

## **Striking gold - Thomson River fishway & walking track (Horseshoe Bend)**

Stork D<sup>1</sup>, Cleven S<sup>2</sup>, Berrill G<sup>3</sup>

1. West Gippsland Catchment Management Authority, 16 Hotham Street Traralgon, 3844. [davids@wgcma.vic.gov.au](mailto:davids@wgcma.vic.gov.au)

2. Alluvium Consulting Australia, 105-115 Dover Street Cremorne, 3121. [stuart.cleven@alluvium.com.au](mailto:stuart.cleven@alluvium.com.au)

3. Thompson Berrill Landscape Design, 251 Chapel St, Prahran VIC 3181. [gberrill@tbl.com.au](mailto:gberrill@tbl.com.au)

### **Key Points**

- A gold mining river diversion tunnel dug in 1912, short-circuited 1 km of the Thomson River. The dry riverbed and tunnel hydraulics became a barrier for fish (incl. EPBC listed Australian grayling), blocking access to over 80km of high value habitat. The tunnel is heritage listed (including the flows through it) and is popular with walkers, sightseers, and the local community.
- Extensive community consultation and iterative designs over 9 years resulted in the construction of a 230m long fishway carved out of the river bedrock, and the formation of a grade 3 walking track. The fishway drains water away for the tunnel entrance to re-engage the bypassed river channel. It replicates the natural waterway features and is in keeping with its natural environment, with no imported materials used in construction. The arrangement maintains more than 60% of river flows through the tunnel (demonstrating its engineered function), while the remaining 40% is diverted into the former riverbed providing conditions suitable for fish to navigate past the tunnel exit, and successfully traverse the former riverbed and constructed fishway. The walking track includes signage and river crossings to enable safe access for recreation visitors to not only experience the Horseshoe Bend Tunnel but interact with the flowing river and surrounding environment.
- The measured and observed positive outcomes of migratory fish repopulating upstream, and visitors enjoying the scenic walk and historical tunnel are clear indicators of project success.
- It is a unique and outstanding project that balances competing objectives, required an innovative fishway design, demonstrates best industry practice, and achieves exceptional environmental and social outcomes.

### **Abstract**

The heritage listed Horseshoe Bend Tunnel was constructed in 1912 to provide dry riverbed access for alluvial goldmining on the Thomson River. While gold mining ceased at the site not long after construction, the tunnel continued to divert the river, presenting a significant barrier for native fish passage, particularly the many migratory species that are present downstream. The West Gippsland Catchment Management Authority (WGCMA) led a project to restore fish passage at the site, whilst preserving the competing heritage, scenic, and social values.

Extensive community consultation and iterative designs resulted in the construction of a 230 m long fishway carved out of the river bedrock, and formation of a class 3 walking track. The arrangement maintains more than 60% of river flows through the tunnel (demonstrating its engineered function), while providing flow conditions suitable for fish to navigate past the tunnel exit, and successfully traverse the former riverbed and constructed fishway. After two years of operation, the success of the fishway design and implementation has been demonstrated by an influx of the native migratory fish Tupong (*Pseudaphritis urvillii*) into the upper reaches of the Thomson River.

The Thomson River Fishway is a unique and outstanding project that balances competing objectives, demonstrates best industry practice, and achieves outstanding environmental and social outcomes.

## Keywords

Engagement, heritage, fish passage, engineering, construction, recreation, environmental outcomes

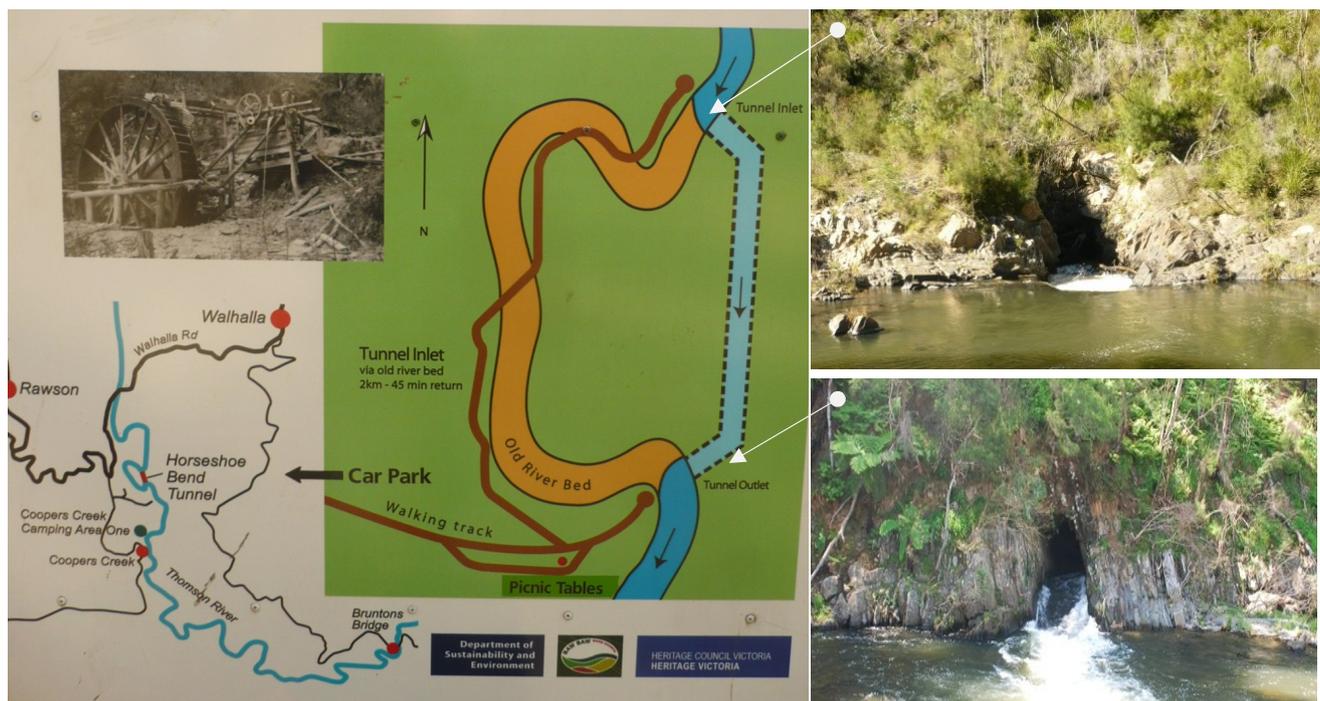
## Introduction

Many have said a TV drama series could be made about this project. The 20-year struggle to reconnect more than 80 km of high value mountainous river habitat of the Thomson River catchment, allowing migratory fish species to freely traverse the 200 km of river again between the Gippsland Lakes and the Victorian Alps. There are too many twists and turns to cover in this one paper. Instead this paper reports on how significant social and physical barriers were overcome to achieve exceptional social and environmental outcomes.

The project provides a number of industry firsts in Australian fishway design, including the first ever bedrock cut fishway, no introduced materials to site and the use of hydraulic modelling to test and modify eddy currents to address fish attraction issues.

## Background

In 1912 the ambitious task to create a 210-metre-long river diversion tunnel through thick bedrock in the upper Thomson River was completed. The tunnel was to provide dry access to one kilometre of riverbed that had provided significant alluvial gold winnings fifty years prior. The tunnel was driven through a ridge of land called Stockriders Spur by the Thomson River Alluvial Gold and Tailings Recovery Company. Stockriders Spur provided the barrier around which the river formed a horseshoe bend. The site was one of many actively mined areas in and around the gold mining town of Walhalla in Victoria.



**Figure 1. Horseshoe Bend on the Thomson River - Site information board (left), inlet and outlet (right)**

Situated within the rugged forested reaches of the upper Thomson River in Gippsland, the site over time became popular with the local community who enjoyed walking within the steep river gorge, surrounded by with the bushland and wildlife, finding artifacts from mining days, enjoying the cool clear water, or seeing the unique spectacle of a river flowing into and then gushing out of the side of a hill.

Because the inlet portal was dug into the bottom of a deep natural pool in the river, it lowered the river significantly leaving the downstream riverbed more than a metre above the new water level. River flows only engaged the abandoned riverbed section during very high flow events that occurred about 30% of the time in an

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average year. Following the completion of the Thomson Dam upstream of the site in 1983, this frequency further reduced to only 6% of the time.

The hydraulics and gradients at the tunnel inlet and outlet, lack of light through the tunnel, and lack of regular flows through the by-passed river channel presented a significant barrier for native fish passage. The Thomson River hosts good numbers of native fish, with 70% of species being diadromous (migrating between fresh and salt water during life cycle). Annual fish surveys conducted by the Arthur Rylah Institute found small bodied diadromous fish like Tupong (*Pseudaphritis urvillii*) and the EPBC listed Australian grayling (*Prototroctes maraena*) existing throughout the river downstream of the tunnel but were absent upstream.

In the late 1990's the WGCMA sought to remove the fish barrier and reinstate river connectivity. This included an attempt to implode the tunnel with explosives, and later designs to seal it up with concrete. These approaches gained disapproval from the local community and led to the successful petitioning for the tunnel to be listed as a site of state significance under the Victorian Heritage Act.

Around 2010 the WGCMA revisited the fish passage issue but this time sought to find a solution that also protected the heritage, social, recreational, and scenic values associated with the site. This was a task as ambitious as the creation of the tunnel itself, as many of these values were in direct conflict with the provision of fish passage. This paper reports on this process and how it was effective in achieving more than just fish outcomes.

## **The barriers**

Aside from the physical barrier for fish, there were a great number of social and technical barriers to be overcome for the project to be successful.

### *Stakeholder and community support*

Resentment and mistrust had built up in parts of the community towards the WGCMA over the project. This was particularly true for community members who formed the Friends of Horseshoe Bend Tunnel group. The group were strong advocates for the heritage significance of the tunnel and were deeply passionate about the social and environmental values that existed at the site. They were successful in lobbying for the tunnel to be listed on the Victorian Heritage Register in 2002, and in garnering political and community support to oppose previous fish passage proposals. For the project to be successful, it would require learning from the past short comings and undertaking a collaborative and transparent approach that ensured all stakeholder objectives were treated with equal respect.

### *Environmental values, remote access, and steep terrain*

The remoteness of the site, its natural picturesque beauty, remnant native vegetation, and its popularity with visitors meant that any constructed fishway would have to appropriately protect these values. This required an overall site design that limited the impact on vegetation removal, retained site aesthetics, and provided ongoing public access. This meant that traditional approaches to fishways, such as cast concrete structures and large rock ramp structures were out of the question.

In addition, the steep terrain that confined the river channel and site remoteness meant that any construction activity would be hampered by limited machinery access. The off-site haulage of any material excavated during works would not be feasible, and similarly the importation of material would be very difficult. The ability to construct a fishway within the site whilst minimising overall site disturbance presented major constraints on the overall design and constructability.

## **Protection of heritage values**

The protected heritage values of the tunnel included the demonstration of its engineered function (i.e. river flowing through it), which created four key challenges:

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1. How to appropriately split flows between the tunnel and abandoned channel to continue to demonstrate the tunnels engineered function?
2. How to reconnect/divert a portion of river flows through the abandoned channel and facilitate fish passage?
3. How to attract fish past the turbulent flows at the tunnel outlet?
4. How to provide sensitive and safe recreation access to the tunnel entry and exit with two river crossings

## **Recreation**

The dry riverbed had become a popular informal walking track, with visitors enjoying the kilometre-long nature trail along the river channel. A reconnected river would cut off the existing track. The steep surrounding hillslopes that boarded the riverbed placed significant limits on relocating the track, and the valley width meant a high span bridge would be too expensive and a low span bridge would be taken out within years by floods.

## **Stakeholder and community engagement**

Due to the conflicts with community interests in the past, and the diverse and conflicting values, meaningful and effective consultation was crucial to the project's success. Over the course of the project seventeen stakeholder and community groups were consulted.

At the beginning, a stakeholder consultative group was established to work collaboratively with the WGCMA and design team to ensure all elements of the site were appropriately incorporated. The first step was to identify and fully understand the critical values and objectives of each stakeholder group. This would provide the basis by which fishway options could be assessed and prioritised. These objectives are listed below.

- River Health Values/ fish passage: Implementation of WGCMA River Health Strategy and Catchment Action Plan to responsibly manage waterways and improve river health in the region – achieved through the provision of fish passage for the Australian Grayling, listed as a threatened species under the Environmental Protection & Biodiversity Conservation (EPBC) Act
- Environmental and Heritage Values: Compliance with the Heritage Rivers Act and Heritage Rivers & Natural Catchment Management Plan, which falls under the Act
- Heritage Values: Compliance with the requirements of the Victorian Heritage Register for the Thomson River Diversion Tunnel under the Heritage Act (Tunnel, 5m curtilage, water flow)
- Heritage Values: Compliance with the planning scheme Heritage Overlay, which if triggered will require a planning permit with BBSC
- Affordability: Affordable solution (cost of works vs. benefit obtained)
- Tourism values maintained: scenic and historic values
- Access to tunnel inlet maintained: a walking track to tunnel inlet is kept
- Recreational value of area maintained: walking values, water play, sightseeing, bird & nature watching

Stakeholders were asked to input to conceptual ideas on providing fish passage at the site. This provided an opportunity to identify innovative options that also protected the specific groups interests. To ensure stakeholders understood what was required for fish passage a presentation was given on the hydraulic and environmental needs for fish to successfully navigate obstacles. This, together with the stakeholder objectives (above), provided everyone with the basis by which options would be assessed. Only one of the five options satisfied these criteria and was progressed to the feasibility design phase; a low flow fishway.

The stakeholder consultative group remained involved through the feasibility and detailed design phases. They provided critical feedback matters like the alignment and track type for the new walking track, locations of old mining sites and other hazards, and flow splits between the tunnel and fishway.

Despite their extensive involvement, one of the key community groups (Friends of Horseshoe Bend Tunnel) disagreed with the final fishway design, believing it to be disproportional in scale, and withdrew from further engagement.

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During the construction planning and implementation phase a stakeholder reference group was established. The purpose was to ensure stakeholders were fully briefed throughout this phase and given the opportunity to ask questions. Site tours prior, during, and after construction were also included.

To counter some negative miss-information and ensure the correct information was being made available to the wider community, the WGCMA implemented a number of public communication tools. Media releases were issued to outlets during critical periods of the project, providing up to date information in a clear manner. A webpage on the WGCMA website was created to provide more detailed information about all aspects of the project, including an FAQ section. A Facebook page was established specifically for the project. This provided an avenue to give updates, provide clear information, answer questions, and for members of the public to provide direct feedback. A series of short videos were developed to provide information on what the project was about and why it was happening, and to provide updates at critical stages.

## **Designing a new type of fishway**

While the overarching design principle for the project was straight forward (provide fish passage for migratory fish), a number of unique site-specific criteria needed to be met to achieve this at Horseshoe Bend. The following set of criteria were identified as critical for the success of the fishway design under the site constraints:

- The flow split between the tunnel and the fishway/river - 60:40 (tunnel:fishway) for design flow rates
- Depth of flow and velocities through the constructed fishway
- The inclusion of resting pools in the constructed fishway
- Modification of existing riffles in the former riverbed to provide fish passage under a 40% flow rate
- The modification of conditions near the tunnel outlet to attract fish into a fishway (without unduly affecting the historic and aesthetic appearance of the tunnel exit area)
- Compliance with heritage listing requirements
- Design and construction requirements must not lead to tunnel degradation/collapse
- Limited machinery access and ability to carry in or out materials for a fishway construction
- Working within a highly sensitive environment
- Site access and terrain is steep, unstable, and dangerous (spoil and mines) to both community and the contractor
- Future access to tunnel inlet and outlet must be maintained and recreational opportunities considered
- Retention of the historic and natural character of the tunnel and river experience (construction to be sensitive to, and not unduly affect, natural and heritage values and fabric)

## **Fighting Eddy**

The first barrier to upstream fish migration at the site was a recirculating current created by the flow exiting the tunnel. The 40% flow split through the fishway and old channel didn't have enough energy to break up this current. Thus, a novel design approach was required that would limit/restrict recirculating current at tunnel outlet and create a path of low velocity and adequate depth at the fishway entrance.

An innovative design approach was undertaken through the use of a high resolution XPSWMM model to test the placement of rock at the top of the potential flow path down the right side of the valley floor. To assist with fish movement past the tunnel outlet, one metre diameter rocks, sourced from the excavated fishway, were to be installed in two parallel rows in the bed of the river opposite the tunnel outlet (Figure 2). The rock concentrated the flow from the fishway and created a sheltered low flow pathway past the tunnel outlet (Figure 2).

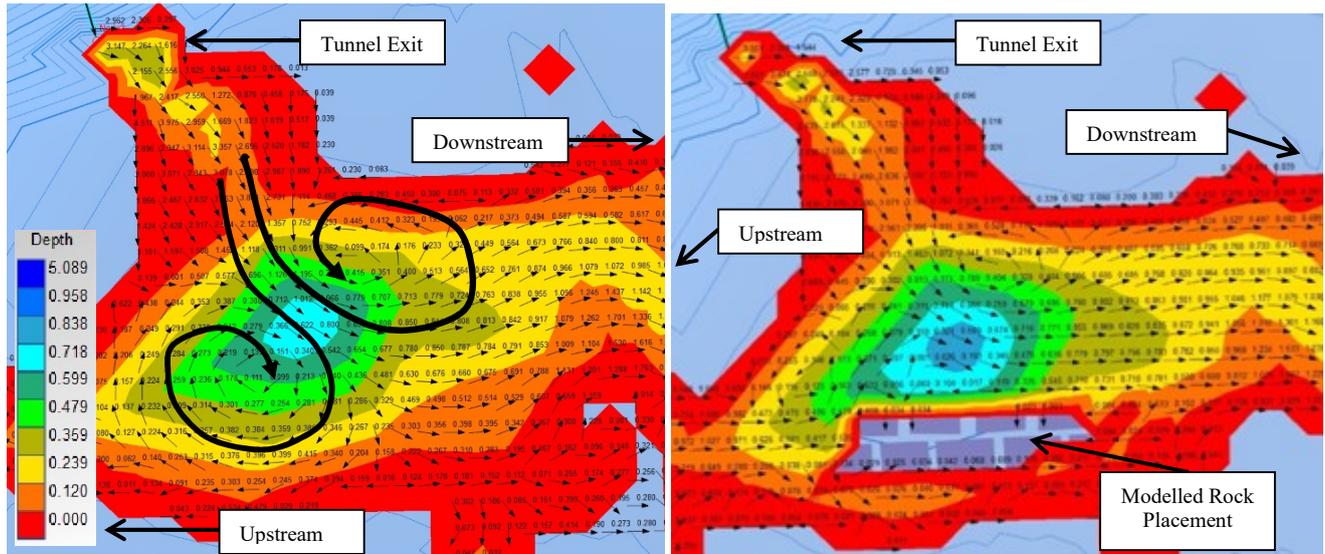


Figure 2. Horseshoe Bend tunnel outlet - modelled recirculating flow before works (left), after works (right)

### Design of a bedrock fishway

The constraints around the fishway design, particularly constructability, no imported materials, and only 40% of flows required an innovative and new design solution. In a first for Australian fishway design, an arrangement was derived consisting of 230 m long excavated fishway through the upstream river bedrock (Figure 3 and 4).

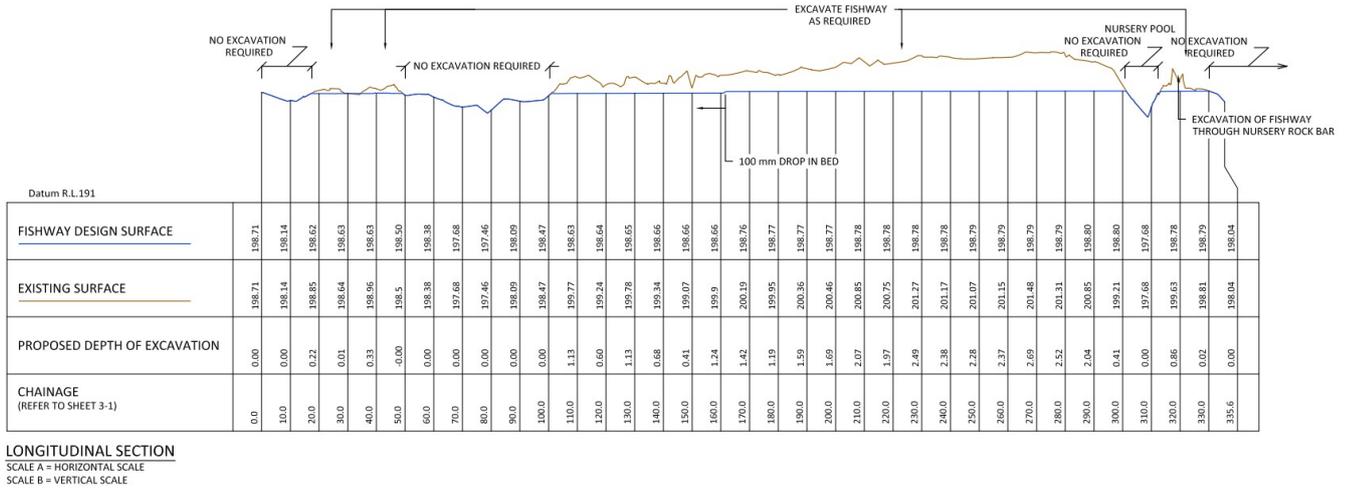


Figure 3. Horseshoe Bend fishway longitudinal section showing cut through rock bars

The design intent was to lower a limited section of the existing bedrock-controlled riverbed to a level that will enable a split of flows between the tunnel and the river. Thereby maintaining the engineered function of the tunnel, while also providing sufficient flows around the old channel for fish passage.



Figure 4. Horseshoe Bend fishway design overview

A stepped cross section arrangement through the bedrock fishway was adopted to provide a more diverse velocity and depth profile than trapezoidal cross sections, minimise excavation volumes, overall footprint and limit the impact on site aesthetics. Use of a stepped bank increases the hydraulic roughness over the left bank resulting in reduced velocity and depth distributions for range of different design flows. A series of deeper resting pools provided further diversity in flow conditions and larger areas for fish to rest during migration up the fishway (Figure 5).

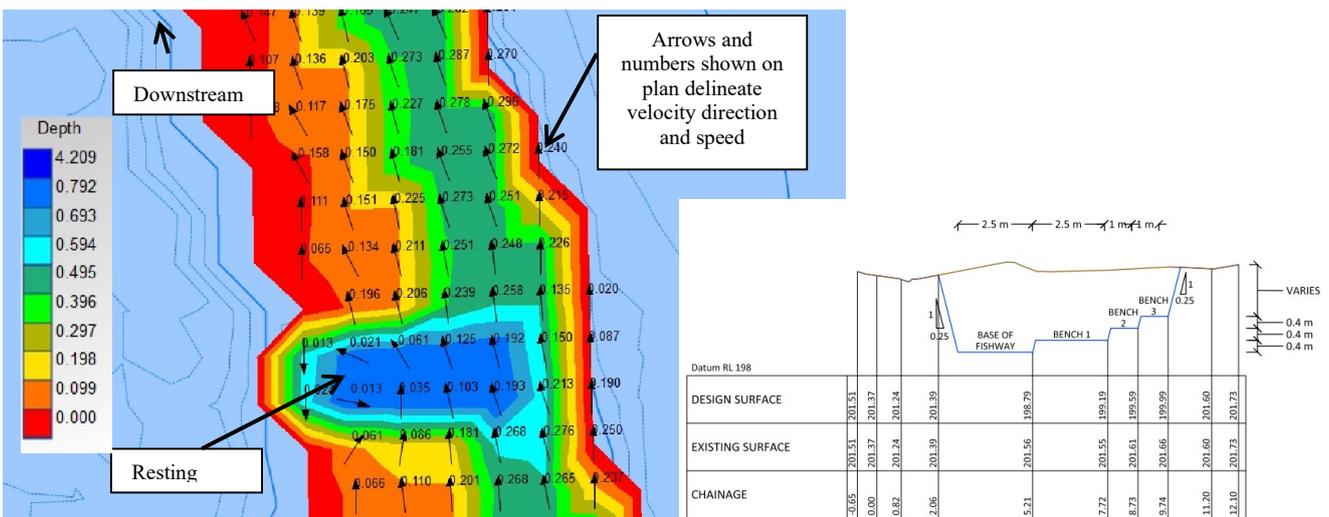


Figure 5. Fishway modelling output showing resting pool (left), fishway cross-section (right)

Testing of the final design arrangement was undertaken using the XPSWMM 2D hydraulic model to assess if water depth, velocity, flow spilt, and a range of other criteria for fish passage were met throughout the constructed fishway.

## **Recreating the experience**

Recreation and enhancement of the walking track was an integral design component for the works to satisfy community and visitor expectations. This required the combined skills of landscape architecture, flood modelling, engineering and fish ecology. In order for walkers to safely cross the river at two designated locations, very large steeping stones sourced from rocks onsite, were used as crossing points. These were designed and spaced to enable safe pedestrian access at a variety of flows but also ensure fish passage was not restricted. In addition, an innovation of the site design involved the construction of a specific section of track which 'drowns out' in higher flows to inform and physically restrict visitors from entering the site and endangering themselves to higher flood depths and flows.

## **Construction**

The unique site constraints meant that traditional construction approaches had to be rethought and new and innovative methods developed to protect both heritage and environmental values at the site. A construction environmental management plan was developed that responded to these constraints and included use of low impact rubber tracked machinery and rock breaking methods. This included the use of fully articulated rubber wheeled Swedish excavator (Menzi Muck or "Spider" excavator) to step through and around the site, and the reuse of all excavated materials on site. The end result being a low impact construction method that retained natural features and facilitated a speedy site recovery.



**Figure 6. Horseshoe Bend Fishway Construction – Use of Spider Excavator to minimise impact**

## **Striking gold (Outcomes)**

In the two years since construction, annual fish surveys undertaken by Arthur Rylah Institute consistently found cohorts of Tupong (one of the target migratory fish species) upstream. These early signs are a strong indicator of the long-term success of the fishway.

Flow monitoring was undertaken during the fishway commissioning. It found that the flow split down the fishway was less than the designed 40% (33%). Despite this, the designed water depths and hydraulic conditions were achieved. This meant that fish passage conditions were achieved with less water, and more water was retained through the tunnel, which was a very important outcome for the local community.

Visitors still enjoy the scenic walk and historical tunnel, and their experience has been enhanced by interacting with a flowing mountain river. Social media posts and interactions with the public on site are consistently complimentary, many unaware of the work that was undertaken.

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The low impact approach to construction and site restoration works have allowed the site to naturally regenerate. Only two rounds of weed spraying have been required and the vegetation is quickly returning.

The project successfully balanced the competing objectives to achieve a unique and outstanding outcome.

## **Conclusions**

By taking an integrated approach to overall design, the project struck the right balance between competing values and priorities to achieve outstanding outcomes. After two years of operation, the success of the fishway design and implementation has been demonstrated by an influx of Tuong (a native migratory species) into the upper reaches of the Thomson. Visitors continue to enjoy the natural environment whilst walking alongside the now flowing river, and the spectacular view of the river gushing out of the historic gold mining diversion tunnel remains a focal point and link to European cultural history.

The Thomson River Fishway is a unique and outstanding project that balances competing objectives, demonstrates best industry practice, and achieves outstanding environmental and social outcomes. The project was identified based on the potential to provide a high level of return on investment for the provision of fish access to the high-quality gravel bed river habitat. At a construction cost of \$1M, the Thomson River Fishway and Walking Track has and will continue to provide significant environmental and social benefits, a highly valued community asset, and exceptional value for money. It's innovative design and construction methods are applicable not just to fish passage projects but waterway restoration and rectification of historically significant sites.

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