**U.S. Army Corps of Engineers, Portland District**

**Willamette Action Team for Ecosystem Restoration (WATER)**

***RM&E Concept Paper Format (Description of content and information to include)***

**STUDY CODE:** *Inserted by Corps*

**TITLE:** **Evaluation of Foster Dam Spillway Operations for Juvenile Fish Passage**

**BIOLOGICAL OPINION ACTION:** BiOp RPAs: 4.8, 4.11, 9.3

**MANAGEMENT PURPOSE:** *This section should address the following three elements:*

Results from this study will inform the effectiveness of the interim nighttime spillway operations during fall (October 16-December 15) and spring (March 1-June 15) months as a benefit for passing juvenile salmon and steelhead and inform timing of operational adjustments for improved downstream fish passage at Foster Dam.

The RM&E Team and Management will review the results from the study and determine if any necessary operational adjustments are required to improve downstream fish passage at Foster Dam. Additionally, the RM&E team will determine if more data is required or identify any data gaps to determine this nighttime spill operation is effective for downstream fish passage.

Data on the effectiveness of the nighttime spillway operation during fall and spring months for fish passage is required to inform management on whether this is the appropriate operation for safe fish passage at Foster Dam. The data should include timing and periods of the operation, and forebay residence time and behavior, distribution, route of passage through the dam, and downstream survival of juvenile salmon and steelhead.

**FUNDING SOURCE:** CRFM

**BACKGROUND:**

Foster Dam has three routes for water and fish to pass the dam; turbines, spillway, and a fish weir located in Spill Bay 4 of the spillway. However, the primary route for water to pass the dam is through the turbines. The spillway is only used to pass excess water as necessary. Therefore, historically the primary route for downstream migrating fish to pass the dam is through the turbines. A fish weir was installed as a surface flow outlet in the 1980s in Spill Bay 4 of the spillway and operated annually for downstream fish passage. The original operation of the weir for downstream fish passage (mainly juvenile steelhead) was for one month each year; April 15 – May 15, at a low reservoir elevation (616 ft). The Corps began operating the fish weir year-round in 2013 for fish passage and survival studies at two reservoir elevations: low winter pool at 616 ft. and high summer pool at 637 ft. These passage studies were conducted to inform structural or operational alternatives for improving downstream fish passage at the dam.

Results from multi-year studies by the Oregon Department of Fish and Wildlife (ODFW) (Romer et al 2014, 2015, 2016; Monzyk et al 2017) and Pacific Northwest National Laboratory (PNNL) (Hughes et al 2014, 2016, 2017) found large numbers of juvenile salmon and steelhead present in the reservoir and passing the dam during periods of low pool elevation (fall, winter, spring) and full pool elevation in late spring (May – mid June). Few fish passed the dam during summer months when the reservoir is at summer full pool elevation. The results from these studies also indicated the fish weir was not an effective route for fish passage, especially during low reservoir elevations, and most fish passed the dam either through the turbines or spillway, when the spillway is operated to pass excess water.

A new fish weir was designed and constructed and went into operation in March 2018. The weir was designed to have improved attraction and entrainment flows and higher discharge; with the goals of increasing passage efficiency rates, minimizing injury, and improving survival. A post-construction study was conducted during 2018 to evaluate the efficiency and effectiveness of the new fish weir at passing juvenile salmon and steelhead compared to other routes of passage (turbines and spillway) at the dam and overall improvements to fish passage and survival.

Results from the post construction study during 2018 indicate the fish collection efficiency substantially improved (by approximately 60%) compared to the old weir (Liss et al 2019). However, the direct injury and direct survival (48 hr post passage) study indicate a high rate of injury and mortality for both juvenile and adult fish (steelhead kelts) on the spillway ogee after passage through the weir. The rates of injuries at low pool elevation were 14% for juvenile Chinook salmon, 12% for steelhead and 8% for kelts, and 29% for juvenile Chinook salmon, 15% for steelhead and 41% for kelts at full pool elevation (Normandeau Associates 2019). Direct mortality (48 hr post passage) ranged from 2% for juveniles and 7% for kelts at low pool to 17% for juveniles and 11% for kelts at full pool (Normandeau Associates 2019).

The overall dam passage and survival study (active tag) indicate downstream survival rates of sub-yearling Chinook salmon were similar for the new weir compared to the old weir at low pool (82%), but decreased for yearling Chinook salmon (61% new weir vs 71% old weir) and steelhead (51% new weir vs 55% old weir) (Liss et al 2019). Downstream survival rates were similar for yearling Chinook salmon for new weir compared to the old weir at full pool (62% new weir vs 63% old weir) and improved for steelhead (83% new weir vs 76% old weir) (Liss et al 2019). Passage timing and distribution indicate 96-98% Chinook salmon and steelhead pass the dam at night and very few fish pass during daylight hours. Additionally, approximately 58% of fish pass the spillway compared to 20% passage through the turbines, and survival rates were higher at the spillway (68%) compared to the turbines (57%) (Hughes et al 2016, 2017; Liss et al 2019).

Research was conducted during 2016 through 2017 to evaluate the influence of Foster operations (turbine, spillway, and fish weir) on total dissolved gas (TDG) on river environment and fish habitat downstream of the dam. Arntzen et al (2018) found that TDG levels in the river downstream of the dam were highest (exceeding 110%) during periods when the spillway was operated by itself (i.e. with no turbine operation). However, TDG levels decreased (less than 110%) during periods of spillway, fish weir, and turbine operations (one turbine unit was operated at approximately 200 cfs flow for Station Service only). The TDG levels, even when they exceeded 110% saturation for short durations, did not appear to affect adult and juvenile salmon in the river (Arntzen et al 2018). Both of these life stages are able to seek refuge in deeper pools during periods of high TDG levels (Arntzen et al (2018). Arntzen et al (2018) suggest juvenile steelhead may be impacted because of their life stage during periods of elevated TDG levels (during periods of spillway operations without turbine operations).

The results of the studies referenced above informed the nighttime spillway operations during fall and spring months for downstream fish passage. This spill operation will be conducted in conjunction with turbine operations for Station Service (one turbine unit operating at approximately 200 cfs flow) to reduce TDG levels in the river downstream of the dam. The timing and periods of the nighttime spill operation scheduled to be conducted annually and should be evaluated for effectiveness are:

1. 7:00pm – 7:00 am during October 16-December 15
2. 7:00pm – 7:00 am during March 1-April 30
3. 8:00pm – 6:00 am during May 1-June 15

**OBJECTIVES:**

Determine if the nighttime spillway operations is a safer and efficient passage route compared to the turbines for sub-yearling and yearling Chinook salmon and age 2 winter steelhead (or appropriate surrogates) using the following metrics:

* 1. Seasonal and diel distribution, behavior, and movements for juvenile fish into and within the forebay of the dam. Document and quantify different behaviors (i.e. milling, traversing, direct downstream passage).
	2. Seasonal and diel downstream passage, including reservoir survival, forebay residency time, route distribution, dam passage efficiency, route specific survival, and dam survival.
		1. Dam survival will be measured to the confluence of the South Santiam River with the mainstem Willamette River.
	3. Efficiency and effectiveness of the nighttime spillway operation compared to the turbines.
	4. The environmental and mechanical conditions (e.g. hydraulic conditions, pressure, shear, and strike) experienced by live fish during passage at the spillway to associate with any injuries, which may occur to fish during passage.

**SCHEDULE:**

Study years: 2022 – 2023. The study will be conducted for a minimum of two years to account for interannual variability in fish behavior and environmental and operational conditions (e.g. hydrology, dam operations).

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**REFERENCES:**

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