

Innovative Fish Passage

First of Its Kind for the Ministry of Transportation

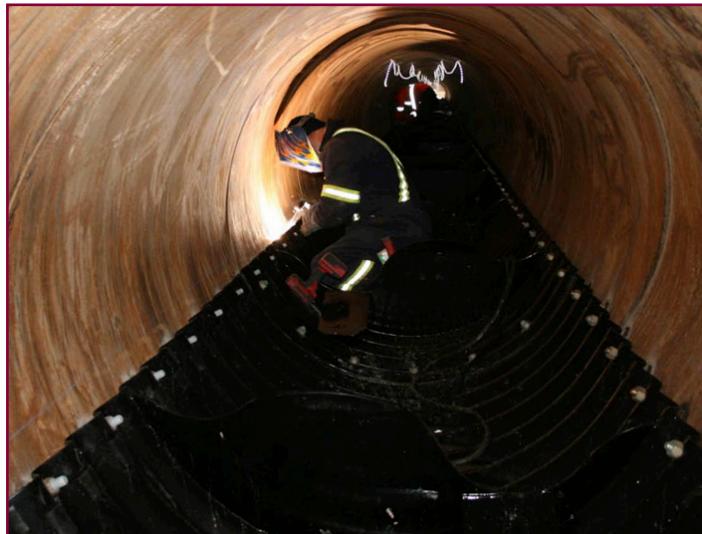
The Ontario Ministry of Transportation (MTO) has installed a replacement culvert on Highway 21, northeast of Southampton, at Craig Street, within Saugeen First Nation #29. The culvert replacement included an innovative fish ladder which promotes improved fish passage through the culvert. This new liner, featuring Duguay-Hannaford fish baffles, is the first of its kind for the ministry.

The outdated Craig Street culvert was assessed in poor condition, requiring replacement. It was also perched above the stream bed and on a steep incline at an approximately seven per cent grade. Perched culverts are often the result of erosion and can lead to the fragmentation of aquatic connectivity for streams and rivers, resulting in restricted movement of fish further upstream.



Inlet at the original Craig Street culvert.

"The inefficiencies of current fish ladder designs and the dangers they pose to fish were the principal reasons why we wanted to design a better, affordable, portable or permanent solution for safe fish passage at vertical barriers such as perched culverts," says Jason Duguay, Civil Engineering PhD candidate at the Universite de Sherbrooke.



*Fish ladder being attached to smooth steel casing pipe.
(Photo courtesy of CSPI)*

Fish ladders have long been a popular solution used to address the challenges of perched culverts. They enable fish to leap up a series of low steps within a culvert or a dam as they migrate through their environment. Some fish baffle designs host sharp baffle edges and excessive turbulence which can injure or even kill fish, especially those that are exhausted from swimming against the combined forces of gravity and flowing water. The velocity of water flowing through the ladder has to be great enough to attract the fish to the culvert, but not so strong that it washes fish back downstream.

The Corrugated Steel Pipe Institute (CSPI), in collaboration with the Universite de Sherbrooke, has developed a fish passage liner to meet fish migration challenges. After four years of development, the ministry's Craig Street culvert replacement project presented a piloting opportunity for the new design.

The design of the new fish ladder is intended to assist fish in traversing the steep grade of the culvert using a series of baffles that slow the flow of water, and reduce debris accumulation in the culvert.

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Duguay-Hannaford baffles prior to polymer coating of steel. (Photo courtesy of CSPI)

Termed the Duguay-Hannaford baffle, the fish ladder consists of a lower (primary) and a higher (secondary) passageway to accommodate passage for as many kinds of fish as possible over a wide range of seasonal water flow rates. The primary and secondary passageways alternate on each side of the successive baffles. The passageways are separated by an arch which protrudes from the water surface under all but the highest flow rates.

Water moves through the primary passageway just above the secondary passageway of the next downstream baffle. This design promotes velocity decrease through the pools between the baffles resulting in improved passage for fish. The primary passage is also wider, allowing more water to flow through, giving fish a larger passage to jump through. The secondary passage serves as an alternative slot during high flow rates, not only for fish, but also for debris.

The key technical refinement of this fish baffle design, by Environmental Scientist, Ken Hannaford, is the use of more natural alternating curved forms rather than angular ones. By sequentially alternating the baffles on either side of the pipe, water velocities are relegated, reducing overall turbulence in each pool of the fish ladder. The corrugated walls of the pipe also help to reduce flow velocities.

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Looking downstream at the fish ladder grouted in place and running full. (Photo courtesy of CSPI)



Water cascading through primary and secondary passage of the fish ladder. (Photo courtesy of CSPI)

During the development of the liner, water simulations were numerically evaluated for barrier velocities, turbulence and maximum vertical drop between pools to ensure that the new design could develop spatial distributions of water similar to those of other designs recommended by the Department of Fisheries and Oceans Canada. The elevated centre arch in the new baffle design creates pool depths, minimizing the volumetric dissipative power in the pools at higher flow rates. Numerical results showed that velocities at the passageways support critical swim speeds for a wide range of North American fish species, including: Brown Trout and Cutthroat,



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*Upstream view of the new culvert.
(Photo courtesy of CSPI)*

Sockeye, Coho and Chinook Salmon species. The presence of adequate refuge zones (calmer areas of water between the baffles for fish to rest as they move up the culvert) was also assessed. The fish ladder simulations were tested at typical seasonal flow rates.

For the pilot project, CSPI incorporated the ministry's design requirements into an innovative solution for the Highway 21/Craig Street site conditions. A new steel pipe culvert was installed adjacent to the original culvert at approximately a seven per cent grade, using a trenchless method (jack and bore), beneath the highway. The fish passage liner was installed inside the new steel pipe culvert, enabling fish to access the watercourse upstream. In addition, favourable fish habitat features were incorporated into the stream at the upstream and downstream ends of the new culvert, including fish pools and riffles.

Noticeable habitat improvements have been observed since the installation of the new culvert. Fish surveys were completed on May 6, 2016, and results indicate that fish are migrating upstream of the culvert. Two Rainbow Trout and five Creek Chub were found upstream during the survey. Prior to the culvert replacement, no fish could migrate upstream due to the barrier imposed by the original culvert. Additional monitoring will take place in the summer, and again in spring and summer 2017.

Plantings and site restoration to complete the project began in spring 2016 and are taking place in two phases. MTO is



The area upstream of the new Craig Street culvert after phase-one of post-construction landscaping.

currently pursuing a post-construction landscaping opportunity where members of the Saugeen First Nation community will help to restore the site after construction by planting native trees, shrubs and grasses to enhance the area surrounding the Craig Street culvert.

MTO is meeting its obligations under the Environmental Assessment Act by balancing environmental protection with transportation engineering considerations. This project is an example of how environmental protection principles which enhance the natural environment can be successfully implemented within highway improvement projects.

The replacement of the Craig Street culvert was a unique project due to its steep perched grade. The ministry will consider using the innovative Duguay-Hannaford fish baffle in future similar scenarios, based on the success of this project and the positive effect on habitat.

The Highway 21 culvert replacement, completed in December 2015, was presented in detail at the 2016 Canadian Society of Civil Engineers (CSCE) Conference in London, Ontario, June 1-4. •

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