Fish Passage Training Aid

5.3

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Contents

Introduction

This document is an aid for tutors teaching, and field personnel learning, the theoretical and practical aspects of providing passage for fish. The target audience for this document is all persons either directly, or indirectly, involved with fish passage remediation, including practitioners, supervisors, engineers, ecologists, and planners.

It is not intended to be a stand-alone training manual.

This document acknowledges the useful information contained in the New Zealand Fish Passage Guidelines but dives deeper into “how-to” aspects for the fish passage remediation practitioner. The document draws on the authors’ many decades of collective experience doing remediation in the field and observing fish navigating various in-stream structures and remediated systems. During that time, materials and methods have changed due the authors’ and other commentators’ critical assessments of the durability and effectiveness of each solution.

There are so many different variations of in-stream structure design, site situation, streamscape and ways that such structures degrade, that remediation solutions need to adapt and evolve. Along with this, research from around the world regularly yields more and more insights into the fish passage realm. Therefore, this document will continue to evolve, taking into account ongoing research into fish behaviour, and development of methodologies, meaning that there are likely to be regular revisions.

Scope

This document is primarily about remediation of existing in-stream structures, however many aspects are relevant for the design and installation of new structures.

The focus is on remediations that may be used for typical types of fish passage barriers that are found in NZ and gives guidance to practitioners using the “current state of knowledge”.

Consideration was given to all remediation tools/techniques as discussed below, that do not impact significantly on a structures’ capacity or structural integrity, as well as using robust materials to withstand high flows and impacts from debris, while not likely to cause blockages.

Remediations can be short or long term, being generally low-cost and of low-impact, with work typically being done in the live waterway where stream diversions and permits are seldom required.

The remediation techniques covered have been widely used through New Zealand along with other countries and have undergone robust monitoring.

The practices covered are typically completed by two persons using basic hand tools.

This document does not provide guidance for more expensive remediation that may involve pouring concrete, trucking of material to site, or the use of heavy machinery, however many of the basic principles remain valid.

Vegetation is also important for fish passage, habitat and refugia, however is not covered in detail in this document.

Cultural Considerations

Sharing the story - indigenous and community engagement

Ecology does not respect political or tribal boundaries, however indigenous peoples, cultural groups, and other individuals are passionate when it comes to water, water bodies, and the life forms within them.

Indigenous people typically have a close connection with the environment, so when planning to undertake work in and around waterways, it is important to understand the relevant local customary practices.,

In Aotearoa/New Zealand for example, indigenous Maori hold the following tenets of paramount importance:

1. Spiritual connection and responsibilities to the water - Te Mana o Te Wai
2. Taking of water - Te Mahi o Te Wai
3. Recreational connection with water - Takaaro Wai
4. Responsibilities to all water life - Te Ora Wai
5. Gathering of food - Mahinga kai

Continuous access to waterways is important, while seasons, phases of the moon, and food gathering are some of the factors that determine the customs and rituals that are practiced.

Two way communication is important, so initial discussions should start with determining the appropriate level of engagement and acknowledge regional differences.

The level of engagement will also depend on the scope and scale of the project.

Some specific sites are considered sacred to local indigenous people, therefore special permission may need to be sought prior to undertaking work.

Sharing of old knowledge, the gaining of new, or relearned knowledge is considered a privilege.

Biosecurity

Biosecurity risks can include the transfer or spread of unwanted organisms e.g.:

- Pest fish,
- Invasive aquatic biota
- Fungal diseases
- Bacterial pathogens.
- Non-aquatic organisms.

In some locations, there is a requirement to sterilise tools, equipment and vehicles when moving from one waterway or property to another.

Fish Passage Background

Many freshwater fish species are in decline, and one of the major reasons is the number of barriers to migration that these fish are presented with that prevent access to habitat.

Culverts and other in-stream structures have long been understood as potential barriers to migrating fish. Structures may be perched (overhanging), meaning fish can't get into structures. Structures can also be velocity barriers where fast laminar flow, and sometimes shallow flows, restrict fish movement through or over structures.

Natural streams usually have complex flows with a range of depths, velocities, and flow directions, whereas manmade structures like culverts, often have fast, shallow, laminar flows and can be barriers to migrating fish.

Below are a few examples of structures that have been poorly installed and/or undersized. They can be barriers from the outset, or become barriers over time if not maintained.

Typical barriers to fish

Perched culvert pipe

Shallow laminar flow

Fast laminar flow

Tide gates

Fish locomotion - how fish move

Fish have evolved to navigate the range of challenges that present themselves.

Note that some species are able to utilise a number of forms of locomotion however, that may be limited to particular life-stages as they develop.
As a general rule, larger fish are less capable of “climbing” whereas more developed fish become stronger swimmers and or jumpers.

- Sustained swimming
- Burst swimming
- Jumping (combined with burst swimming)
- Wriggling - serpentine
- Wriggling - serpentine + sucker mouth (lamprey)
- Wriggling - “gecko”

Why & when fish move

Overview

All fish have limitations in their swimming abilities and modes of locomotion, however, measuring water velocity to determine if this is exceeded is challenging, particularly in complex flows. Offering fish a range of depths and velocities, interspersed with resting places, is more likely to achieve effective fish passage for a wider range of species than attempting to target a specific maximum velocity.

Factors influencing upstream fish migration

Understanding fish behaviour helps us to create the opportunities for fish to make their way upstream.
Below are some of the factors that will determine whether or not a fish migrates upstream and should be carefully considered when undertaking monitoring or evaluating data to conclude success or failure.

Site characteristics:

Depth - fish need a minimum depth in order to swim.
Continuity - perched or overhanging elements prohibit upstream passage.
Velocity - fish have limits for both sustained and burst swimming.
Flow rate - volume of water can affect swimming ability.
Rainfall - recent rain increases flow and flushes detritus (food) into the stream.
Flow type - Laminar or complex?
Wet margins - splash zones.
In-stream vegetation - breaking up laminar flow
Water quality - pollution/pathogens
Water temperature - Lack of shade.
Presence of vegetation - overhanging or instream. Can break up flow, provide habitat and refugia.

Motivation:

Primal urge to swim ever upwards - evolutionary advantage.
Physicality - it is easier to breathe and control position when facing upstream.
Attractant pheromones - secreted by same species upstream
Natal stream (only some species) - homing in on the specific chemical characteristics of the stream they were born in.
Search for food - drift-feeders still push up to where food is coming from.
Evade predators - resident predators can reside in rest pools causing migrating fish to push on upstream.
Peer pressure for food and/or space - overcrowding as more fish arrive from downstream.
Schooling - follow the crowd - safety in numbers - not wanting to be left behind.
Spawning - finding suitable spawning sites.
Species specific behaviour - different species seem to have different levels of motivation to migrate upstream.
Already in their "happy place"

Physical ability/limitations:

Species physicality - different species have a range of swimming abilities.
Life stage - Physical development/size - Jumpers do better when they have grown. Climbers generally do better when they are smaller (juvenile)
Physical condition - food and effort in the preceding hours/days
Methods of locomotion - burst swim, jump, climb, wriggle
Stamina/Fatigue - periods of big effort without opportunities to rest and feed

Other considerations:

Day/night - Some fish prefer to move at night when it is cooler and/or to evade predators.
Moon phases - Tides affect water levels. Moon phases also affect other behaviors.
Season - Seasonal changes in water flows and temperature.

The Basics

Fish passage is essentially a hydrological challenge. From a fish perspective, remediation should aim to match or better the flow characteristics of the stream that the structure is in.

What are we trying to achieve?

Backwater structures
Provide complex flows (non-laminar) - multi-directional flows with rest pools.
Areas of fast water (HVZ) must be shorter than fish burst-swim capabilities (if known).
Provide sufficient depth.
Ensure continuity - no overhangs or sharp edges.
Give fish a range of migratory choices.
Ideally retain bed-material (retention of bed material is a good indicator that a structure is unlikely a barrier to fish). Be aware that bed material can cause blockages if not managed.

Riparian and instream planting helps with fish passage and improves habitat.

Within culverts and flumes where the aim is to get swimming species through, the nature of the flow is important.

1. If the flow is laminar/lineal/longitudinal, the velocity must be less than the sustained swimming ability of the fish, as there will not likely be any opportunities to rest.
2. The closer the velocity is to this limit, the shorter the culvert must be for success.
3. If the flow is complex/turbulent, then the focus is on the length and severity of the High Velocity Zones (HFV), as fish can, to varying degrees, burst-swim from a Low Velocity Zone (LVZ) through the HVZ to the next LVZ and rest.

Note: Precise measurements and symmetry are not generally necessary for improvements to fish passage.

Fish Passage Principles

FISH PASSAGE PRINCIPLES AT MANMADE STRUCTURES & EROSION CONTROL

Assuming it is agreed that there is fish habitat upstream, and sufficient water, fish passage mitigation/remediation interventions should subscribe to the following principles regardless of the species or life stage:

1st Principles (imperative for all species and life-stages)

1. Provide sufficient depths and swimmable velocities or climbable surfaces.
2. Ensure continuity of the steam bed - not perched or undercut.
3. Maintain surface flow - avoid flow going sub-surface.

2nd Principles: (ideal)

1. Create hydrological conditions (depth, velocity & complexity) akin to those occurring naturally upstream - this should provide passage for local fish species.
2. Provide complex flows (various flow directions and velocities down through the water column) – giving a higher chance of meeting a range of fish migration needs.
3. Provide rest pools - areas to rest and/or feed between high velocity zones.
4. Provide a range of options, including wetted margins/splash zones - to cater to fish with a climbing ability.

3rd Principles: (aspirational)

1. Constrain flows and/or increase depth - maximise whatever water is available
2. Provide shade and cover – structural or vegetation
3. Retain bed material - without causing blockages

Practice principles:

Only use mussel-rope for existing structures when no other option is available e.g. small diameter pipes, or to augment other interventions such as ramps.

Avoid pouring concrete on site – highly toxic and prone to failure over time

Avoid dewatering existing structures for simple remediation – stressful for fish, costly, and requires permits.

Practitioners notes:

1. The diameter, gradient and length of the structure, along with site specific characteristics, will also determine the nature of interventions.

2. The areas immediately upstream and downstream need to be considered, particularly if within the construction zone where ground has been broken.

Outcomes:

Ecological Outcomes

1. Fish and other aquatic organisms that arrive at the downstream end of a structure are able to migrate upstream to suitable habitat.
2. Where practical, bed material accumulates and is retained within the structure providing both roughening and, to some degree bethenic, habitat for fish and invertebrate communities.
3. Maintain and manage flows to allow for passage for as many days as possible.
4. If possible, provide habitat within structures e.g., provide shade, rest pools, refugia.

Engineering and Hydrological outcomes:

1. Match or better the upstream flow characteristics - depth, complexity, velocity etc.
2. Reduce exit velocities - prevent or reverse scouring and the creation of plunge-pools at the outlet.
3. Maintain or improve water depth - maintain surface flow, constrain available flow without inducing fast laminar flows.
4. Meet catchment capacity requirements - pipes of sufficient size to prevent overtopping in flood events.
5. Meet load bearing requirements - culverts selected that will withstand design loads
6. Increase life of the structure - reducing abrasion/corrosion of the invert

Cultural outcomes:

1. Sanctity of the waterway conserved.
2. Connectivity maintained.

Overall outcomes:

1. Meet regulatory requirements - compliant across all regulations and consent conditions.
2. Reasonable cost - within budget.
3. Minimal maintenance - durable and robust.
4. Minimal risk of blockage or failure - design to avoid long-term risk to asset.

Fish Passage Remediation Effort Matrix (non-tidal)

When considering remediating in-stream structures, the first step is to determine the nature of the fish habitat upstream. It is particularly important to determine whether a structure in a stream that is not flowing should be remediated e.g. when there are residual pools. There are also some situations when a wet/flowing structure might not be remediated e.g., when a road drain intercepts groundwater.

A suitable upstream ecological or habitat assessment usually costs more than a typical remediation so it is impractical to undertake one at every site.

Ultimately the nature of the structure together with upstream habitat, will determine the methods used to improve fish passage.

Consideration needing to be made:

1. Where you are within the landscape e.g., beside a road, within a gully, on the valley floor etc.
2. The bed structure and flow type at the site. A bed is formed by the long term, but not always permanent, occurrence of water. This may include bare cobbles or gravel, aquatic plants etc.

The table below can be used to help determine where on the landscape a structure needs to provide for fish passage.

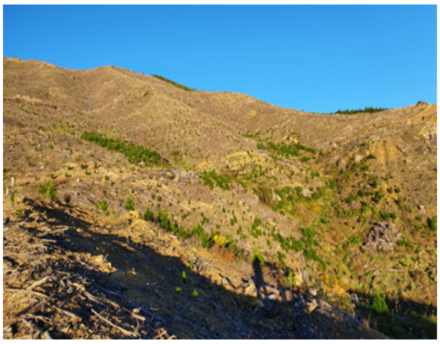
Where are you within the landscape →	Road drain	Gully	Valley Drain	Valley Stream or Wetland
Aquatic bed structure and flow type at the site ↓	Colour code can be adjusted for each region or geographical area			
No bed				
Bed and dry				
Bed and flowing				

Low - Not worth the effort. Would not generate an abatement notice if not remediated

Medium - Considered for low level remediation on a case-by-case basis. May not generate an abatement notice. If in doubt - remediate.

High - Must fix

Some examples

Low **Road drain** Man-made ditch for road runoff that does not serve any natural stream.		
Medium **Gully** Upper catchment		
Medium **Valley Drain** Modified water course		
High **Valley Stream or Wetland** Mid to lower catchment		

Remediations

Which tools to use and where?

Barrier	Tools
High velocity	Baffles or mussel-rope
Shallow flow	Baffles or bunds
Perched/overhanging	Flexible ramp, floating ramp, rope & V-baffle
Tide-gates	Cantilever or off-set top hinge

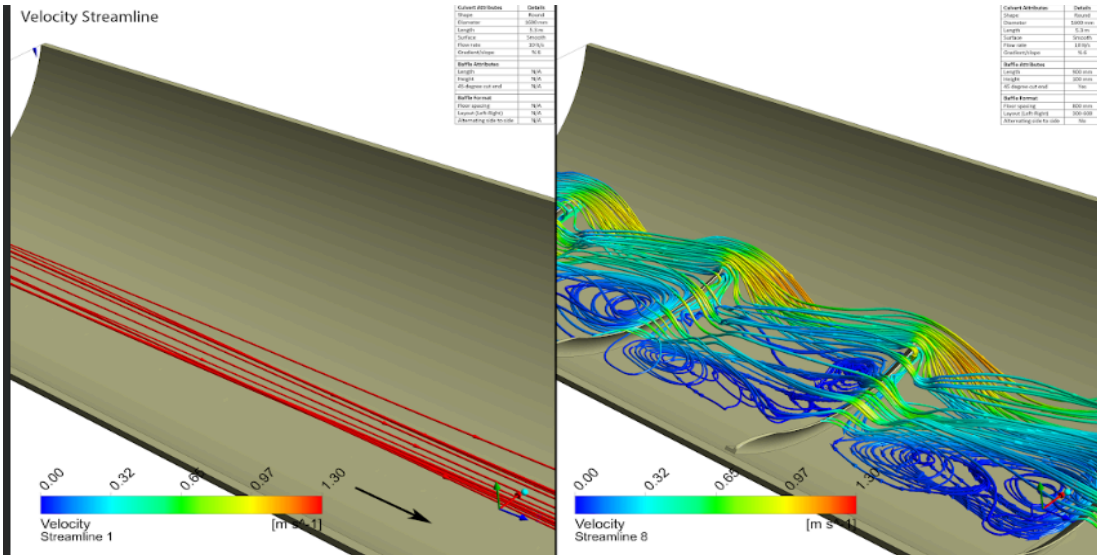
Shade

Why is shade important and needs to be considered alongside fish passage?

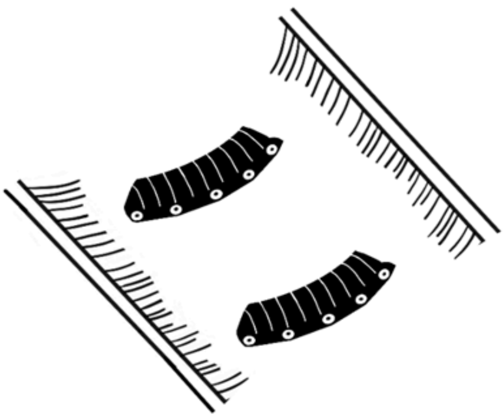
- Habitat
- Food supply - insects etc
- Refuge - somewhere to hide from predators
- Disruption to laminar flows - helps with fish passage

Within culverts and flumes

Flexible baffles



CFD modelling showing with and without baffles



Typical installation

- Baffles effectively backwater culverts incrementally.
- Fitted to the culvert invert to slow water velocities, create complex flows, retain bed-material and create a series of rest pools with the culvert.
- Used in culverts that are accessible to installers.

FLEXI-BAFFLE SPACING	
Grade (%)	**Flexi-baffle spacing**
0 > 1	2400mm
1 > 2	1200mm
2 > 4	1000mm
4 > 6	800mm
6 > 8	600mm
8 > 10	480mm

Baffle Installation

- Baffle sizes are determined by the size of the culvert and to some extent, the base flow rate.
- Baffle spacings are determined by the culvert gradient however the gradient is often difficult to measure. Therefore, the general rule of thumb is that flexible baffles should be placed so that the pool created by a baffle comfortably reaches the next upstream baffle.
- Baffles come with pre-drilled fixing holes. More fixings may be used for plastic or metal culverts and can be drilled straight through the baffle.
- Baffles may be offset to one side or alternating depending on what outcomes are desired.
- In box culverts, baffles should be placed across approximately two thirds of the width of the culvert, alternating side to side to create a meander.
- Baffles may also be attached vertically on the walls of box culverts to assist with fish passage during high flows.
- Installation can occur in new pipes prior to the pipes being laid.

See the YouTube video for a tutorial of installing Flexi-baffles.

Mussel-Rope

Typical installation

- Fitted to culvert inverts to slow water velocities and create complex flows.
- Gives a range of navigation choices - beside, under, within or over the ropes.
- Used in culverts that are not safely accessible (e.g., less than 900mm diameter), have an eroded culvert invert, or in culverts that are steeper than 10% grade.

Installation

- Rope can be either doubled back through a D-ring or folded and pushed through a D-ring to form a Lark's Foot knot (see Lark's Head Knot - YouTube) to make two strands the length of the structure.
- As a guide, two strands of rope should be used in culverts up to 500mm diameter and four strands in culverts from 500-800mm.
- Up to six strands of rope can be used if you are remediating a larger culvert (greater than 900mm) that is steeper than 10% grade.
- Consider having a separate D-ring for each set of strands to reduce the load on each fixing and provide redundancy if one fixing was to fail.
- Ropes fitted through a culvert should not extend beyond the culvert outlet.
- Only fix the ropes at the upstream end to avoid debris jams i.e., not mid-way or at the downstream end.
- It is best practice to melt the ends of plastic rope to avoid fraying.

Outlets

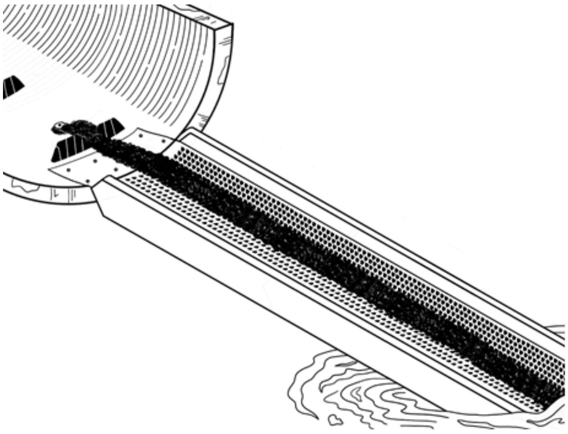
Flexible ramp with mussel-rope

- Fitted to the culverts invert to provide a swimming and climbing surface for fish to enter pipes. Flexible ramps offer aquatic species several choices when migrating e.g., passage over/through mussel-rope, adjacent to mussel-rope or on the wetted margins at the edges of the ramp.
- Used at culverts and flumes that are perched/overhung.
- Flexible ramps may provide scour protection and prevent further downcutting of the stream bed. Extending the ramp well into the plunge pool also ensures the ramp is accessible to fish through water level changes e.g., in summer where the water levels can significantly drop.
- The flexible ramp material can be reused rubber conveyor belting or new reinforced PVC belting.

Installation

- Flexible ramps should be as wide as the site will allow i.e., approximately two thirds of the culvert diameter.
- The belting should always go shiny side (black) down when using PVC belting.
- Fix the ramp to the culvert invert approximately 150mm from the outlet.
- Fixings should be no more than 100mm apart to secure the ramp to the culvert invert.
- Ramps (rubber belting/PVC belting) should be installed well into the culvert plunge pool (if present).
- “Looped” mussel-rope should be used as alternatives are more prone to shedding fibres.
- At least four strands should extend down the ramp. To achieve this, two lengths of rope should be doubled-back through the D-ring.
- The strands of rope pass up over the V-baffle and are fixed approximately 75mm upstream with a D-ring and clasp.
- Mussel-rope should be secured with cable-ties (or equivalent) to the centre of the ramp approximately every 250mm. Note: Do not pull the cable ties taut - keeping the ropes slightly loose will allow fish to move through the rope bundle.
- Rocks may be added underneath the ramp to help position the ramp and lessen the grade (site specific).

Floating ramps




- Fitted to the culverts invert to provide a swimming and climbing surface for fish to enter pipes.
- Used at culverts that are perched/overhung.
- Floating ramps may provide scour protection and prevent further downcutting of the stream bed.
- Ramps should extend into the plunge pool. Note: floating ramps will be less effective if they do not sit in a pool.
- Floating ramps are currently available in 1200mm and 2400mm lengths.

Installation

- Fix the ramp to the culvert invert approximately 250mm from the outlet.
- Fixings should be no more than 100mm apart to secure the ramp to the culvert invert.
- Ramps should sit parallel to the structure/water where practicable.
- To give fish more navigation pathways, ramps should have a mixed-texture surface e.g., dimples and mussel-rope
- Ramps should have at least 4 strands of mussel-rope installed down the centre.
- Give consideration to scouring that may occur depending on where the ramp is positioned.

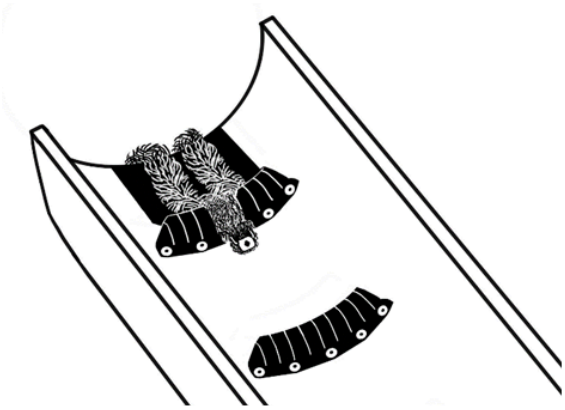
Mussel-rope only


- Fitted to the culverts invert to provide a climbing surface for fish to enter the culvert.
- Used in culverts where there is no plunge pool below the culvert or where a flexible ramp is impractical.

Installation

- "Looped" mussel-rope should be used as alternatives are more prone to shedding fibres.
- At least two strands of rope should be doubled back through the D-ring (giving a total of four strands).
- Can be used in conjunction with a V-baffle.

V-baffles



- Fitted to the culvert inverts to slow water velocities at the outlet and provide effective passage of fish into the pipe.
- Used in conjunction with mussel-rope in culverts that are 500mm diameter or greater and where baffles cannot be installed throughout.

Installation

- Ideally a V-baffle should be placed on the culvert invert approximately 150-200mm from the outlet.
- Mussel rope lies within the "V" of the baffle and is attached approximately 150mm above.

Culvert add-ons

Flumes & aprons

The tools discussed in this training aid can help with remediating culvert add-ons.

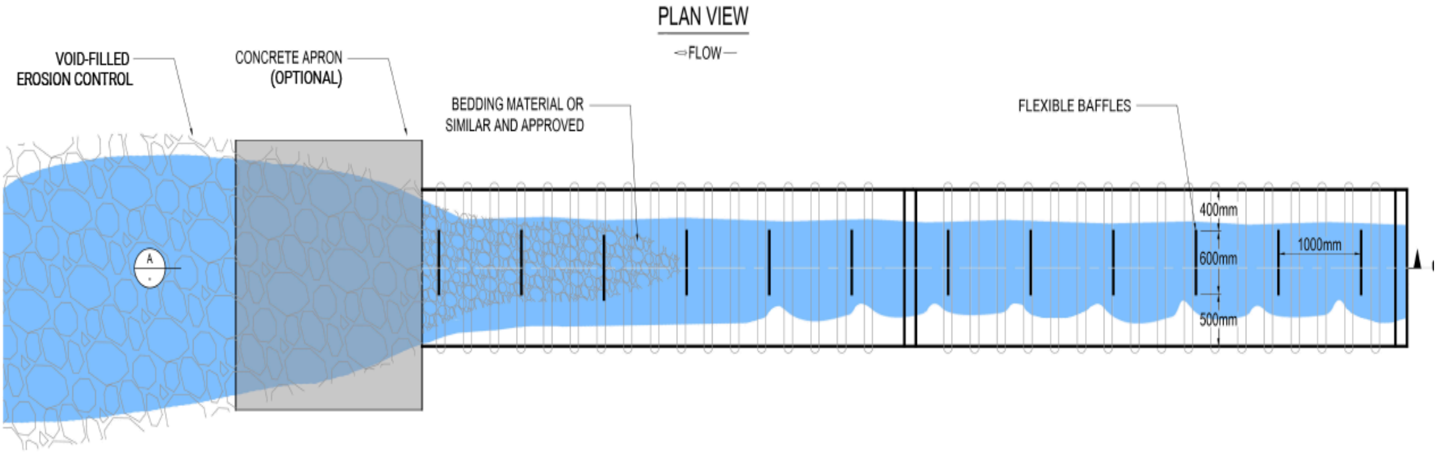
Fish passage fixes to these structures will need to be on a case-by-case basis.

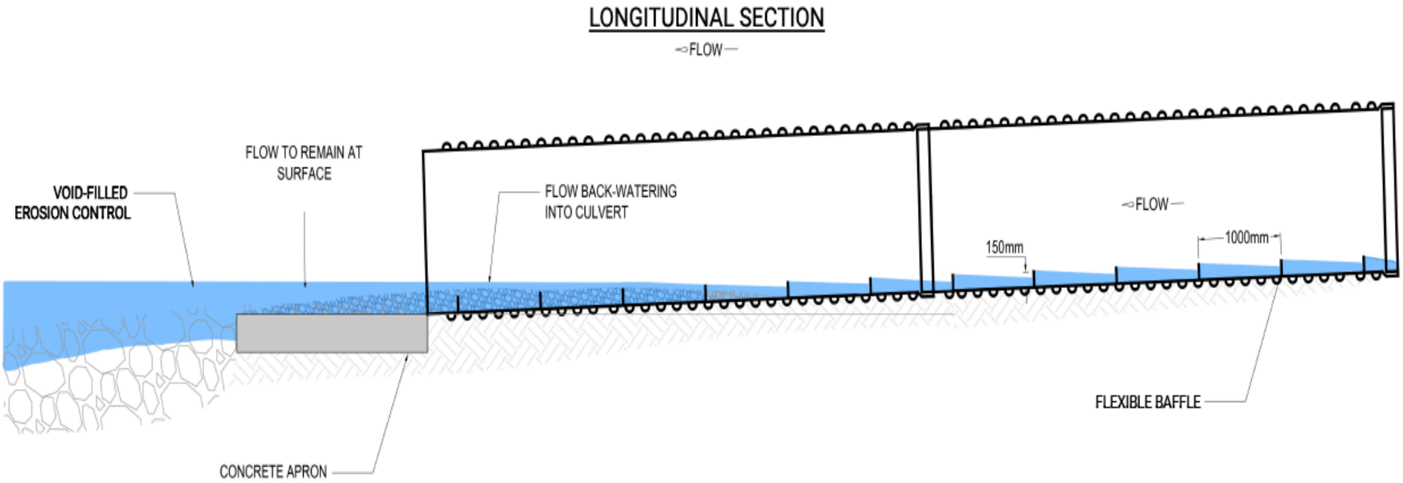
← Culvert apron fitted with a flexible ramp, mussel-rope and flexible baffles.

New Culvert Installation

Embedded culverts may look nice but it can be tricky to install and manage the bed-material if the culvert is long, steep or has a small diameter.

Below is an example of how culverts can be installed with a view to providing long-term fish passage and reducing the risk of blockages.





Notes:

- The culvert outlet is embedded to prevent it becoming perched then gradually transitions to flexible baffles providing complex flows including rest pools and low velocity zones.
- Site conditions will determine if an apron is required and how much the culvert can be embedded.
- Baffle length is dependent on the diameter/width of the culvert and flow to an extent.
- Baffle spacing is dependent on the gradient and flow.
- Baffles help retain bed material, and/or act as artificial bed material.

Tide Gates

While there are relatively few tide gates compared with culverts, they can be the first barrier that fish migrating upstream encounter.

The sites usually have quite specific characteristics that will determine what remediation can occur.

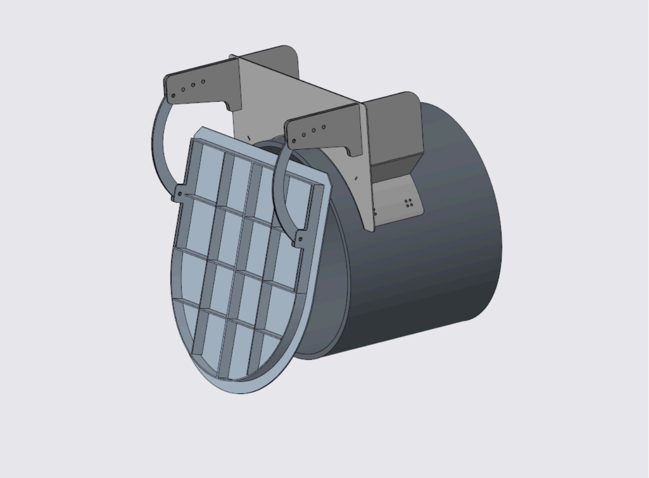
Typical remediation aims to delay the closing of the gate to thereby allow fish a greater opportunity to pass.

Delaying the closing can also allow better tidal flushing upstream thereby improving aquatic habitat

Examples:

Adjustable offset top-hinge style - pipe mounted

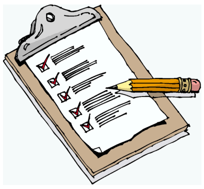
Adjustable offset top-hinge style - head-wall mounted



Notes & general rules for practitioners

1. If in doubt, do not hesitate to provide a number of opportunities for fish passage i.e. over delivery.
2. Pipe manufactures have had input into how solutions are fixed to their products.
3. Trials are currently underway to test the practical effectiveness of natural fibres as an alternative to plastic mussel-rope.
4. Rope should not be used in culverts if baffles can be fitted - even if just climbing species are targeted. This is because rope does not provide rest-pools or retain bed material.
5. Baffles should be spaced so that the rest pool from one extends easily up to the next baffle to minimise zones of high velocity.
6. Ramps should provide multiple pathways i.e., wetted margins and substrate (e.g., rope) to cater for a range of fish locomotive techniques.
7. Flexible ramps should extend into the plunge-pool as far as practicable to ensure fish can find the end of the ramp in most flow conditions.
8. If rope is fitted through a culvert that is also perched, then a second set of ropes should be fitted at the outlet to extend over the drop.
9. Rope should only be attached at the upstream end of the structure and not part way through or at the downstream end. This reduces or eliminates the likelihood of debris causing blockages.
10. Interventions should not unduly reduce culvert capacity or cause debris jams. For example, flexible baffles will flex in very fast flow or when hit by larger debris.
11. Tide-gates should be designed/modified to delay the closing as long as possible without causing undue adverse effects due to water inundation or saline influence upstream unless part of the design goal.
12. Even if the structures need replacing or require significant maintenance, a low-impact, low-cost remediation should be considered in the meantime. This is because it may be years before the maintenance or replacement occurs.
13. Ideally provide passage options for fish at different flows through or over the structure.

Monitoring



In some situations there may be a requirement for monitoring the effectiveness of fish passage mitigation or remediation.

Monitoring has two aspects:

1. Fish surveys
2. Structural assessment

Fish Surveys

The nature of the upstream waterway limits the method used e.g. traps, PIT tags, eDNA, EFM, spotlighting etc. As a minimum there will need to be a survey upstream of the structure. If however the fish that are expected are not present, there will need to be a downstream survey to confirm that those species are present in the waterway in the vicinity of the structure.

Structural Assessment

Based on the Principles (page 11), structures can be assessed focusing on the following:

1. Continuity
2. Depth
3. Flow characteristics
4. Shade

Structural surveys can be undertaken independently or as part of an Asset Management program.

Notes:

- When trialing or monitoring the effectiveness of remediation techniques, be it in the lab or in the field, the challenge is to replicate the migration factors across the trial and the control.
- Trials need to embrace the fact that some fish may move up and down through a structure and/or reside for quite some time in the structure.
- Clear "measures of success" need to be established and referred when discussing the results

Below is an example of a filed sheet used for assessing the navigability of a stream or structure.

Upstream Navigability Matrix

Small to medium streams

Site:
Date:
Time:
Assessor:
Diameter/Width (mm):
Perch Height (mm)::
Length (M):
Flow at time of Assessment: Low flow/Base flow/High flow   Measured/Estimated
Element:
Upstream of structure = 1
Within structure before remediation = 2
Downstream of structure = 3
Within structure after remediation = 4

	Flow rate l/sec					
Complexity Score See details below	**0**	**0.1>1.0**	**1.1>2.0**	**2.1>5.0**	**5.1>10**	**10.1+**
1. Not assessed or obscured	N/A	N/A	N/A	N/A	N/A	N/A
2. Dry - no flow		N/A	N/A	N/A	N/A	N/A
3. Still or very slow*						
4. Straight or laminar flow**						
5. Slightly complex						
6. Moderately complex						
7. Highly complex						
8. Extreme						
9. Near vertical or waterfall						

* Dependent on depth - deep enough for local species.
**Dependent on depth and length - distance between rest pools
N/A
No fish
Only climbing species able to utilise wetted margins and splash zones. Strong swimmers
Very restricted
All fish Generally passable

Health & Safety

Fieldwork (data collection or physical works) naturally comes with some risks. These can be environmental or manmade. When preparing work safety plans, some of the more obvious hazards are:

Weather elements, off-road driving, traffic, deep and or fast flowing water, trips, slips & falls, minor cuts, scraps & burns. Insect bites and stings, heavy lifts.

Other less common hazards to consider are:

Dumped refuse, contaminated water, aggressive wild or domestic animals, hunters,irate members of the public.

Some structures may be considered “Confined Space” and will require specific H&S plans, whereas others may be managed with gas detectors and/or forced ventilation.

For the most part, general fitness and good health, along with good planning and appropriate Personal Protective Equipment will mitigate the above.

When working within construction zones,there may be a requirement to comply with the site H&S regulations.

Oftentimes fish passage fieldwork can be in remote areas outside of cell phone coverage. If working remotely or alone, consider taking a PLB or similar.

Practitioners should maintain general fitness and good health.

Fish passage remediation work can be difficult and challenging, however, is not typically dangerous.

Work sites may be remote and have no cell phone coverage.

Projects often involve many sites over multiple days.

Many sites will share the same characteristics, however, each site will need to have the hazards identified

Hazards may include one or more of the following:

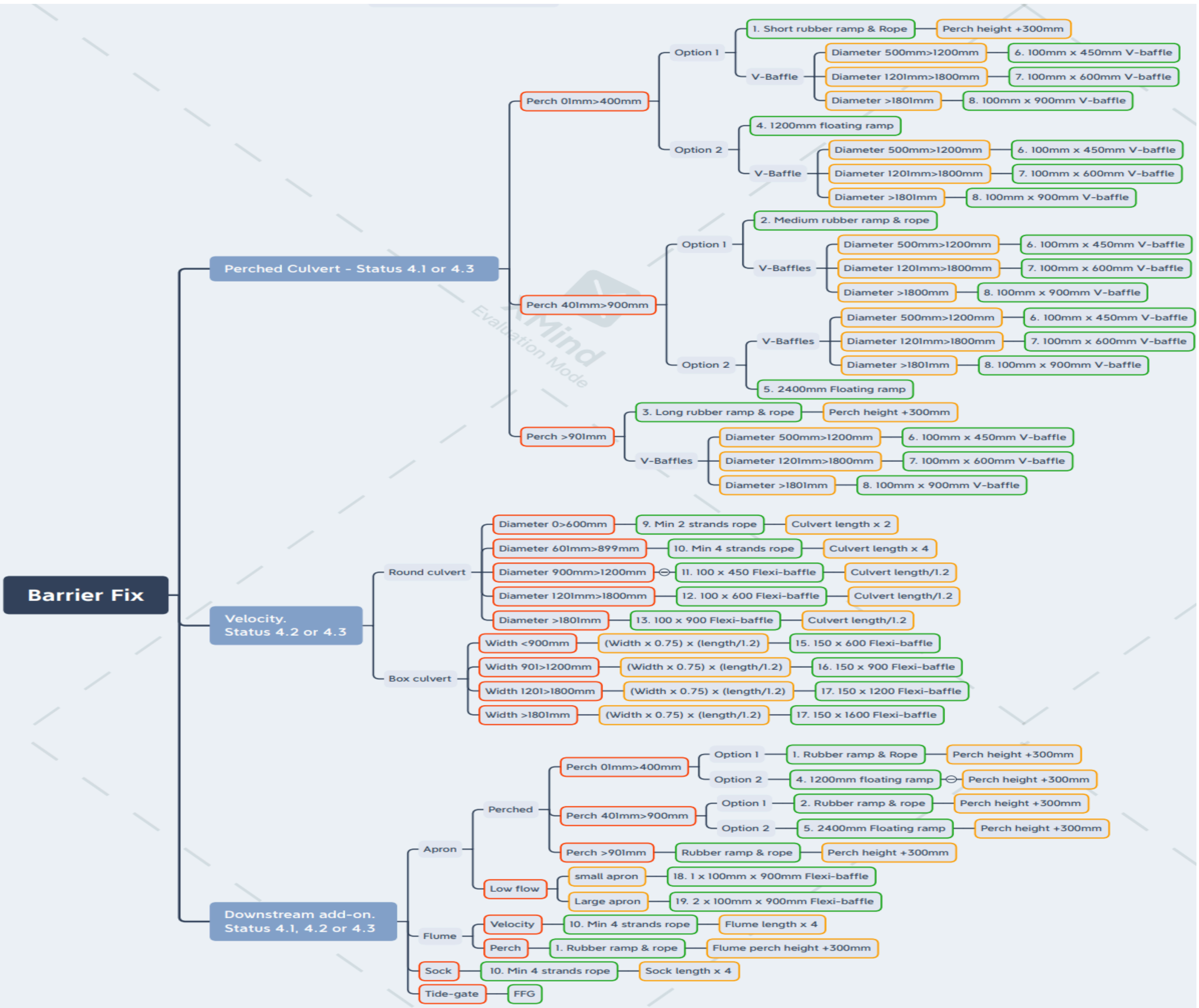
1. Traffic
2. Off-road driving
3. Water - deep and or fast flowing
4. Dangerous debris (e.g.broken glass)
5. Exposure to the elements
6. Trips and falls
7. Dangerous animals
8. Insect stings and bites
9. Restrictive work space
10. Sudden weather events
11. Cuts/scrapes/burns

Specifier's guide for remediating culverts for fish passage

Decision Tree

Follow this decision tree to help you decide the appropriate fix for a culvert that is a barrier to fish.

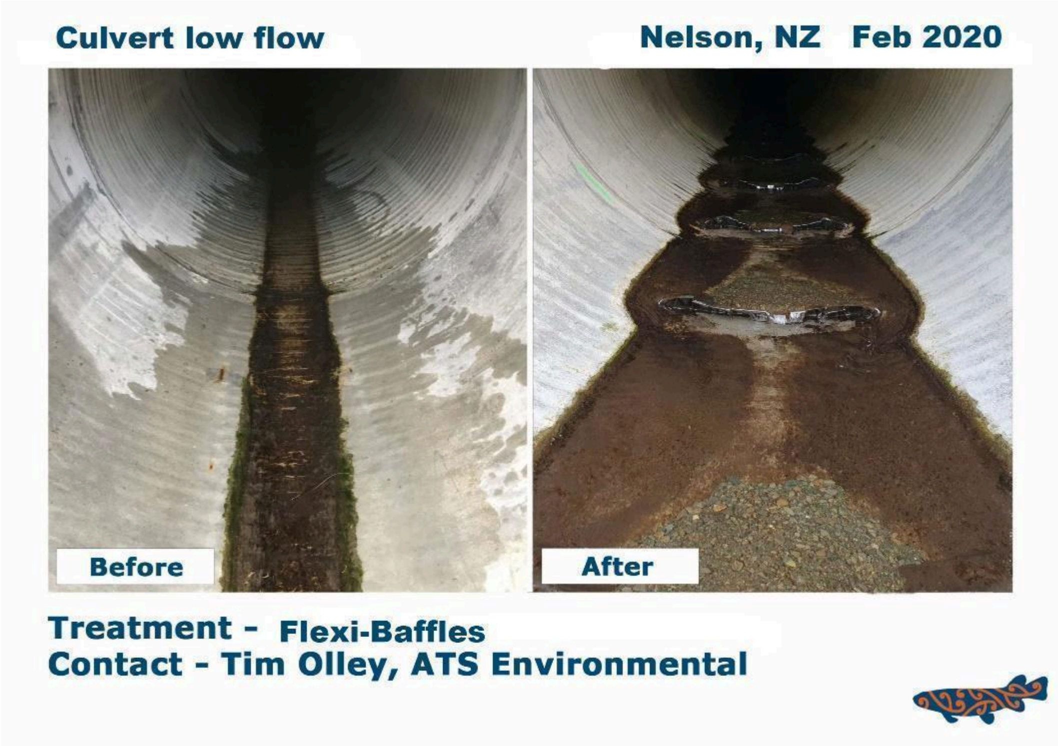
[Help me choose the right fix for my barrier]() (link to PDF)



Notes:

- The decision tree is a guide only.
- Each culvert may have several elements that need fixing.
- Training will give more detail and discuss exceptions.
- An interactive version of the decision tree can be found online if you follow the link below.

Before & After examples of fish passage remediation



Link to several more before & after examples can be found here

Below are several short videos showing various aspects of fish passage remediation.

Link to Fish Passage Video Library

Summary

This document is designed to complement more comprehensive tuition and fieldwork.

Naturally, all remediation should be done safely and in a tradesman like manner.

While this document highlights a number of remediation tools, effective intervention is not limited to these.

Providing the basic principles of providing continuity, depth and complex flows is adhered to, there is always room for creativity and innovation.

Footnotes:

1. There is always a need to know your catchment or region's fish communities. It is important to know if there are situations where exotic and/or particular native fish are not wanted upstream and not provide passage for these fish because they may compete with, or prey on threatened species. Therefore, it is important not to provide fish passage for these unwanted species in these circumstances.

2. The authors are always investigating alternative or more sustainable solutions, however they need to be effective, robust, long-lasting, inexpensive and relatively easy to handle.

3. The team is currently putting together some guidance around fish passage mitigation of new structures where it is not practicable to follow prescriptive regulations.

4. The authors are happy for this document to be referenced and shared (in its entirety).

5. For the latest version, comments or contributions please contact the authors:

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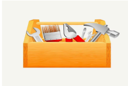
Trevor James - Trevor.James@tasman.govt.nz

Equipment list 

Item	Details
Safety Equipment:	
Road cones	1-2
Flashing lights and road work signs on vehicle	"Pass with care" – if on public roads
PPE	Ear defenders, eye protection, high-viz vest etc.
Gas detector	Only required for long culverts (usually in urban environments)
Power Tools & Associated Parts:	
Hammer drill*	Battery, SDS
Masonry drill bits*	SDS long and short - 6.0mm (wedge anchors) 6.5mm (sleeve anchors)
Drill	Cordless, 13mm keyless chuck, with hammer option as backup
Twist drill bits	Various sizes. Pre-drill for self-tapping screws in plastic etc.
Grinder	Cordless 110mm
Impact driver	Cordless
Spare batteries	For power tools Min 4
Wood bit	10mm for holes in baffles. Can be hex drive
Hollow bit	Set of "wad punches" for PVC sheeting
Assorted Hex Bits*	Tek drivers, allen keys, extensions, drill bits etc.
SDS chisel and point	Fits into a hammer drill. For breaking concrete etc.
Other Tools:	
Spade	Strong & sharp
Hedge clippers/loppers	Old school from op shop are best
Pruning Saw	
Small bucket	For fixings etc.
Crowbar/Pinch-bar	
6mm rebar	500mm lengths x 2
Lighting	Head torch, handheld flashlight
Gas torch	2 x butane canisters. Lighter as backup when igniter fails
Marker pens	Spirit, chalk
Tape measure	Builder's type

Long tape/measuring wheel	30M+
Hammer	Club type
Small ratchet	¼ inch drive x 2
Sockets	10mm deep throat to suit M6 x 50 wedge anchors. 2 x spares
Knives	For cutting PVC sheet and mussel rope. Long blade for mussel-rope
M6 rod	3 x 300mm to hold PVC etc
Hacksaw	With spare blades
Vice grips	Various sizes and types e.g., deep reach
Full socket set	e.g., Bacho. Has ring spanners, various screwdriver attachments etc.
Plank of wood (300-400mm)	For protecting drill bits or cutting when working on the ground
Broom-handle (or similar)	For feeding out rope
Draw cord and float	For pulling ropes through culverts
Consumables:	
Cable ties	Usually needed for mussel-rope anyway
Insulation tape	Handy to have
Grinder consumables	1mm cutting discs, diamond grinding and cutting disks. Concrete cutting and grinding disks
Other:	
Waterproof, lockable work box	One or two for each ute. For tools and fixings etc. Removable if not a dedicated vehicle.
Storage bins	e.g., Fish bins x 4 for fixings,
Drill depth gauge	Make to suit. Use PVC conduit or similar

Authors

Tim Olley

Having spent the better part of six years living and breathing fish passage, Tim has developed an extensive knowledge of the subject. He has been actively involved with fish passage remediation, education, advocacy, training, and research throughout New Zealand, and has authored several fish passage papers/reports. While working as a professional field ecologist Tim has spent countless hours fixing barriers and observing how New Zealand's native fish interact with structures in our waterways. These observations have led to several educational videos being produced by Tim and shared through the Fish Passage Action Team.

Kelly Hughes

Over the past 15 or so years, Kelly has arguably spent more time than anyone else in New Zealand at the "culvert-face" and developing new solutions to the many different situations out there. Kelly has worked at some level relating to fish passage, in every region in New Zealand, along with giving advice and supplying solutions to other countries. Being a founding member of the NZ Fish Passage Advisory Group, he has also been actively involved in advocacy and education. The key driver has been developing effective interventions and methodologies that remove the traditional excuses for poor enforcement of fish passage regulations. A highlight has been working alongside Trevor James and Tim Olley to see the Tasman Region become one of the leaders in fish passage remediation programmes.

Trevor James

Trevor's fish passage journey began in 2001 after a Freshwater Science Society conference and then starting assessments using Waikato Regional Council's methodology. The initial focus was on assessing district council road culverts and promoting remediation while at West Coast Regional Council and then at Tasman District Council from 2004. However, very little traction was made in the remediation sphere until he teamed up with Kelly Hughes in 2008-09. The first big remediation projects were four culverts in Wainui Bay (in Golden Bay) and were expensive using a lot of concrete, rock and effort (including resource consents). More viable methods were subsequently developed using second-hand rubber conveyor belting and mussel-rope. These breakthroughs led to a roll-out of remediations across Tasman District, to the point that almost all the district council road culverts have been remediated and a total of in-stream structures on the database reaching well over 2000. Trevor was instrumental in making the first fish passage symposium happen in 2013 and was a founding member of the Fish Passage Advisory Group, which he is still a member of. His greatest moments were getting effective rules for Fish Passage in the Tasman Resource Management Plan and NES for Plantation Forestry, as well as getting Freshwater Improvement Fund money for Tasman allowing for the most progress ever in addressing this issue.

Glossary of terms

Perched - overhanging and often undercut outfall.

Backwatering - flooding of structure by way of raising the water level downstream.

Invert - bottom inside of culvert.

Complex flow - flow with mixed directions, depths and velocities throughout the water column..

CFD - Computational Fluid Dynamics

Rest pool - an area of low velocity and sufficient depth for fish to rest, feed, recuperate..

HVZ - High Velocity Zone

LVZ - Low Velocity Zone

Baffle - a physical element that disrupts the flow of water, usually reducing velocity and creating depth.

V-baffle - a baffle with a "V" cut into it to allow mussel rope or similar to pass through.

Flexible baffle - a baffle that is able to bend during high flows or when struck by debris.

Floating ramp - a ramp that is fixed only at the upper end and is able to rise and fall with water levels.

Remediation - repair or improvement of an existing structure.

Mitigation - installation or design features of a new structure.

Monitoring - on-going assessment of a structure or fish population.

Wetted margin - splash zone or damp areas out to the sides of the main flow.

Bed-material - the material that lines a stream. Also known as substrate.

Notes:

- Fine bed substrate (mud, silt etc) in itself, does not assist with fish passage.
- While bed material retention is strived for, there are situations where coarse substrate is not naturally occurring (e.g. wetlands), not easily retained (e.g., long urban culverts) or where it is not practicable to introduce such material.
- If bed material is achieved, either via natural processes or via introduction, there are no guarantees it will be retained over time (may be washed out in floods or accumulate at the downstream end).
- To facilitate fish passage, help accumulate and retain bed material, flexible fish baffles can be used.
- Installing baffles will allow natural bed material to accumulate, while accepting that if nothing accumulates, then the baffles will provide "artificial" bed material i.e. will create appropriate hydrological conditions to facilitate fish passage.

Certification

Fish Passage

Level One - Theory

Name:	
Org:	
Date:	
Tutor:	
Location:	
Signed: (tutor)	

Level Two - Practical

Date:	
Tutor:	
Location:	
Signed: (tutor)	

Level 3 - Refresher

Date:	
Tutor:	
Location:	
Signed: (tutor)	