McNary Lock and Dam

Engineering Documentation Report

Spillway PIT Detection Upgrade

Umatilla, Oregon

September 2025 Final Report

Prepared By:

U.S. Army Corps of Engineers

Walla Walla District

EXECUTIVE SUMMARY

This Engineering Documentation Report (EDR) documents engineering and biological investigations and provides a recommended prototype for additional juvenile fish passive integrated transponder (PIT) tag detection at the McNary Lock and Dam (McNary) spillway. Study goals are focused on increasing the overall number of PIT-tagged fish detected passing through the McNary spillway to improve survival estimates through the Federal Columbia River Power System (FCRPS). Pacific States Marine Fisheries Commission (PSMFC) and National Marine Fisheries Service (NMFS) supported the Project Delivery Team (PDT) by generating various design concepts for detecting PIT tagged fish through the spillway at McNary.

Eleven alternatives were proposed by PSMFC and NMFS:

1) Spillway Reshaping Insert
2) Skimming Detection Array
3) Articulation Fin Array
4) Detection Embedded Temporary Spillway Weir
5) Temporary Spillway Weir Embedded Fin Array
6) Embedded in the Existing Ogee
7) Embedded in Ogee with Reshaping
8) PIT Barges in Tailrace
9) Juvenile Bypass System Outfall Antenna
10) Split-Leaf Spillway Detection
11) Matrix Antenna PIT Detector

The PDT developed a list of criteria and constraints to evaluate each alternative. First, the alternatives were assessed according to the constraints and eliminated if the constraints were violated. A decision matrix was then used to evaluate and rank the alternatives not eliminated according to the criteria.

Alternatives 1 through 3, and 7 violated the constraints and were removed from consideration. The PDT and external stakeholders from the Fish Facilities Design Review Work Group (FFDRWG) rated each alternative on a scale of 1-5 (low to high) for each criterion. The scores were then summed, and the total was used to rank the alternatives from low to high. The top four alternatives remain in consideration, and the rest of the alternatives were screened out.

The top four alternatives are Alternative 4 (score of 28), Alternative 6 (score of 28), Alternative 8 (score of 27), and Alternative 11 (score of 29).

The PDT recommends that Alternative 11 Matrix Antenna PIT Detector be carried forward for further development in the Design Documentation Report Phase.

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PROJECT DESCRIPTION

Stream	Columbia River (river mile 292)
Reservoir	Lake Wallula
Location	Umatilla, Oregon
Owner	U.S. Army Corps of Engineers
Project Authorization	Rivers and Harbors Act of 1945
Authorized Purposes	Power, Navigation
Other Uses	Fisheries, Recreation
Minimum Instant Flow (kcfs)	Dec-Feb: 12.5 \ Mar-Nov: 50
Forebay Normal Operation Range (ft)	337’ – 340’
Tailrace Rate of Change Limit (ft)	1.5’/hour
Powerhouse Length (ft)	1,422’
Powerhouse Hydraulic Capacity (kcfs)	232 kcfs
Turbine Units (#)	14 Main Units
Turbine Generating Capacity (MW)	Rated: 980 MW \ Max: 1,127 MW
Gatewell Orifice Diameter (in)	Two 12” orifices per gatewell (6 per unit)
Spillway Length (ft)	1,310’
Spillway Hydraulic Capacity (kcfs)	2,200 kcfs
Spillbays (#)	22
Spillway Weirs (#)	2 (Bays 19-20)
Navigation Lock Length x Width (ft)	650’ x 84’ (Usable Space)
Navigation Lock Maximum Lift (ft)	75’

FISH PASSAGE FACILITIES AND FEATURES

Adult Fish Ladders:
- Washington Shore Ladder
- Oregon Shore Ladder

Juvenile Bypass System (JBS)
Juvenile Fish Transportation Facility
Extended-Length Submersible Bar Screens (ESBS)
Temporary Spillway Weirs (TSW)

Acronyms and Abbreviations

CRSO	Columbia River System Operation
EDR	Engineering Documentation Report
EL	Elevation
EMI	Electro-Magnetic Interference
ESA	Endangered Species Act
FFDRWG	Fish Facilities Design Review Work Group
FPP	Fish Passage Plan
GFE	Government-Furnished Equipment
HVAC	Heating, Ventilation, and Air Conditioning
JBS	Juvenile Bypass System
kcfs	kilo cubic feet per second
MOU	Memorandum of Understanding
MW	Mega watts
NMFS	National Marine Fisheries Service
NWFSC	Northwest Fisheries Science Center
O&M	Operation and Maintenance
PDT	Product Development Team
PIT	Passive Integrated Transponder
PSMFC	Pacific States Marine Fisheries Commission
R&D	Research and Development
RM	River Mile(s)
TSW	Temporary Spillway Weir
UPS	Uninterruptible Power Supply

USACE	U.S. Army Corps of Engineers

1. INTRODUCTION

1.1. PURPOSE AND SCOPE

The purpose of this Engineering Documentation Report (EDR) is to document engineering investigations and provide a recommended alternative for increasing the precision of system survival estimates through the installation of additional juvenile fish passive integrated transponder (PIT)-tag detection at the McNary Lock and Dam (McNary/Project). This report will assess the feasibility of installing additional juvenile fish PIT-tag detection at McNary by evaluating and comparing various alternatives.

1.2. BACKGROUND

McNary is operated with the Fish Passage Plan (FPP) and aims to minimize impacts to Endangered Species Act (ESA) listed fish. Accurate detection is vital to understand fish survival and meet ESA requirements. McNary has existing PIT detection located in the juvenile fish bypass system (JBS). Juvenile fish migrating downstream through McNary may pass through the spillway, which has no PIT-tag detection capabilities, thus bypassing the existing PIT-tag detection systems.

Juvenile salmonids pass downstream primarily in the spring and summer; however, some adults pass downstream year-round. In recent survival study from 2024, approximately 16 percent of yearling chinook and 43 percent of juvenile steelhead used the Temporary Spillway Weirs (TSW) as the route of passage (Deng et al. 2025). Only 3-4 percent of fish used the JBS, resulting in low detection rates and negatively impacting the precision of survival estimates (Deng et al. 2025).

1.3. PROJECT AUTHORIZATION

McNary Lock and Dam was authorized by the River and Harbor Act of 1945. Structural changes to the dams are within United States Army Corps of Engineers' (USACE) authority to manage the projects for fish and wildlife conservation purposes. Modifications to the projects for fish passage are funded under appropriations made for the Columbia River Fish Mitigation Program.

1.4. PROJECT LOCATION

The project is located at McNary, near Umatilla, Oregon, at river mile (RM) 292 on the Columbia River (Figure 1). Additional location details are as follows:

- Umatilla County.
- Oregon and Washington.
- Coordinates: Northeast quarter of Section 10, Township 5 North, Range 28 East, Willamette Meridian.

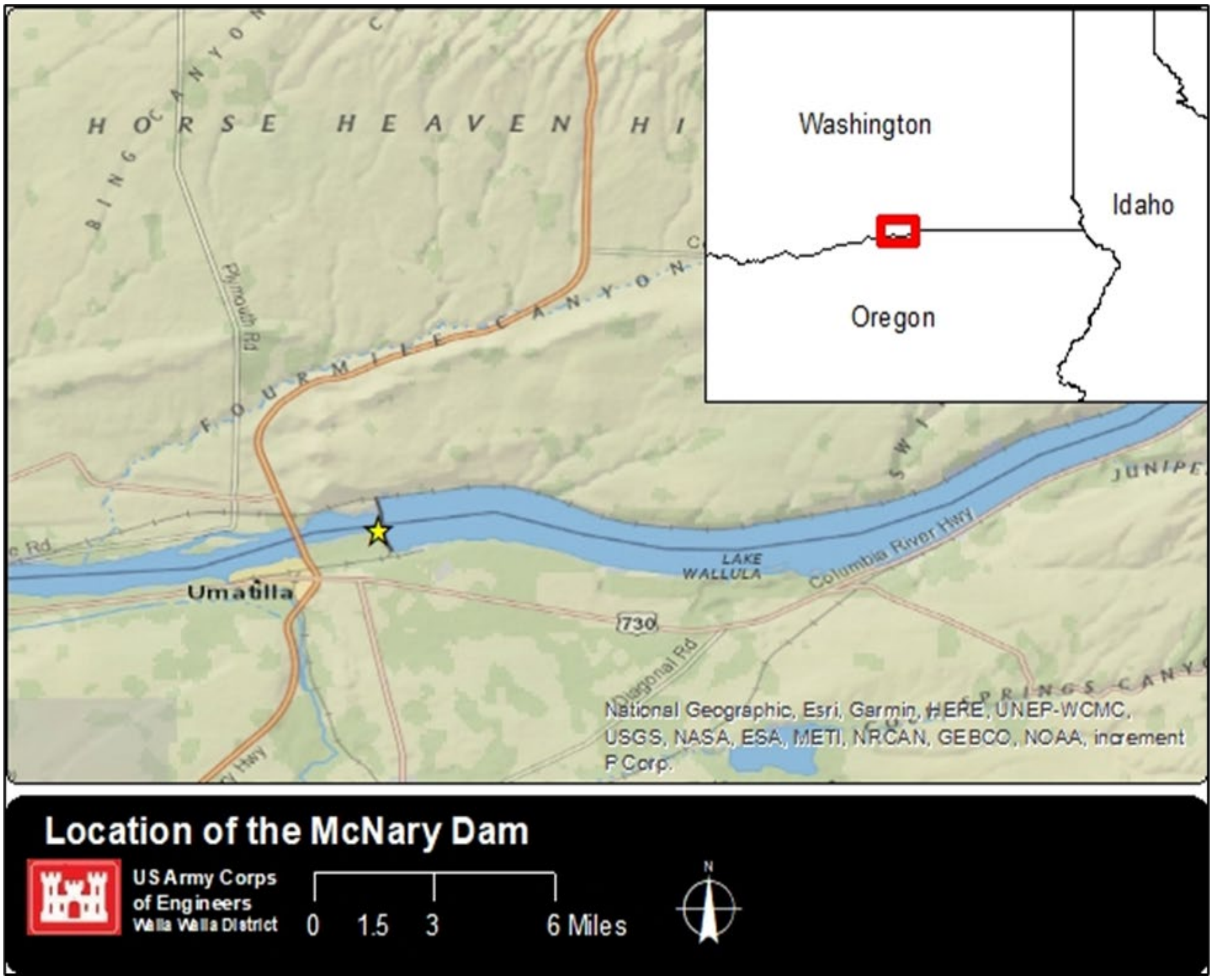


Figure 1. Project Location

2. DESCRIPTION OF MCNARY FISH PASSAGE FEATURES

2.1. JUVENILE FISH BYPASS SYSTEM

The JBS was originally installed in 1980 to guide a portion of the fish that enter the powerhouse intake (via mesh screens), divert them around the turbines and release them via bypass pipe into the tailrace downstream. The current bypass system was finished in 1994, and new extended-length submersible bar screens (ESBS) replaced the original mesh screens in 1997. The outfall pipe was relocated in 2012 to release the fish further downstream away from the tailrace.

2.2. TEMPORARY SPILLWAY WEIR

Two TSWs were added to the spillway in 2007 to allow fish to pass through the spillway near the surface. The TSWs are installed into conventional spillway bays and the weirs allow flow to spill from the surface. These structures pass a higher number of fish per volume spilled due to the better attraction for fish approaching the dam near the surface. The TSWs have historically been moved around into different spillway bays for testing but they are currently located in spillway bays 19 and 20. The TSW is a desirable place to add PIT detection at McNary. The TSWs attract and pass more fish than any other specific route in the spillway, and passage occurs near the surface where fish are more concentrated than when passing through conventional spillway gates. Furthermore, the TSW is opened for a longer duration each year to allow adult fish that overshoot their destination a safer method of downstream passage.

2.3. CONVENTIONAL SPILLWAY

The conventional spillway consists of 22 bays where water is passed underneath double spillway gates. In 2024, due to constraints with the spillway hoists and crane, the majority of the spillway gates were moved to the upstream slot and operated in a split-leaf orientation where water is passed in between the two spillway gates by only lifting the top gate with the crane to reduce the load. Current orientation of the McNary spillway is illustrated in Figure 2 (Deng et al. 2025).

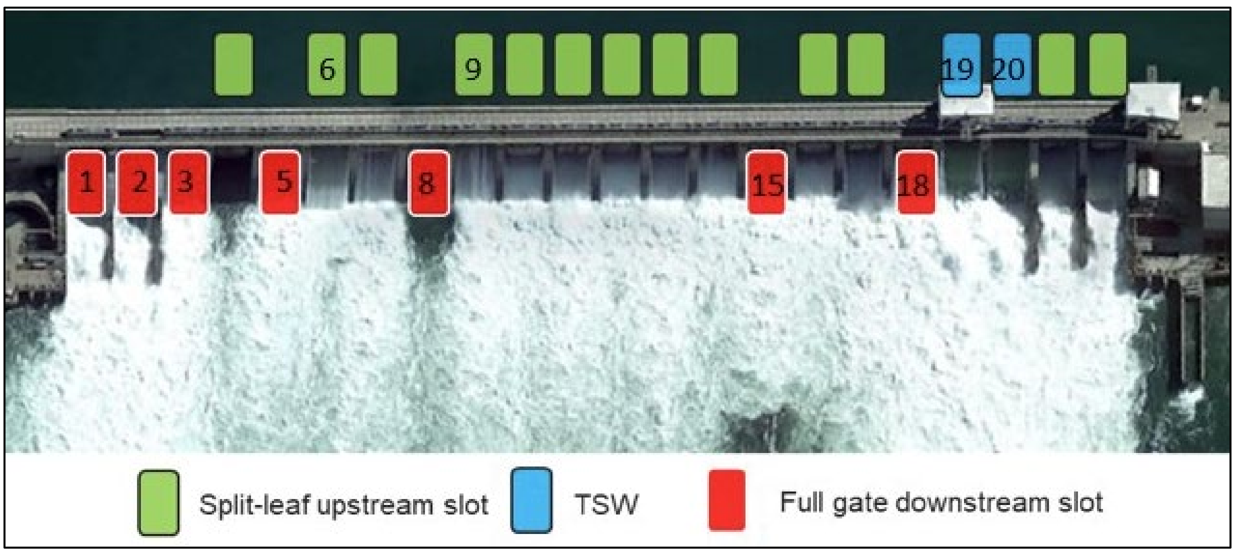


Figure 2. McNary Spillway

2.4. POWERHOUSE

McNary has 14 main Kaplan turbine units for generating electricity. Fish that are not guided into the JBS by the fish screens enter the powerhouse intake and are passed through the scroll case, the turbine runner, and the draft tube before entering the tailrace.

2.5. ADULT FISH LADDERS ON OREGON AND WASHINGTON SHORE

McNary has two fish ladders for passing adult fish upstream. One ladder is located on the Oregon (south) side of the river and the other on the Washington (north) side. The fish ladders include a powerhouse fish collection channel and three separate entrance areas for fish to the enter the ladders from downstream.

3. PROBLEM STATEMENT

Estimating survival of juvenile salmonids through the Columbia River System (CRS), has been a key component of the National Marine Fisheries Service (NMFS) Biological Opinions and is included in Term and Condition #1 in the 2020 CRS Biological Opinion. Estimation of this metric is dependent on detecting PIT-tagged fish migrating downstream at McNary. Currently, detection of PIT-tagged fish requires passage through the JBS.

In recent years, the relative proportion of water passing through the spillway has increased to meet Endangered Species Act (ESA) and 2019 NMFS Biological Opinion requirements, increasing the number of fish passing the spillway and decreasing the number passing via the JBS. This has resulted in reduced numbers of fish passing through the JBS, thereby reducing the overall detection of PIT-tagged fish at McNary and subsequently, the ability to precisely estimate system survival.

Regional stakeholders have consequently requested that the Action Agencies increase detection capability at McNary. Conservation Recommendation #8 of the 2020 NMFS Biological Opinion also directed the Action Agencies to “Investigate and install, if feasible, a PIT detection system at McNary that improves the Snake River reach survival estimate by detecting a portion of spillway passed fish”.

The goal of this study is to increase the detection of PIT-tagged juvenile fish passing through the McNary spillway. Passage of detected fish are deemed “dedicated,” where they could not turn around and move back upstream or pass through a different route.

4. CONSTRAINTS AND CRITERIA

4.1. CONSTRAINTS

Constraints will be used to define the physical and schedule limitations of the alternative. Universal constraints are resource, legal, or policy considerations that limit the range or type of actions that could be implemented. All USACE projects must comply with Federal and applicable state and local laws, regulations, and policies. For example, safe operation of the dam is required to continue protection of downstream communities and invested entities from unnecessary risk. Regardless of how effective the prototype is at fish detection, if it places the project into an unsafe or unstable state, the prototype is unacceptable. Additionally, the alternatives must consider the impact to the structural integrity of the dam and its capacity to meet all dam safety requirements. The constraints of this project place limitations on an alternative’s impact to the dam’s structure and must fit within the existing infrastructure and flow surfaces at McNary.

The constraints considered for the alternatives are as follows:

- Prototype must fit within existing infrastructure.
- Prototype cannot impede fish passage or have a measurable increase in fish injury or mortality.

- Prototype cannot prevent emergency spilling requirements.
- Prototype cannot impact dam structure or prevent operations required for safety or regular and reoccurring maintenance.
- Prototype must be based on technology that either exists or could exist by time of construction.

4.2. CRITERIA

For the purpose of this evaluation, criteria will be used as a means to evaluate the effectiveness of each alternative at achieving a specific performance goal of the design. Criteria were developed in coordination with the Fish Facilities Design Review Work Group (FFDRWG) to ensure collaboration for a thorough analysis. The criteria used for evaluation and comparison of the alternatives are as follows:

- Detection Delta.
- Durability and Reliability.
- Routine O&M.
- Constructability.
- Hydraulics.
- Fish Behavior.
- Research and Development.
- Cost.

4.2.1. Detection Delta

This criterion is valued on the estimated percentage of PIT tag detection expected from implementing the different alternatives. Each alternative has an estimated detection coverage and efficiency that was determined with the help of Pacific States Marine Fisheries Commission (PSMFC), and a proportion of fish passage was estimated for each alternative based on the Acoustic Tag Study from 2024 (Deng et al. 2025)

4.2.2. Durability and Reliability

The long-term durability and reliability are important to maintain accurate detections during operation, limit the possible points of failure, and minimize downtime in the event of a system failure. Each alternative will be evaluated on its likely resilience to damage and/or malfunction, and how long the system will be down for repair in the event of malfunction. The alternatives will also be evaluated on how reliable the system is to continue providing accurate readings in harsh environmental conditions such as turbulent waters and passing debris.

4.2.3. Routine O&M

Each design concept will be evaluated on the added burden of day-to-day operations and maintenance expected to keep the system functioning properly. This could include tasks like clearing the system of debris; moving the system for other routine tasks; or if it interferes with gate operation, fixing any mechanical parts that may get damaged or stuck; or any other adjustments. Each alternative interacts with the spillway in a different way and brings its own potential for routine burden.

4.2.4. Constructability

The constructability determines the alternative's level of difficulty to install. This includes any structural, mechanical, and electrical construction requirements for a completely functional system to be installed. Some obstacles that may be faced during construction include space limitations for the new electrical equipment required, transceiver cable length limits, structural integrity of new or existing spillway features, extensive spillway or TSW modifications, or concrete and underwater work.

4.2.5. Hydraulics

The hydraulic criteria that will be used to evaluate the alternatives were based on how the presence of the prototype will affect dam safety. The hydraulics criteria are used to evaluate how the presence of each design concept will affect the flow of water. Attention is given to how the concept may impact flow volume, flow characteristics and associated fish passage and survival impact. Concepts will be evaluated based on ability to prevent harmful fish passage conditions such as increased shear and collision potential as well as infrastructure changes leading to reduction in project ability to pass flow.

4.2.6. Fish Behavior

It is important to consider whether a prototype placed in the spillway will injure fish or affect their likelihood to pass through the PIT detection system or not. Each alternative will be evaluated on its expected effect on fish behavior. Fish can be deterred from entering a PIT detection system by many factors including turbulent waters, vibrations from the mechanical components of the prototype, or obstacles in the fish passage path.

4.2.7. Research and Development

Depending on the complexity of a design concept and whether the concept has been tested previously can determine the amount of research and development required to progress a design from conceptual to functional. Each alternative will be evaluated on the expected level of research and development it will require to have a functioning prototype ready to install. If a design features complex systems and mechanisms or new technology not previously tested, then one could expect a longer lead time before a functioning prototype is available. A simpler design with less complex features and technology that has been previously tested and used could be developed more quickly and ready for implementation sooner with a higher confidence of success.

4.2.8. Cost

Each alternative will be evaluated by its expected cost. Since the designs are conceptual, a rough order of magnitude cost estimate will be used to predict how much each concept would cost to research, develop, and implement.

5. ALTERNATIVES DEVELOPMENT

Alternatives were initially developed by PSMFC and NMFS technical experts with collaboration from the USACE PDT. Certain considerations were used to produce conceptual designs, which included biological, hydraulic, structural, electrical, and mechanical aspects.

The location of the TSW is important to fish passage and how the hydraulics will affect the fish survivability. The TSW are in spill bays 19 and 20, which aligns the outfall with the original thalweg of the river, providing the best egress through the tailrace for juvenile fish passing the TSW. The flows from bays 18 and 22 help channel the TSW flow downstream. These factors optimize fish survivability and egress times. Additionally, the TSW has the highest number of fish per volume spilled and therefore presents the best location to detect a large percentage of fish passing the dam.

The degree of turbulence the water will have when it passes near the PIT tag detection antenna must also be considered. The overall efficiency of the antennas to detect PIT tags correlates with the degree of turbulence within the flow. True laminar flow is not achievable for any fish passage routes at the McNary, as velocities to achieve such flow would be considerably low. However, the degree of turbulence can vary significantly between proposed alternatives, allowing for favorable (low turbulence) and unfavorable (high turbulence) flow distinctions.

Low turbulence flow is preferred because the fish can retain their orientation in the water column as they pass near the antenna, providing an easy “target” for the antenna to detect and record the PIT tag, as opposed to high turbulence flow where the fish are less likely to retain their orientation in the water column due to the random nature of the flow. In high turbulence flow, the fish are more likely to “tumble” past the antenna, resulting in orientation issues and reducing the chance of detecting the PIT tag.

The alternatives considered in this report have very little impact to the structure of the dam except for the embedded antenna design, which would require extensive concrete work in the ogee. Any concrete demolition will be limited to preserve the structural integrity of the affected system and removal of any ferrous supporting materials (rebar, etc.) will need to be replaced with a suitable non-ferrous material to maintain structural integrity. However, most alternatives are installed into the existing gate slots and a couple installed downstream outside of the dam structure.

Mechanical and electrical design considerations are as follows:

- Minimize radio frequency interference (RFI) and electromagnetic interference (EMI) by providing “clean” power.
- Provide “clean” power source and isolated ground (where necessary) for transceiver system. This is to minimize radio and electrical interference.
- Power conditioners will be installed where necessary to provide “clean” power.
- Backup power will be provided for each transceiver through an uninterruptible power supply (UPS). Backup power is already provided by PSMFC for their data collection equipment.
- Provide an environmentally controlled location, such as a room, for PSMFC data collection equipment and electronics. This can be provided by existing PIT tag rooms where data collection capacity and logistics allow.
- Transceivers will most likely be installed outdoors. A sun and rain shield will be provided for outdoor transceiver panels to provide protection from heating and moisture when panels are open for maintenance.
- Installation of transceiver power and data transmission could be temporary (for prototype purposes) and made permanent later.
- Transceiver panels, cabling, etc., will need to be protected from routine O&M hazards.
- The spillway is currently limited for space and a location elsewhere at the project might need to be considered. If the FS3001 transceivers are to be used, then this distance between the antennas and the transceivers will be a significant consideration due to the maximum cable length of 150 feet between the antennas and transceivers.
- The mechanical design will support the data collection infrastructure through heating, ventilation, and air conditioning (HVAC) design, and any other mechanical requirements of the prototype design and installation.
- The physical weight of an alternative needs to be considered for any system that is hoisted in and out of the spillway gate slots and can’t exceed the existing gate hoist or crane lifting capacity.

6. ALTERNATIVES

The following eleven alternatives were originally identified as potential solutions for increasing the overall number of PIT-tagged fish detected passing McNary. (Refer to Appendix B for conceptual designs of alternatives.)

1. Spillway Reshaping Insert
2. Skimming Detection Array

3. Articulation Fin Array
4. TSW Embedded PIT Detectors
5. TSW Embedded Fin Array
6. Embedded in the Existing Ogee
7. Embedded in Ogee with Reshaping
8. PIT Barges in Tailrace
9. JBS Outfall Antenna
10. Split-Leaf Spillway Detection
11. Matrix Antenna PIT Detector

Alternatives 1 and 2 were eliminated due to the reduction of flow capacities in the spillway. Alternatives 3 and 7 were eliminated due to preventing timely closure of the TSW since the alternatives would have to be removed before the top gate could be lowered into the slot. Applying the evaluation criteria on the remaining alternatives resulted in three more Alternatives (5, 9, and 10) eliminated from consideration. Alternative 5 was screened due to the required additional research and development, resulting in low confidence that the detection would perform as needed in a timely manner. Alternative 9 was screened due to the low detection coverage, especially for the target spillway passed fish, and concerns over durability and routine O&M. Finally, Alternative 10 was screened due to concerns over durability and required additional research and development. This screening process resulted in Alternatives 4, 6, 8, and 11 carried forward for further analysis.

6.1. ALTERNATIVE 4 – TSW EMBEDDED PIT DETECTORS

6.1.1. General Description

There are two TSWs located in spill bays 19 and 20. This alternative would embed five antennas into the surface of one of the TSW crests (Refer to Figures 3 and 4 and Appendix B). PIT tags passing over the TSW and within the vertical detection range of the antennas would be detected and recorded. This design would work best with the FS3001 transceivers to maximize vertical detection range over the TSW. The FS3001 transceivers allow for larger antennas to be used with a maximum detection range of approximately 50 inches. Due to the cable length limitations, the transceivers need to be located within 150 feet of the antennas. However, there is limited space on the spillway deck and around the TSW bays due to the spillway gate hoists sitting on the deck, it is likely one of the TSWs would need to be moved to bay 22 to accommodate an electronics shelter on the powerhouse tailrace deck. This alternative could also be designed with the smaller IS1001 transceivers and antennas, but the detection range would be limited to approximately 30 inches. This would allow the transceivers to be mounted in the TSW with the antennas, eliminating any cable length limitations. Since the TSW is made from ferrous steel, the embedded surface needs to be shielded with a non-ferrous material to prevent interference with the antennas but still be strong enough to support the weight of a bulkhead sitting on top of the TSW.

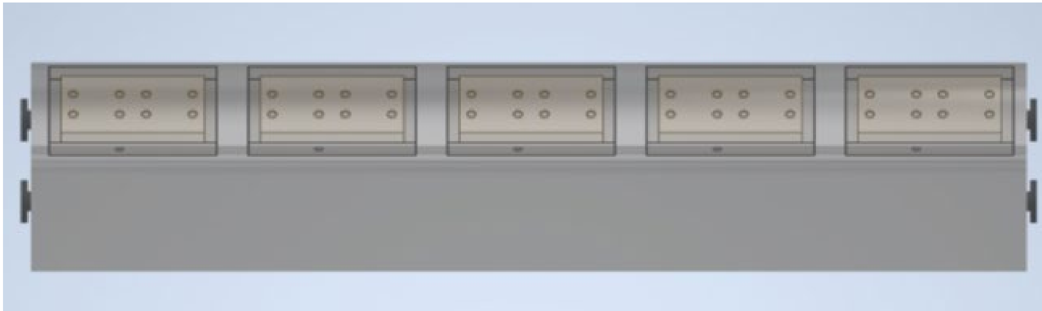


Figure 3. Alternative 4 Conceptual Design (Front View)

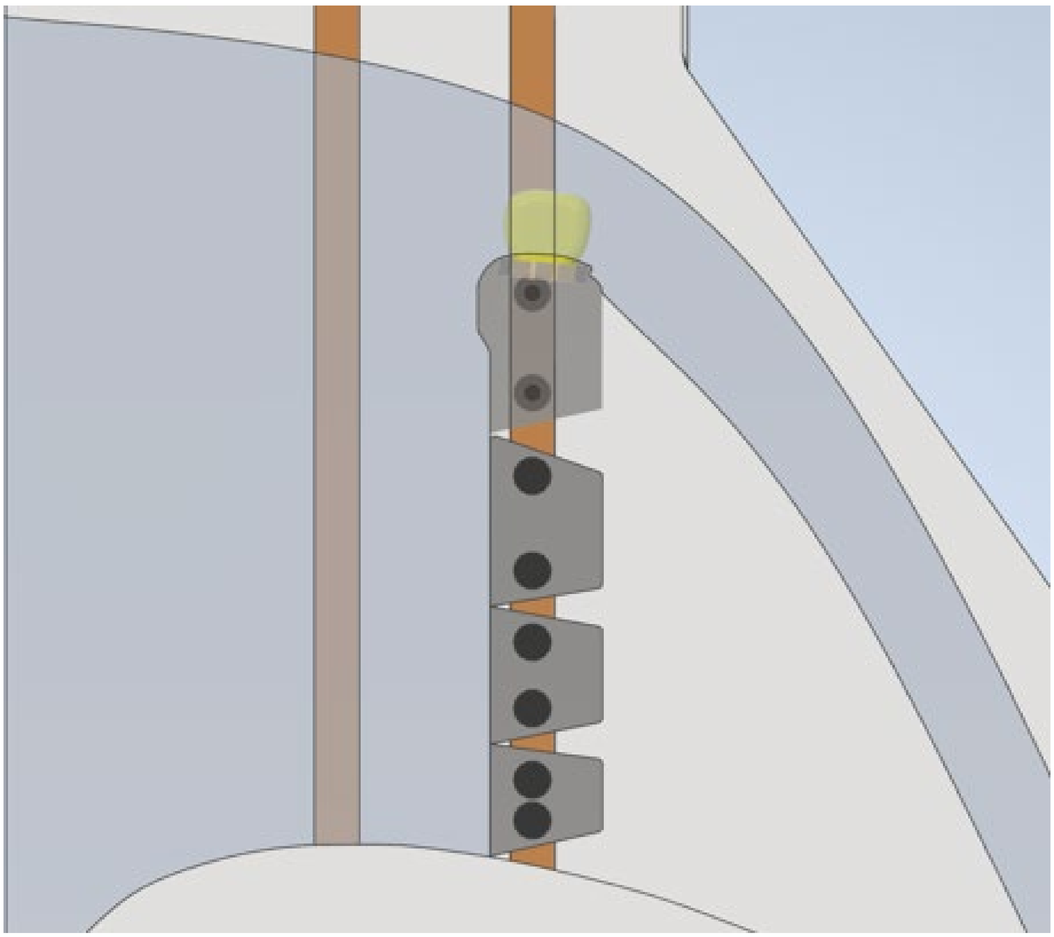


Figure 4. Alternative 4 Conceptual Design (Side View)
Note: Yellow is detection range.

6.1.2. Structural Design Components

A new TSW will be required, and a non-ferrous material will need to be used at the crest’s surface where the antennas are embedded. The structural integrity can’t be compromised and must be able to support the weight of a of an upper bulkhead without damaging the TSW or the embedded antennas where the bulkhead would sit. Structural analysis of the new TSW design will be required to ensure it can withstand the hydraulic forces and weight of an upper closure bulkhead.

6.1.3. Electrical Design Components

To maximize detection capabilities of this alternative, the FS3001 transceivers would be used to drive 8.5' x 5' antennas. These antennas with the FS3001 transceivers would provide approximately 50 inches of vertical detection over the crest of the TSW. The FS3001 transceiver is housed inside a 36" x 36"x 10" enclosure, and the power supply is housed in a 24" x 24" x 10" enclosure. Due to space limitations on the spillway deck, the IS1001 transceivers can be used with smaller antennas, which would allow the transceivers to be mounted in the TSW with the antennas; however, this would result in a shorter detection range of approximately 30 inches, and the transceivers would need to be protected in a watertight enclosure or sealed to prevent water damage. Power will be provided to the transceivers and fiber optics will be provided for PIT tag data transmission to PSMFC data collection electronics.

6.1.4. Mechanical Design Components

The weight of the TSW cannot exceed the lifting capabilities of the hoists and/or cranes at the spillway. If the FS3001 transceivers are used, extra cooling equipment will be required to keep the FS3001 transceivers from overheating whereas the IS1001 transceivers do not require cooling equipment.

6.1.5. Biological Considerations

Assuming the detector is the same shape as the existing TSW crest, there should be no additional biological impacts. However, if the TSW is moved to spill bay 22 to accommodate the FS3001 transceivers then there are concerns with increased entrainment and egress times due to its proximity to the powerhouse flow for fish trying to pass over the TSW. A research study conducted by USGS from 2006-2009 using acoustic telemetry tags to determine juvenile fish survival estimates at McNary showed lower survival rates, especially for juvenile steelhead, when the TSW was located in bay 22 in 2007 (Adams 2011).

6.2. ALTERNATIVE 6 – EMBEDDED IN THE EXISTING OGEE

6.2.1. General Description

This alternative would utilize an array of 11 antennas embedded in the concrete of the ogee in spill bay 22 (Figures 5 and 6). These antennas would be driven by the FS3001 transceivers providing approximately 50 inches of vertical detection right around the spill's point of contact to maximize the potential for fish detection. Currently the two TSWs are in spill bays 19 and 20 but due to distance constraints of the FS3001 transceivers, one TSW would need to be relocated to spill bay 22. There would be significant concrete work done in the spillway to install the antennas, and all the ferrous metal rebar would need to be replaced with a non-ferrous material without compromising the structural integrity of the ogee.

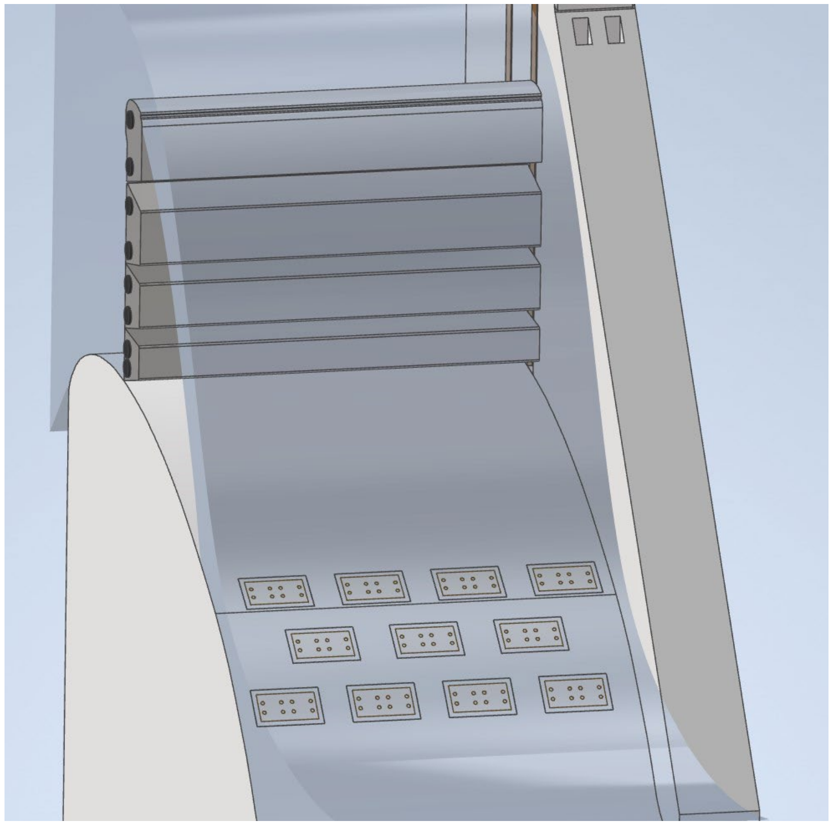


Figure 5. Alternative 6 Conceptual Design (Front View)

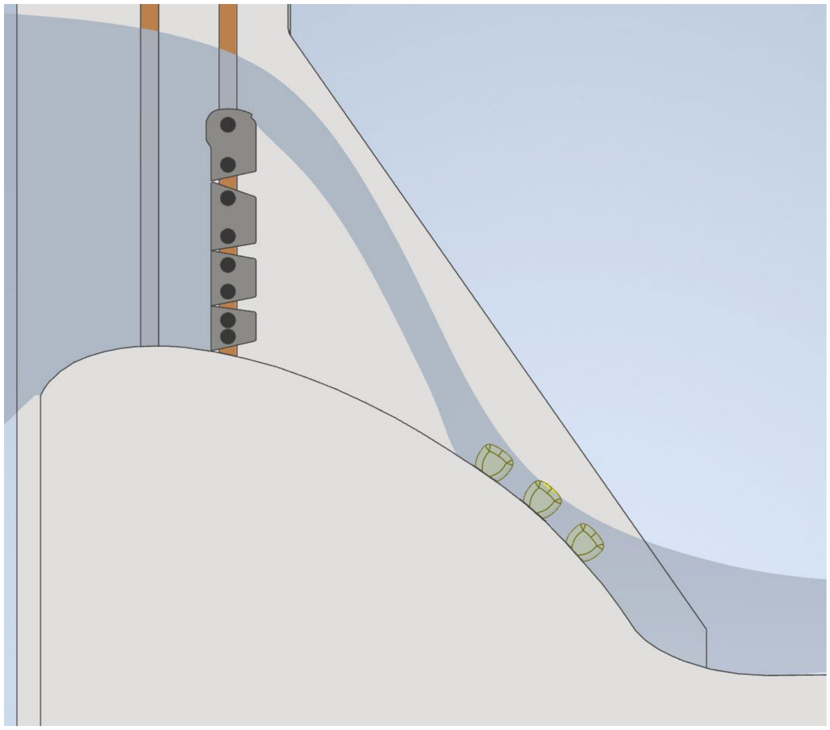


Figure 6. Alternative 6 Conceptual Design (Side View)

6.2.2. Hydraulic Design Components

This alternative replicates efforts made at Lower Granite dam with the RSW. Design considerations during development of that antenna system assumed future TSW installations with antennas located such that nappe impact was upstream of the most upstream antenna. Lower antenna can be submerged during elevated tailwaters during non-operation like Lower Granite. Lower antenna can detect fish that did not pass the spill bay during non-operation and PTAGIS database needs to filter results based on TSW operation.

6.2.3. Structural Design Components

This alternative will require concrete excavation in the ogee to fit the eleven 8.5ft by 5ft antennas and ferrous metal rebar around the antennas will need to be replaced with a non-ferrous material to preserve the structural integrity. A new structure will likely need to be built to house the electronics and receivers. This could be built on top of the existing training building located next to spill bay 22 if structurally feasible.

6.2.4. Electrical Design Components

Eleven 8.5ft by 5ft antennas will be embedded into the concrete of the ogee. These antennas require FS3001 transceivers which will need to be located within 150ft of the antennas due to the cable length limitations of the FS3001.The FS3001 transceiver is housed inside a 36" x 36"x 10" enclosure and the power supply is housed in a 24" x 24" x 10" enclosure. There is not enough space on the spillway deck to install these enclosures due to the spillway gate hoists which will require the PIT antennas to be installed in bay 22 and the TSW moved there as well.

6.2.5. Mechanical Design Components

The FS3001 transceivers require extra cooling equipment to keep them from overheating. HVAC should be provided in the electronics room.

6.2.6. Biological Considerations

Assuming the ogee is the same shape after installation, there should be no additional biological impacts. However, if the TSW is moved to spill bay 22 to accommodate the FS3001 transceivers then there are concerns with increased entrainment and egress times due to its proximity to the powerhouse flow for fish trying to pass over the TSW. A research study conducted by USGS from 2006-2009 using acoustic telemetry tags to determine juvenile fish survival estimates at McNary showed lower survival rates, especially for juvenile steelhead, when the TSW was located in bay 22 in 2007 (Adams 2011).

6.3. ALTERNATIVE 8 – PIT BARGES IN TAILRACE

6.3.1. General Description

This alternative puts multiple PIT barges in the tailrace downstream of the spillway. For this evaluation, at least five PIT barges are assumed to be needed for detection and data acquisition. The PIT barges are pre-designed and quickly deployable (Refer to Figure 7).

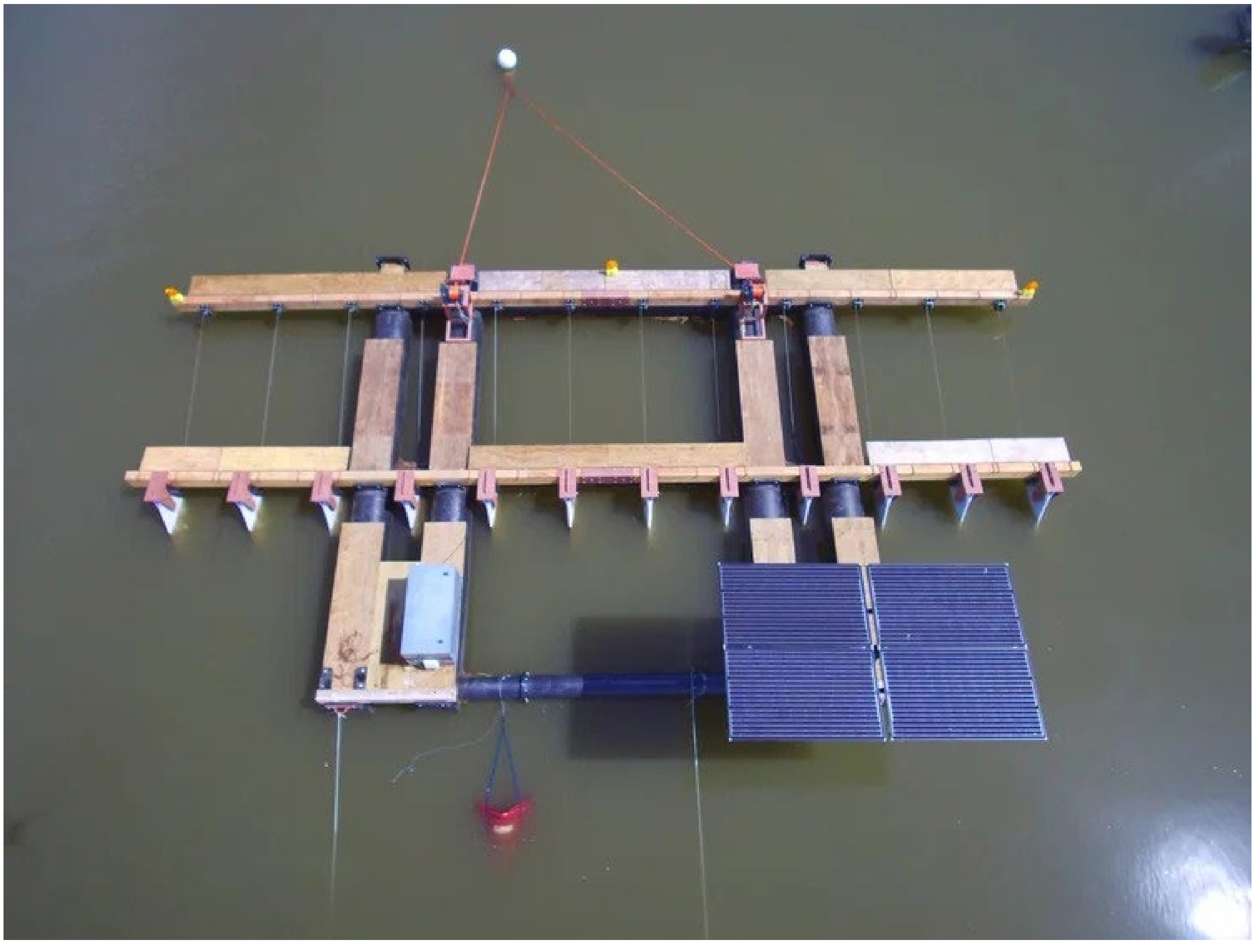


Figure 7. Alternative 8 Typical Configuration

6.3.2. Hydraulic Design Components

The PIT barges will likely be deployed in a region just outside the boat restricted zone in an environment substantially more turbulent that previous deployments. Attention to drag and wave loading will need to be addressed, as well as consideration for debris impact.

6.3.3. Structural Design Components

The PIT barges downstream of the spillway will need to be adequately secured to not wash away downstream. Anchors will need to be designed to withstand possible debris strikes. There are concerns that anchor lines used in the past may have caused fish avoidance due to vibrations in the anchor line.

6.3.4. Electrical Design Components

These PIT barges are pre-designed and require very little engineering.

6.3.5. Mechanical Design Components

No mechanical design components currently.

6.3.6. Biological Considerations

The anchoring structures and detection fins could cause fish avoidance due to differences in hydraulics and vibrations, as well as physical obstacles in the river. The barges could also be sought as holding structures by piscivorous fish predators which could lead to concentrated areas of fish predation in the tailrace.

6.4. ALTERNATIVE 11 – MATRIX ANTENNA PIT DETECTOR

6.4.1. General Description

This alternative utilizes the IS1001 transceivers and antennas in an array built into a 52--foot by 26-foot large metal frame that is lowered into the upstream slot of one of the spill bays with a TSW installed. The frame would feature two rows and approximately six columns of non-ferrous metal members with antennas built in. The openings within the frame would be approximately 10 feet by 12 feet for fish to pass through. The antennas built into the frame are directed into the openings and can detect PIT tags as they pass through (Refer to Figures 8 and 9).

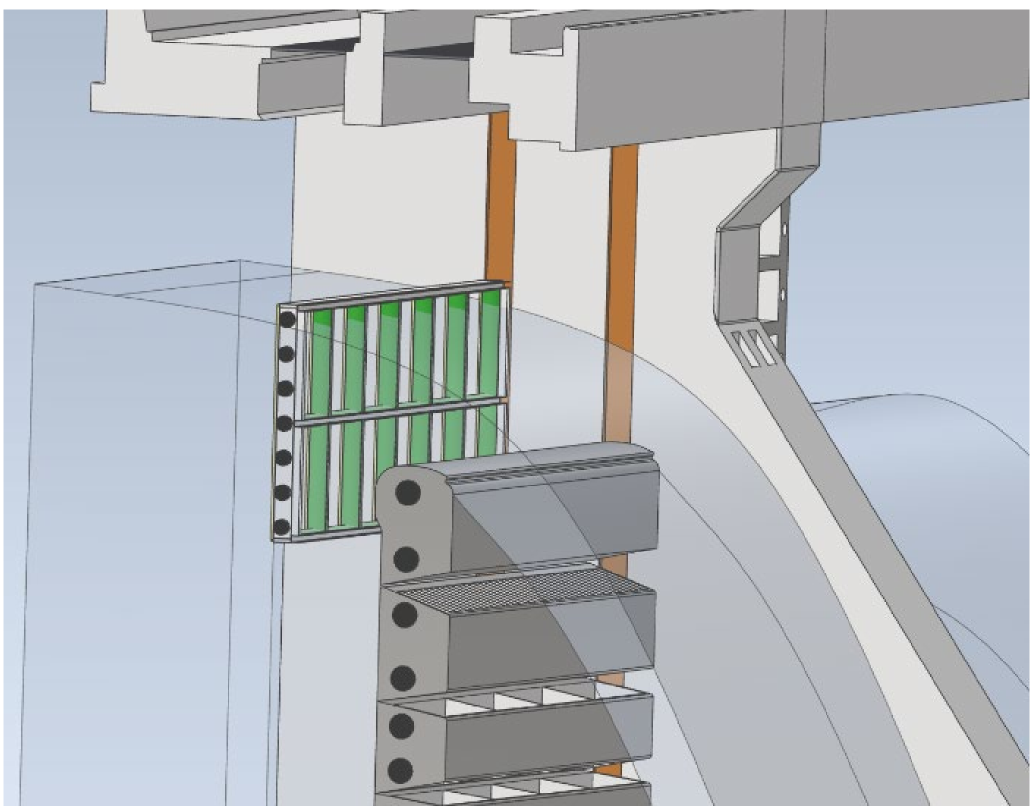


Figure 8. Alternative 11 Conceptual Design

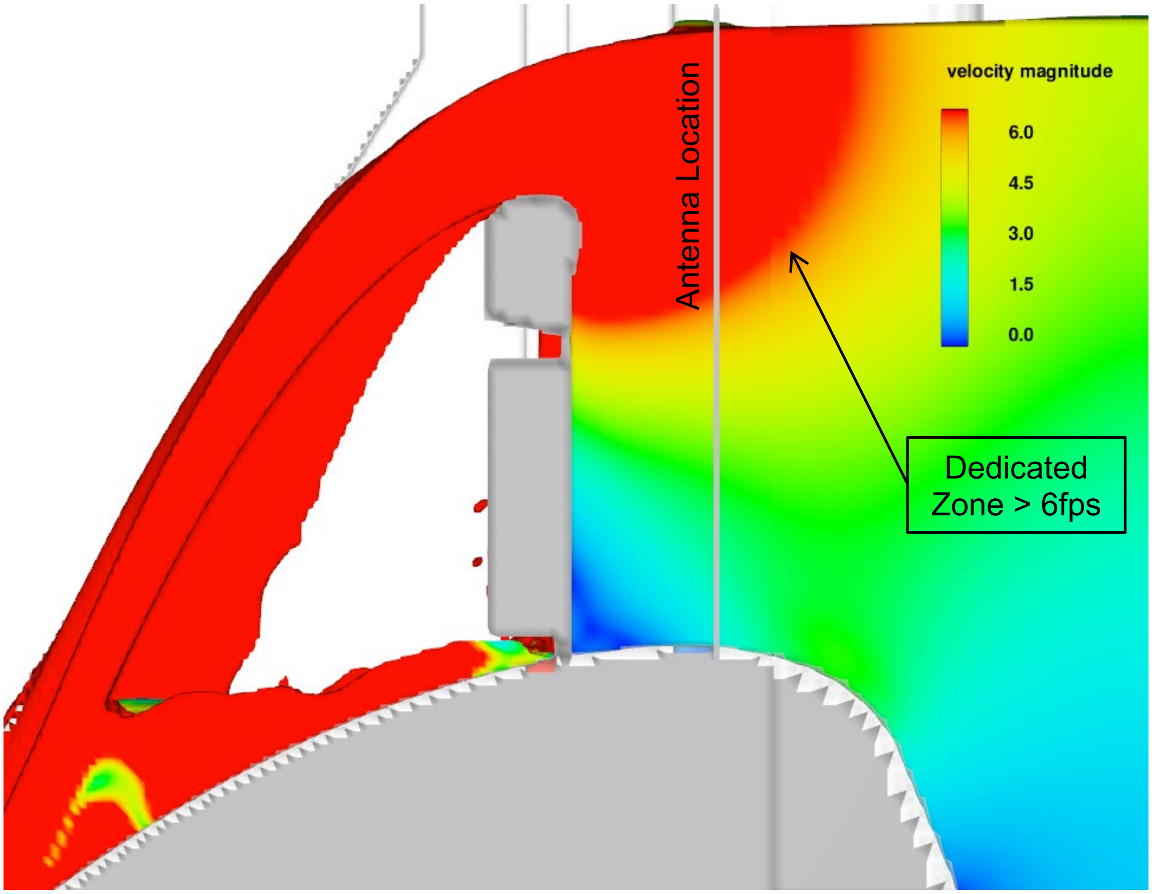


Figure 9. Alternative 11 Detection Zone

6.4.2. Hydraulic Design Components

The antenna design will need to evaluate drag loading and vibration analysis as well as minimizing turbulent flow structures that can produce rooster tails down the spillway after passing over the TSW crest. Maximizing open area while maintaining detection will be imperative to reduce debris loading concerns and overall maintenance requirements. The proposed location and extents of the antenna appear to fall within the zone where fish are dedicated to passing the TSW route since flow velocities are in excess of 6fps. Further analysis to determine depth and submergence of antenna needed.

6.4.3. Structural Design Components

The steel frame needs to fit within the upstream slot of the spill bay and be strong enough to withstand the flow of water and build-up of debris. The loading from debris will likely be the greatest load on the structure and should be designed to withstand a build-up of debris without bending or breaking. The frame will also need to be rigid and minimize any sort of vibrations that may deter fish.

6.4.4. Electrical Design Components

Since the device is removable and lowered into the spill bay upstream slot, a detachable power cord and watertight plug will be used to provide power to the antennas and transceivers in the device. The frame of the device housing the electronics must be watertight to avoid damaging the electronics.

6.4.5. Mechanical Design Components

The device's weight must not exceed the lifting capabilities of the spillway hoists or cranes. No additional cooling is required for the IS1001 transceivers.

6.4.6. Biological Considerations

Vibrations and changes to existing hydraulics could lead to fish avoidance through a known high survival passage route. Significant debris accumulation on the detector could cause sharp edges and constriction points that could injure fish as they pass. Without proper design considerations, the structure itself could be struck by fish as they pass through it causing injury even though velocity will be low enough strikes should be infrequent and not mortal.

7. ALTERNATIVES EVALUATION

7.1. ALTERNATIVES MATRIX

After the initial screening of the alternatives, a matrix (Appendix A) was used to evaluate and compare the remaining alternatives developed in this study. The alternatives were compared utilizing criteria described below (detailed in section 4.1) and were refined based on input from the FFDRWG members at the 20 March 2025 workshop meeting.

- Detection Delta
- Durability and Reliability
- Routine O&M
- Constructability
- Hydraulics
- Fish Behavior
- Research and Development
- Cost

Scoring of the alternatives under each criterion ranged from 1 to 5 (poor to exceptional).

The alternatives were initially scored by the USACE PDT and FFDRWG members collaboratively, and updated, as PSMFC continued to research each alternatives effectiveness and feasibility. Alternatives 4, 6, 8, and 11 scored the highest and remain for further consideration. Sections 7.2 through 7.5 provide advantages and disadvantages for these alternatives (scores for each alternative are included in the section heading).

7.2. ALTERNATIVE 4 – EMBEDDED TSW PIT DETECTORS: 28

Advantages

This alternative makes little to no changes to the geometry of the spillway flow and function or the hydraulics of the spill flow, which is ideal and has no measurable impact on for fish behavior and passage, which means there is minimal concern for fish safety and fish avoidance. Since the antennas will be flush with the top of the TSW, there will be no significant increase in debris buildup, which will have minimal impact on operational burden. The detection capabilities span the width of the spillway and provide approximately 50 inches of detection which will effectively detect and record most fish passing within that detection window.

Disadvantages

There are significant constructability and feasibility hurdles to overcome with this alternative. If the FS3001 antennas are to be used, there will need to be adequate space to mount them within 150 feet of the TSW. The FS3001 transceiver is housed in a 36”x36”x10” enclosure and the power supply is housed in a 24”x24”x10” enclosure. There is currently no space on the spillway deck due to the spillway gate hoists and the nearest space is outside of that limit. The IS1001 transceivers could be used instead but this would reduce the detection range from 30 inches to 50 inches. This would require the IS1001 transceivers to be mounted in the TSW with the antennas and would require the transceivers to be protected in a watertight enclosure or sealed. The surface of the TSW is currently made from a ferrous metal which could interfere with the antennas and would need to be replaced with a non-ferrous material and shielded. The TSW will still need to support the weight of a bulkhead sitting atop without comprising structural integrity or damaging the antennas.

7.3. ALTERNATIVE 6 – EXISTING OGEE EMBEDDED PIT DETECTORS: 28

Advantages

Similar work has been done successfully at the Lower Granite project. The antenna array provides optimal PIT detection coverage right where downstream of the TSW spill nappe intersecting enters the ogee which will detect most fish passing through over the TSW bay. The geometry of the spill bay will remain unchanged.

Disadvantages

This alternative features the largest scale of work and highest cost. There are fish survival concerns since the TSW would need to be moved to spill bay 22. Moving the spill bay surface passage adjacent to the spillway would increase entrainment since the TSW flow can flow into the powerhouse tailrace, decreasing egress times over the spillway. The TSW outfall would no longer align with the original thalweg of the river, increasing egress times through the tailrace for juvenile fish.

7.4. ALTERNATIVE 8 – PIT BARGES IN THE TAILRACE: 26

Advantages

The advantage to this alternative is that the PIT barges are already designed and can be quickly deployed.

Disadvantages

The PIT barges can only cover so much of the river and can’t detect fish that are lower than the antennas which are currently proposed to be around 10 feet deep (thalweg of river 85’ deep). There are also concerns that the vibration of the anchor lines or the fins could cause fish avoidance and with the depth and width of the river, the fish could easily avoid the barges.

7.5. ALTERNATIVE 11 – MATRIX ANTENNA PIT DETECTOR: 29

Advantages

This alternative is not a fixed installment and can be removed from the upstream slot and placed in a different spill bay if needed. The device features a wide detection area of approximately 52 feet by 26 feet behind the TSW. The concept has been successfully done previously in a smaller scale.

Disadvantages

There are concerns that device could vibrate in the spill flow and deter fish from passing through. There are some fish strike concerns even though the velocity is low enough that strikes are expected to be infrequent and not mortal. The project sees a lot of debris such as tumbleweeds, driftwood, and logs which could build up on the device and require the project personnel to routinely clear it of debris. Accumulation of debris on the detector could cause injuries to passing fish by constricting flow and leaving sharp edges. The use of IS1001 transceivers built into the detector with the antennas will require the detector to be watertight to avoid water damage to the electronics.

7.6. PRELIMINARY COST ESTIMATES

The cost estimate for each alternative is a Class 5 Rough Order of Magnitude estimate derived from a combination of sources such as historical data, quotes from manufacturers, and engineering estimates from the Walla Walla District Cost Engineering MCX. The Class 5 Construction cost estimates include a 30 percent contingency (Refer to Table 1.)

The Class 5 construction cost includes the cost associated with providing the required infrastructure and installation of the antenna system. The estimate does not include the system programming, calibration, and final testing for a complete and functional system. The estimates do include the antennas and transceiver system electronics to provide a comprehensive alternative comparison, though PSMFC will provide transceivers, antenna cables, and associated electronics. These items will be installed by a USACE contractor. A Class 3 cost estimate for the recommended alternative will be refined during the next phase as more design details are understood.

Table 1. Estimated Class 5 Costs.

Alternative #	Type	Quantity	Cost	Contingency	FY2032 Mid-point CWCCIS	Total estimate cost of construction:
4	TSW Embedded PIT Detectors	1	$7,498,418.30	$2,249,525.49	$1,918,395.34	$11,666,339.13
6	Embedded in Existing Ogee	1	$10,001,809.58	$3,000,542.87	$2,558,862.96	$15,561,215.42
8	PIT Barges in Tailrace	5	$4,523,707.20	$1,357,112.16	$1,157,345.25	$7,038,164.59
11	Matrix PIT Detector	1	$3,917,971.64	$1,175,391.49	$1,002,373.86	$6,095,737.00

8. RECOMMENDATION

Based on the alternative evaluation and comparison, the selected alternative is Alternative 11, with the highest score of 29. This alternative scored high for its high detection delta, constructability, and deployment flexibility. These advantages were able to outweigh the concerns that were identified such as O&M burden and possible impacts to fish survival and avoidance. This alternative has the highest score and is the most cost effective at providing the highest detection among other alternatives. (Refer to Appendix A for more details.)

Table 3 provides calculations for total construction cost per estimated percent of PIT tag detection through the spillway for each considered alternative.

Table 2. Estimated Cost per Percent of PIT Tag Detection through the Spillway

Alternative #	Cost	% Detection	Detection Efficiency	Passage Proportions	Cost Per % Detection
4	$11,666,339.13	9.75%	50%	*19.5%	$1,196,547.60
6	$15,531,215.42	12.68%	**65%	*19.5%	$1,225,342.44
8	$7,038,164.60	1.15%	15%	7.6%	$6,146,663.75
11 (Recommended)	$6,095,737.00	17.52%	90%	*19.5%	$347,956.74

*calculated using PNNL 2024 research (Deng et al. 2025)

**post-construction evaluation at Lower Granite Dam (Axel et al. 2024)

Under a Memorandum of Understanding (MOU) between USACE and BPA, USACE pays for construction and infrastructure of PIT tag detection systems, and BPA provides the PIT tag antennas and associated electronics, plus funding for O&M. BPA funds PSMFC for the O&M and funds NMFS for the purchase of equipment. NMFS will provide certain detection system components, such as transceivers, antennas, and antenna cables as Government-Furnished Equipment (GFE). Design of the detection system will be closely coordinated with NMFS and PSFMC.

9. PDT MEMBERS

Project Manager: Karen Zelch/Kat Herzog
Technical Lead/Electrical: Andrew Glencross
Environmental: Chuck Barnes/Ryan Ashcraft
Fish Biologist: Chris Peery/Tiffany Stoeckig-Dixon
Civil Engineer: Jana West
Hydraulic Engineer: Travis Foster/Ryan Laughery
Structural Engineer: Branden Tewell
McNary: Bobby Johnson/Anthony Ohare/Marty Ahmann
PSMFC (Pacific States Marine Fisheries Commission): Gordy Axel Mark Leonard Darren Chase Scott Livingston

10. REFERENCES

Adams, N.S. and Evans, S.D., 2011. *Summary of juvenile salmonid passage and survival at McNary Dam-Acoustic survival studies, 2006-09* (No. 2011-1179). U.S. Geological Survey.

Axel, G.A. et al. 2024. *Post-Construction Assessment of Passive Integrated Transponder Detection Efficiencies in Spillbay 1 at Lower Granite Dam*. National Marine Fisheries Service.

Deng, Z.D. et al. 2025. *Survival of Spring Migrant Smolts at McNary Dam During Split-Leaf Spill Operations.* Prepared by Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Walla Walla District. Walla Walla, Washington.

Appendix A: Alternative Evaluation and Comparison Matrix

Alternative	Screening Criteria (5=good, 1=bad)										
	Detection Coverage	Durability and Reliability	Routine O&M	Constructability	Hydraulics	Fish Behavior	Cost	Research and Development	Total Ranking	Construction Cost	Notes from workshop
Alternative 4: TSW Embedded PIT Detectors	4	3	4	3	5	5	2	2	28	$ 11,666,339.13	Fish behavioral concern limited. Detection unknown, moderate. Might need supplemental alt. Can be applied to other projects. extensive R&D to figure out how to modify the existing or build a new TSW with a non-ferrous top surface and still maintain structural integrity. concern coming from PMSFC, which is the FS3001 type transceivers that have a 150ft maximum cable span.
Alternative 6: Existing OGEE Embedded PIT Detectors	5	5	5	1	5	3	1	3	28	$ 15,531,215.42	Due to the constraints of the antennas and tranceivers, spillbay 22 would need to be used for this alternative. There are fish survivabiliy concerns in spillbay 22 which creates a fish behvior issue, not due to avoidance but due to safety.
Alternative 8: PIT Barges	1	3	4	5	4	3	3	3	26	$ 7,038,164.60	Prefers to be in tailrace, not forebay. Might not be best for standalone alt.
Alternative 11: Matrix Antenna PIT Detector	5	5	2	4	3	3	4	3	29	$ 6,095,737.00	12X10 squares. How often to clean this? Could lead to fish passage concerns with too much debris. Combine with other alts (4?).

Appendix B: Conceptual Designs

#1 SPILLWAY RESHAPING INSERT

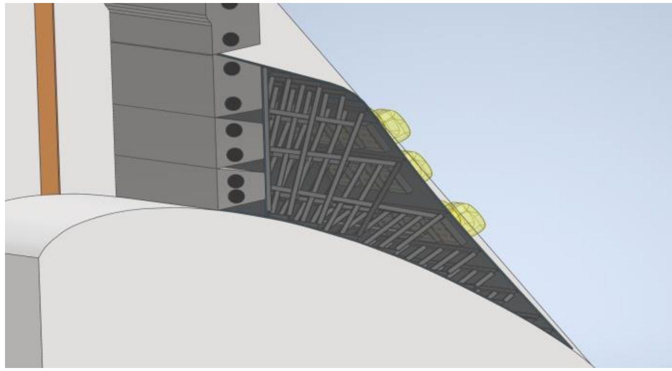
PDT Notes:

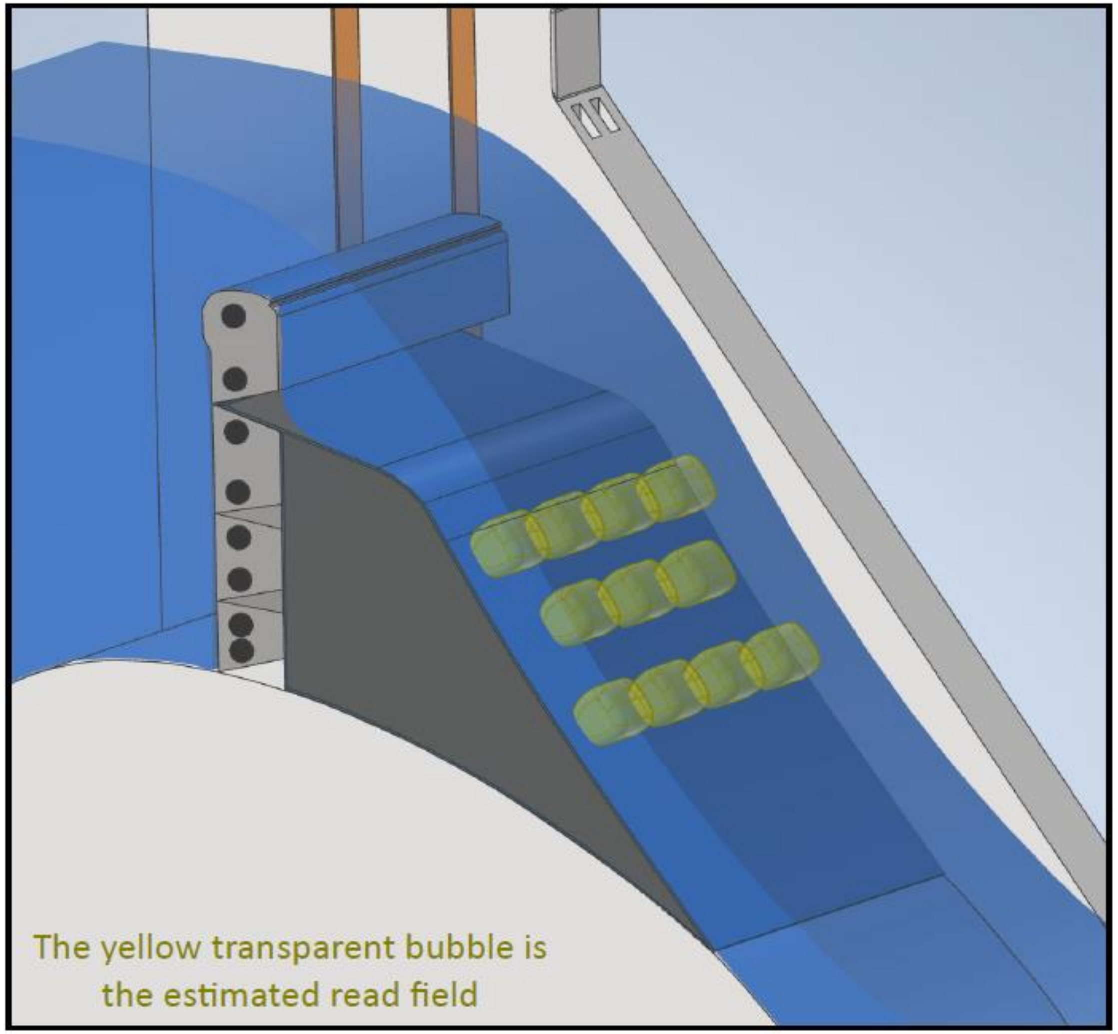
Pros:

a. Wide detection coverage
b. Similar to Lower Granite without concrete work

Cons:

a. Structural- Constraint- too heavy. Not likely to move the structure with a crane.
b. H&H- Constraint- not able to impact the PMF (probable max flood)
c. Civil concern- how to anchor this structure to existing spillway w/o damage
d. Inspection concern- how would this be inspected
e. How much time for R&D before this could be implemented? - several years at least





The yellow transparent bubble is the estimated read field

#2 SKIMMING DETECTION ARRAY

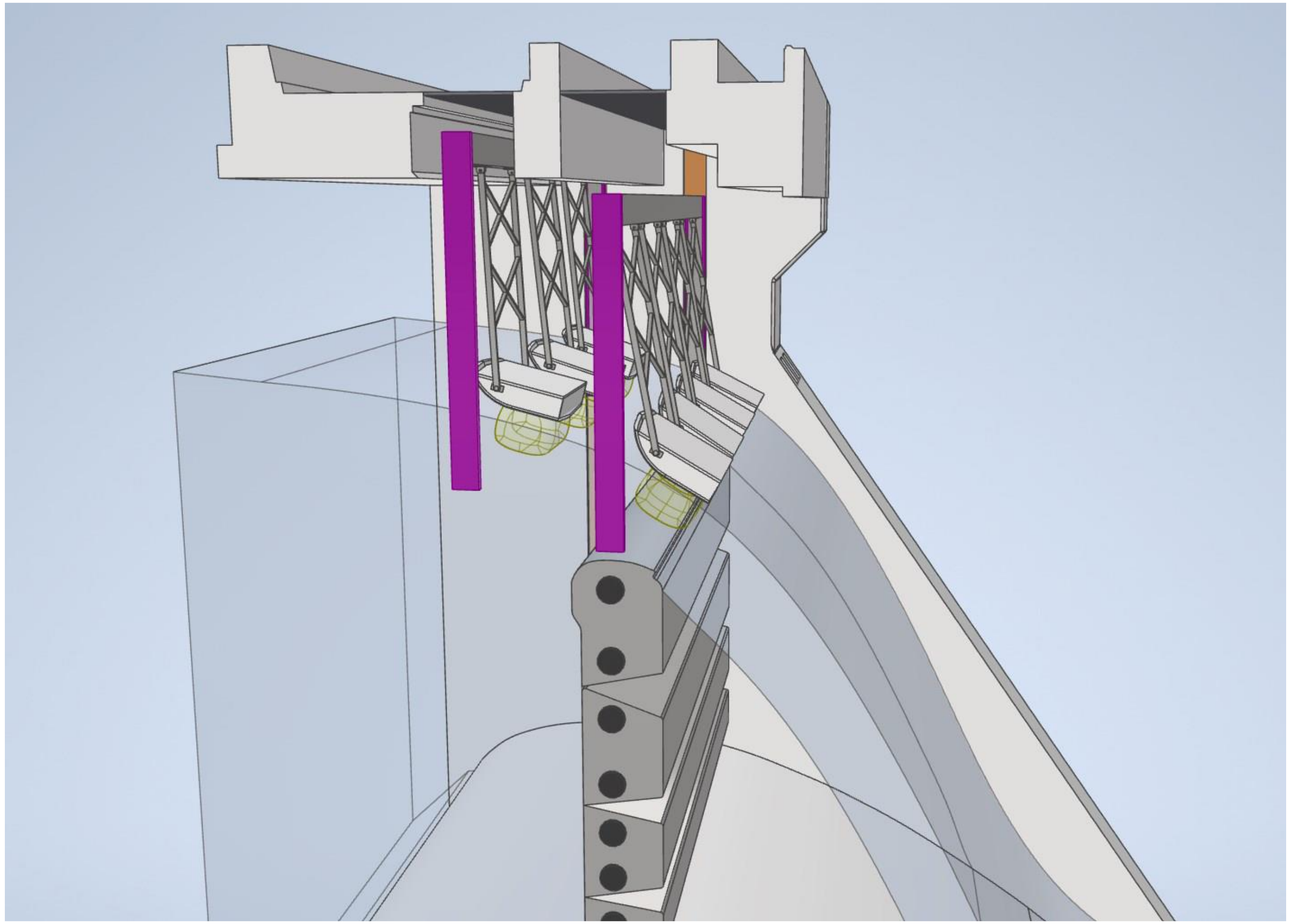
PDT Notes:

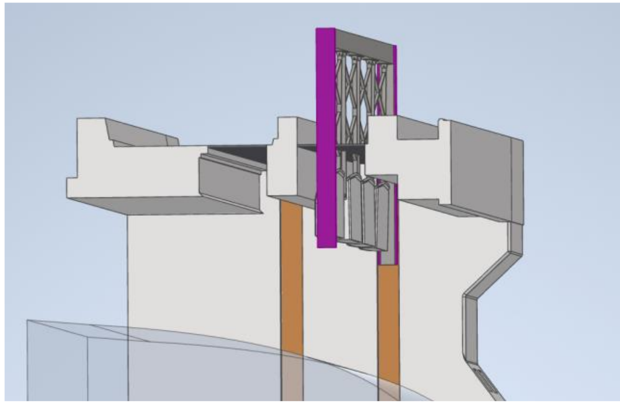
Pros:

a. Removable
b. Floats; unlikely fish strikes

Cons:

a. Debris; the TSW is the main route debris is pushed through
b. Located at surface and fish are not exactly at the surface
c. Operations concerned with device getting stuck in the slot when needing to close the TSW
d. Detection rates decrease with debris flow
e. Operational concerns about day-to-day operations and moving parts failure
f. Appears to be high maintenance costs/time





#3 ARTICULATION FIN ARRAY

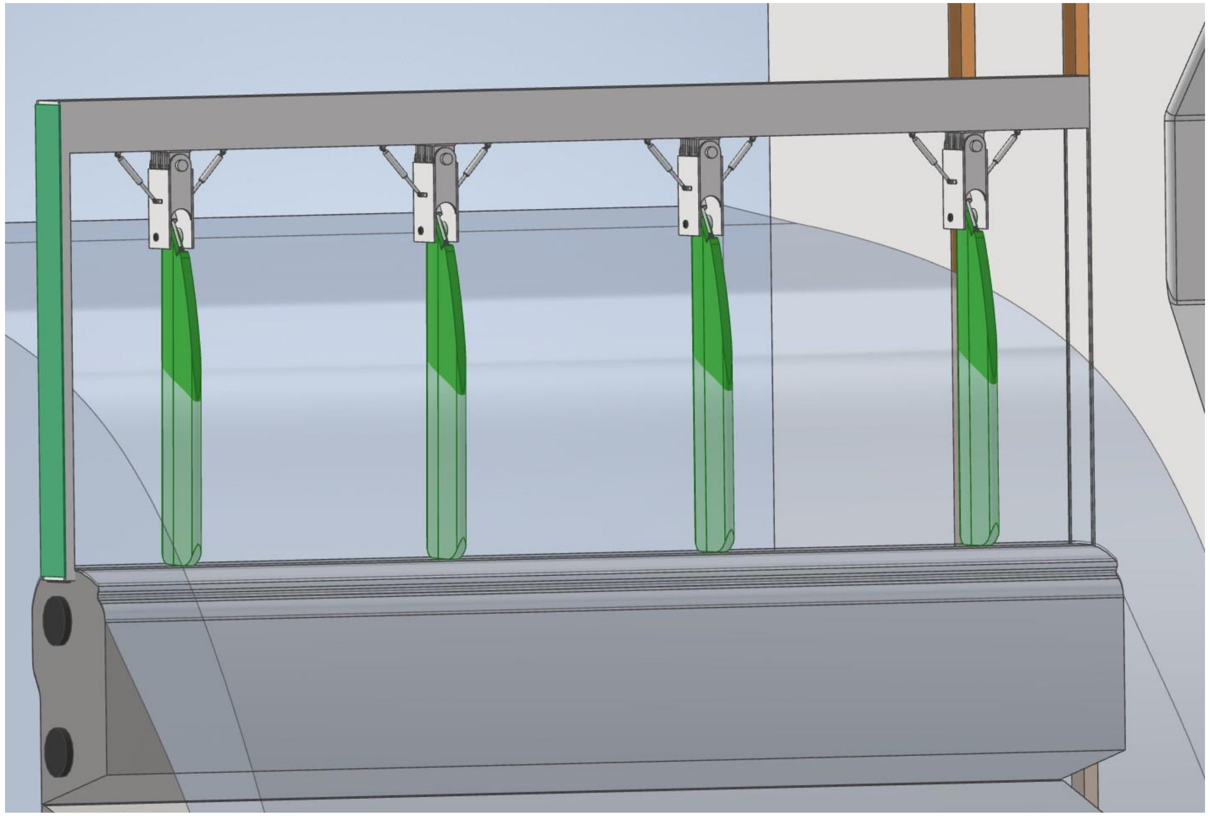
PDT Notes:

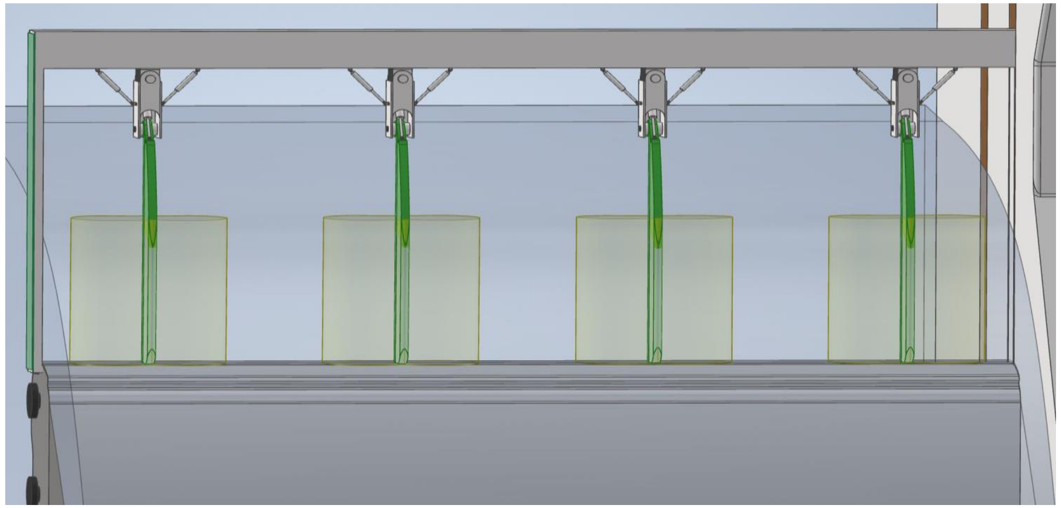
Pros:

a. Wide detection range near the bottom of the water column
b. Removable

Cons:

a. Concerned about garbage and debris getting tangled
b. Possible fish strikes
c. Operational concerns about the addition of hydraulics- trying to minimize oil spill
d. More moving parts usually equates to more maintenance and money spent





#4 DETECTION EMBEDDED TSW

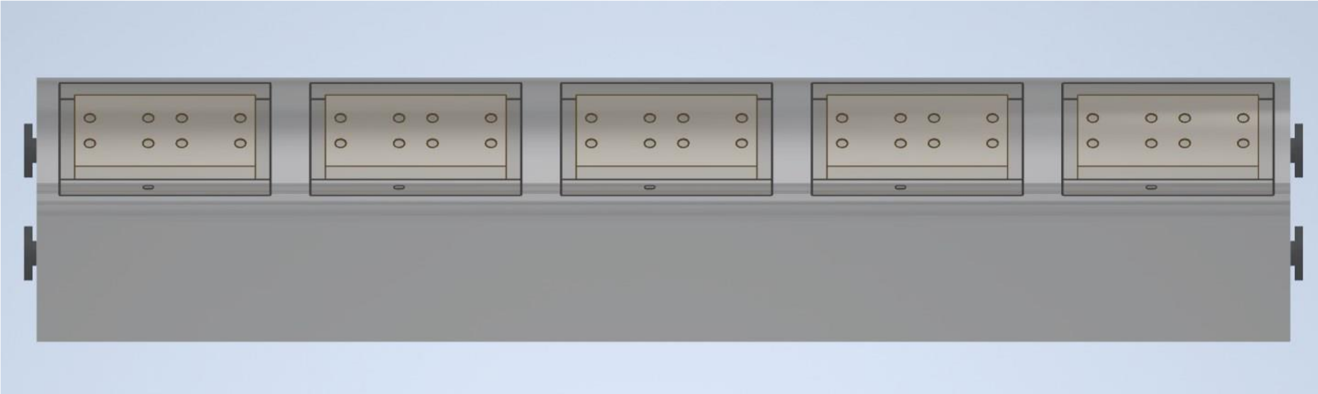
PDT Notes:

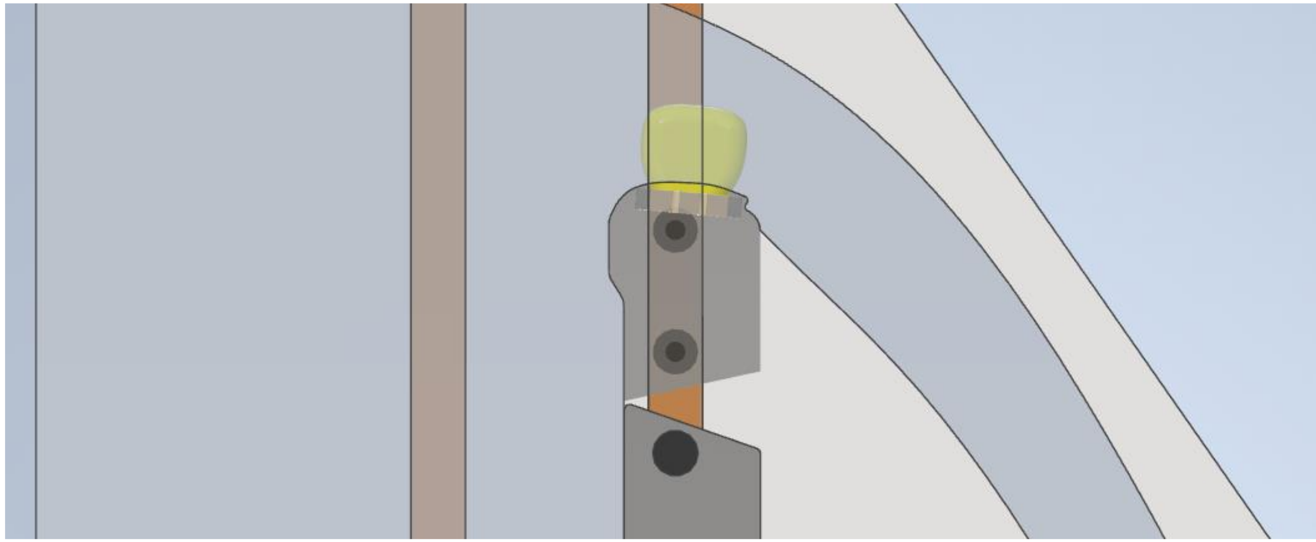
Pros:

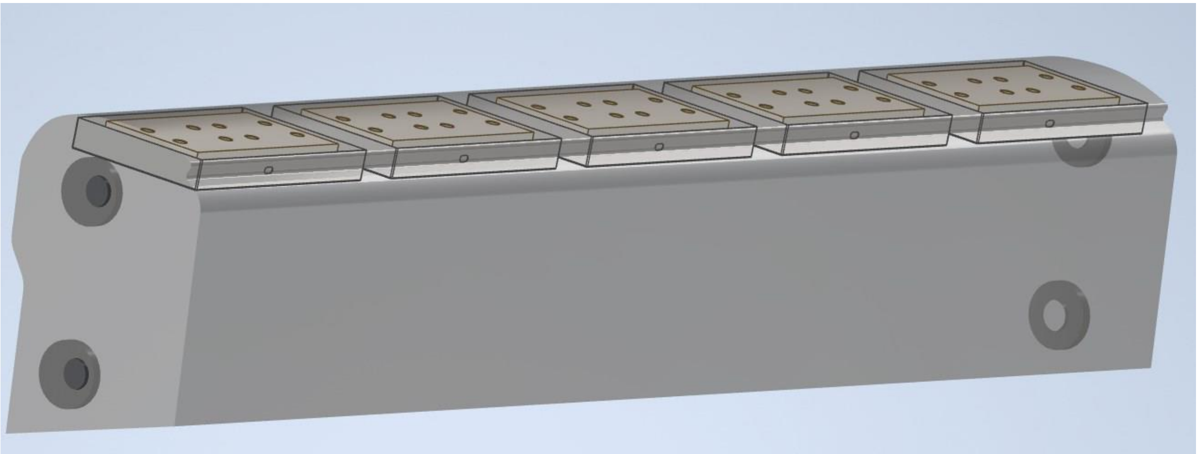
a. This alternative is favorable to PDT
b. Fixed antenna position with no moving parts
    a. Simple and lower O&M
c. Removable
d. Electronics possibly installed inside new TSW structure

Cons:

a. Limitations from cable length requirements
    a. Max 150ft
    b. Could be overcome if spillway deck has space for transceivers
b. Requires removal of surface of TSW
    a. Might require a new TSW structure instead of modifying existing







#5 TSW EMBEDDED PIT TAG FIN ARRAY

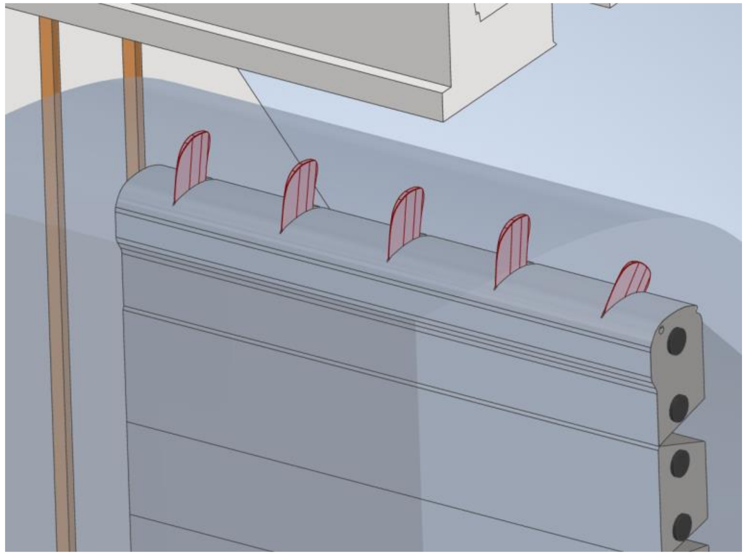
PDT Notes:

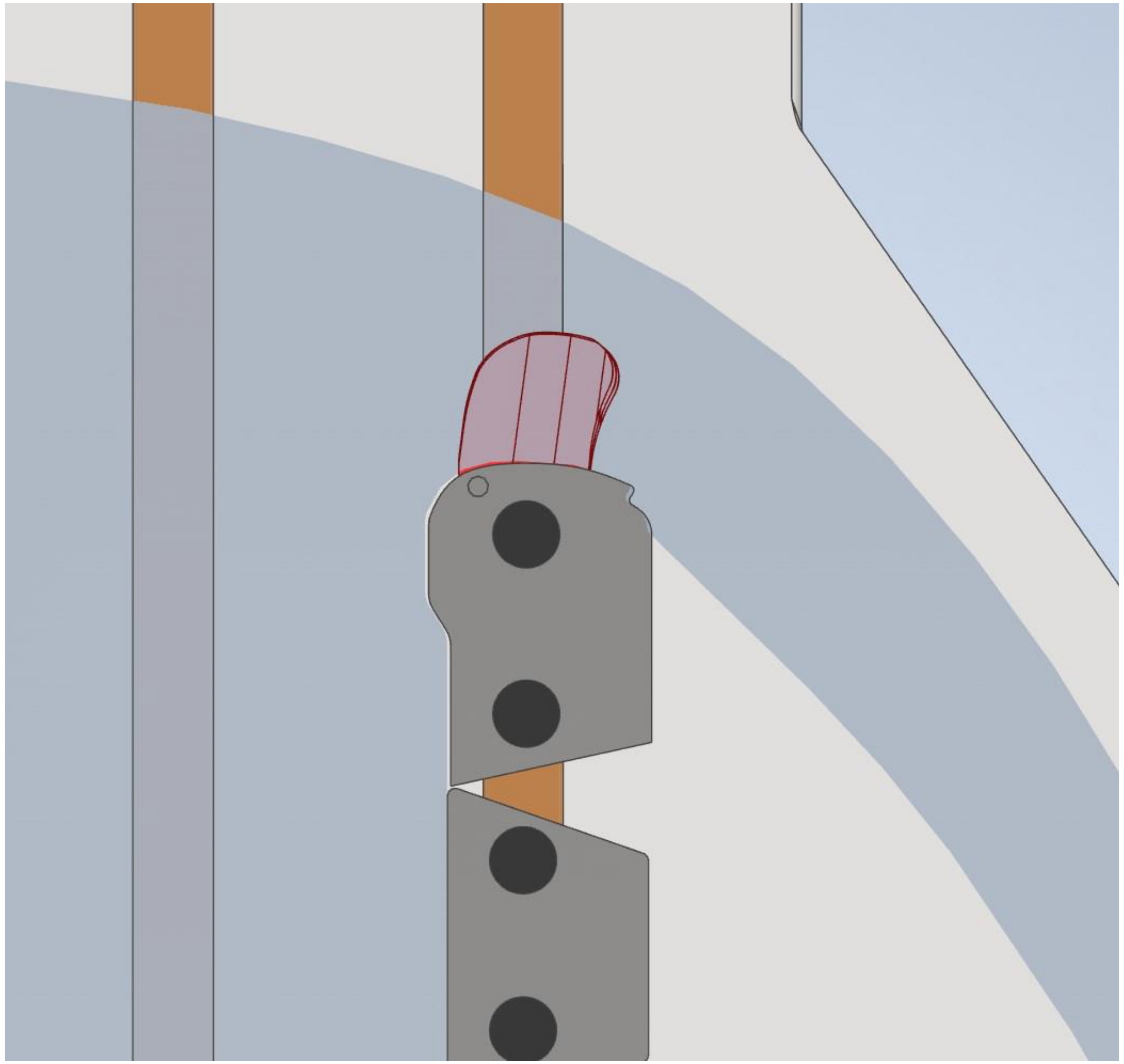
Pros:

a. Similar pros to concept #4
    a. Possibly better detection coverage
b. Longer cable length capabilities
    a. Longer than 150ft

Cons:

a. Log strikes at angles could damage fins
b. Debris likely to get stuck in slot
c. High-cost maintenance and probability for problems
d. Possible fish strikes
e. Requires modification to the TSW
    a. Possibly require a new TSW





#6 EMBEDDED IN THE EXISTING OGEE

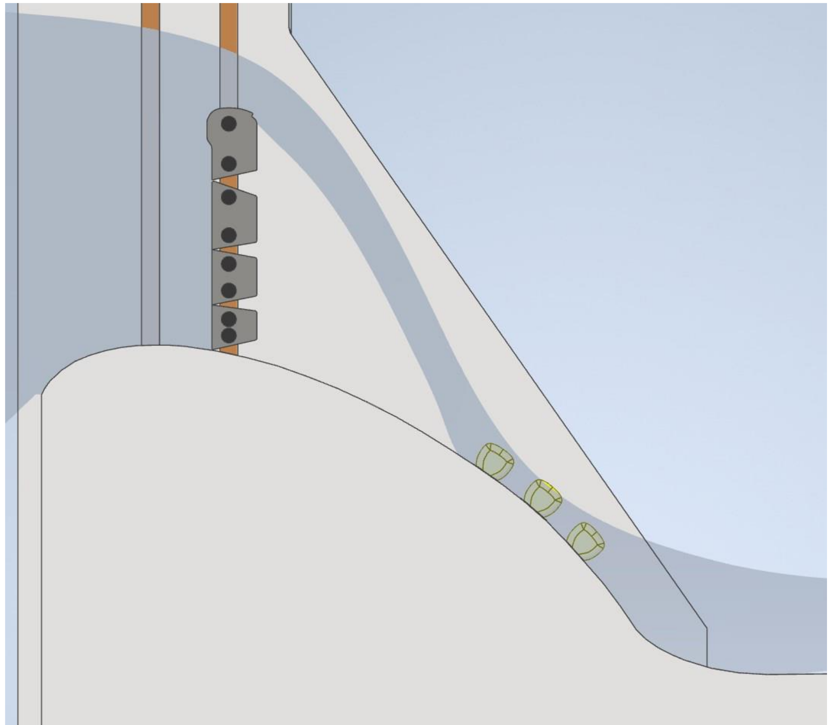
PDT Notes:

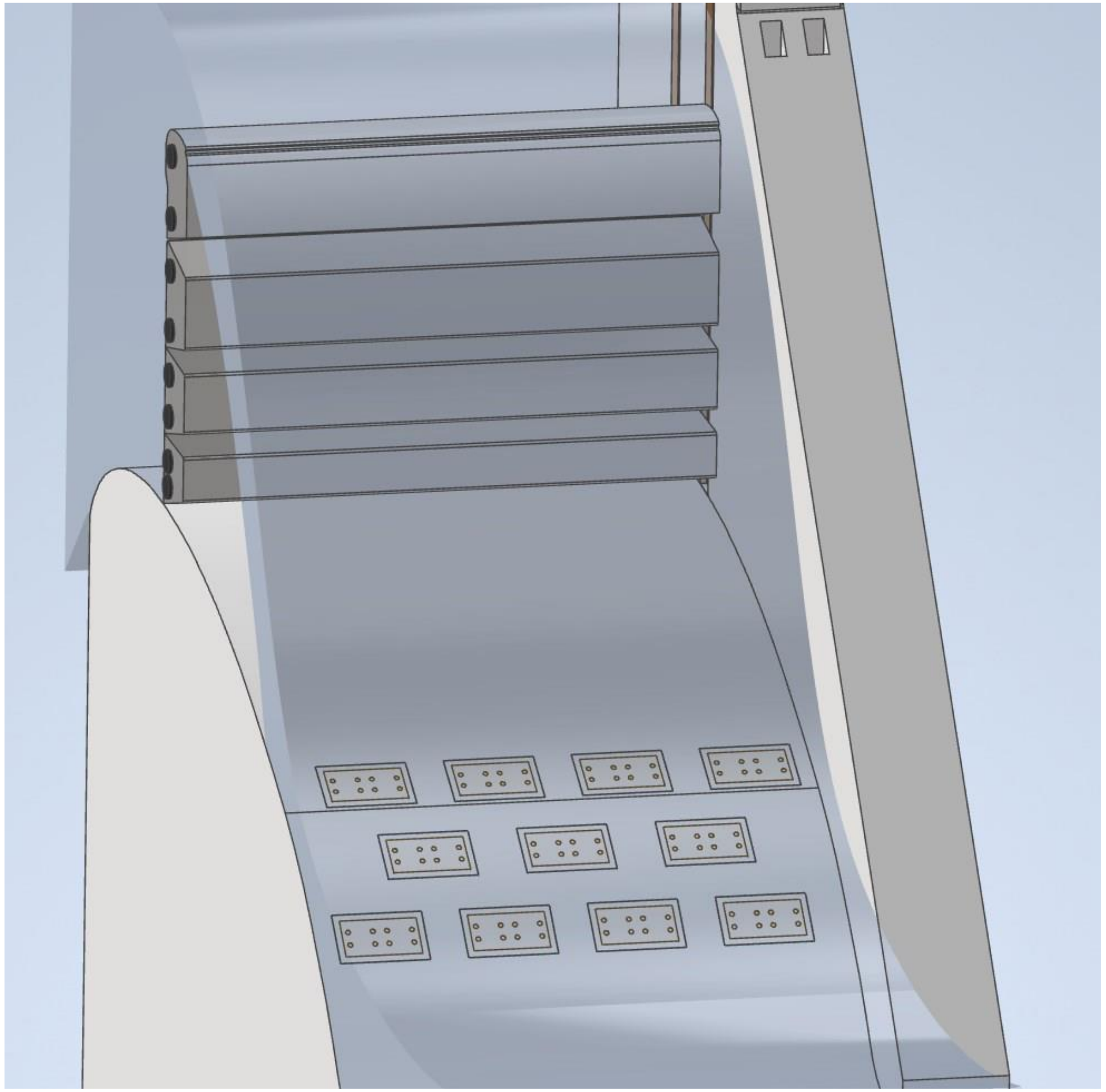
Pros:

a. Similar to Lower Granite work
b. Wide detection coverage
c. Fixed antennas and no moving parts

Cons:

a. Would need to move TSW to bay 22 to reach electrical
    a. Could be overcome if spillway deck has space for transceivers
b. Very costly
c. Not easily serviceable or accessible





#7 EMBED IN OGEE WITH RESHAPING

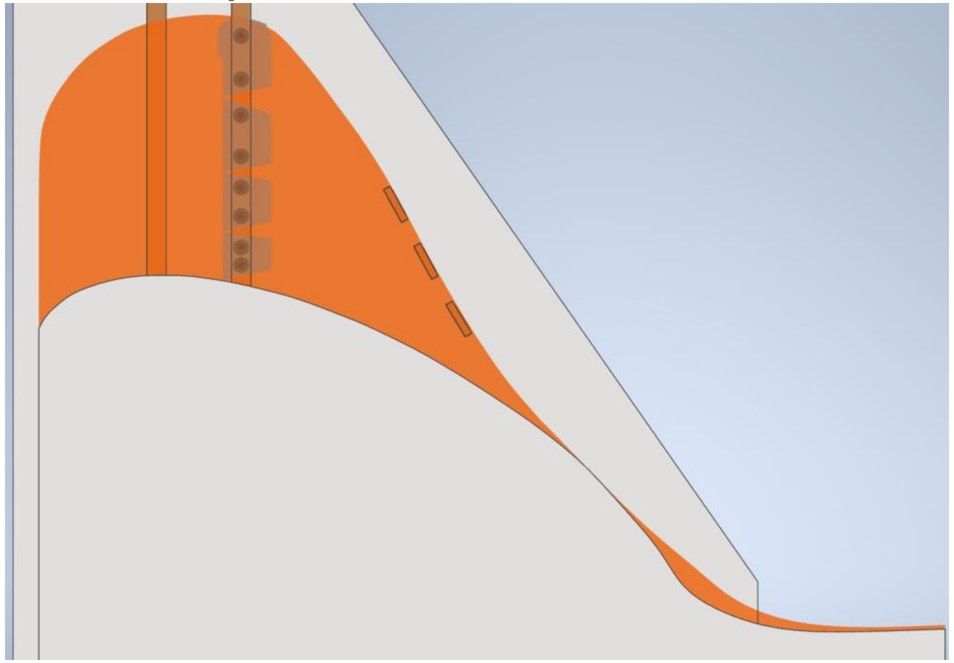
PDT Notes:

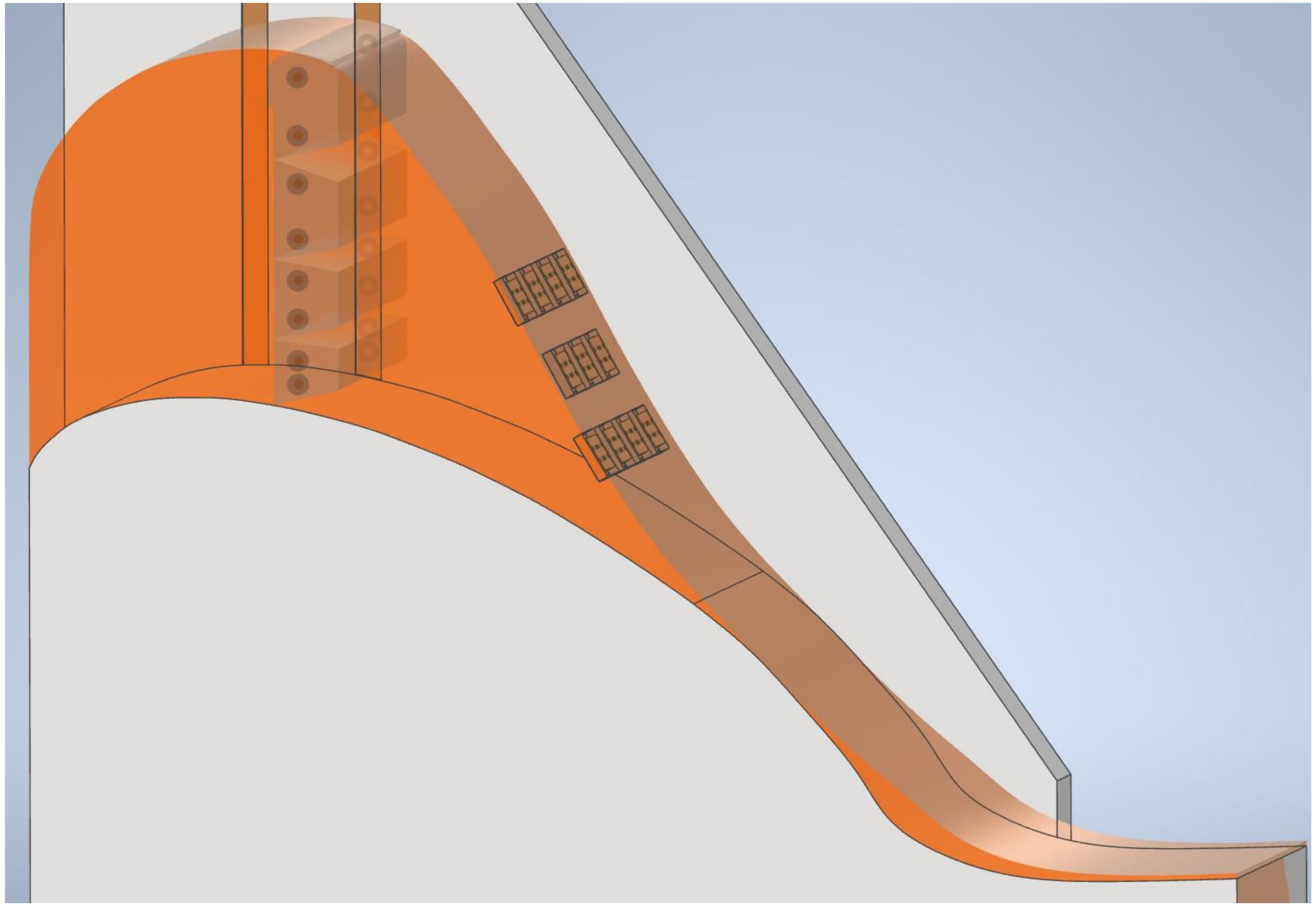
Pros:

a. Similar to Lower Granite work
b. Wide detection coverage
c. Fixed antennas and no moving parts

Cons:

a. Very Costly
b. Would need to move TSW to bay 22 to reach electrical
c. Not easily serviceable or accessible
d. Reshaping would change max flood
    a. Life safety issue





#8 PIT BARGE IN FOREBAY OR TAILRACE

PDT Notes:

Pros:

a. Quick solution that has been done before
   a. Less R&D
b. Autonomous system

Cons:

a. Need it to be placed in a location where most fish are (upstream would be in shipping channel)
b. Immediately upstream of spillway would raise dam safety concerns
c. April-may peak run time for fish but would need to extend through summer to capture all fish
d. Lots of vibration, especially in tailrace

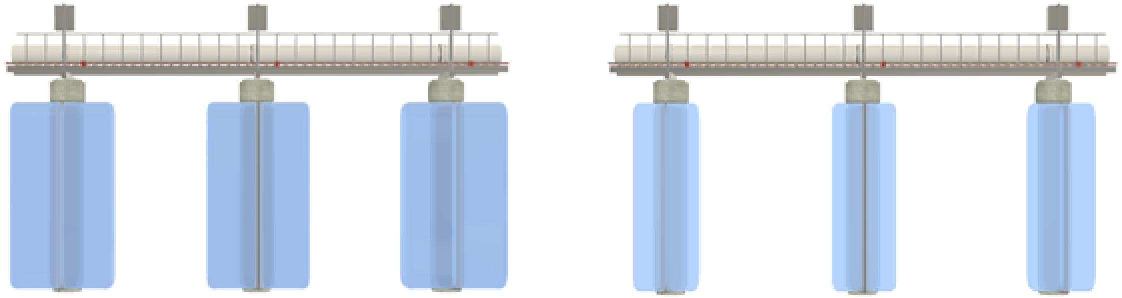
#9 JBS OUTFALL ANTENNA

PDT Notes:
Pros:

a. Scalable
b. Power would be on shore

Cons:

a. High water goes over the top of the outfall pipe and has taken out the water gun on multiple occasions and parts of the catwalk. High probability of losing any infrastructure placed on outfall piers from debris
b. Last pier is 120 ft depth
c. Lots of space between piers so would need to know what detection we would get



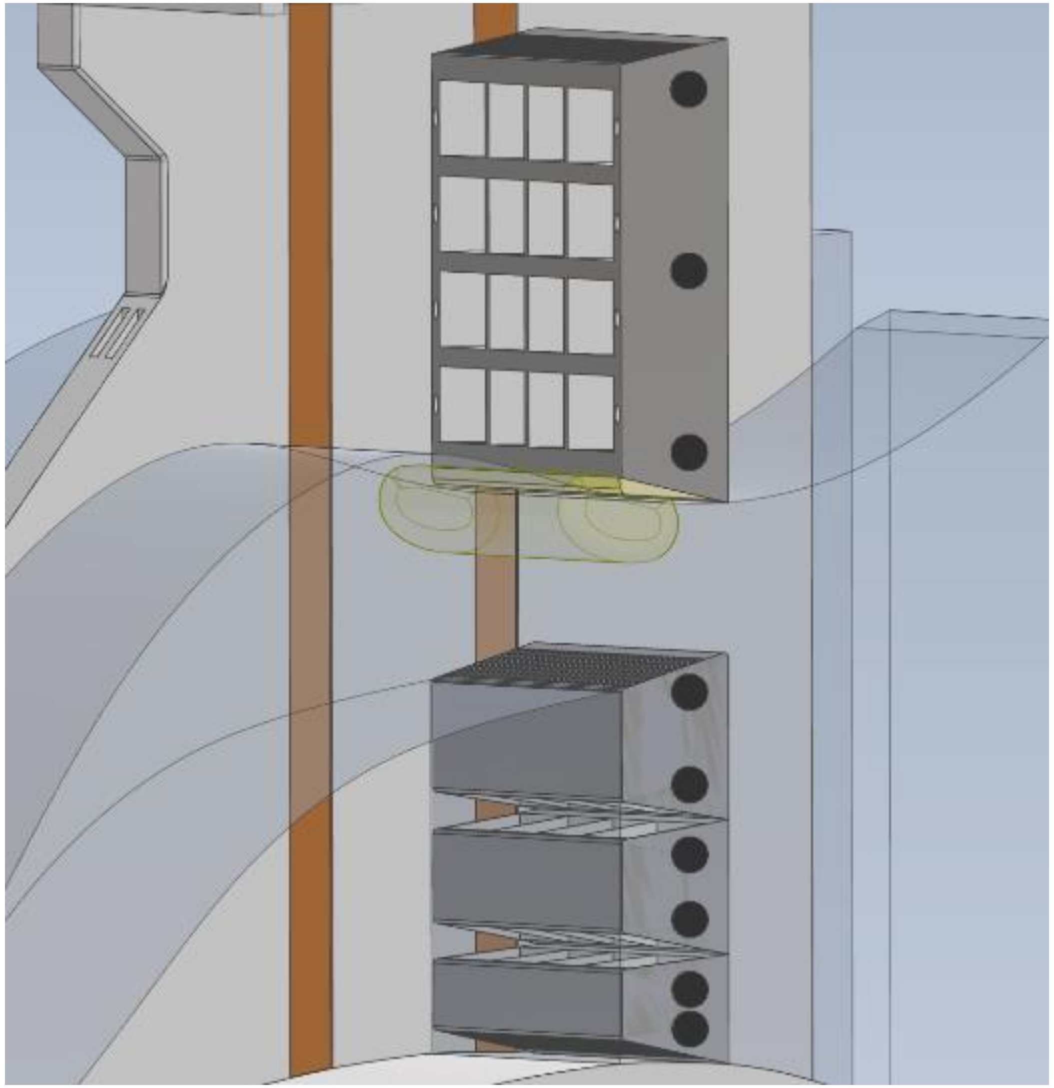
#10 SPLIT-LEAF SPILLWAY DETECTION

PDT Notes:
Pros:

a. Could potentially combine with a lower antenna
   a. Minimum gap of split leaf is 4ft
b. Fixed antenna position with no moving parts
   a. Simple and lower O&M

Cons:

a. MNA is moving away from split leaf gates
b. Located at surface and fish are not exactly at the surface



#11 "TRASH RACK" STYLE PIT DETECTOR

PDT Notes:
Pros:

a. High detection coverage
b. Removable
c. Fixed antenna position with no moving parts
   a. Simple and lower O&M

Cons:

a. MNA will need to clear the trash rack of debris
   a. Clearing trash racks is a normal maintenance task
b. Possible fish strikes
c. Trap too much debris; labor intensive