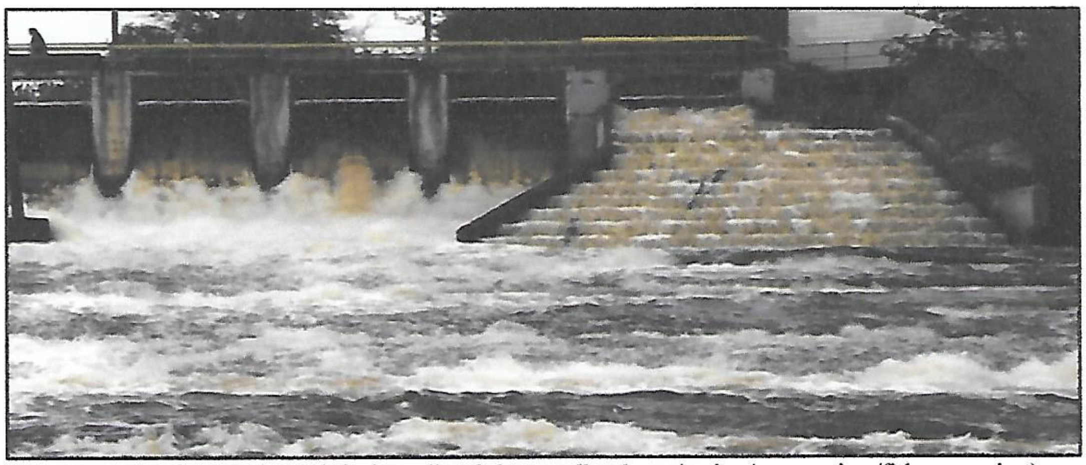
# FISH PASSAGE ASSESSMENT FOR THE LOWER REACHES OF THE CURRENT RIVER



(Photograph from NSSA website https://northshoresteelhead.com/project/current-river/fishway-project)

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## About the Authors

Larry Weber, Ph.D., P.E.

Larry earned a Ph.D. from the University of Iowa in civil and environmental engineering in 1993 and received his professional engineering license in Iowa in 1996. He is an independent consultant but also currently is the Edwin B. Green Chair in Hydraulics and a full professor in the Department of Civil and Environmental Engineering at the University of Iowa.

From 2004 to 2017, Larry served as the Director of IIHR – Hydroscience & Engineering, the nation's oldest academic research program focused on hydraulics, hydrology, and fluid mechanics. He has extensive knowledge in community resilience and planning; flooding; flood mapping; flood mitigation; river hydraulics; fate and transport of nutrients; hydropower; coupling individual-based ecological and fluid mechanics models; fish passage facilities; environmental hydraulics; hydraulic structures; and river restoration and sustainability. Through these research programs, Larry's impact has ranged from theoretical numerical model development and scientific discovery (as demonstrated in over 60 peer-reviewed scholarly publications) to the broad application of numerical models and systems-level design approaches to solve complex large-river ecological challenges (as demonstrated in over 200 conference papers and engineering research reports for contracted projects).

Larry's current area of focus range from fish passage to large-scale water resources projects, includes coupling computational fluid dynamics models to community and individual-based behavioral models to further understand fish behavioral decisions in the immediate vicinity of passage facilities. These models have been applied to natural river reaches and hydraulic structures both for fundamental advancement of scientific understanding of fish swim path selection and for practical application to the design of successful fish passage facilities.

Troy Lyons, P.E.

Troy earned an M.S. in civil and environmental engineering in 2002 and received his professional engineering license in Iowa in 2007. He is an independent consultant but also a Principal Engineer and the Director of Engineering Services at IIHR – Hydroscience & Engineering at the University of Iowa.

Troy's research has focused on the design and optimization of hydraulic structures, primarily related to dams, fishways, drop structures, gates, storm water conveyance structures, and deep tunnels. He has extensive experience in hydraulic modeling of rivers and streams, design of hydraulic structures, and hydraulic field data collection. His work has included projects on many rivers, including the Columbia, Snake, Mississippi, Missouri, Ohio, Des Moines, and Ohio rivers, among others. Troy has expertise in evaluating and modeling engineered and natural riverine environments including investigating the performance of hydraulic structures and their impacts on river flow patterns, the effects of bed roughness on water surface slope, sediment transport and deposition, design and optimization of fish passage structures at hydropower installations, modifications of spillway designs to reduce levels of total dissolved gas, and investigations of erosion potential downstream from spillways. Nearly all of Lyons' research has been applied to practice for federal, state, and private projects.

## EXECUTIVE SUMMARY

A study was completed to assess fish passage on the lower reaches of the Current River between Lake Superior and Boulevard Lake Dam. A hydraulic analysis showed that the fishway at Boulevard Lake Dam does not conform to recommended hydraulic design criteria for most fish due to the size and shape of the pools, drop between pools, and the slope. However, adult steelhead (the target species) are extremely capable swimmers and leapers and should be able to navigate the fishway once inside. Hydraulic anlysis performed in this report indicate the fishway should operate at flows between 1 and 2.7 cubic meters per second, with a recommended flow of 1.5 cubic meters per second.

The fishway entrance is not ideally located relative to the spillway, and spillway flows may attract migratory fish upstream past the fishway entrance. Fish ladder effectiveness could likely be improved by enhancing attraction flow at the fishway entrance. Enhanced attraction might be achieved with weir modifications that concentrate the entrance flows, but more extensive modifications may be necessary. Field studies should be considered to quantify fish passage efficiency and to optimize the fish ladder flow.

The Current River between Lake Superior and Boulevard Lake Dam has sections of shallow, fast flow that may inhibit passage of some fish. Resting pools have been blasted in two sections to aid passage. The most notable impediment is a bedrock ledge that likely blocks passage of many fish, including adult steelhead, particularly during periods of low flows. Options should be explored to improve passage past the bedrock ledge. A steep reach just downstream of the fishway entrance may also impede passage during some flow conditions due to shallow, fast flow between the blasted resting pools. Field studies should be implemented to inform the need for improvements past the bedrock ledge and through the final ascent to the fishway entrance.

## ACKNOWLEDGEMENTS

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Because pool dimensions are non-uniform, the hydraulics in each pool vary for a given flow rate, and therefore limits will be exceeded in one pool before another. The following fishway flows are required to meet the criteria in all pools:

   a. 1 to 2 cms for adequate flow depths over the weirs.
   b. 0.8 cms or less to provide adequate energy dissipation for fish to rest.
   c. 2.7 cms or less to maintain stable plunging flow regimes.

7. The fishway exit would typically be located further upstream from the spillway. However, given the operational plan for the spillway which distributes flows evenly through additional sluiceways, velocities near the fishway exit are expected to be low and there is minimal fallback risk for adult fish under normal flow conditions.
8. Decommissioning the powerhouse will be beneficial to fish passage. It frees up water that was formerly required to operate the turbine. This water can be used to operate the fish ladder and provide flow in the bypass reach, both critical to successful passage. Insufficient bypass reach flows were likely an impairment to fish passage in the past during periods of low river flows. Attraction to powerhouse discharge also likely impacted upstream passage by causing delays to migrating fish.

# 7 Recommendations

This study identified the most likely impediments to fish passage in the lower reaches of the Current River. Existing information is not sufficient to support detailed design recommendations. However, based on our observations and findings, a number of recommendations have been developed for consideration. For more detailed solutions, additional assessments and studies are needed.

1. The fishway should be operated at flows of 1 cms or higher, but not in excess of 2.7 cms. A flow of 1 cms provides stable plunging flow and the recommended depth over each weir and is only slightly higher than the recommended flow for energy dissipation. Fishway flows up to 2.7 cms should be considered to enhance attraction flow at the fishway entrance. While this will attract more fish, it may be offset by higher levels of energy in the ladder and possibly a decrease in passage efficiency. Fishway flows should be assessed with field studies to determinal biological efficacy of the effect of fishway flow on passage

efficiency. Pending new guidance from future studies, we recommend operating the fishway at 1.5 cms during spring and fall fish passage seasons.

2. Excess flows should be discharged through sluiceways starting with sluiceway 2 immediately adjacent to the fishway. This keeps the strongest currents close to the fishway, attracting fish upstream along the left embankment and to the fishway entrance.
3. Options should be explored to enhance attraction flows to the fishway. For the current configuration, the flow signature in the tailrace is weak and should be enhanced with higher fishway flows and/or structural modifications to concentrate the flow volume. Modifications could include narrowing or otherwise modifying the weirs and outlet to increase flow signature in the tailrace. Flows could be concentrated by either cutting a larger notch in the downstream weir or by adding flashboards (e.g., 2x12 timbers) (Figure 7-1 and Figure 7-2) to block the flow over a portion of the downstream weir. Development of these concepts are outside the scope of this study, but either option could potentially increase attraction flows without compromising fishway hydraulics.
4. Options should be explored to modify the existing fishway to create hydraulics more favorable to fish passage. This could include, but is not limited to, adding low-level orifices, enlarging existing notches, cutting new notches, adding flashboards, and changing the flow rate. Illustrative examples of possible modifications are shown in Figure 7-3.
5. Further work should include a more detailed analysis of the tailrace hydraulics, focusing on the interaction between the fishway flow and spillway flow for various flow conditions The study should explore alterations to the fishway entrance that minimize the risk of fish swimming past the entrance or not finding the entrance. The focus should be to enhance attraction flows and control the eddy that forms just downstream of the entrance.
6. Options should be explored to deter upstream movement of fish past the fishway entrance toward the spillway. Holding fish at the fishway entrance is advantageous and should increase the number of fish entering the fishway. An elevation or velocity barrier may be possible, but would require further investigation to determine the feasibility of this approach.
7. A biological study should be performed to assess fish movement from the bay to the fishway entrance including access to the bedrock ledge and to the base of the fishway. Existing natural conditions present considerable impediments to passage. Unless access is

improved, modifications to the fishway may not provide the desired passage improvements.

8. Consideration should be given to enhancing passage at the bedrock ledge. Solutions could involve a series of blasted step pools, the addition of strategically placed boulders, or the installation of a Denil-type fishway.
9. Consideration should be given to placing boulders in the bypass reach to roughen the channel and create flow refugia between the bedrock ledge and fishway entrance to enhance resting and passage opportunities for upstream migrants.
10. A biological study should be performed to assess fishway passage efficiency. Fish passage efficiency requires knowing how many fish of a certain species attempt passage compared to the number that successfully pass upstream.
11. To meet recommendations for distancing the exit from adjacent competing forebay flows, an upstream training wall extending 5 to 10 meters could be considered to create a channel that allows fish to swim further upstream and away from spillway flows before exiting the ladder. This could be assessed with a 3D numerical model of a portion of the forebay and fishway entrance.
12. Alternative approaches to providing fish passage at the dam should be considered. These approaches could include the following:
    a. Significantly modify the existing fishway to create hydraulics more favorable to fish passage. This could include modifying the pool dimensions, adjusting the step height, adding low-level orifices, adding notches, or a combination thereof.
    b. Replace the fishway with a design that meets the recommended design guidelines.
    c. Abandon the fishway and replace it with a bypass channel and nature-like fishway.
13. Other possible issues that inhibit fish passage should be explored. Environmental factors such as pollutants or marginal water temperature in the river or in the bay could be a critical component to limiting fish even attempting to enter the river.