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Session B3: Replacement Turbine Design for Improved Fish Passage at Ice Harbor

Item Type	event;event
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Download date	2025-07-04 04:24:53
Link to Item	https://hdl.handle.net/20.500.14394/24951

Replacement Turbine Design for Improved Fish Passage at Ice Harbor

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Fish Passage 2015, June 22nd – 24th, Groningen, Netherlands



Contents

- Background (Provided by Martin Ahmann)
- **Development and Evaluation**
- Summary and Conclusions



Ice Harbor Development

- Iterative Design Process

Fixed blade:
CFD design → York testing → Vicksburg testing → Repeat

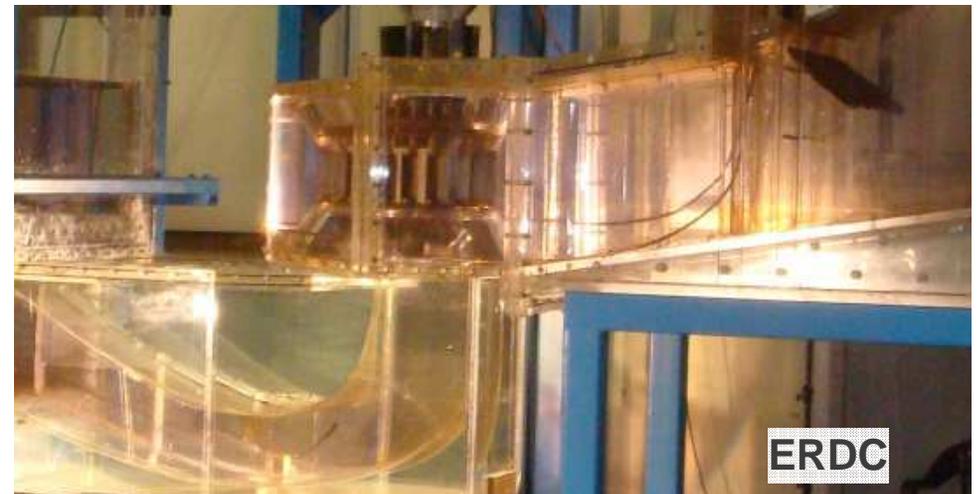
Power, efficiency, cavitation, etc. Bead observation, draft tube flow visualization, etc.

Completed
Summer 2013

Adjustable Blade:
CFD design → York testing → Vicksburg testing → Repeat

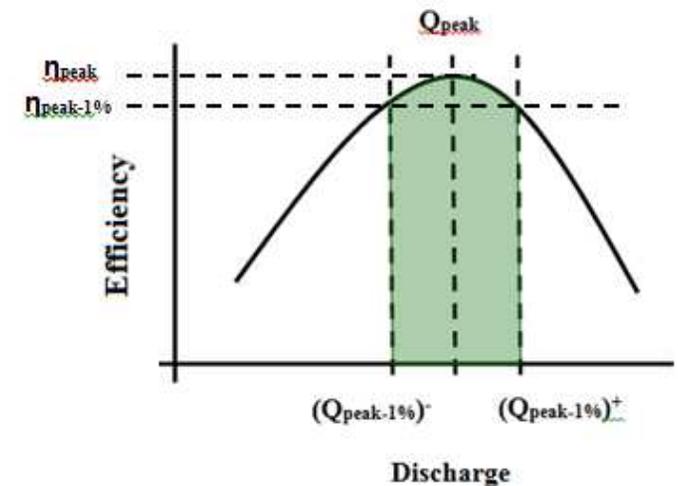
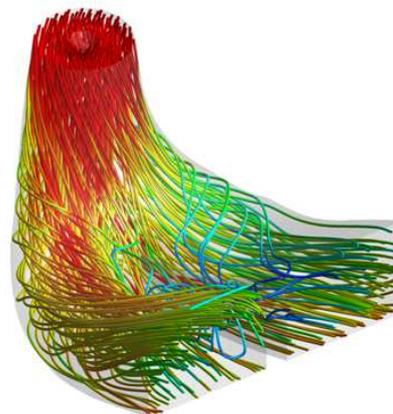
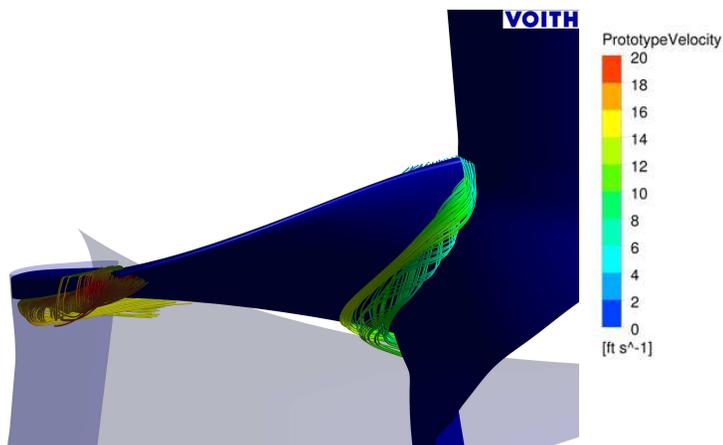
Completed
Summer 2014

Performance model 1:25 to match ERDC model. Includes trash racks, VBS & STS.



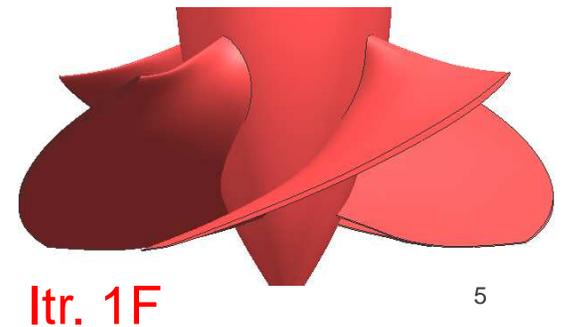
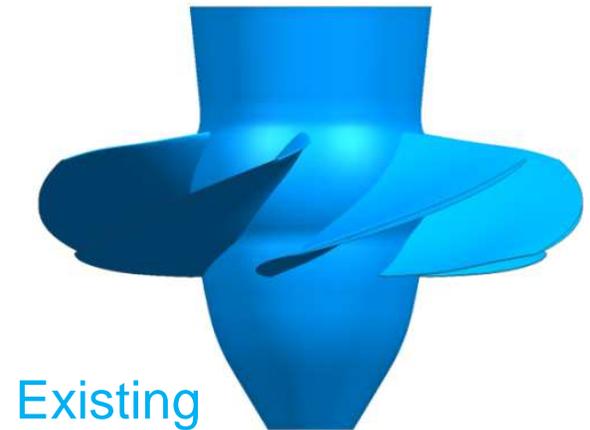
Ice Harbor Development

- Fish Passage Design Criteria
 - Minimum pressures (69 to 83 kPa, 10 to 12 psia)
 - Optimize flow quality in runner & DT
 - Minimize blade strike by considering blade number and length
 - “1%” discharge range target



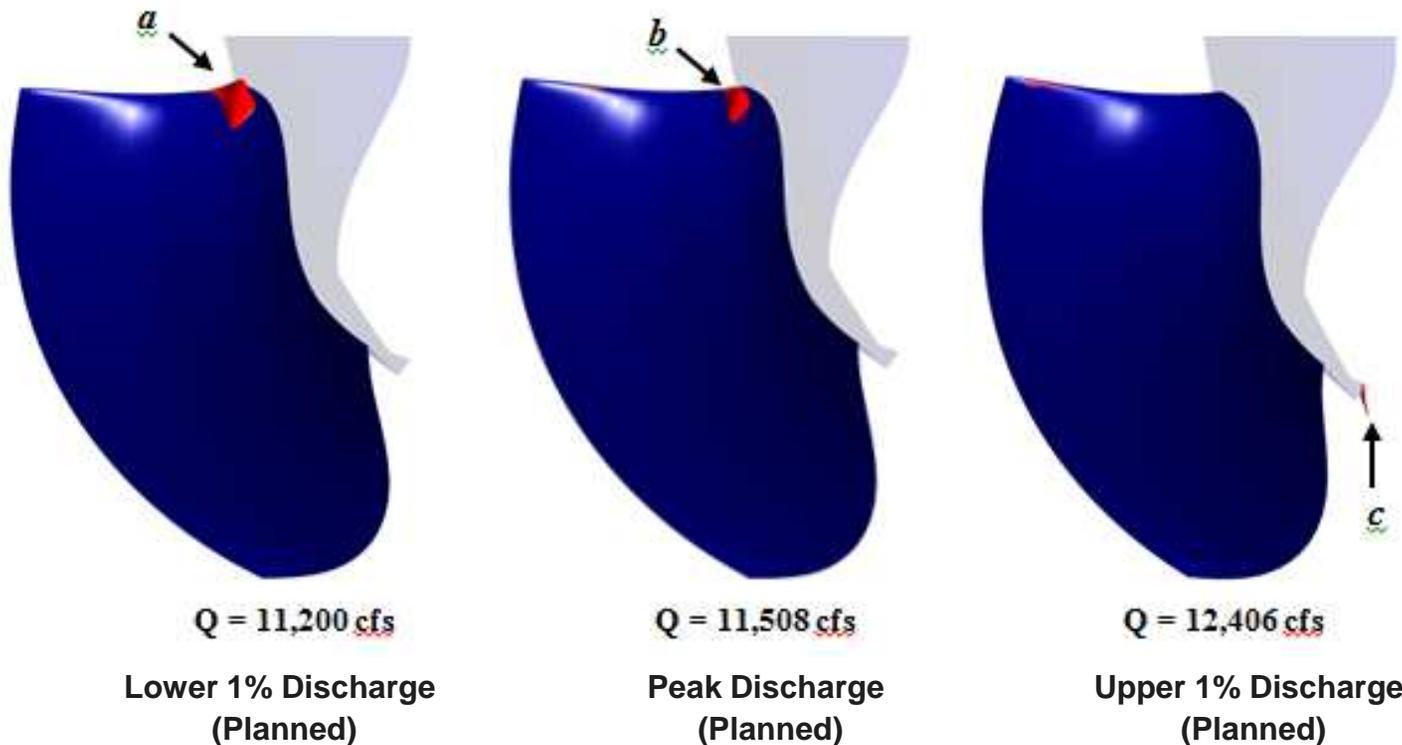
Ice Harbor Development

- Initial fixed blade development focused on meeting pressures with the fewest blades:
 - 4 blades (existing has 6 blades).
 - Blades lengthened to meet pressures.
 - Hub diameter kept small to reduce velocities between blades.



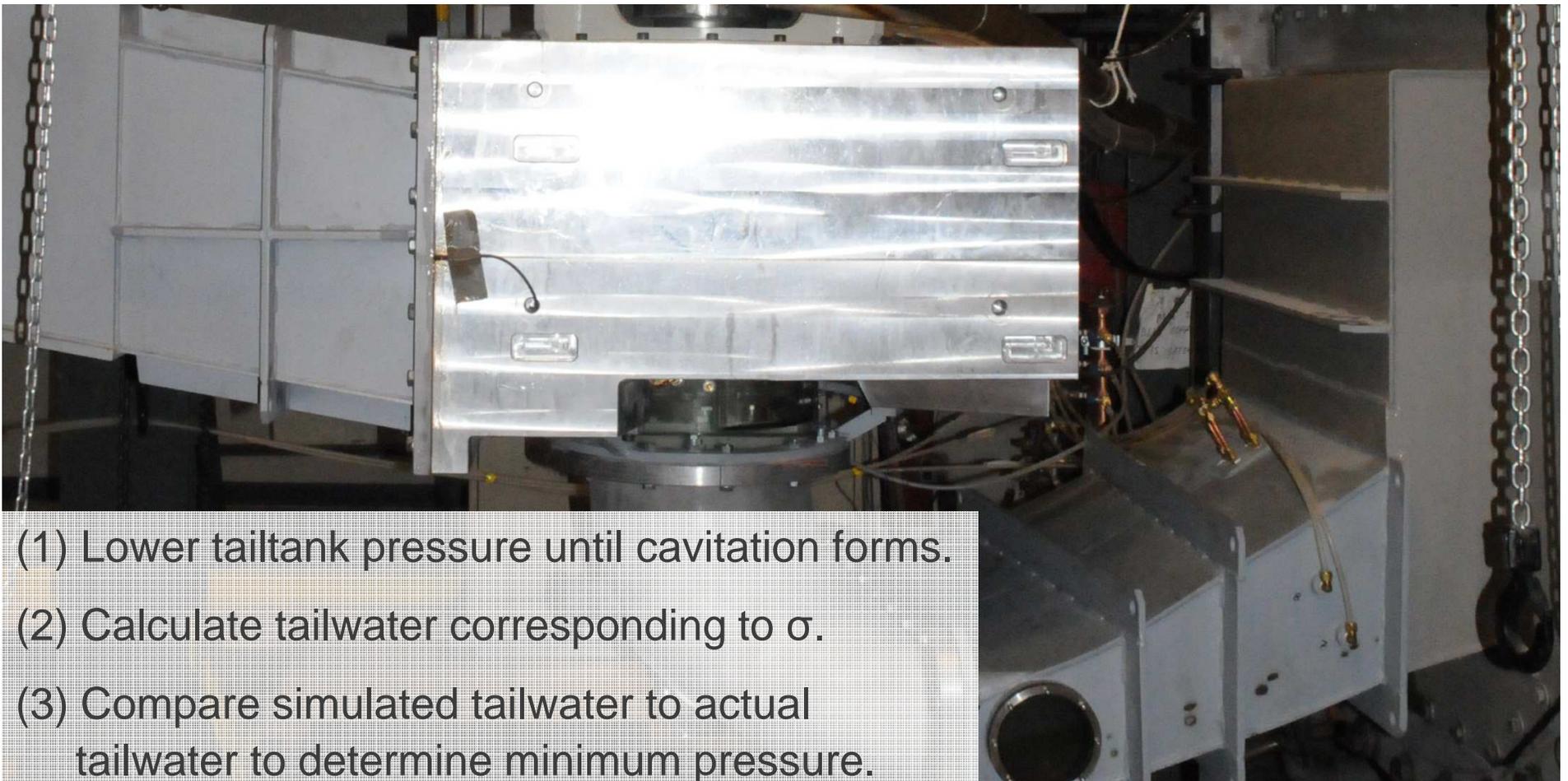
Ice Harbor Development

- Initial Propeller Design (103.4 kPa pressure iso-contour, 15 psia)
Calculations run at model size, but at correct Froude speed.



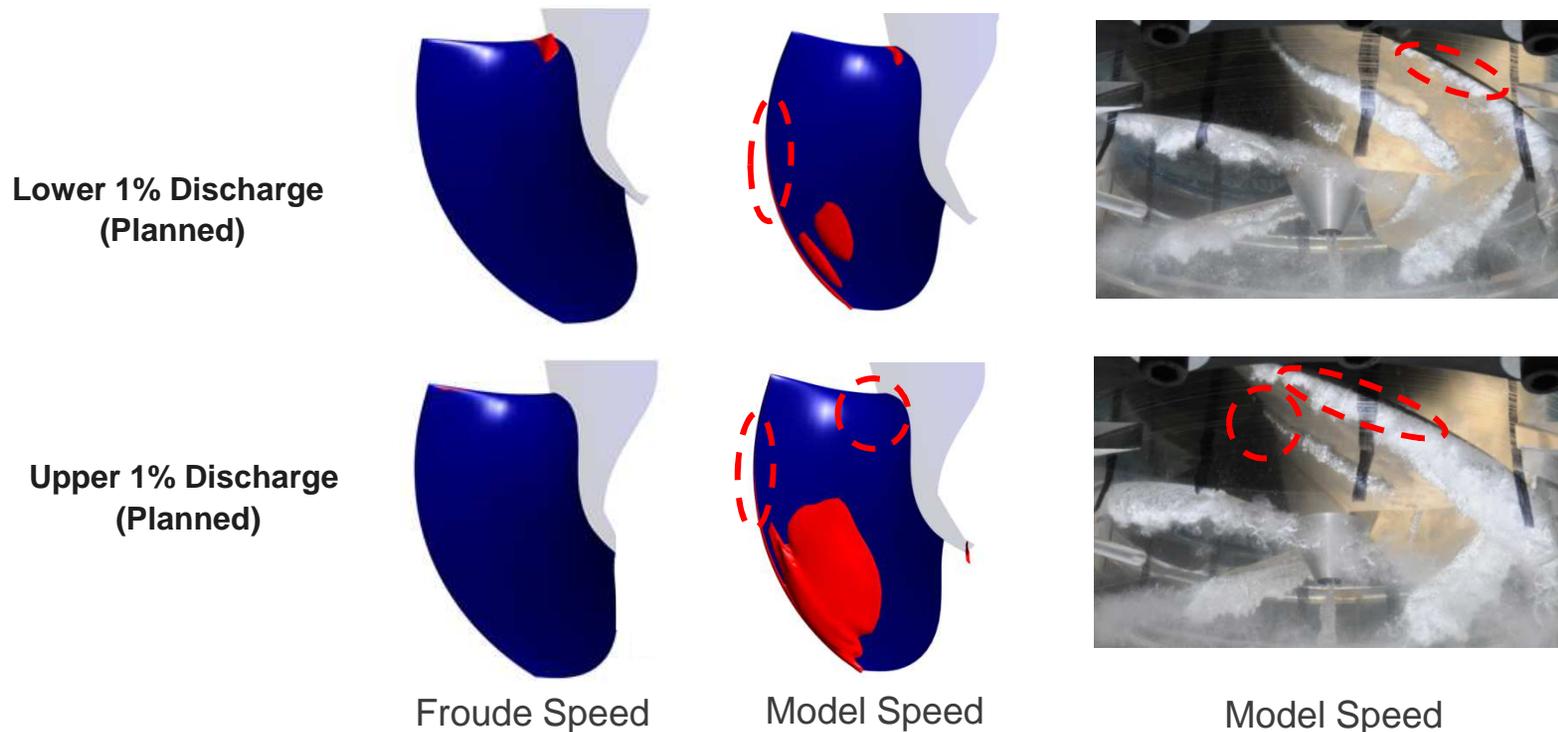
Ice Harbor Development

- Minimum pressure evaluation on performance model



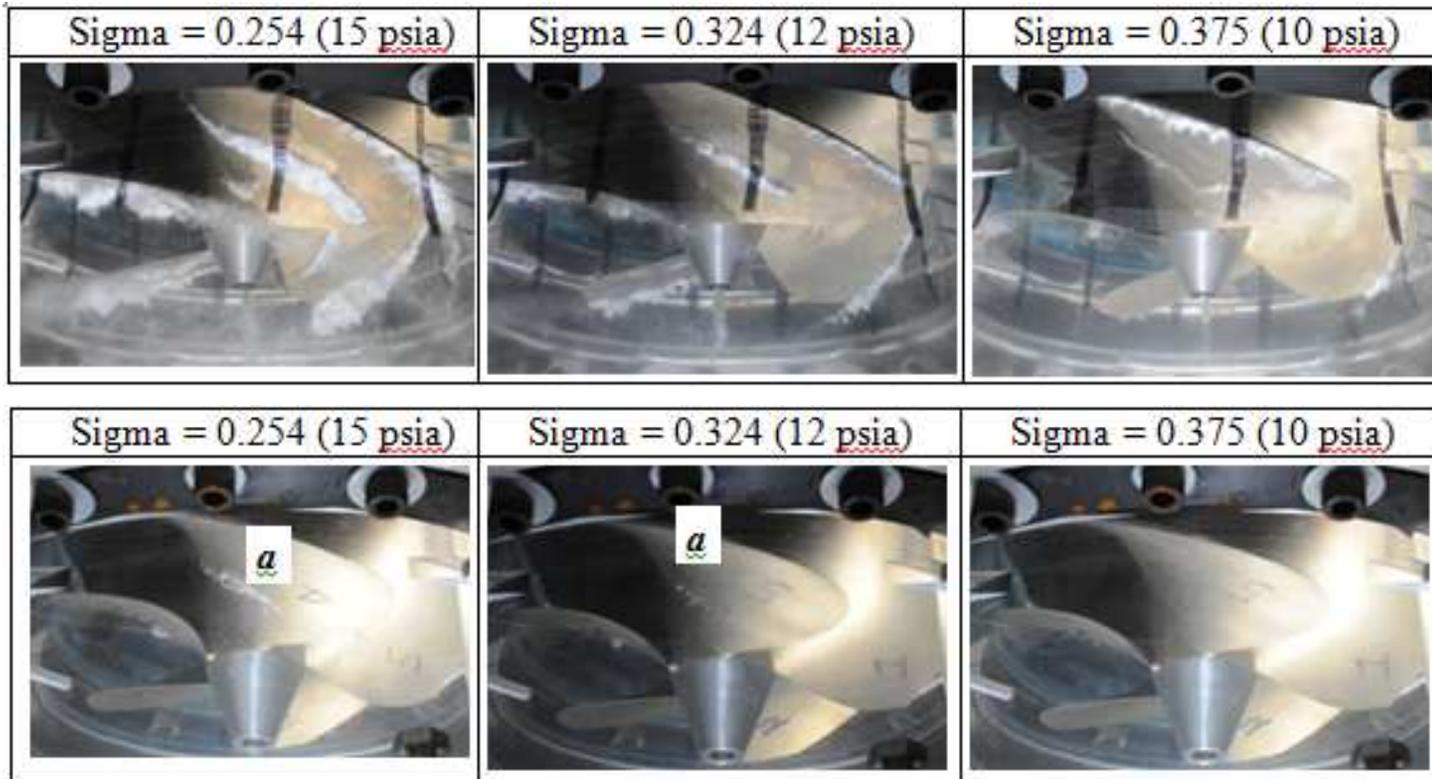
Ice Harbor Development

- Minimum pressure evaluation on performance model
 - sigma corresponding to 103.4 kPa, 15 psia minimum pressure
 - not able to match Froude speed on performance model



Ice Harbor Development

- Lower 1% discharge:

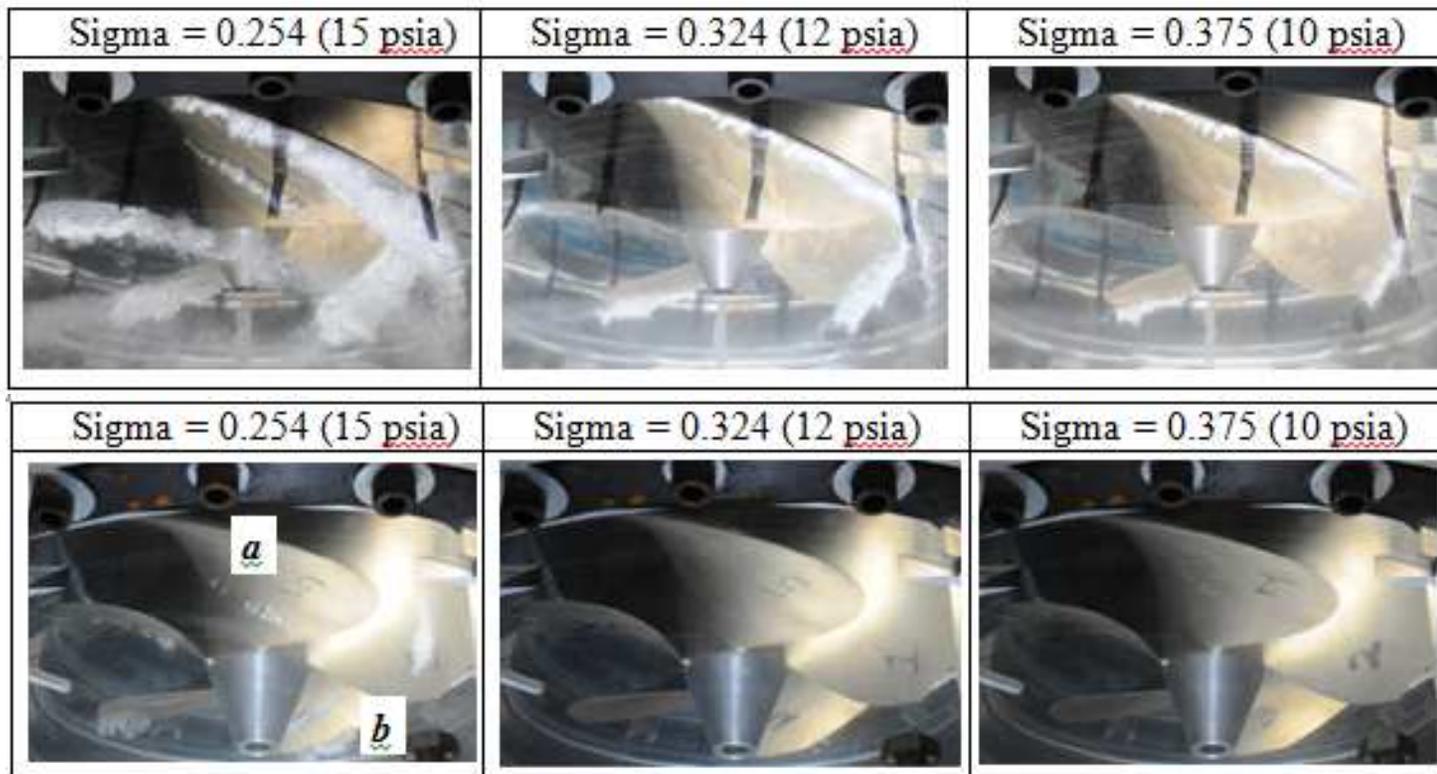


Initial Design

Intermediate Design

Ice Harbor Development

- Upper 1% discharge:



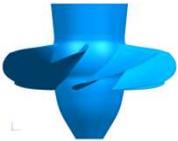
Initial Design

Intermediate Design

Ice Harbor Development

- General Bead Summary (relative to Existing Kaplan)
 - up to 650 beads released per location



		1 st Iteration	2 nd Iteration	3 rd Iteration	4 th Iteration
Hub Contact	Baseline	Comparable (some discharges worse)	Improved	Further Improved	Same as 3 rd
Tip Contact	Baseline	Worse	Comparable	Large Improvement	Same as 3 rd
Hub Direction Change	Baseline	Worse	Improved	Further Improved	Same as 3 rd
Tip Direction Change	Baseline	Worse	Comparable	Improved	Further Improved

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Conclusions

- Ice Harbor was a collaborative design effort between engineers and biologists.
- During the fixed blade development, model test results showed a strong correlation between local minimum pressures and flow quality.
- As minimum pressure levels improved, observed fish passage characteristics also improved.
- Goal of design process was to balance tradeoffs (pressure, contact, flow quality, etc.) to provide best overall design for fish passage.
 - After 4th fixed blade iteration, improving one aspect of fish passage expected to negatively impact others.
- Next step – Prototype testing after installation.

VOITH

Engineered Reliability

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