Computational Fluid Dynamics Modeling Applications in the Columbia and Willamette Basins

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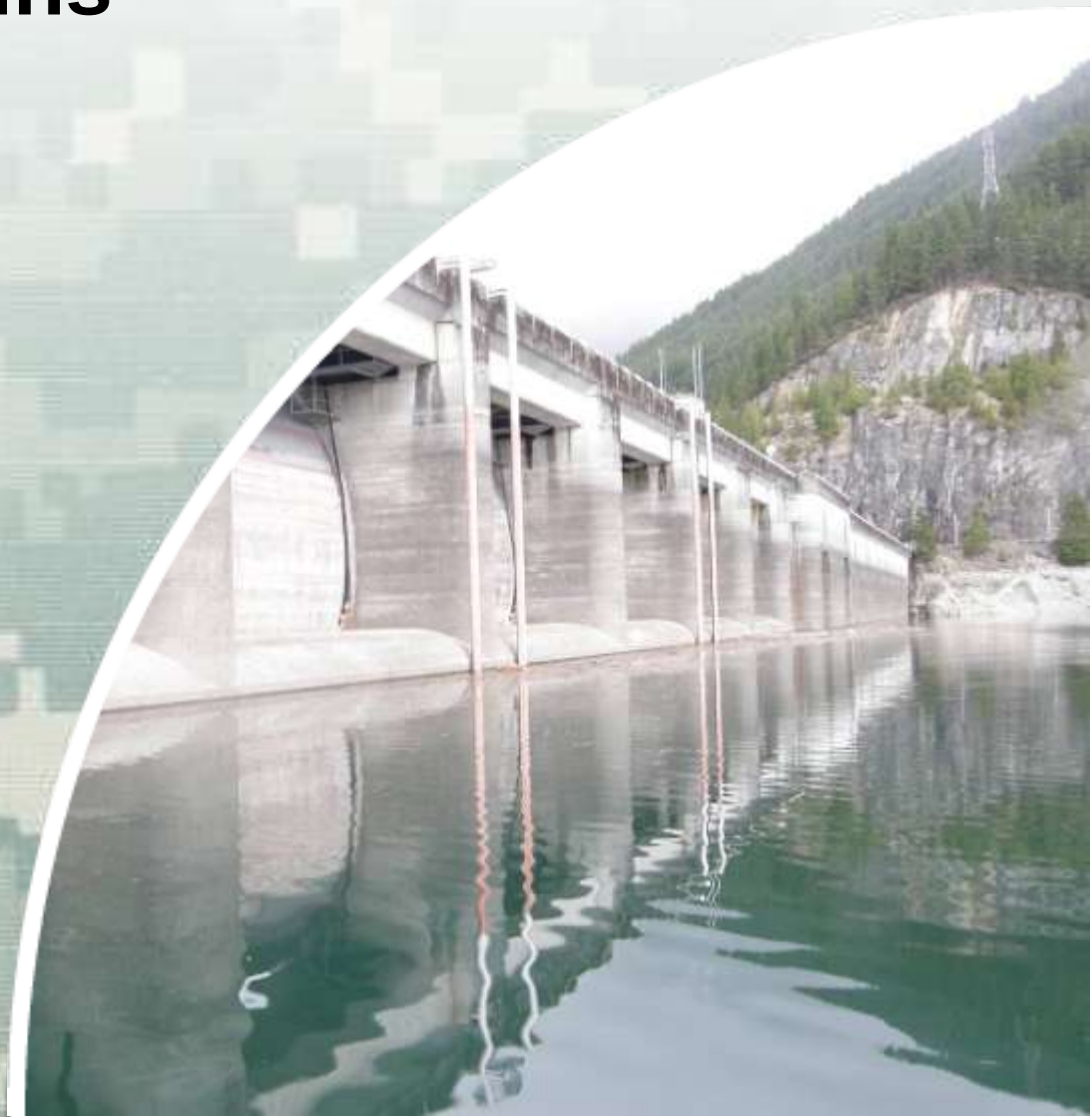

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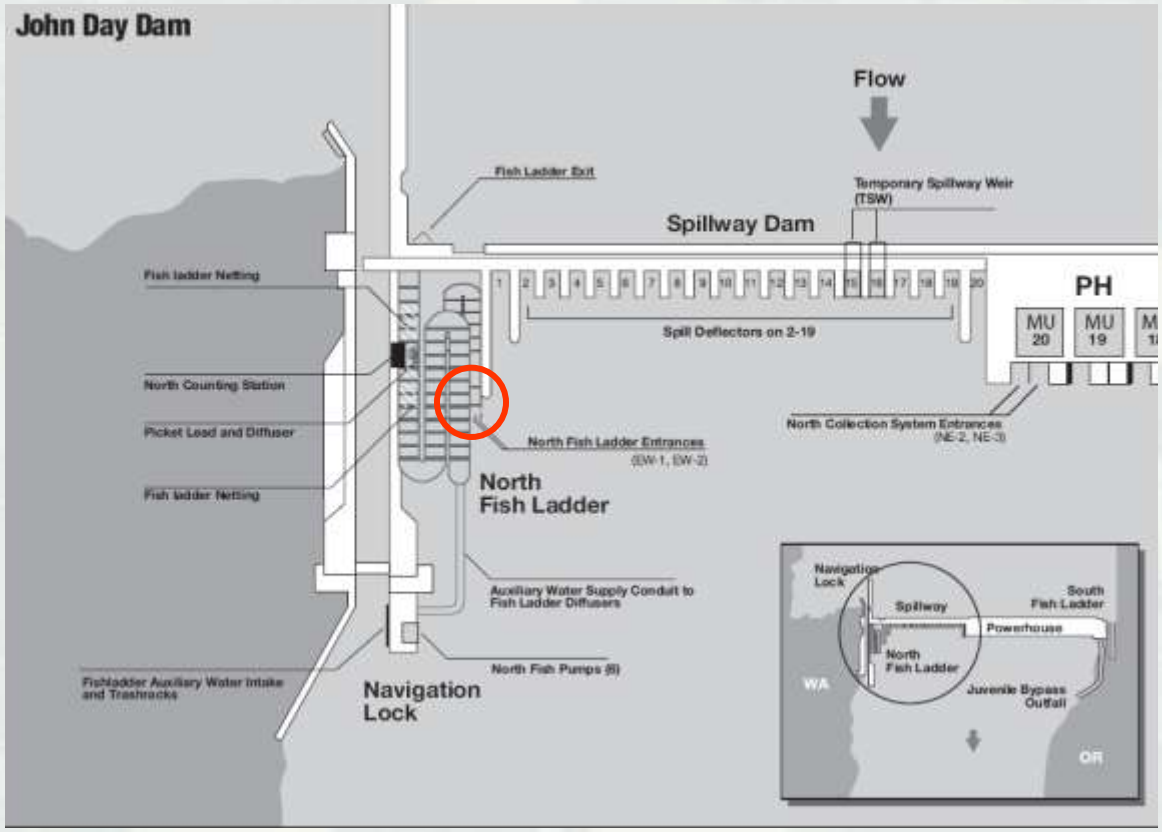
Focused CFD Modeling Applications

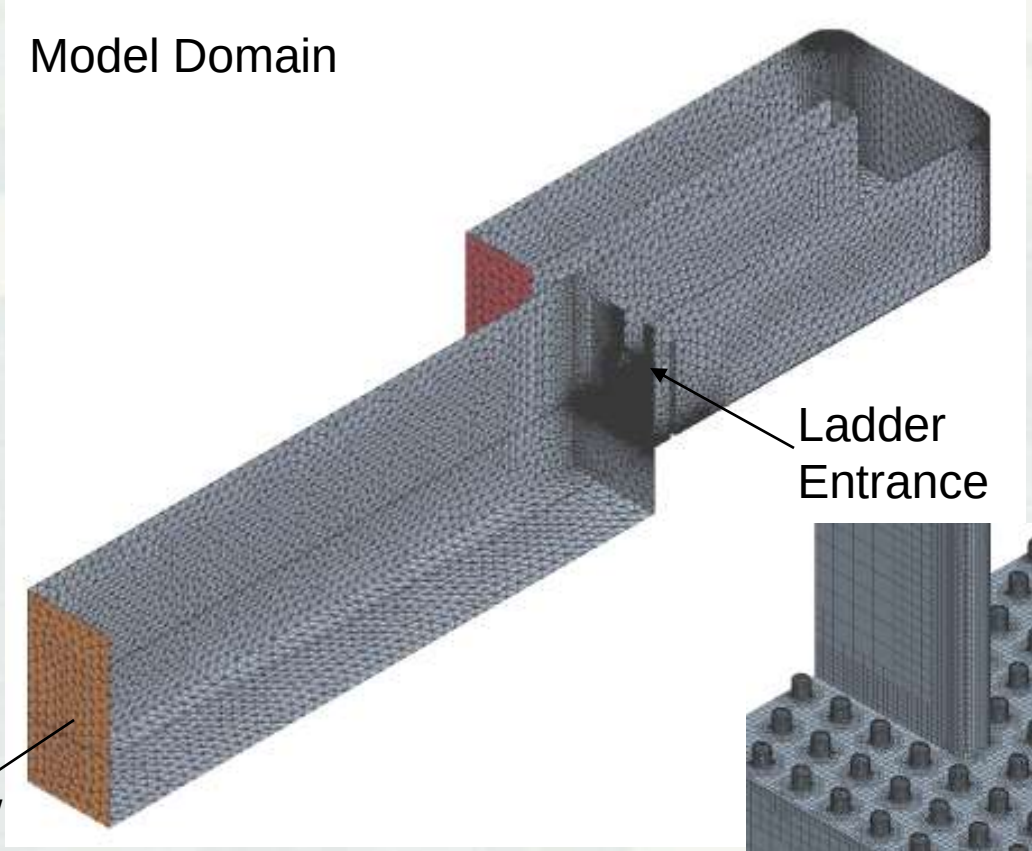
- Computational Fluid Dynamics (CFD) Modeling as a design tool
- Short turnaround or focused footprint projects
- Recent examples in Columbia and Willamette basins:
  - John Day Fish Ladder Improvements
  - Bonneville BGS (Behavioral Guidance Structure) Hydraulics
  - Minto Fish Barrier Inspection
  - Detroit Spillway Survival Tests
  - Cougar Regulating Outlet Survival Tests

John Day Dam Fish Ladder CFD Model

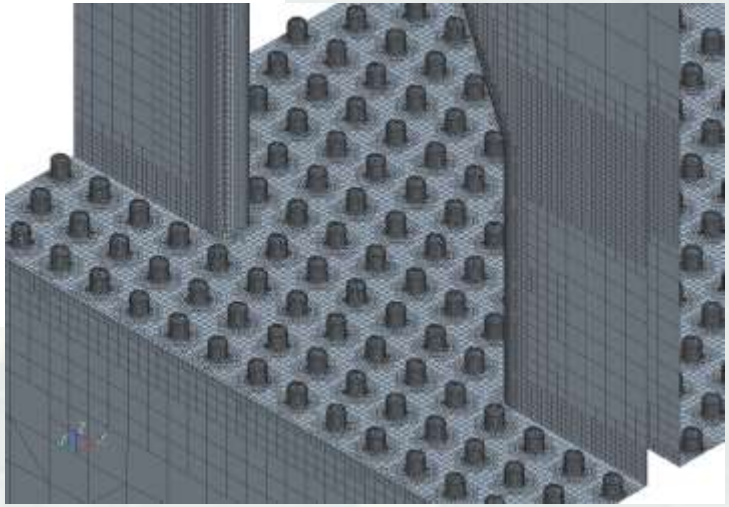
- Located at Columbia River Mile 215.6
- STAR-CCM CFD model developed to investigate hydraulic effects of improvements for lamprey passage
- Free-surface CFD model developed of focused area of JDA North Fish Ladder Entrance



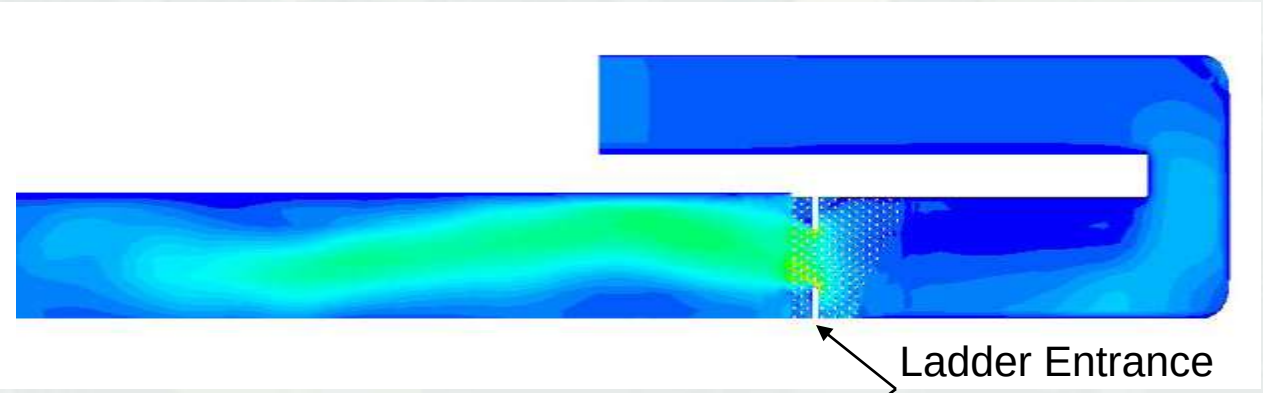
John Day CFD Modeling



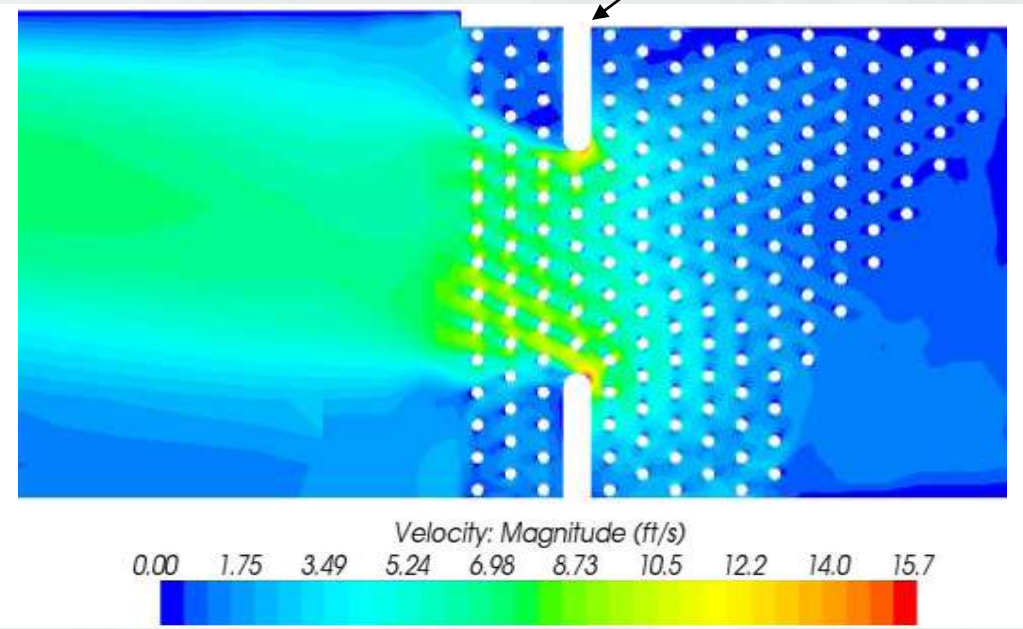
- Staggered pattern of roughness elements proposed at ladder entrance bottom
- Intent is to reduce bottom velocity for lamprey passage



John Day Dam Fish Ladder CFD Model



- CFD results for a preliminary configuration showed reduction in velocity near bottom
- Currently using CFD model to refine design of roughness elements to further reduce velocities

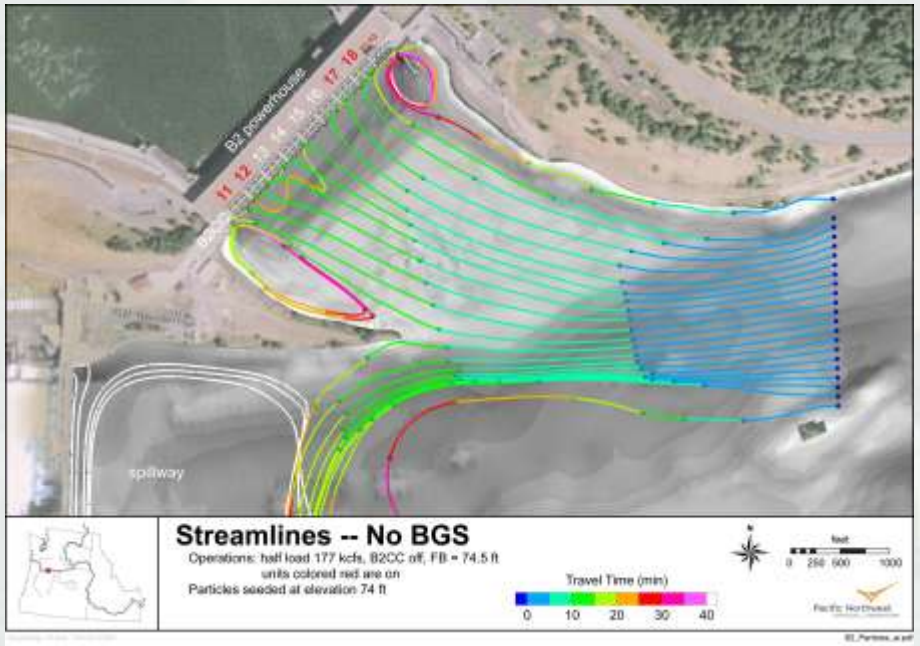


Bonneville BGS CFD Modeling

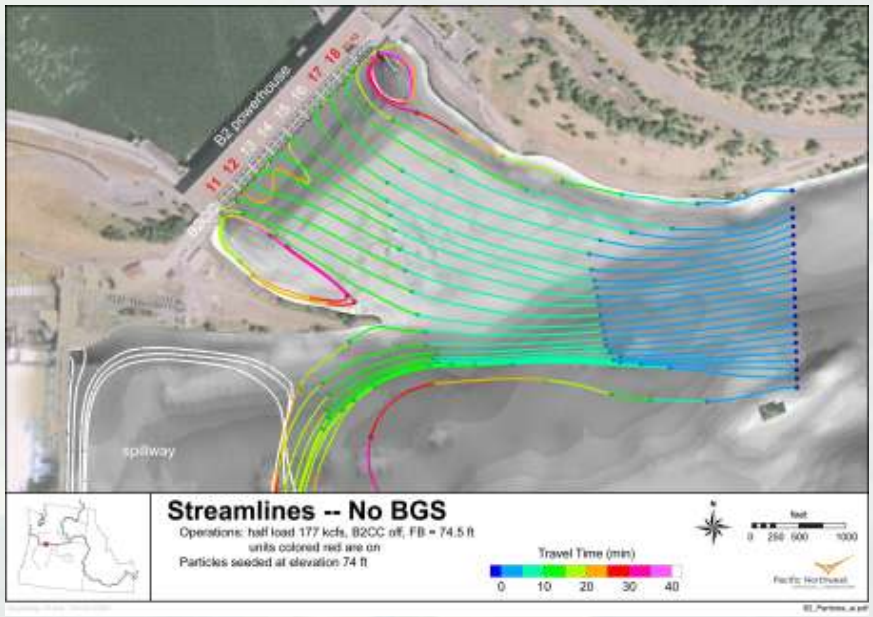
- Located at Columbia River Mile 146.1
- Shallow-draft Behavioral Guidance System (BGS) installed in 2nd Powerhouse forebay in 2008
- Modeling objective was to characterize physical environment encountered by juvenile salmon approaching and passing the BGS
- PNNL modified existing 3-D CFD forebay model to include BGS

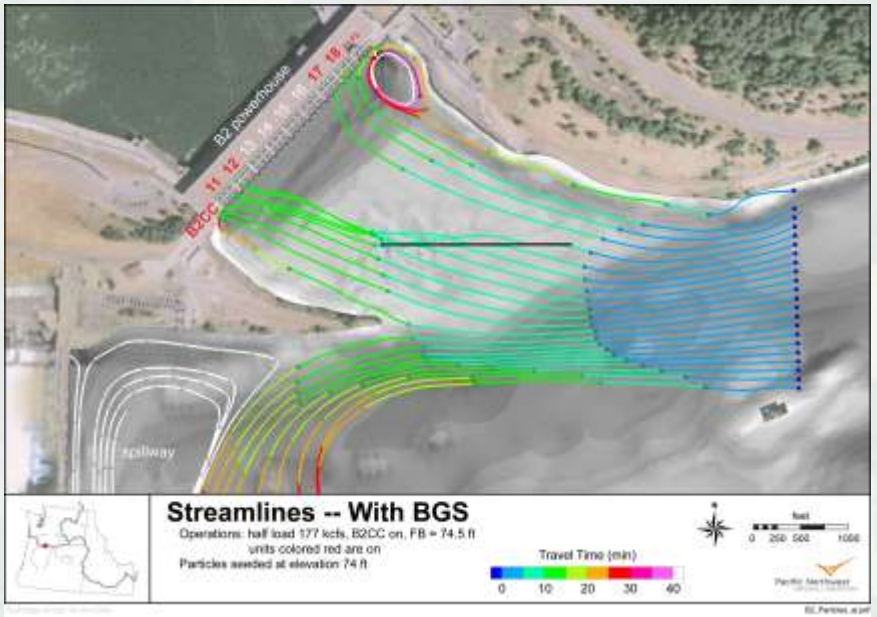
Bonneville BGS CFD Modeling

- Existing forebay model developed by PNNL in STAR-CD
- PNNL developed and validated truncated model domain with detailed grid near BGS
- Portland District ran CFD model for scenarios matching periods with fish data
- CFD results analyzed by hydraulic engineers and biologist to evaluate conditions near the BGS



Bonneville BGS CFD Modeling





- Particle tracking from CFD results showed streamlines moved across forebay toward Corner Collector and lower number units
- Later look into CFD results showed hydraulic changes at turbine intakes that may be impacting Juvenile Bypass System
- Focused modeling for BGS required follow-up with holistic look at impact on forebay hydraulics

Minto Fish Barrier CFD Modeling

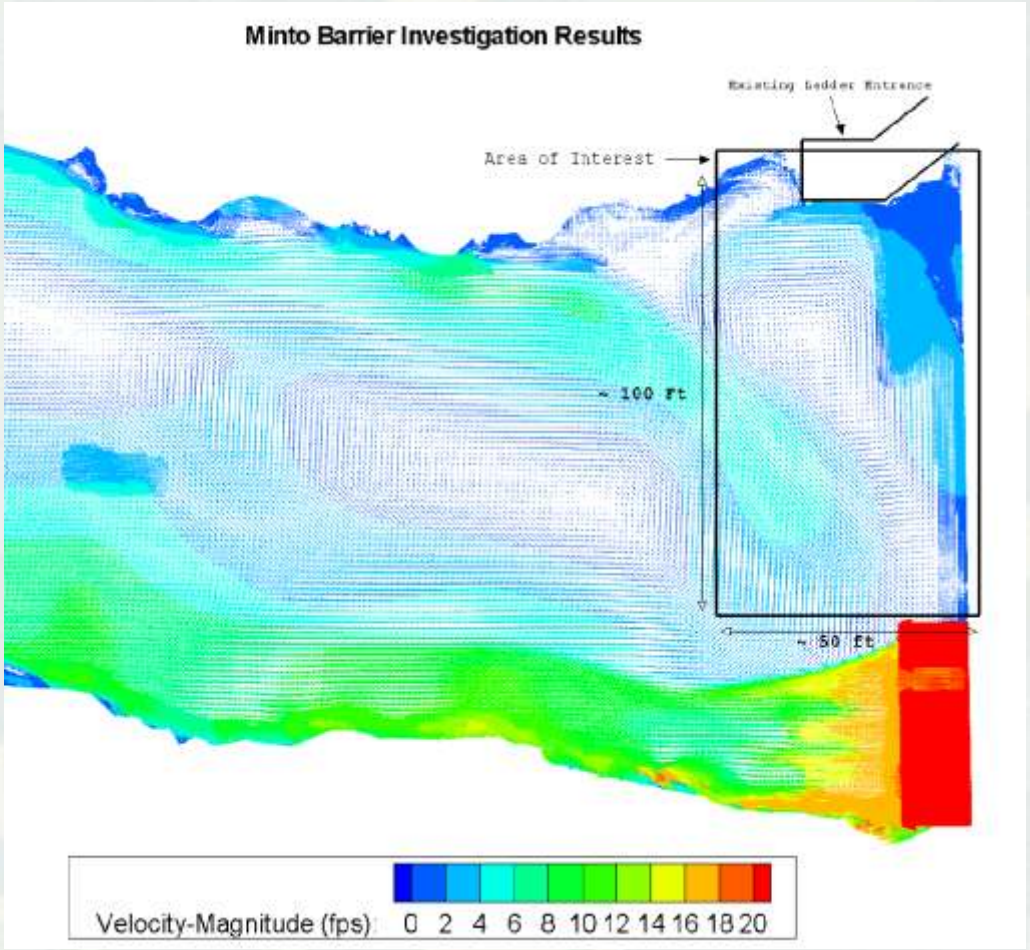
- Located downstream of Detroit/Big Cliff dams on the North Santiam River
- Potential erosion at toe of fish barrier required inspection
- Proposed flashboards on the barrier to provide low velocity area for inspection by ROV/divers

Minto Fish Barrier CFD Modeling

- Needed to predict velocities in inspection area for two flashboard scenarios:
  - Flow to right bank
  - Flow to left bank
- CFD modeling conducted to determine feasibility of inspection

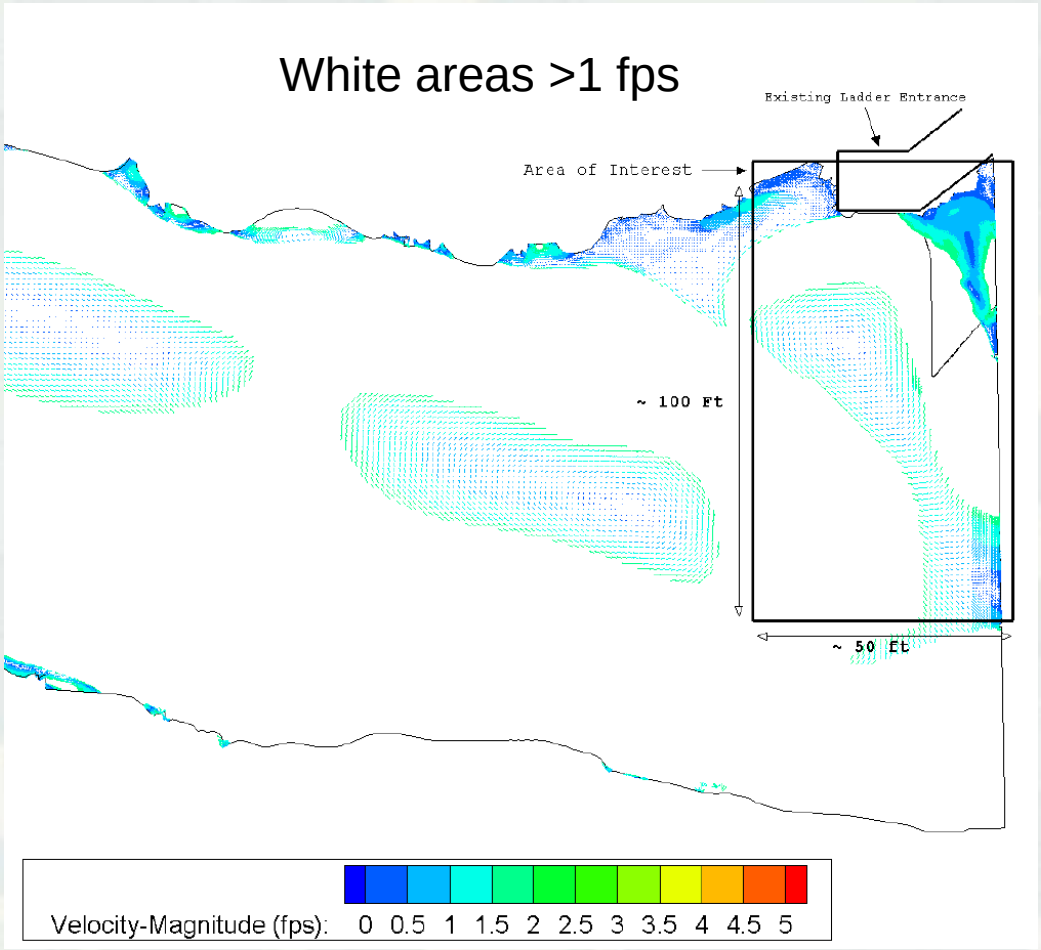
Minto Fish Barrier CFD Modeling

- CFD model developed using STAR-CCM
- Predicted velocities downstream of barrier for two flashboard scenarios
- Identified velocity thresholds for diver/ ROV inspection



Minto Fish Barrier CFD Modeling

- Compared CFD model predicted velocities to diver/ ROV thresholds
- Found inspection would not be feasible
- Focused CFD modeling completed in less than two weeks



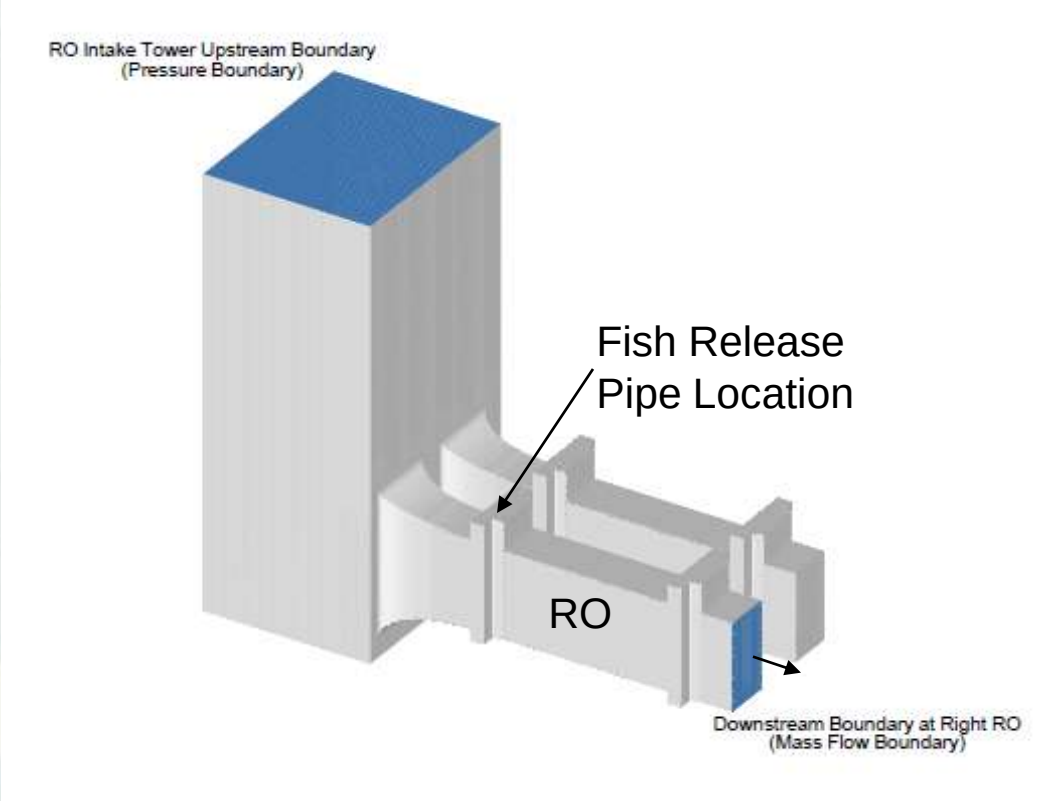
Cougar Regulating Outlet CFD Modeling

- Cougar Dam located on McKenzie River in Willamette Basin
- Juvenile survival tests through Cougar Regulating Outlet (RO) Winter 2009

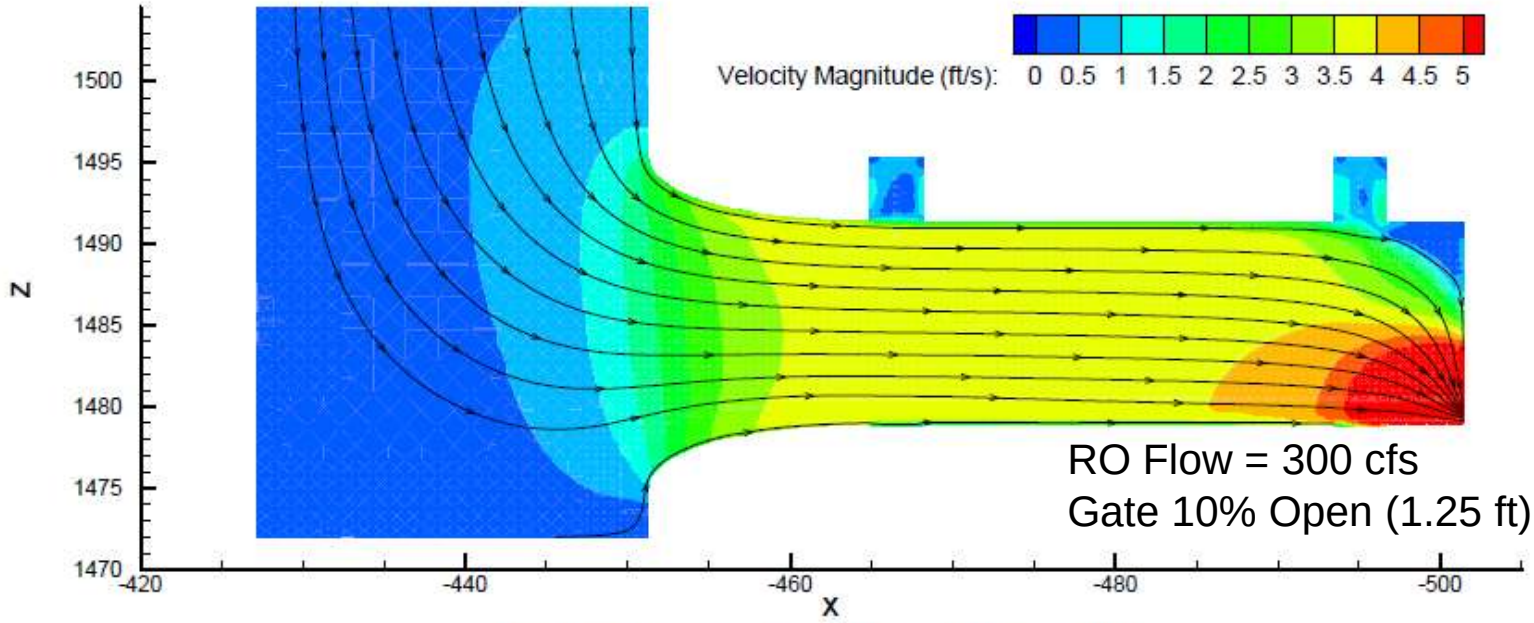
- Biological test plan required hydraulic information for fish release locations and methods

Cougar Regulating Outlet CFD Modeling

- CFD Model developed using STAR-CCM
- Model domain included
  - a portion of the Cougar temperature control tower
  - both ROs
  - gate slots



Cougar Regulating Outlet CFD Modeling



Regulating Outlet Longitudinal Section at Centerline

- CFD results showed relatively uniform velocities at release point and provided velocity magnitudes for several gate openings
- CFD model turnaround time on the order of one week

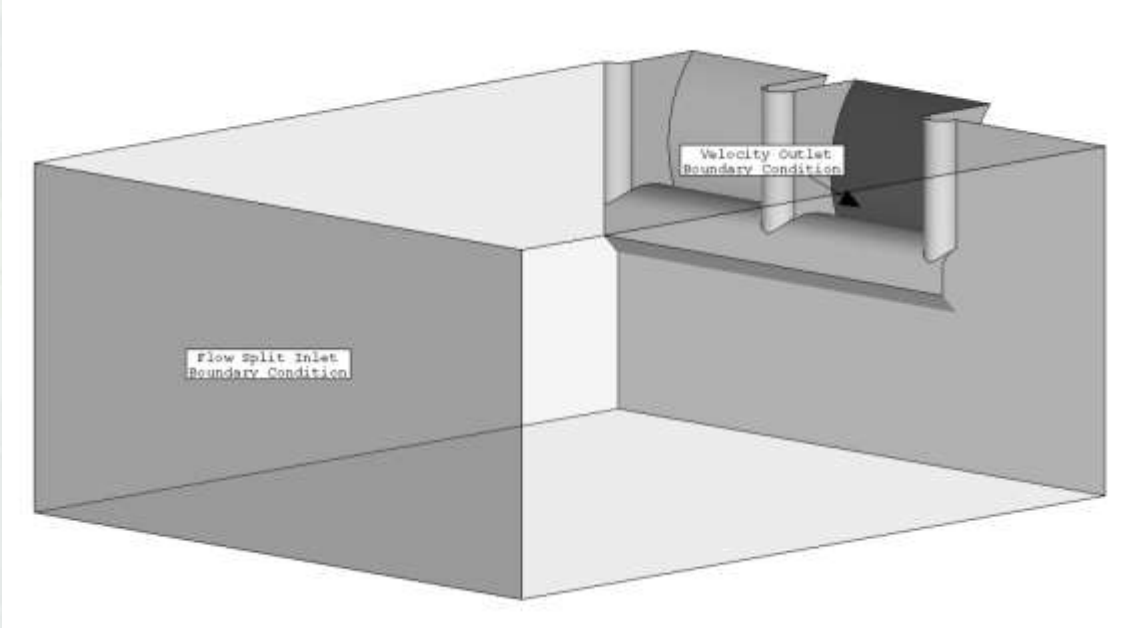
Detroit Spillway CFD Modeling

- Detroit Dam located on North Santiam River in Willamette Basin
- Juvenile survival tests through Detroit spillway bays Summer 2009

- Biological test plan required hydraulic information for fish release locations and methods

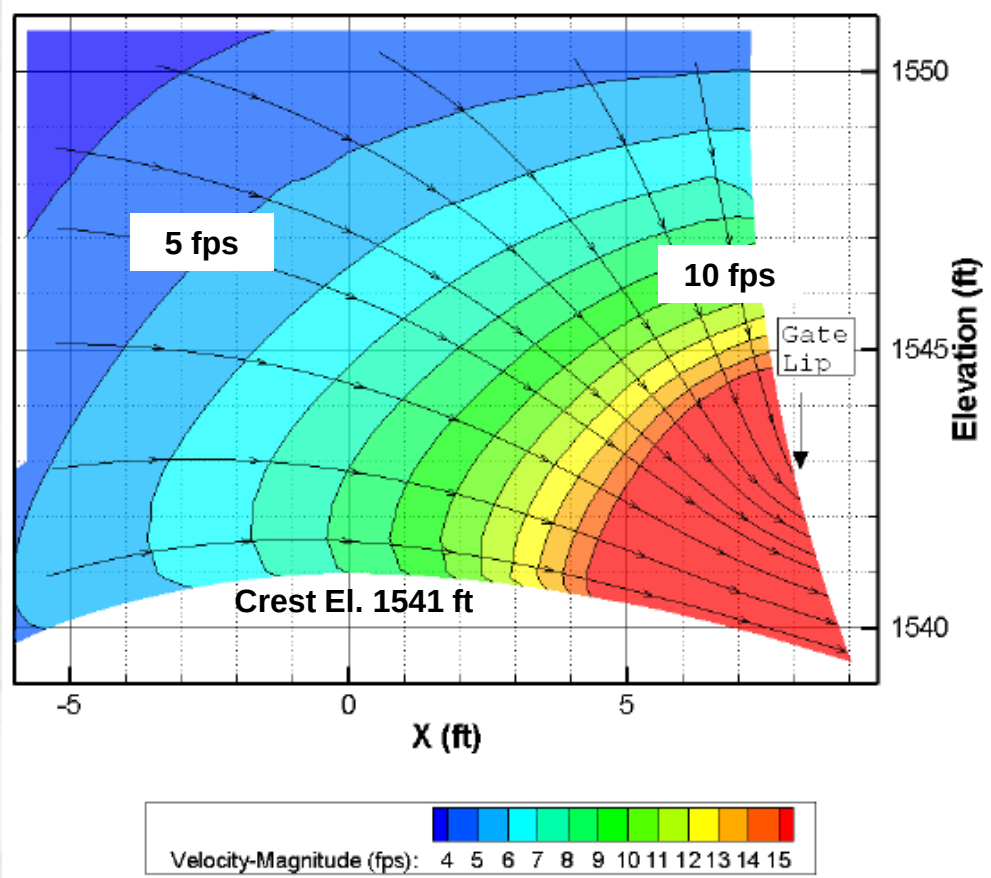
Detroit Spillway CFD Modeling

- CFD Model developed using STAR-CCM
- Model domain included:
  - Forebay 180 ft upstream
  - 50 ft of depth below spillway crest
  - 50.5 ft to either side of spillway
  - Spillway gate and crest geometry



Detroit Spillway CFD Modeling

- Analyzed CFD model results for two gate positions
  - 1-ft opening (1,225 cfs)
  - 3-ft opening (3,550 cfs)
- Target velocity at fish release location ~ 5-10 ft/s to move fish without delay
- Used CFD model to pinpoint release locations at spillway
- Modeling conducted in less than two weeks facilitated test program



Focused CFD Modeling in Columbia and Willamette Basins

- CFD modeling is an effective focused design tool
- Can be used for short turnaround, small footprint efforts
- Effective for predicting hydraulics for planning field programs, prototype testing, retrofits
- Remember: focused approach requires big-picture view of results