Getting fish moving:

Promoting effective fish passage management in NZ

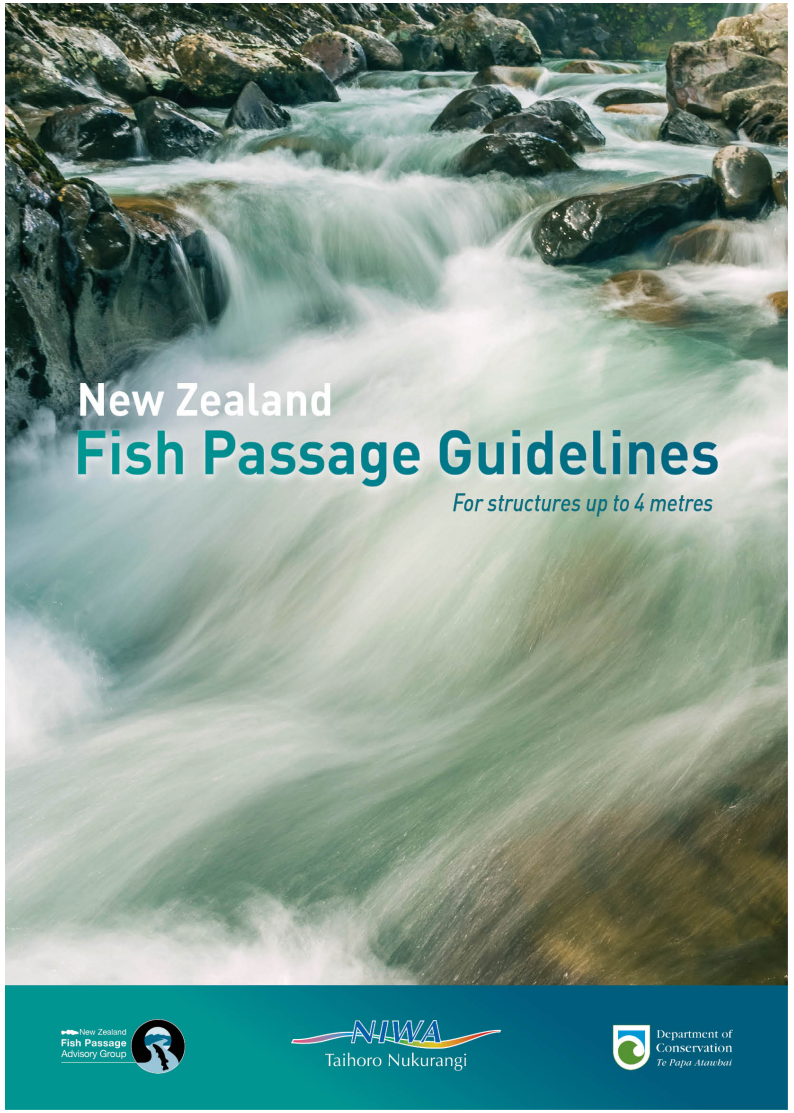
Dr Paul Franklin, NIWA Hamilton

Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi

Outline

- What is fish passage & why does it matter?
- Introduction to the NZ Fish Passage Guidelines
  - New structures
  - Existing structures
- Putting it in to practice
- Introduction to the NZ Fish Passage Assessment Protocol
- Q&A session



NIWA
Taihoro Nukurangi

What is fish passage & why does it matter?

Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi

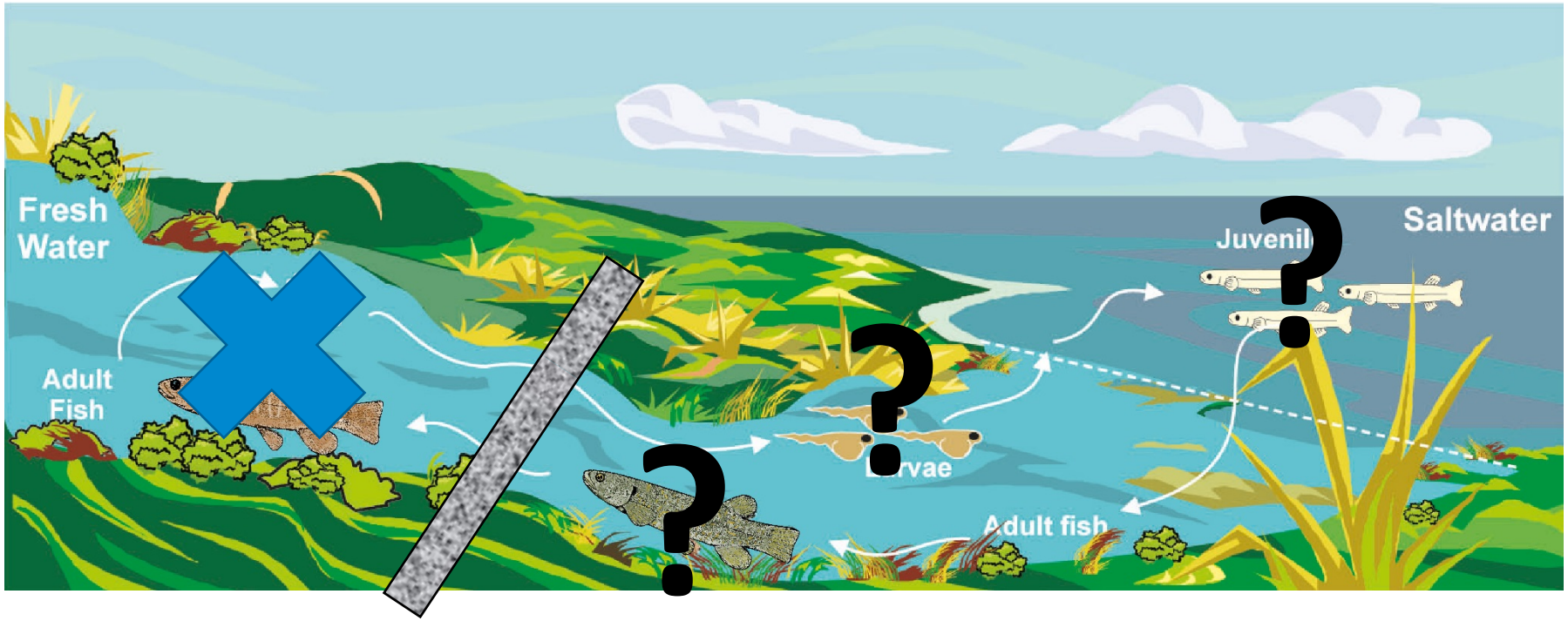
What is fish passage?

The “promotion of healthy aquatic ecosystems through restoration or maintenance of ecological connectivity”

(Silva et al. 2018)

Silva et al. (2018) The future of fish passage science, engineering, and practice. *Fish & Fisheries*, 19(2): 340-362

Why does it matter?



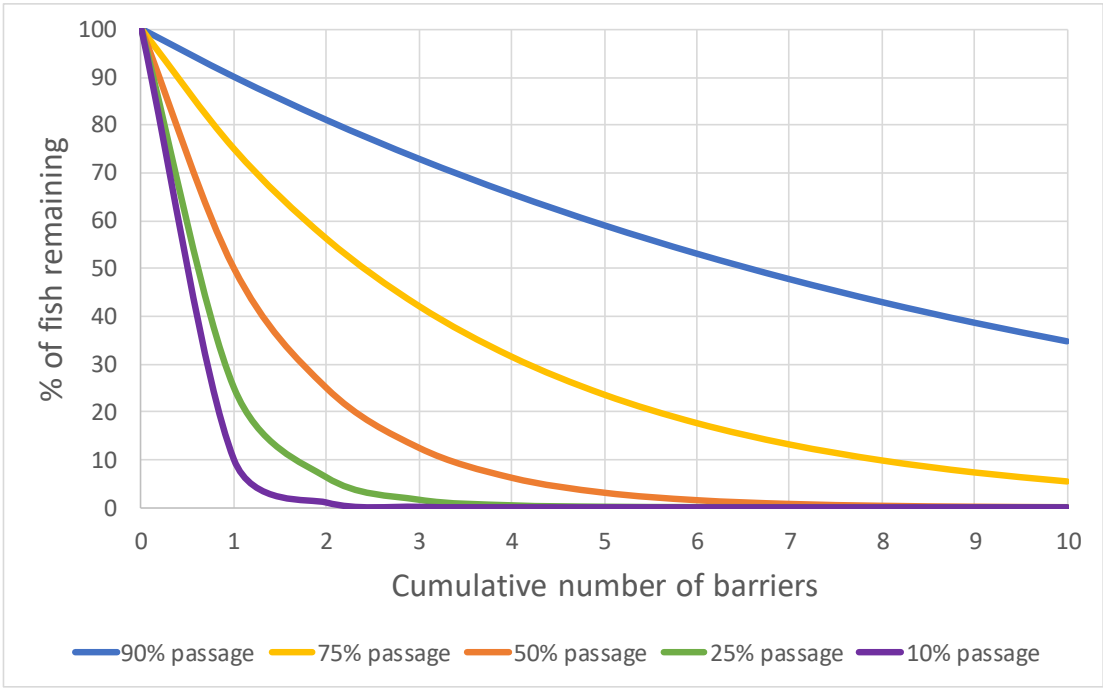
NIWA
Taihoro Nukurangi

Why does it matter?

- Structures such as culverts, weirs and dams can limit or block migrations
- When fish can't access critical habitats their populations decline

BUT…

- Barriers can also protect threatened species & prevent spread of exotic species



NIWA
Taihoro Nukurangi

Why does it matter?

- Freshwater Fisheries Regulations 1983
  - Culverts & fords **may not be built** in such a way as to **impede fish passage** without a permit from DOC
  - Culverts & fords **must be maintained** to **prevent** the development of **fish passage barriers** unless removed or exempted
  - DOC may **require** that any **dam or diversion structure** has a **fish facility** included & set conditions on their design & performance

Why does it matter?

- Resource Management Act 1991
  - s.13 refers to **avoiding**:
  - **damaging**, **destroying**, **disturbing**, or **removing** the **habitats** of animals; or
  - using, **erecting**, **reconstructing**, **placing**, **altering**, **extending**, removing or demolishing any **structure**

    …in, on, or under the bed of a lake or river
- National Policy Statement for Freshwater Management 2017
  - Ecosystem health as compulsory national value

Introduction to the new NZ Fish Passage Guidelines

Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi

Rationale

- Provide access to information needed to design for fish passage
- Set minimum design standards
- Enable more consistent fish passage management across NZ
- Basis for shifting expectations

Scope

- Structures ≤4 m high
- Design of new structures
- Remediation of existing structures
- Creation of built barriers
- Monitoring

Objectives

Good fish passage design will achieve:

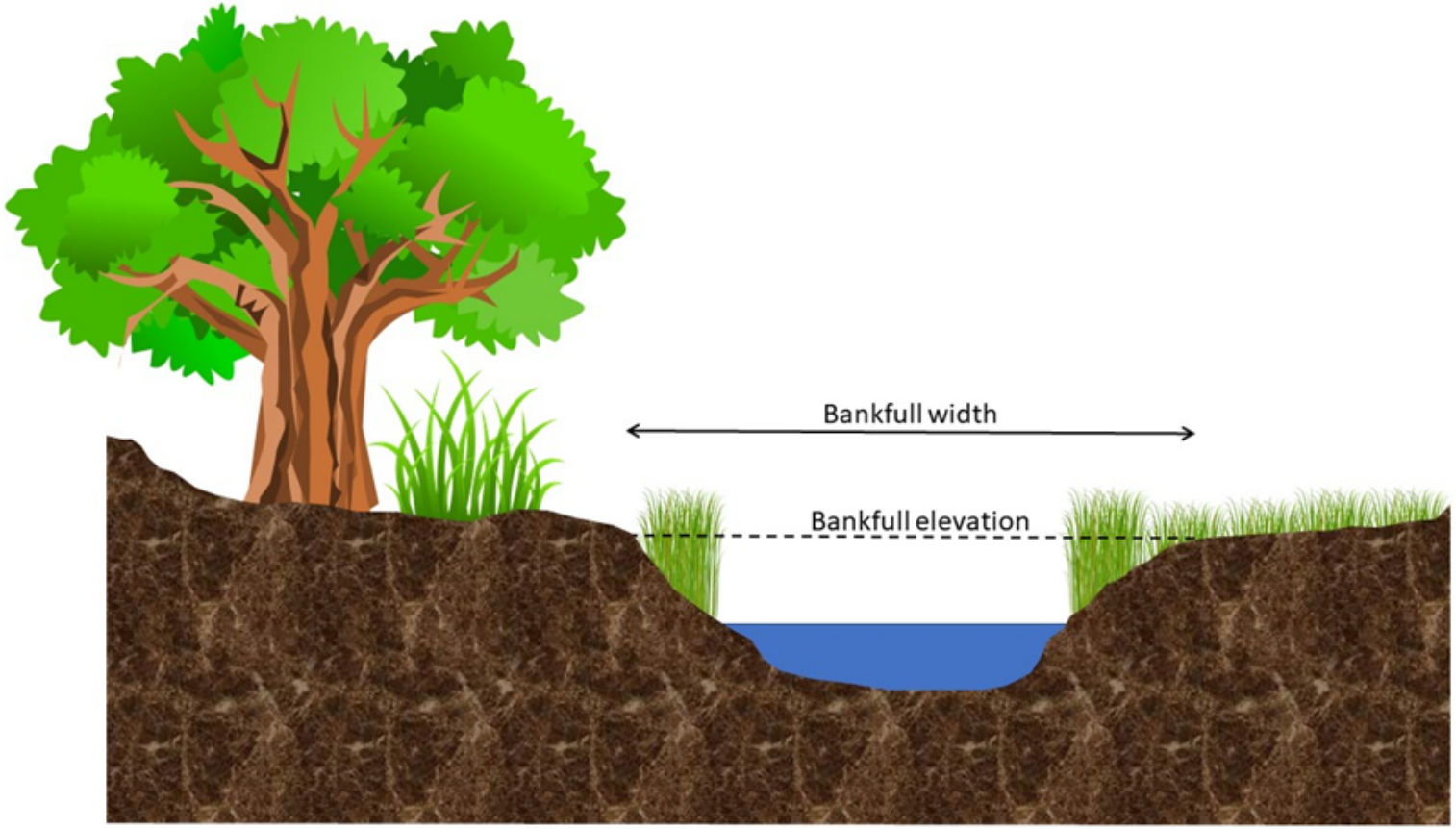
- Efficient and safe upstream and downstream passage of all aquatic organisms and life stages with minimal delay or injury
- The structure provides no greater impediment to fish movements than adjacent stream reaches
- A diversity of physical and hydraulic conditions leading to a high diversity of passage opportunities
- Continuity of geomorphic processes such as the movement of sediment and debris
- Structures have minimal maintenance requirements and are durable

Principles of good fish passage design

The principles of good fish passage design include:

- Maintaining continuity of instream habitat
- Minimising alterations to stream alignment
- Minimising alterations to stream gradient
- Maintaining water velocities within a range equivalent to adjacent stream reaches
- Maintaining water depths within a range equivalent to adjacent stream reaches
- Minimising constraints on bankfull channel capacity

Principles of good fish passage design



Principles of good fish passage design

The principles of good fish passage design include:

- Maintaining continuity of instream habitat
- Minimising alterations to stream alignment
- Minimising alterations to stream gradient
- Maintaining water velocities within a range equivalent to adjacent stream reaches
- Maintaining water depths within a range equivalent to adjacent stream reaches
- Minimising constraints on bankfull channel capacity
- Avoiding vertical drops
- Providing an uninterrupted pathway along the bed of the structure

Design of new structures

Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi

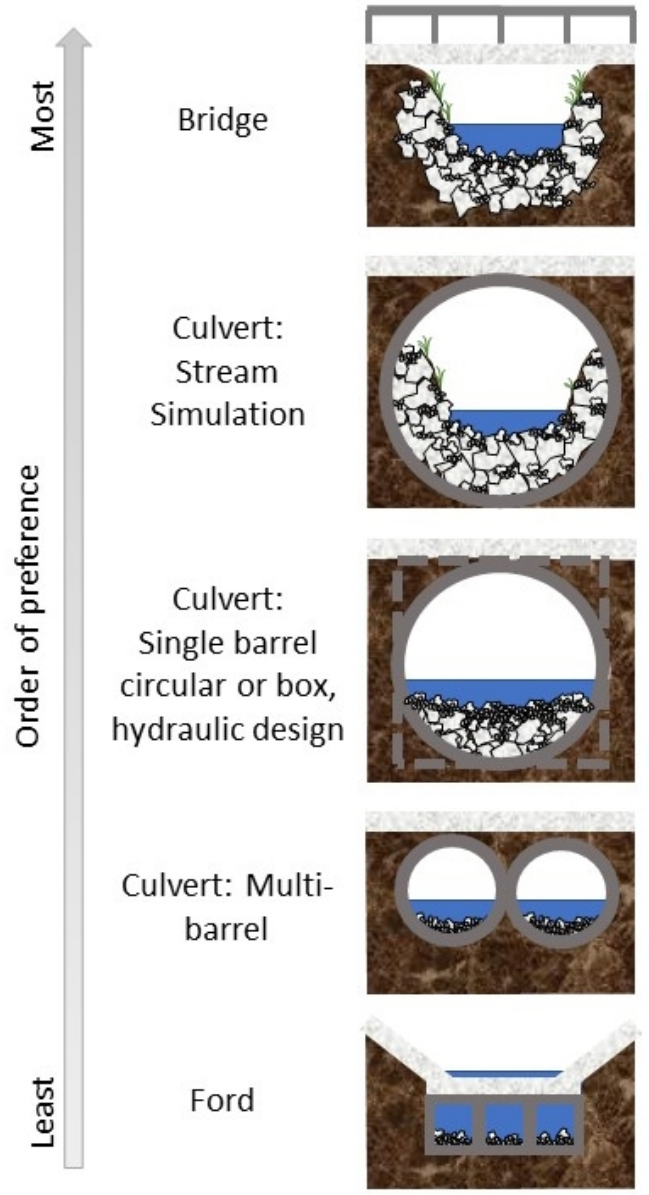
Guidance for new structures

Don’t build new barriers!

Minimum standards v best practice

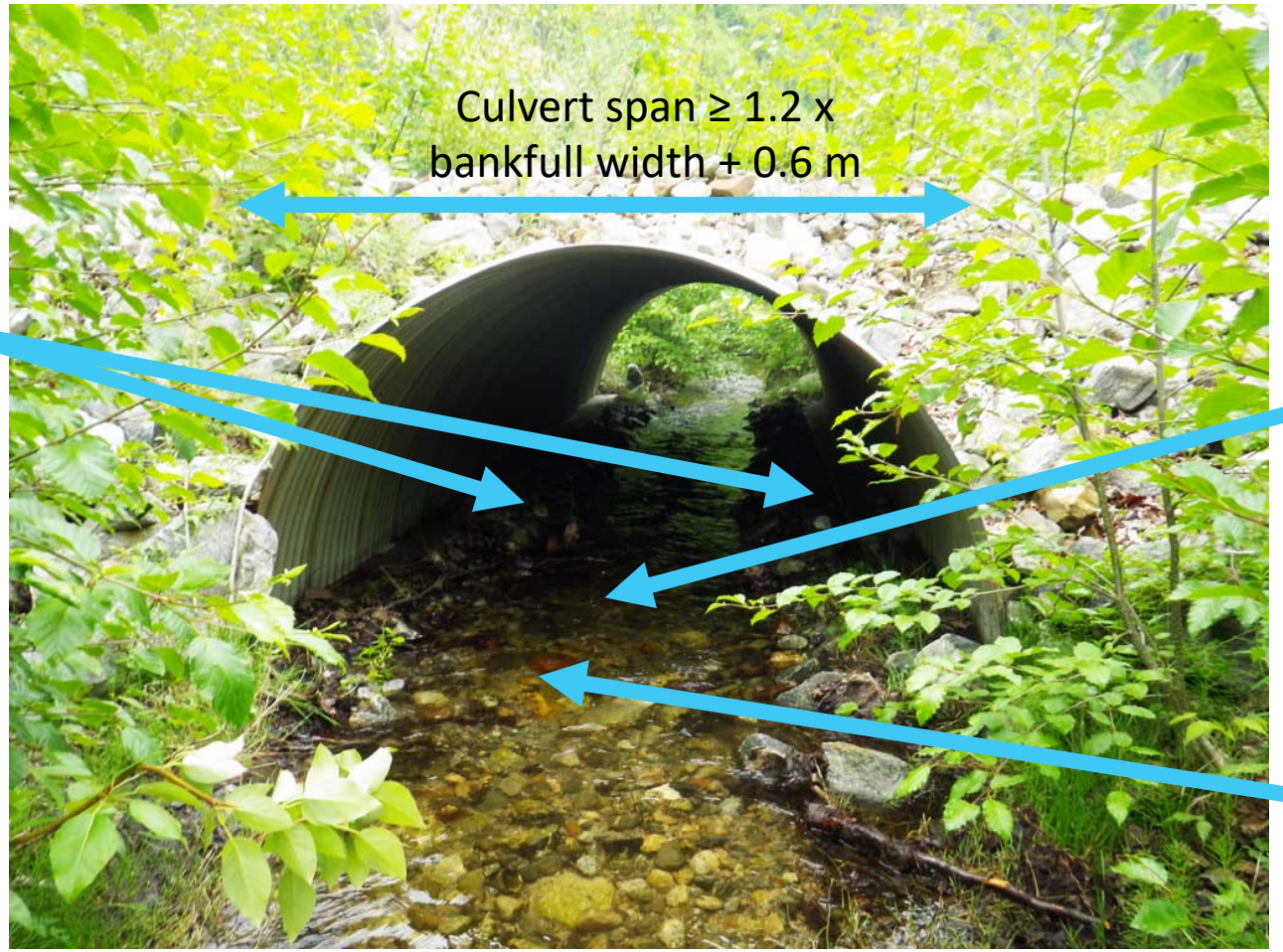
Stream crossings

- Bridge:
  - Natural bed and banks
  - Natural water depths and velocities
  - Natural substrate
  - Preserves stream gradient and alignment
  - Minimal construction disturbance
- …
- Ford:
  - Artificial bed and banks
  - Reduced depth and increased velocity
  - Often creates a vertical barrier on the downstream face



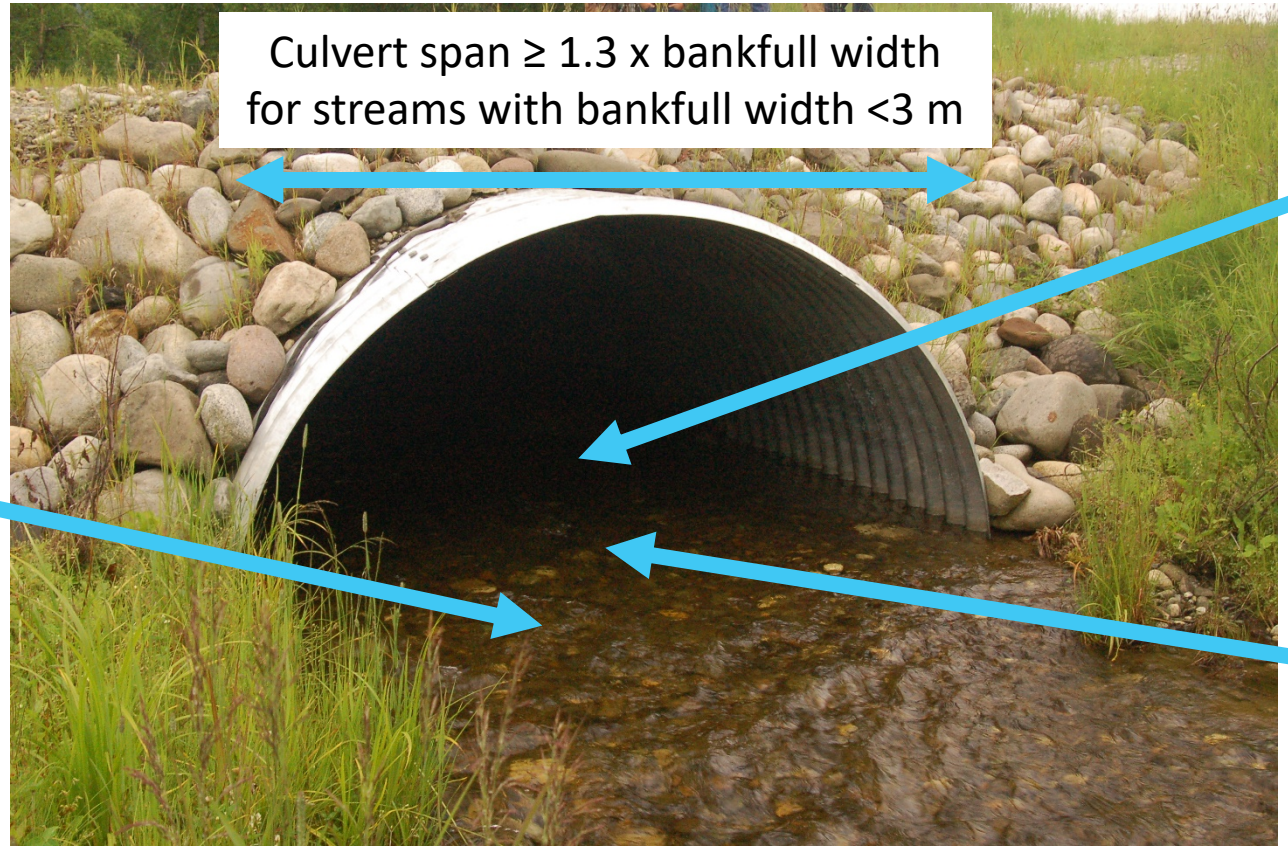
NIWA
Taihoro Nukurangi

Stream simulation culvert design



NIWA
Taihoro Nukurangi

Hydraulic culvert design



NIWA
Taihoro Nukurangi

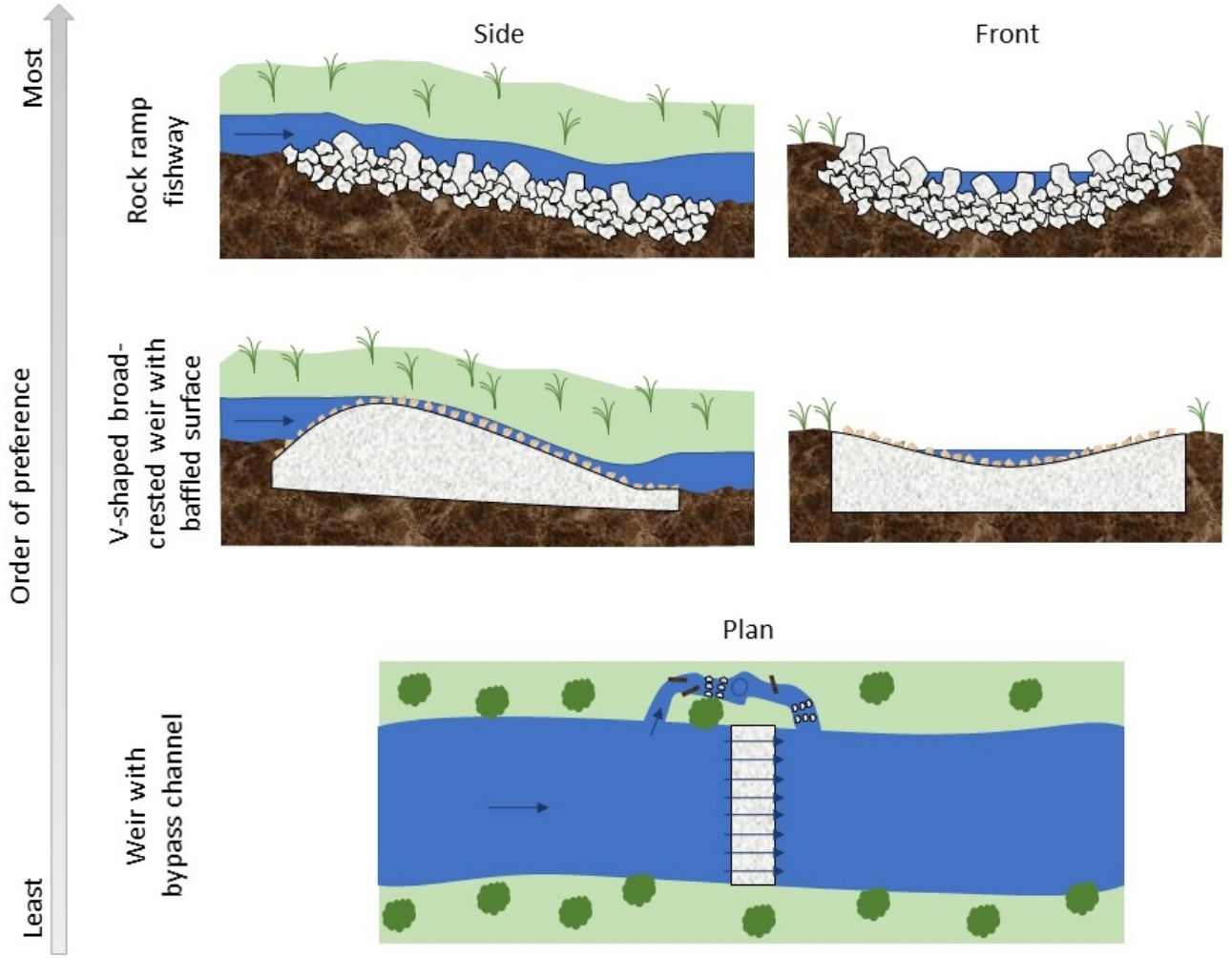
Fords – Avoid them!

- Shallow, fast flows
- Downstream vertical face
- Undersized culverts
- Bed disturbance

Fords – if you have to…

- Avoid or minimise any reduction of the channel cross-sectional area at the ford
- Where multiple barrels are required, box culverts should be used to span the full wetted width of the stream without significantly constricting cross-sectional area.
- Substrate must be maintained through the full length of the culverts
- Avoid or minimise alteration of natural stream channel alignment & gradient.
- The ford surface should be roughened (e.g. through embedding rocks) to facilitate passage of fish over the ford when flows overtop the structure.
- The lateral profile of the ford should be V-shaped to ensure that wetted margins are maintained when it is overtopped during elevated flows.

Head control structures

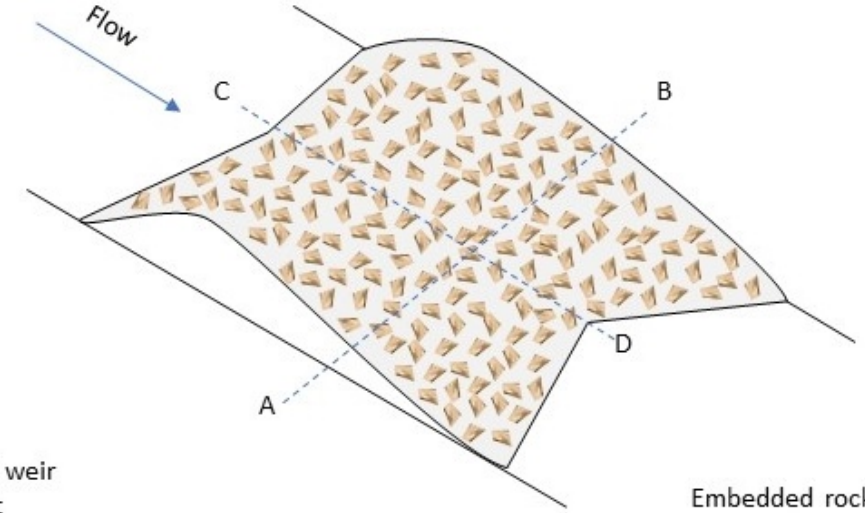


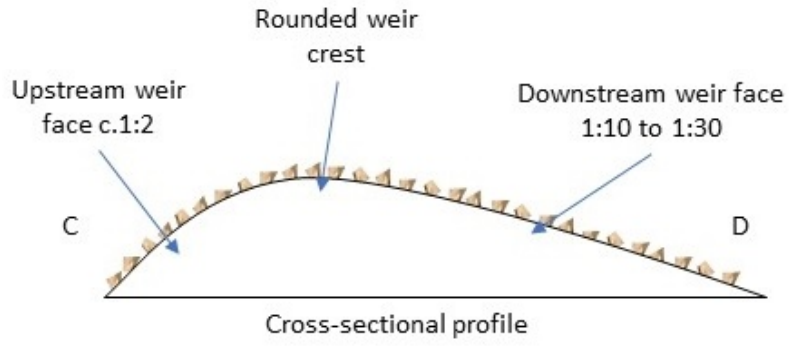
NIWA
Taihoro Nukurangi

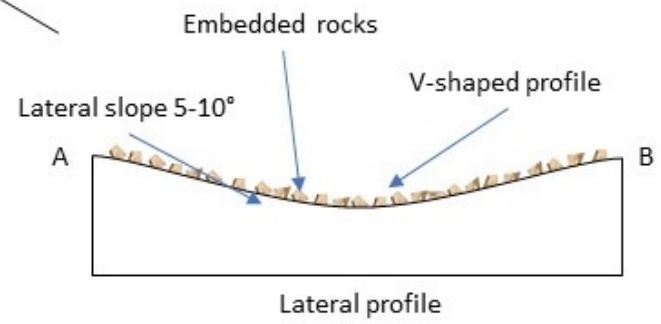
Rock-ramp weir design

NIWA
Taihoro Nukurangi

Conventional weir design







NIWA
Taihoro Nukurangi

Dealing with existing structures

Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi

Guidance for existing structures

- Many existing structures do not allow effective fish passage
- Removal should be first option & will ALWAYS have best result
- Replacement with fish friendlier design
- Remediate existing structure to improve connectivity
  - Ensure fit for purpose!

Common problems	Possible fixes							
	Removal	Replacement	Backwatering	Ramp fishway	Baffles	Mussel spat ropes	Bypass structure	Fish friendly flap gate
Excessive fall height	✓	✓	✓	✓		?	✓	
High water velocities	✓	✓	✓		✓	✓	?	
Insufficient water depth	✓	✓	✓		✓		?	
Physical blockage	✓	✓		✓			✓	✓

Remove…

- Many structures are now redundant
- If it's no longer needed, get rid of it!

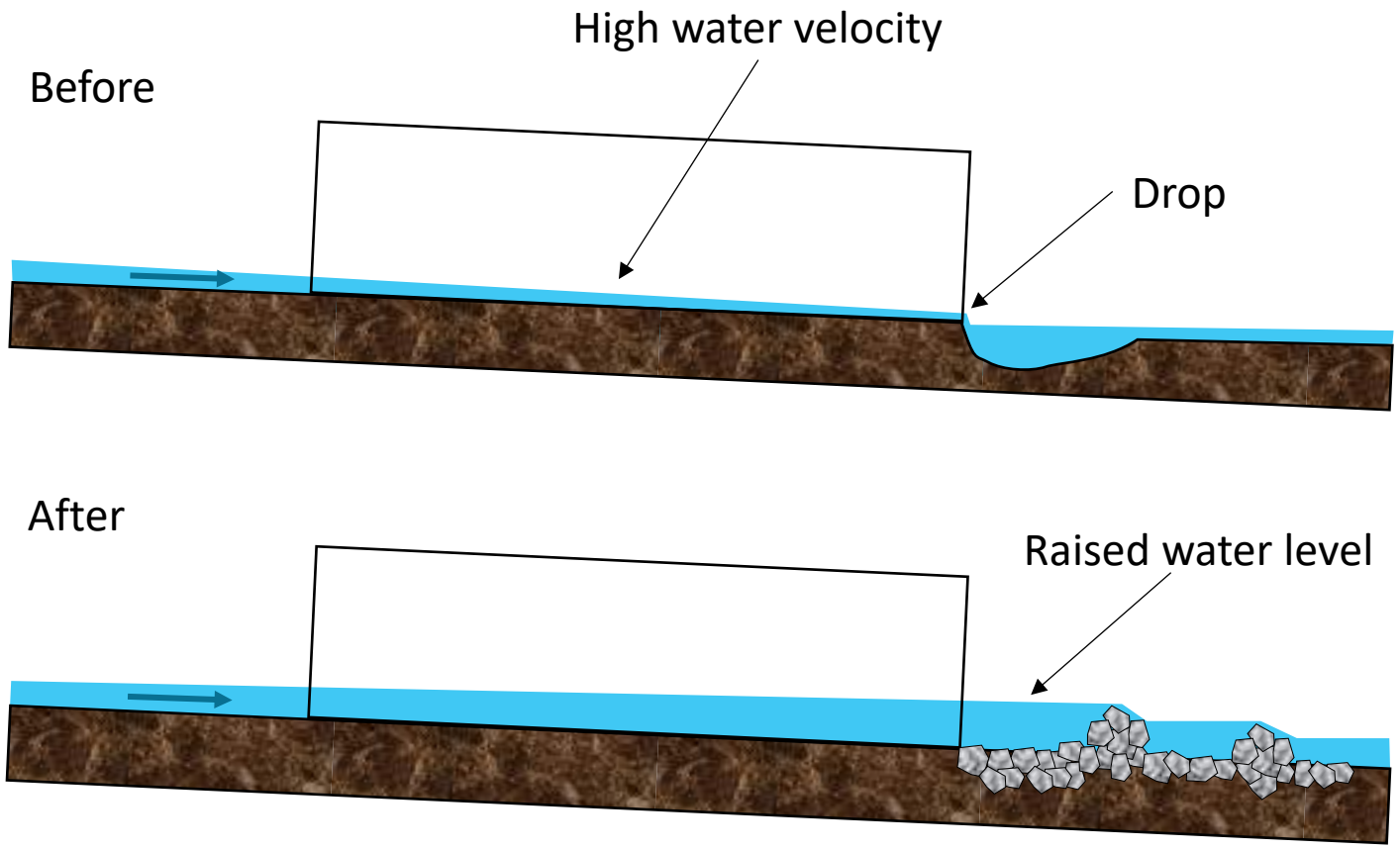
- Example:
  - 30 year old decommissioned gauging weir on Great Barrier Island
  - Blocked access to 19 km of stream
  - Removed in summer & free access restored

Credit: Auckland Council

Replace…

- Is the structure:
  - In poor condition?
  - Near the end of its lifetime?
  - At risk of failing?
  - …
- Consider replacement with new structure that meets minimum standards

Backwatering



NIWA
Taihoro Nukurangi

Ramps

- Fish ramps can be effective for overcoming drops
- Quite a bit of research done on ramp length, slope & substrate
- Simple summary:
  - Short = Good; Long = Bad
  - Gentle slope = Good; Steep = Bad
  - Roughened substrate = Good; Smooth substrate = Bad

Rock-ramp fishway

- Best practice to use rock-ramp fishways
- ‘Nature-like’ design
- Low slope (≤1:30)
- V-shaped cross-section
- Pools >2 m long
- Drop between pools <75 mm

Concrete rock-ramps

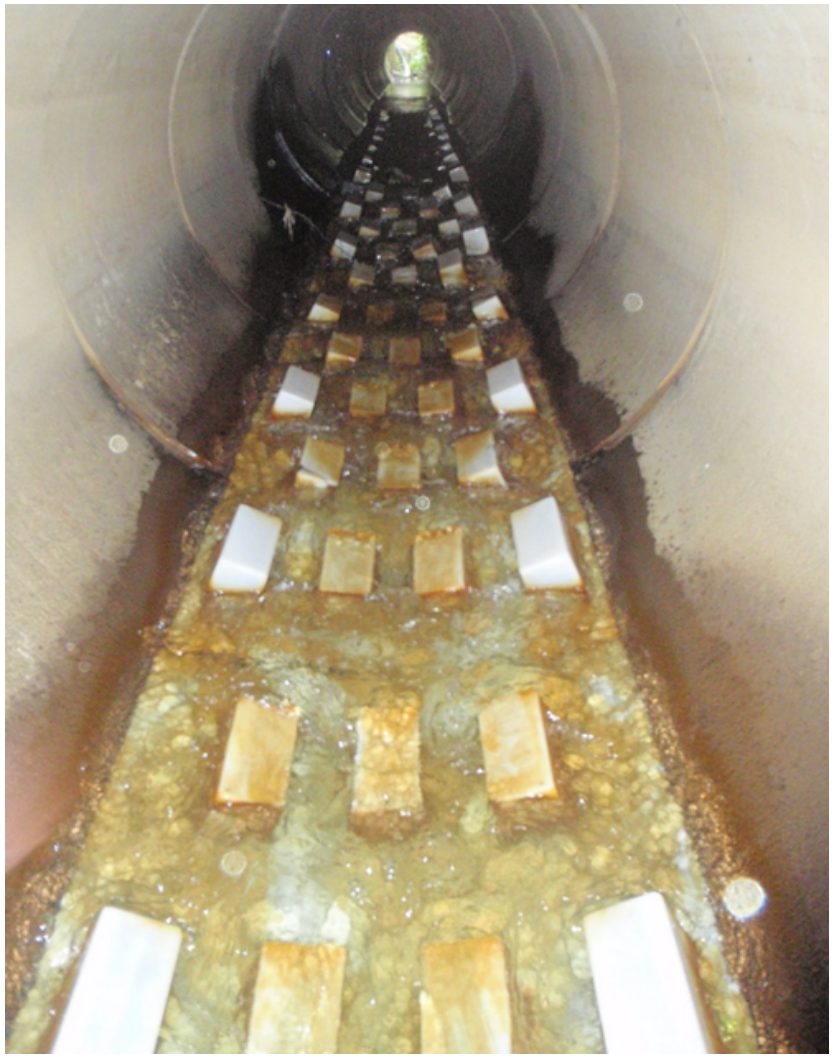
- Formal v informal designs
- V-shaped cross-section
- Low slope
  - Drop ≤0.5 m, slope ≤ 1:5
  - Drop ≤1.0 m, slope ≤ 1:10
  - Drop 1-4 m, slope ≤ 1:15
- Embedded rocks
- Resting pools

Plastic ramp

- New moulded plastic ramp
- Promising results under certain conditions
- Best results likely when:
  - All flow goes down ramp
  - Ramp isn't full of water
  - Drop ≤0.5 m
- How does floating ramp impact success?

Baffles

- Culvert baffles can be effective where high water velocities limit fish passage
- Variety of designs proposed
- Spoiler baffle designs recommended option
- Weir type baffles **not** currently recommended



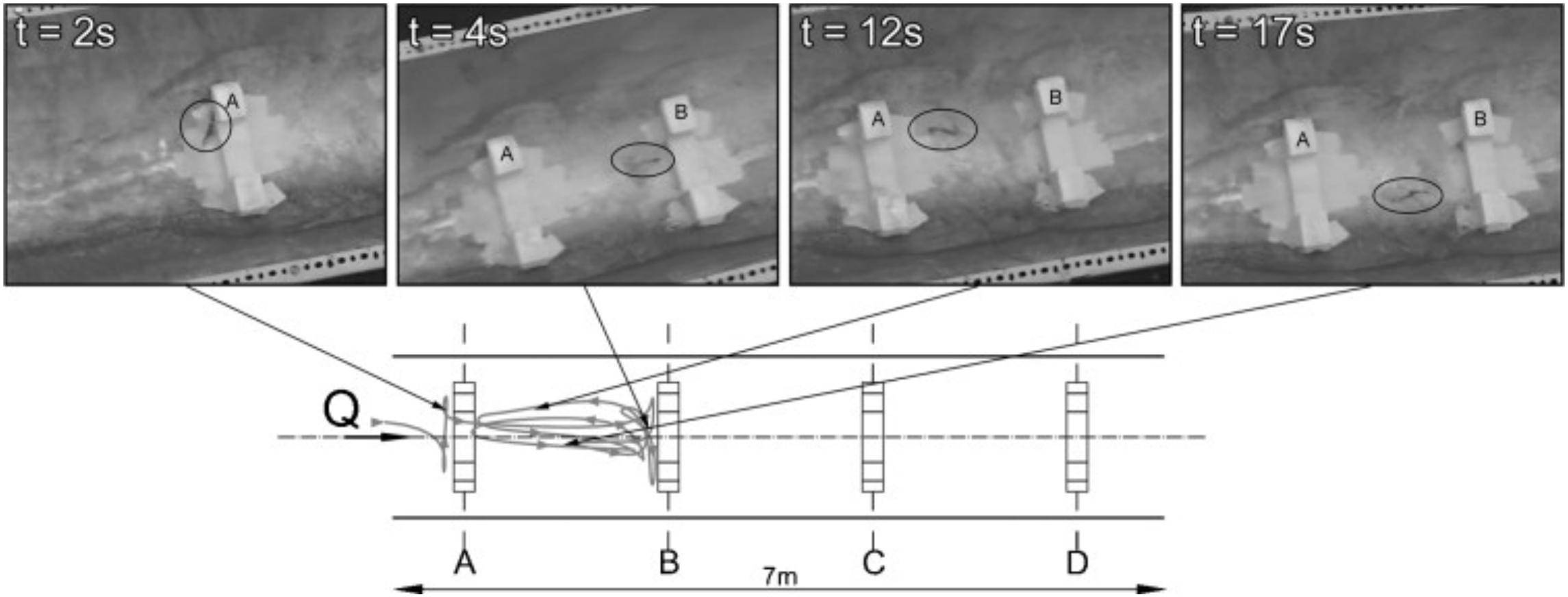


Fig. 3. Example of overhead images taken of a fish attempting to negotiate a circular culvert fitted with Alberta fish weir. A plan view of the experimental set up showing a typical path taken by fish during the test is also shown. Source: Feurich et al (2012)

Feurich et al (2012) Improvement of fish passage in culverts using CFD.
Ecological Engineering 47: 1-8

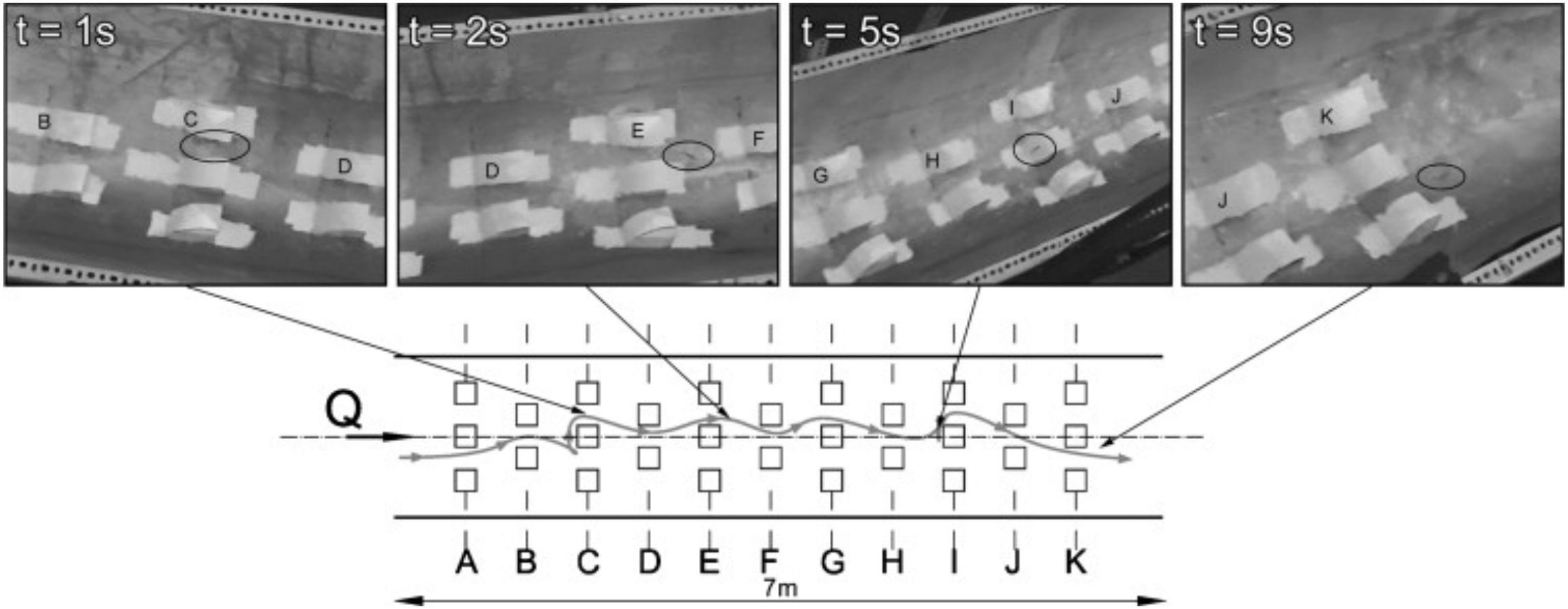


Fig. 4. Example of overhead images taken of a fish negotiating a circular culvert fitted with spoiler baffles. A plan view of the experimental set up showing a typical path taken by fish during the test is also shown. Source: Feurich et al (2012)

Feurich et al (2012) Improvement of fish passage in culverts using CFD.
Ecological Engineering 47: 1-8

Mussel spat ropes

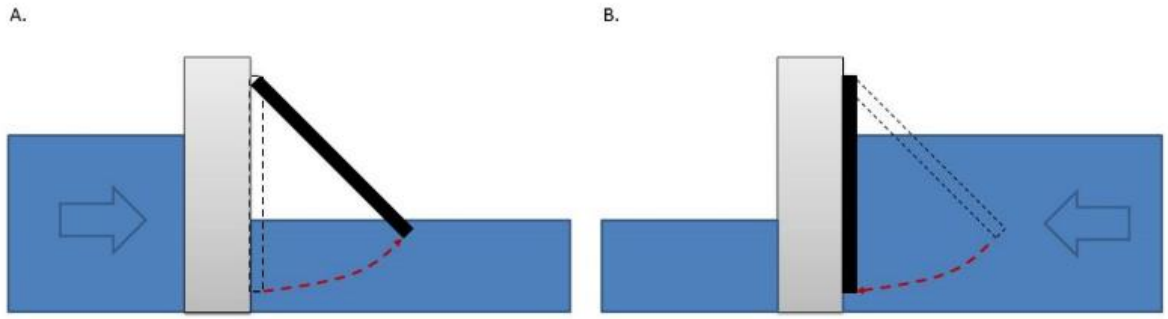
Mussel spat ropes can be cost-effective fix for SMALL culverts IF installed correctly

- Number of ropes scaled to culvert size
- Ropes tight and flush with culvert base
- Ropes full length of culvert
- ‘Swimming lanes’ between ropes for fish

- Too few ropes
- Ropes out of water!
- Ropes loose
- Ropes not full length of culvert
- Ropes old and worn

Tide gates

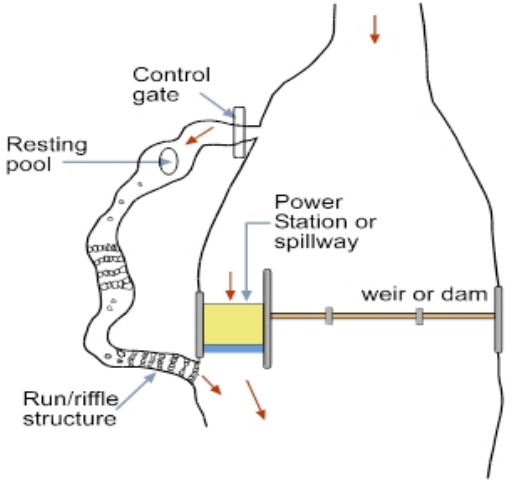
- Tide gates obstruct the movement of fish
- Gates close on incoming tide when most fish move upstream
- Automatic gates that only operate when required preferred option
- ‘Fish friendly’ self-regulating gates can be used to hold gates open for longer



NIWA
Taihoro Nukurangi

Bypass structures

- Bypass structures
- Nature-like fishways
  - Mimic natural stream characteristics
- Technical fishways
  - Hard engineered designs
  - Vertical slot, denil, pool & weir
- Relatively few examples in NZ



Putting it in to practice

Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi

Putting it in to practice

- Solutions must be tailored to the site & target fish
- Promote best-practice & enforce minimum standards
- Aim high: minimise departure from unimpeded passage
- Not all ‘fixes’ are made equal
  - Some ‘off-the-shelf’ fixes aren’t good practice designs or have not been properly tested
  - Even a good fix won’t work if not installed correctly

Putting it in to practice

- Minimum design standards for new structures set out in Appendix G of the guidelines
- Intended for easy reference in regional planning framework
- Covers culverts, weirs & fords
- Difficult to specify similar minimum standards for remediation options
  - BUT, Executive Summary does include list of recommended design parameters

Appendix G Minimum design standards for fish passage at instream structures

1. Minimum design standards for fish passage will achieve:
   a. Efficient and safe passage of all aquatic organisms and life stages with minimal delay, except where specific provisions are required to limit the movement of undesirable exotic species.
   b. A diversity of physical and hydraulic conditions leading to a high diversity of passage opportunities for aquatic organisms.
   c. A structure that will provide no greater impediment to fish movements than adjacent stream reaches.
   d. Structures that have minimal maintenance requirements and are durable.

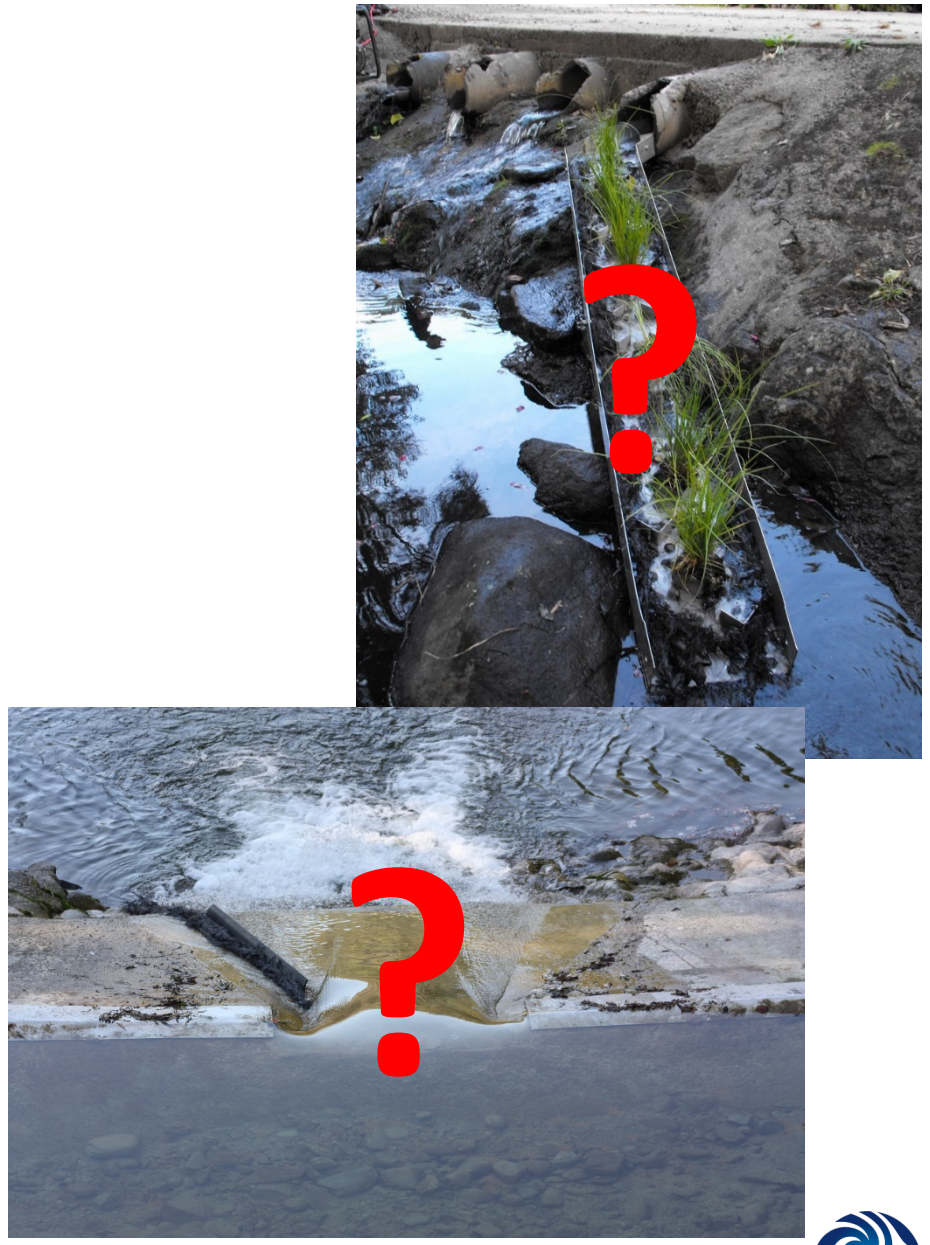
2. Culverts installed in freshwater bodies will meet the following minimum design standards for fish passage[14]:
   a. Alteration of natural stream channel alignment will be avoided or minimized.
   b. Alteration of natural stream gradient will be avoided or minimized.
   c. Culvert span[15] will be:
      i. Equal to or greater than 1.3 x stream bankfull width[16] for streams with a bankfull width ≤3 m.
      ii. Equal to or greater than 1.2 x stream bankfull width + 0.6 m for streams with a bankfull width >3 m.
   d. Open bottom culverts will be used or the culvert invert will be embedded by 25-50% of culvert height.
   e. Well graded substrate will be present throughout the full length of the culvert bed.
   f. Substrate within the culvert will be stable at the high fish passage design flow[17].
   g. Mean cross-sectional water velocity in the culvert over the fish passage design flow range will be equal to or less than the greater of:
      i. mean cross-sectional water velocity in adjacent stream reaches, or
      ii. the maximum allowable water velocity calculated from fish swimming speeds of agreed target fish species and/or life stages[18].
   h. Minimum water depth in the culvert at the low fish passage design flow will be the lesser of:
      i. 150 mm for native fish passage, or 250 mm where adult salmonid passage is also required, or
      ii. mean cross-sectional depth in adjacent stream reaches.
   i. Ancillary structures must not create an impediment to fish passage.
   j. Vertical drops will be avoided throughout the structure.

[14] Culverts must also meet relevant hydraulic conveyance and technical design standards
[15] Culvert span is defined as the width of the culvert at the point it intersects with the stream bed
[16] Bankfull width is defined as the width of the river channel at the bankfull discharge. The bankfull discharge is the discharge that fills a stable channel to the elevation of the active floodplain.
[17] Low (Q_L) and high (Q_H) fish passage design flows represent the range of flows at which fish passage is required. As a rule of thumb $Q_L \leq$ 95% exceedance flow and $Q_H \geq$ 20% exceedance flow.
[18] See Section 4.2.2.3 for methodology and 0 for look-up tables of maximum allowable water velocity.

Putting in to practice

Some things to think about:

- Is this the right design for the situation?
- Is the design proven & well tested?
- Is the proven design being applied in a novel context?
- Is it a new/novel design?
- Has effectiveness of the new design been tested/proven?
- Does it have a good chance of working well?



Putting it in to practice

- Setting clear objectives is important
- Value of monitoring cannot be underestimated
- Pick a method suitable for your needs
  - Before-after-control-impact design
  - Mark-recapture
- Seek advice from experts if you need it!

Putting it in to practice

Regardless of method, critical to ensure data are collected in consistent, standardised and reproducible way:

- same method at each survey & site
- same sites are used each survey
- sampling effort is equivalent between reaches and surveys (i.e. the same area is fished)
- sampling is carried out under similar conditions (e.g. similar flows & same time of year)

Where can you find more information?

- Download the guidelines:

  www.niwa.co.nz/fishpassage
- Visit the DOC fish passage web pages:

  www.doc.govt.nz/fishpassage
- Sign up to the NZ Fish Passage Advisory Group mailing list

  Email: advisorygroup@fishpassagenz.org

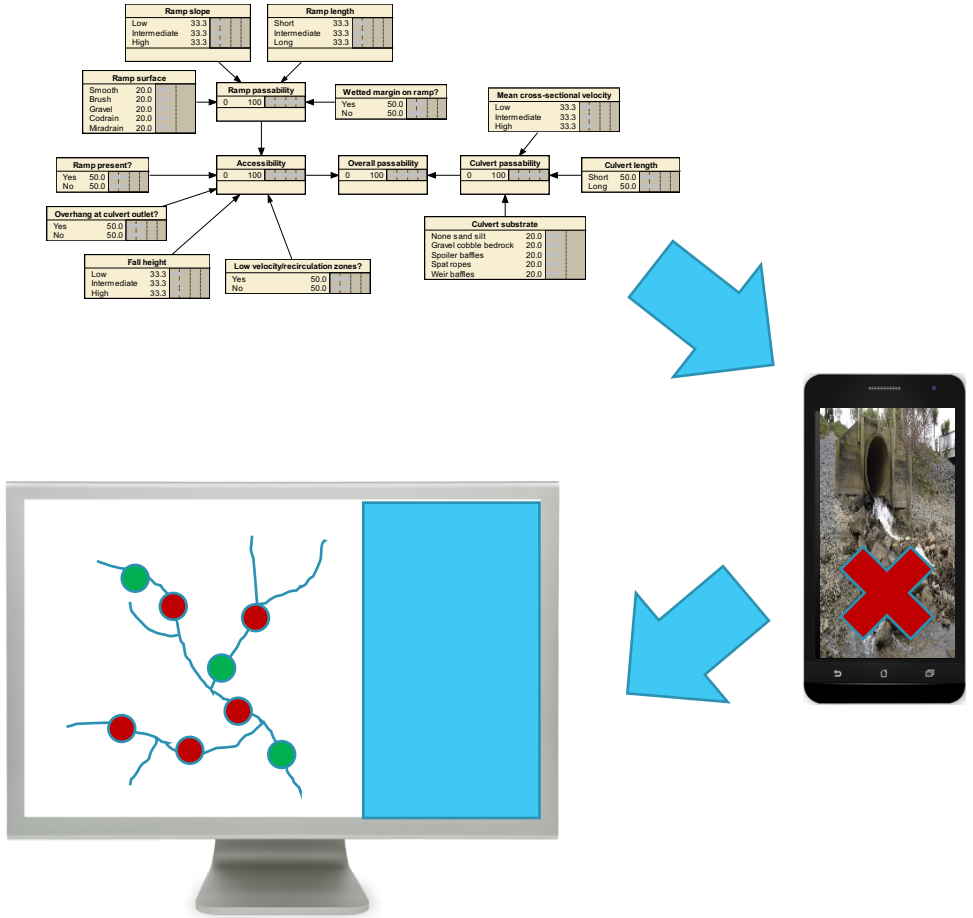
NZ Fish Passage Assessment Protocol

Climate, Freshwater & Ocean Science

NZ fish passage assessment tool

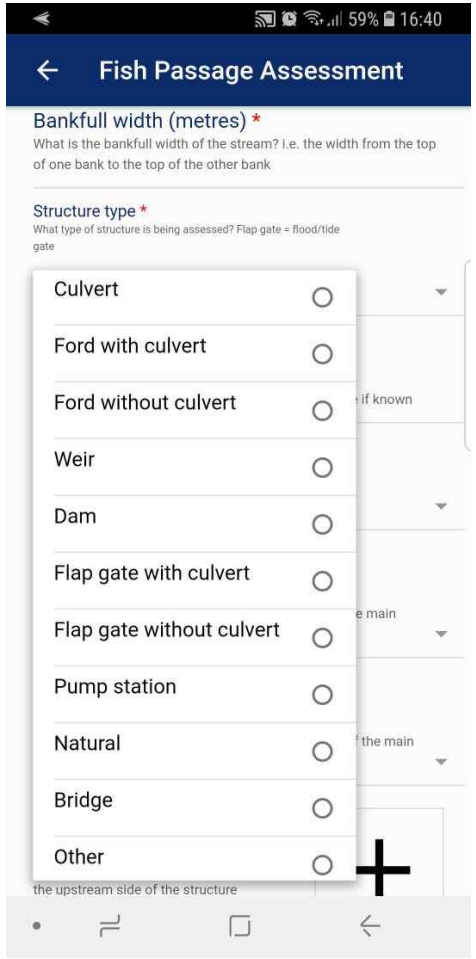
National fish passage assessment protocol tool due for release soon

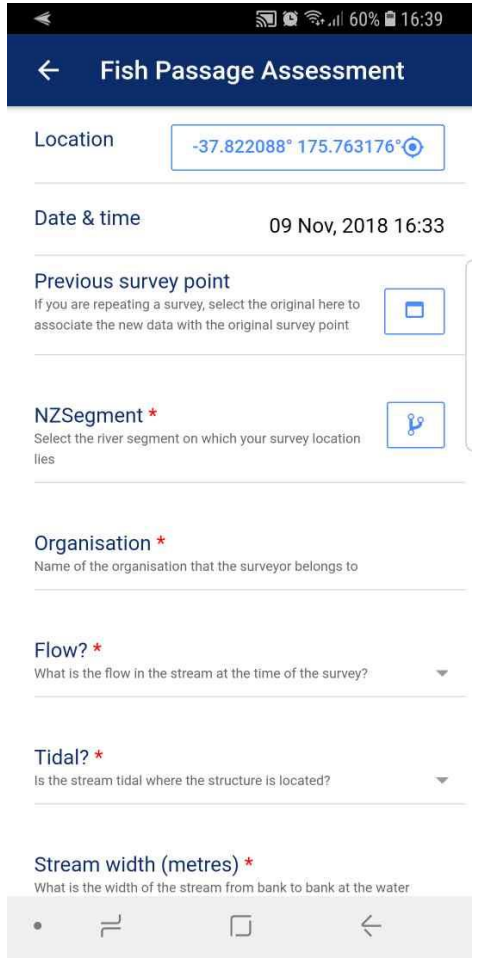
- Objective
- Mobile application
- Web-tools



NZ fish passage assessment tool

- Standardised method for recording & assessing structures for fish passage
- Android & iOS versions
- Works for multiple structure types
- Links automatically to national database

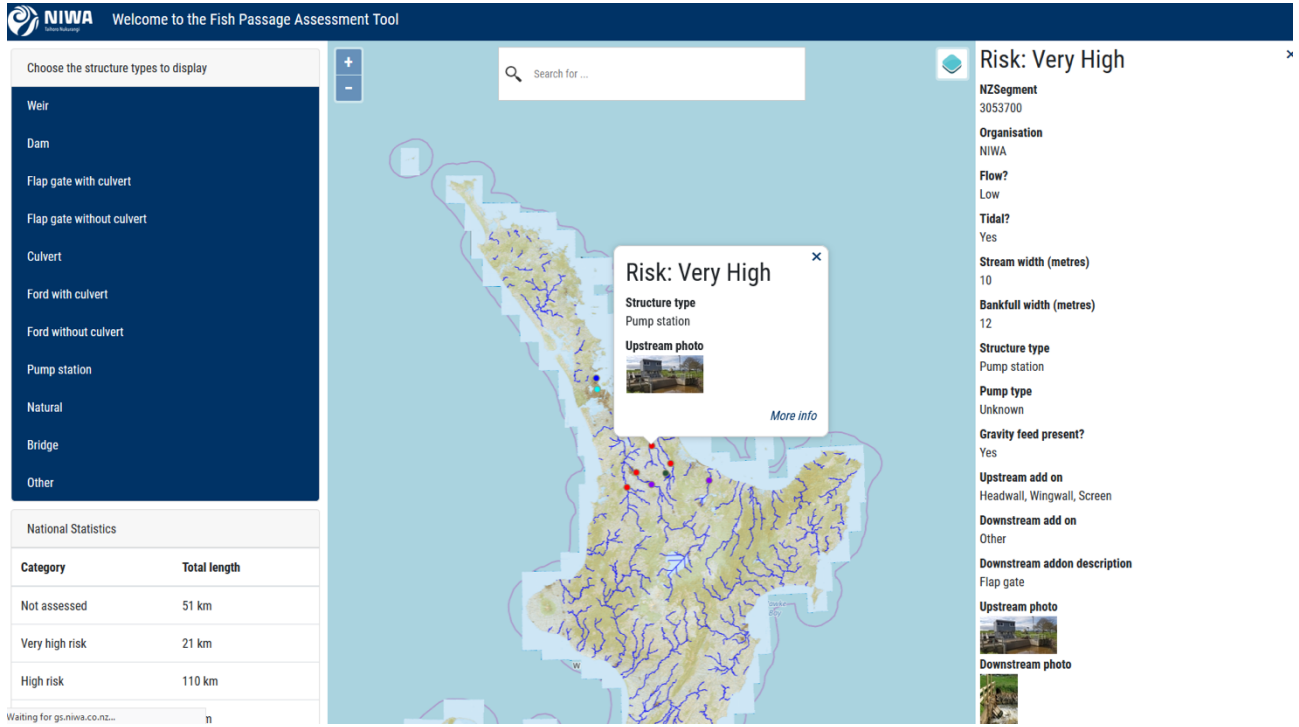




NIWA
Taihoro Nukurangi

NZ fish passage assessment tool webpage

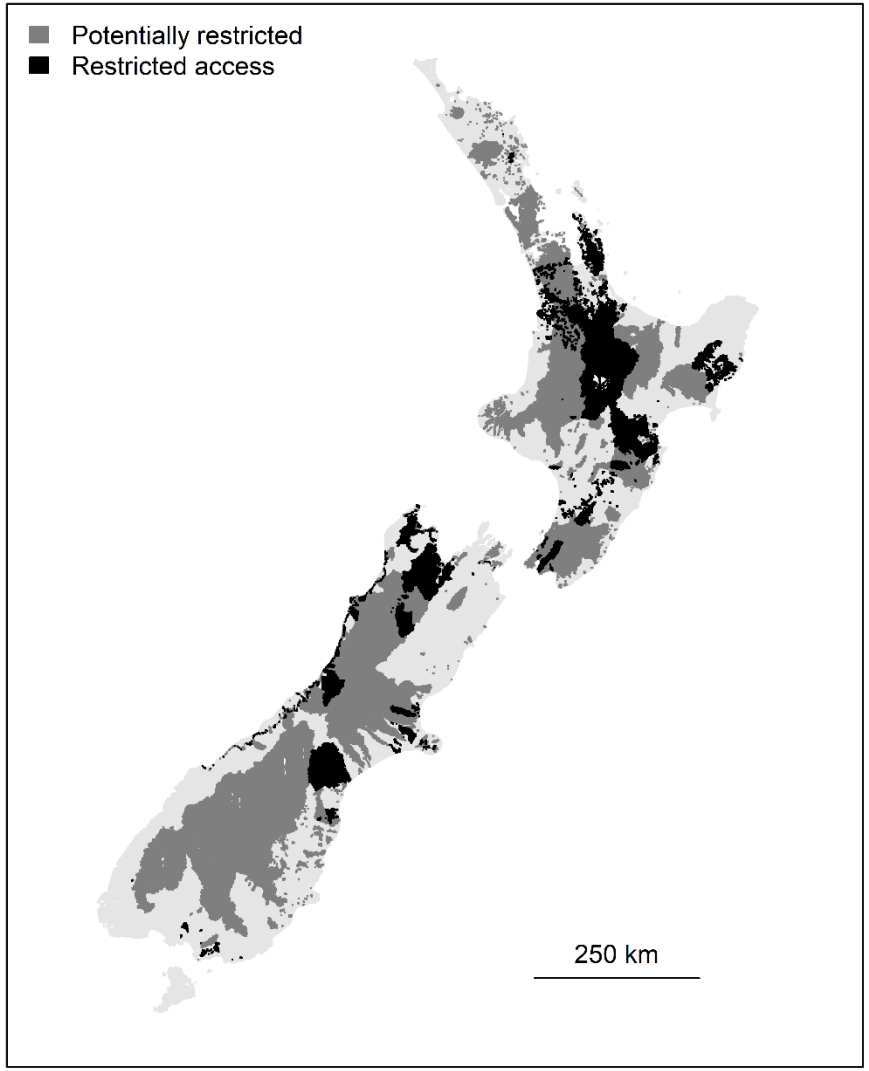
- View & download data
- Determines risk to fish passage
- Calculates national statistics
  - Number of barriers in different risk classes
  - Proportion of the river network in different risk classes
- Calculates basic ecological prioritization scores for each structure



NIWA
Taihoro Nukurangi

NZ fish passage assessment tool

- Scheduled for completion & sign-off in next few weeks
- Workshop planned for NZFSS conference
- Will be available to download from app stores
- Please use it for any fish passage assessments from now on!

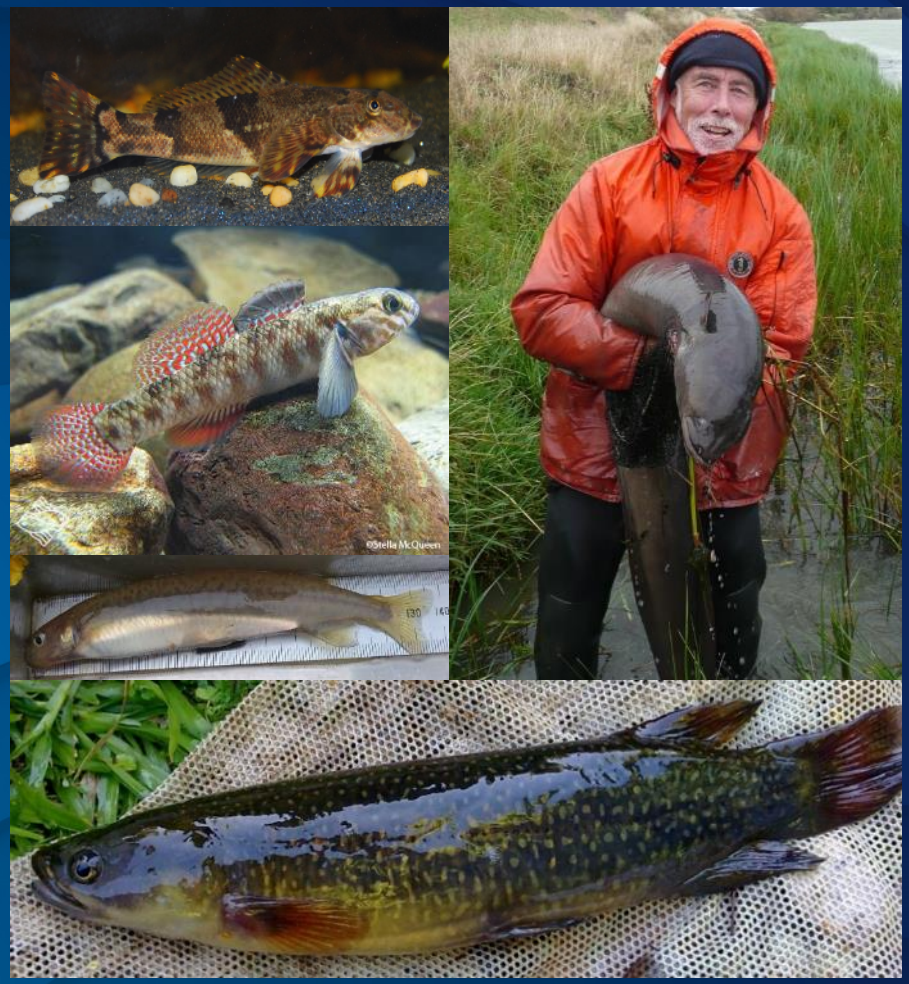


NIWA
Taihoro Nukurangi

Thank you

Paul Franklin
+64 7 859 1882
paul.franklin@niwa.co.nz

Any questions?



Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi