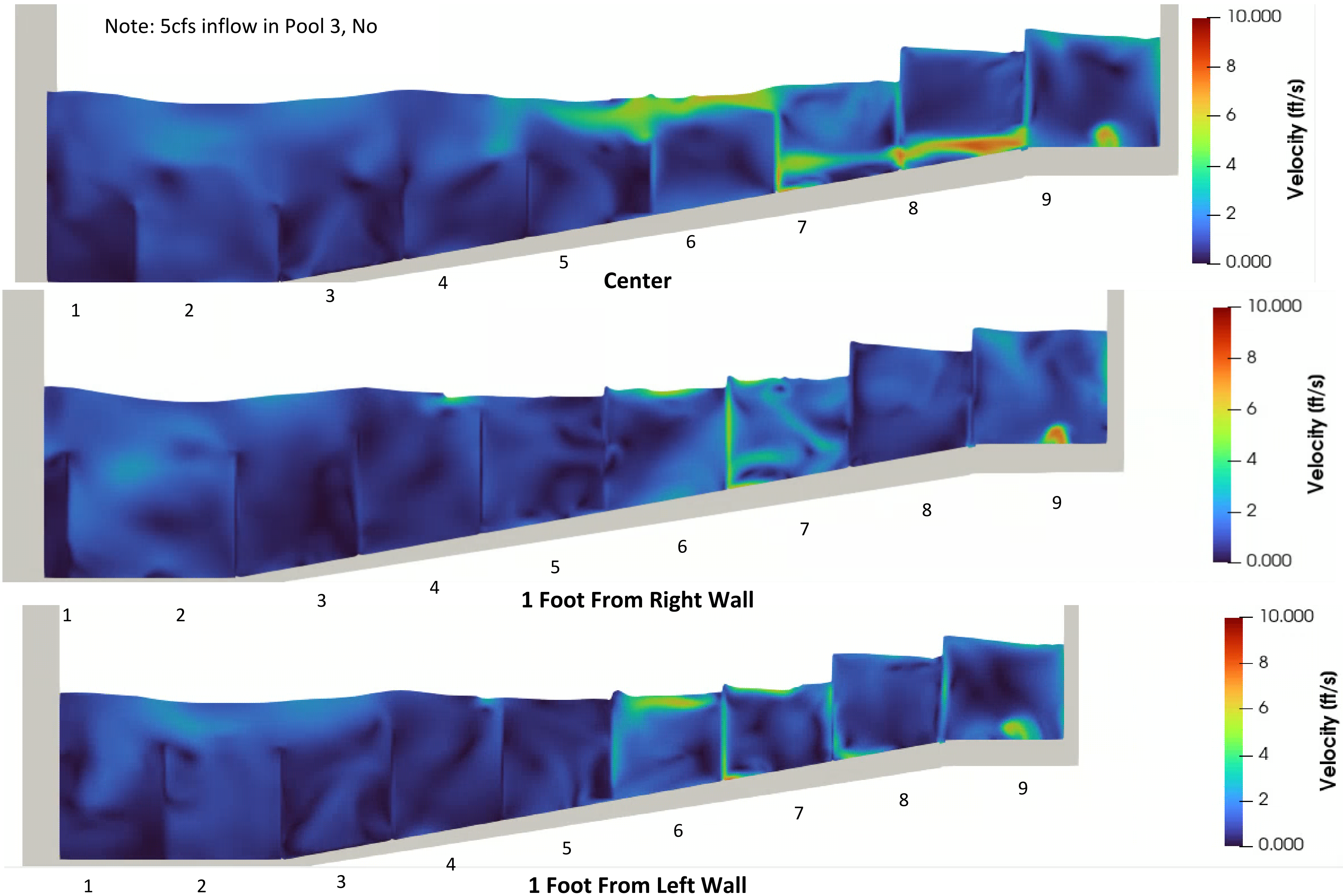


Thompson Falls
Fish Ladder CFD Analysis

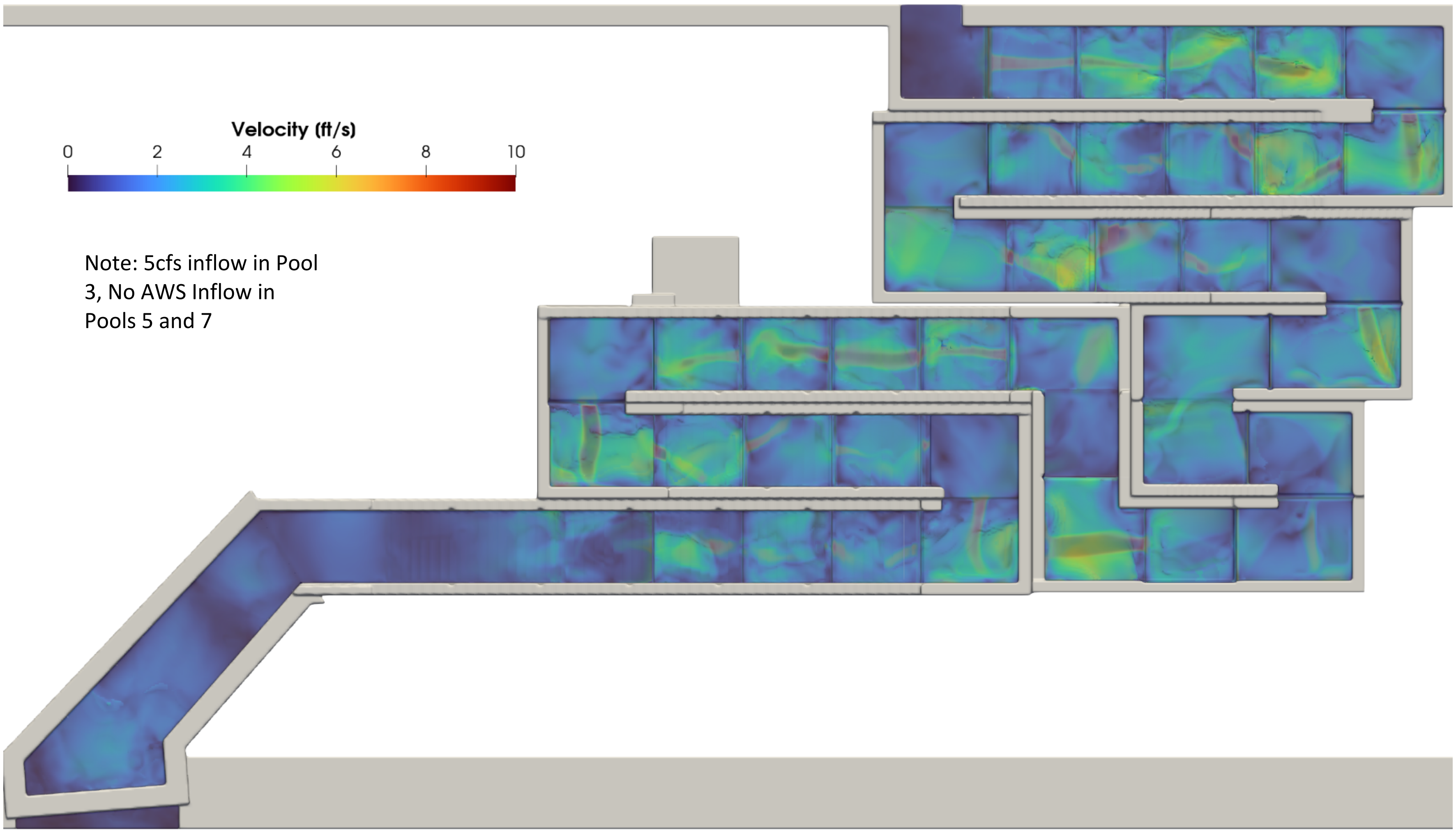
GEI Consultants

Scenario 5 Lower Pools Weir Mode TW EL 2354 Plan View Velocity and Vorticity

Project 2500476	**November 2025**	**Figure 23**



Thompson Falls Fish Ladder CFD Analysis	GEI Consultants	Scenario 5 Lower Pools Weir Mode TW EL 2354 Velocity Profiles
	Project 2403711	November 2025 — Figure 24

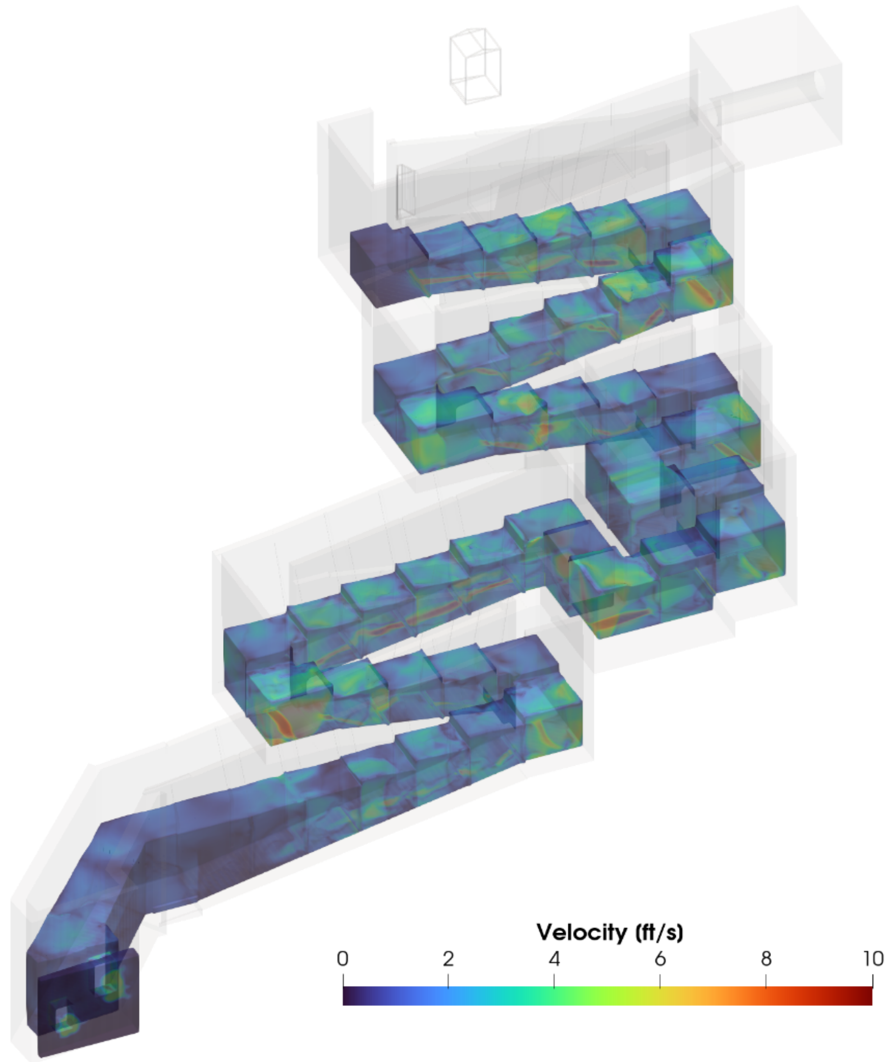


Thompson Falls
Fish Ladder CFD Analysis

GEI Consultants

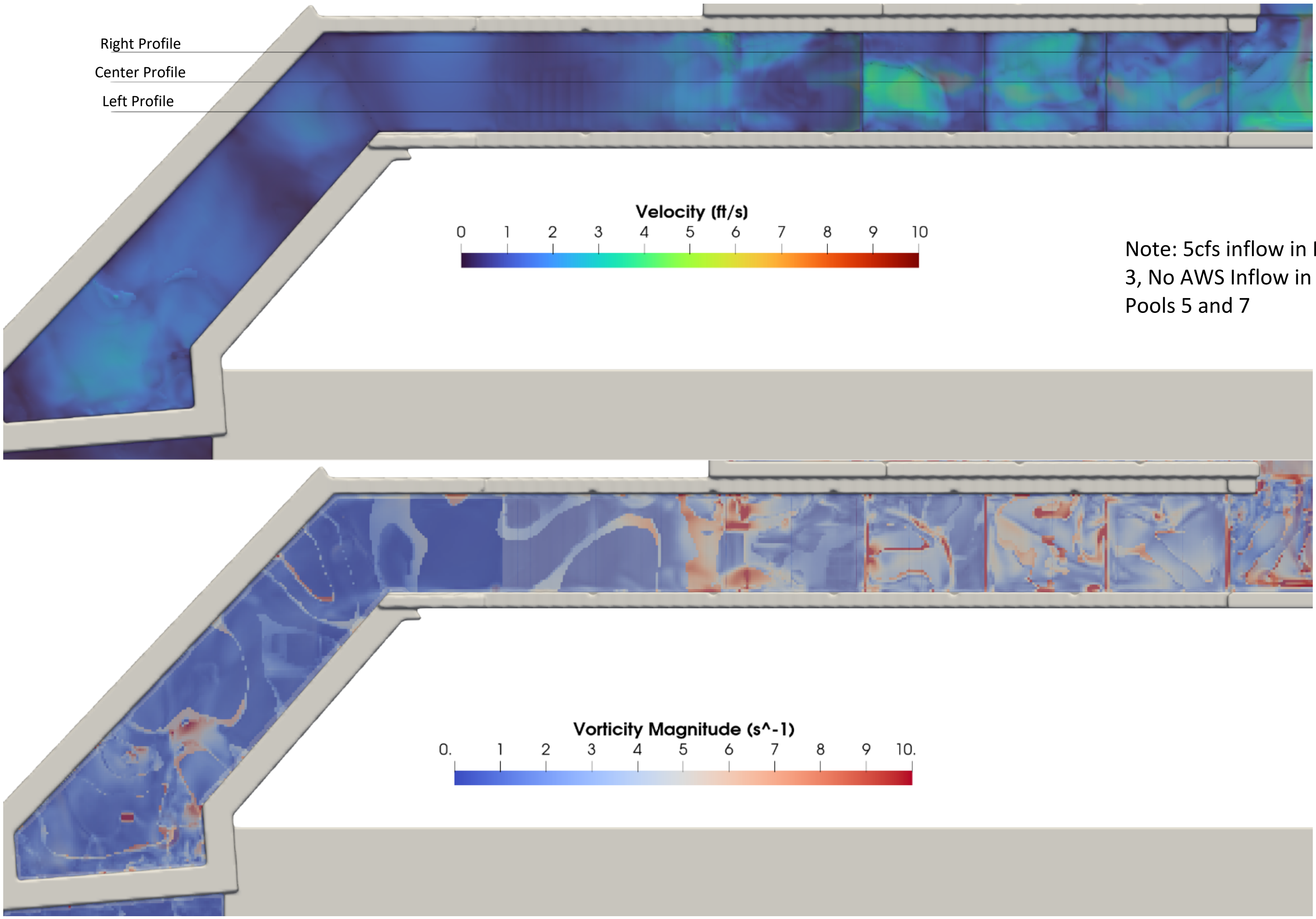
Scenario 6 Full Model Plan View Orifice Mode TW 2354 Velocity

Project 2403711	**November 2025**	**Figure 25**



Note: 5cfs inflow in Pool 3, No AWS Inflow in Pools 5 and 7

Thompson Falls Fish Ladder CFD Analysis	GEI Consultants	**Scenario 6 Full Model Isometric View Orifice Mode TW 2354**	
	Project 2403711	**November 2025**	**Figure 26**

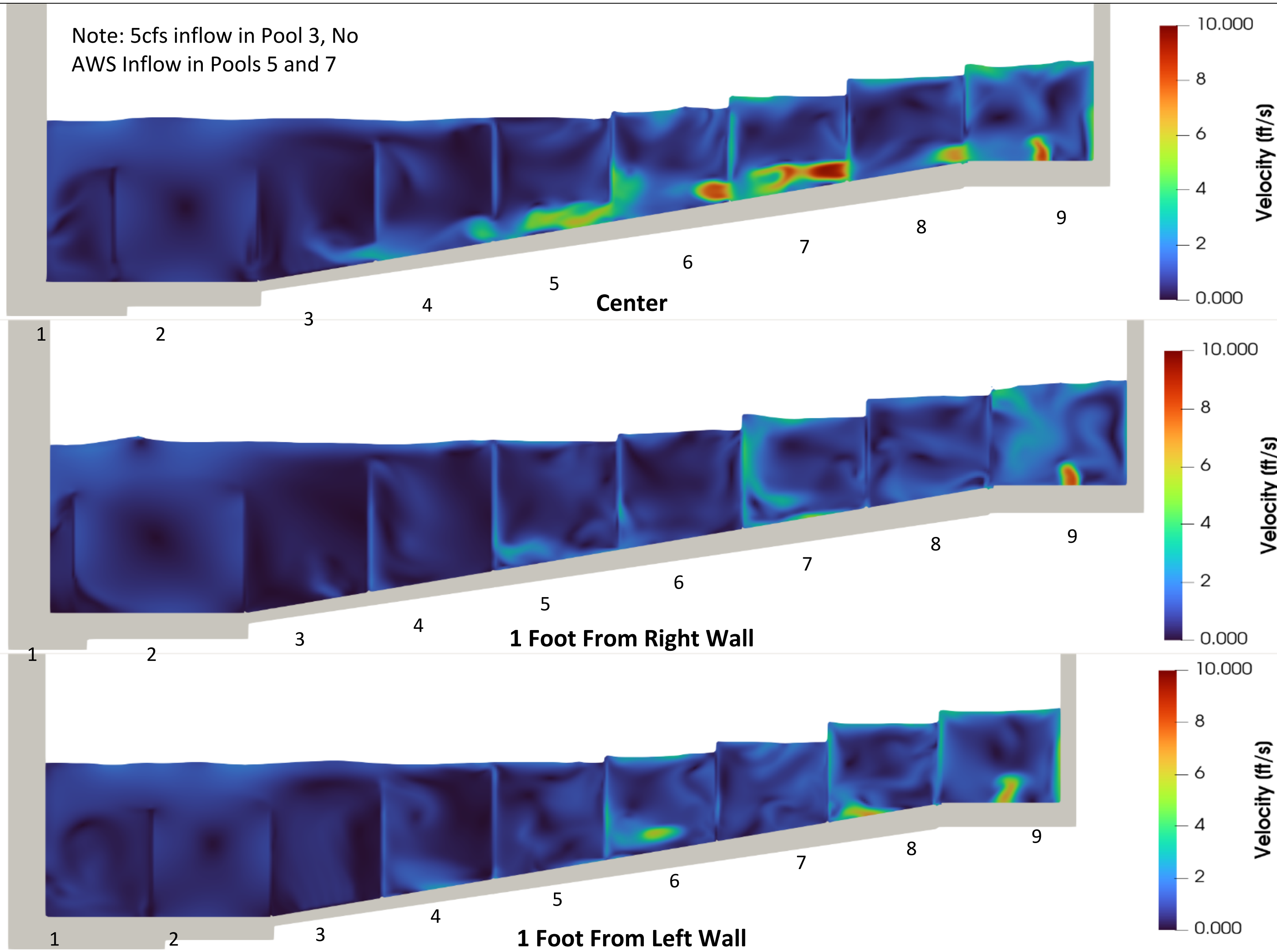


Thompson Falls
Fish Ladder CFD Analysis

GEI Consultants

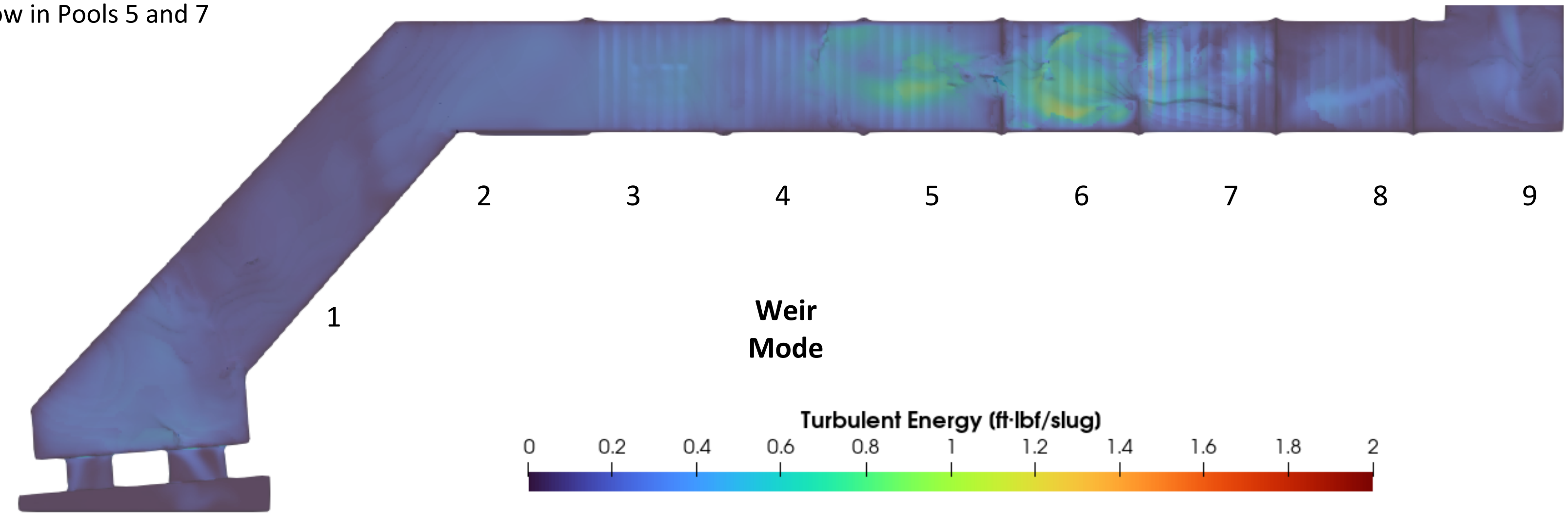
Scenario 6 Lower Pools Orifice Mode TW EL 2354 Plan View Velocity and Vorticity

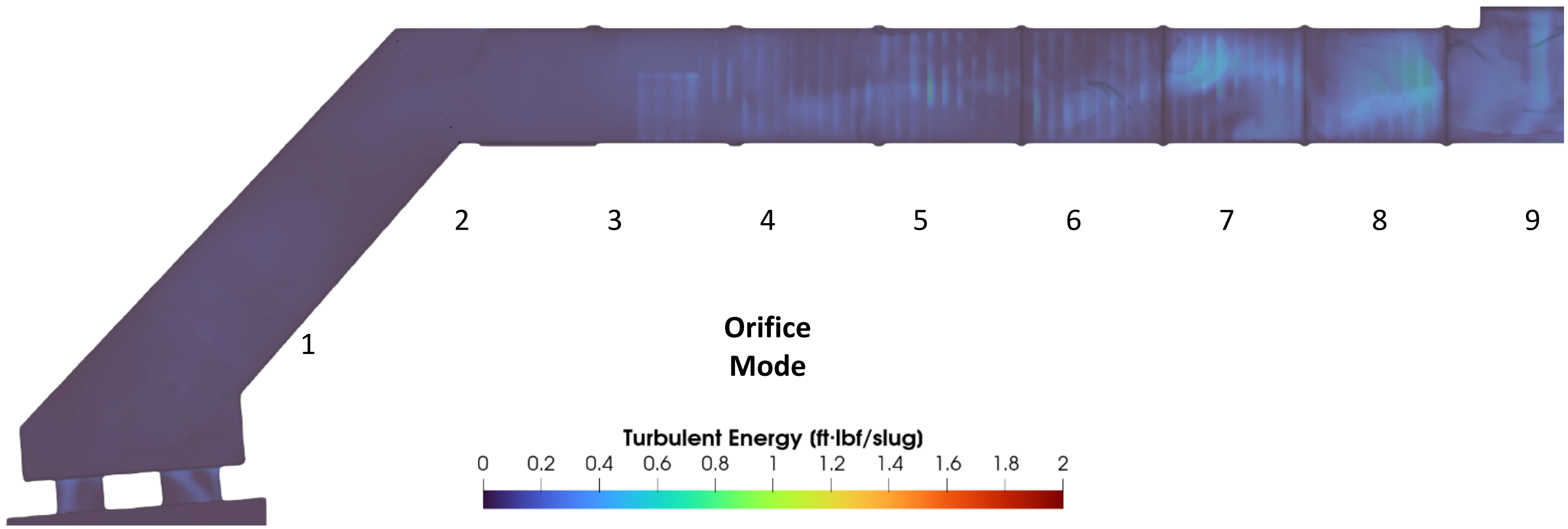
Project 2403711	**November 2025**	**Figure 27**



Thompson Falls Fish Ladder CFD Analysis	GEI Consultants	Scenario 6 Lower Pools Orifice Mode TW EL 2354 Velocity Profiles	
	Project 2403711	November 2025	Figure 28

Note: 5cfs inflow in Pool 3, No AWS Inflow in Pools 5 and 7





Thompson Falls **Fish Ladder CFD Analysis**	GEI Consultants	**Lower Pools Turbulent Energy Plan View Weir and Orifice Comparison TW EL 2354**	
	Project 2403711	**November 2025**	**Figure 29**